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

Research results from the Participatory Plant Breeding and Community Supported Agriculture project, China

Hannah Reid and Yanyan Zhang

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Author information

This report was written by:
Hannah Reid, research consultant to IIED
Yanyan Zhang, Senior Assistant Researcher, Centre for Chinese Agricultural Policy, Chinese Academy of Science (CCAP)

Corresponding author: Hannah Reid, hannah.reid@iied.org

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International Institute for Environment and Development
80-86 Gray's Inn Road, London WC1X 8NH, UK
Tel: +44 (0)20 3463 7399
Fax: +44 (0)20 3514 9055
www.iied.org

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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 the Centre for Chinese Agricultural Policy, Chinese Academy of Science, at the project site in China, where farmers were assisted in improving and conserving crop varieties that are tailored to local conditions, especially drought.

It concludes that the project has clearly improved the resilience and adaptive capacity of local communities and reduced their vulnerability to climate change, with women and the elderly benefitting the most in this respect. The project also brought a multitude of social co-benefits. Local knowledge and practices were an integral component of many project activities. Interviewees were unanimous in their view that the project had also enhanced ecosystem resilience and supported ecosystem services provision. The fact that 'economic and market needs' are the most important motivating factor for implementing project activities suggests that the project is cost-effective. The most significant barriers to EbA implementation were a lack of government support and China's top-down approach to policy implementation.

Acronyms

BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
CBD	Convention on Biological Diversity
EbA	Ecosystem-based adaptation
IIED	International Institute for Environment and Development
IKI	International Climate Initiative
IUCN	International Union for Conservation of Nature
PES	Payments for ecosystem services
SDGs	Sustainable Development Goals
UNEP	United Nations Environment Programme
UNEP-IEMP	UN Environment - International Ecosystem Management Partnership
UNEP-WCMC	United Nations Environment - 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?

Participatory plant breeding and community-supported agriculture in Southwest China

The 'Participatory plant breeding and community-supported agriculture' project (henceforth, the participatory plant breeding project) was implemented from 2000 to 2016 in the mountain communities of Yulong County in Lijiang City, Yunnan Province, and also in Duan, Mashan, Hengxian, Luocheng, Wuming, Yizhou and Dahua Counties in Guangxi Province in Southwest China, a region that is rich in biodiversity and culture and home to most of China's rural poor ethnic minority communities. Project activities targeted ethnic mountain communities, in particular 11 villages in Guangxi Province and seven in Yunnan Province. Villages here grow a number of crops including rice, maize, potato, wheat, soybean, sweet potato, wild grape, vegetables, beans, cassava, fruits, grass, Tibetan barley, millet, sorghum and *Pelagonium citrosa,* among others.

The project aimed to improve and conserve crop varieties (especially maize, wheat, rice and soybean) that were tailored to local conditions (especially drought) using local landraces.[1] It also aimed to conserve crop diversity and resilient landraces for food security and climate adaptation. It worked to link local and formal seed systems through direct collaboration on participatory plant breeding, raising awareness on the need to conserve landraces for adaptation within formal agricultural research systems, and improving the policy support available for genetically diverse local seed systems and securing farmers' rights to benefit from these. The project also promoted climate resilient and nutrition-sensitive agroecological farming practices by improving links to urban markets. Box 2 provides more details on the technical innovations and coping strategies developed by farmers to tackle climate change and other socioeconomic and environmental challenges under the project.

Box 2: Innovations and strategies developed by farmers to tackle climate change and other challenges under the 'Participatory plant breeding and community-supported agriculture' project

- Communities **conserve and continually improve drought-tolerant landraces of maize, wheat, rice and soybean** through field and post-harvest selection. Even when farmers are primarily growing hybrid or other varieties of these grains, they will still maintain these landraces and turn to them in times of drought. All the communities in Yunnan and Guangxi maintain at least one maize landrace explicitly for their drought-tolerant properties. In Yunnan, all wheat being grown is from drought-tolerant landraces. Some villages in Yunnan have conserved landraces of maize and rice that can be planted later in spring, thereby remaining resilient to the drought conditions. In the Yunnan stone villages, they have begun replacing rice with less water-intensive traditional crops such as maize and walnuts.
- Farmers are bringing back **traditional farming techniques for pest control**. In Yunnan, rice farmers grow a traditional fragrant herb called Chinese mugwort, the smoke from which repels pests. In Guangxi, villages are reintroducing traditional biopesticides using wild herbs and chilli pepper, and farmers have brought back traditional techniques of combining organic rice production with duck and fish production for natural pest control. Farmers are also **experimenting with new crops for natural pest control**. Pelargonium citrosa, a cash crop used in perfumes, medicine and incense, is grown next to rice and wheat fields so that its potent citronella-like smell deters pests.

[1] A landrace is a domesticated, locally adapted, traditional variety of a species of animal or plant that has developed over time, through adaptation to its natural and cultural environment of agriculture and pastoralism, and due to isolation from other populations of the species.

- Villages have begun **reintroducing traditional farming techniques and crops for soil management**. In Guangxi, project villages are bringing back previously abandoned traditional intercropping approaches, traditional composting approaches and methods of applying fish waste as fertilizer. The Yunnan stone villages have reintroduced traditional walnut trees because they help with soil conservation, require little labour and water, and because of their cash crop value. Traditional walnut oil processing methods were also reintroduced due to the growing need for healthy cooking oil by villagers and city consumers.
- Communities in Guangxi have developed a number of new maize varieties through **participatory plant breeding**, which combines local landraces and traditional knowledge with external varieties and knowledge through a joint innovation process. Some farmer-preferred maize and rice landraces have also been improved by farmers with assistance from scientists. All of these varieties have satisfactory yields, agronomic traits and palatability, and are better adapted to the local conditions such as drought and pests than modern hybrids.
- **New institutional innovations** designed jointly by farmers and scientists to link these previously separate actors have emerged. These have led to pilot access and benefit-sharing agreements between breeders and project villages in Guangxi, while turning leading agricultural scientists into champions of in situ conservation and farmers' rights over seeds. **Community seed banks** ensure access to a diversity of quality seeds and support recuperation after disasters. Farmers in Guangxi have also started a **platform for farmer seed and traditional knowledge exchange** involving different villages. These began as womens' seed fairs, organised annually by the villages.
- In Guangxi, farmers are **finding new market channels for their goods**, notably urban farm-direct link restaurants and farmers' markets, with support of a local non-government organisation, Farmers' Friend. As a result of this new, high-value, stable market channel, farmers have reintroduced traditional varieties and breeds that had gone locally extinct as well as traditional farming techniques. For example, Farmers' Friend has established a restaurant in Yunnan, spurring the rediscovery and further development of traditional crops like walnuts and traditional techniques such as ham curing and walnut oil production that had nearly disappeared.

Source: Song et al. (2015).

The Centre for Chinese Agricultural Policy, Chinese Academy of Science, led the project, the components of which included research, implementation and policy influence. Support was secured from a number of donors: the International Development Research Centre, the European Union, the United Kingdom Department for International Development and the Christenson Fund.

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. Whilst the participatory plant breeding project was not specifically called an EbA intervention, it clearly meets all of these criteria, so can be classified as such.

Methodology for assessing effectiveness

The methodology applied for assessing EbA effectiveness is detailed in Reid et al. (2017). This guidance describes a process, based around asking a detailed set of questions, that can be used to draw conclusions about the effectiveness of an EbA project that is ongoing or has ended. Table 3 describes the participatory plant breeding project stakeholders interviewed for this paper.

Table 3: Stakeholders interviewed under the participatory plant breeding project

Level of interviewees	Those interviewed
National	The following interviewees did not have detailed project implementation knowledge, but could provide information on the context within which EbA projects operate and bringing lessons to scale: Dr Zgang Zongwen and Xu Yinlong, Chinese Academy of Agricultural Sciences; Linxiu Zhang, Chinese Academy of Science.
Local authority	The following representatives from the Research Institute of Guangxi Academy of Agricultural Science were interviewed: Lanqiu Qin, Kaijian Huang and Hexia Xie.
Project implementers	Five representatives from the Agricultural Policy Research Center of the Chinese Academy of Science, the Centre for Chinese Agricultural Policy at the Chinese Academy of Science, the Beijing Liangshuming Rural Reconstruction Center, and Third World Network.
Beneficiaries	One representative from Guzhai Village, Mashan County, Guangxi Province was interviewed, and also the leaders of the Nonglvtun women-led Cooperative, Hongdu Village, Duan County, Guangxi Province. Interviews were also conducted in the following villages: Youmi, Wumu and Stone Villages, Yunnan Province. Most villagers interviewed were women.

Along with the interviews conducted, publications on the participatory plant breeding 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?

Climate change has affected both Yunnan and Guangxi Provinces, with changes to rainfall, increased drought, more extreme weather events and increasing pests observed over the past ten years (see Table 4) (Song et al. 2015; 2016). Conditions were particularly severe during a recent prolonged regional drought in 2010–2012. The drought in Yunnan lasted five years from 2010 to 2014, and Yunnan villages were especially affected due to their more mountainous and remote location. Pests such as snout moth's larva have also been increasing in recent years due to the droughts (Song et al. 2016). Swiderska and Malmer (2016) describe how droughts in Yunnan have meant that villagers' crops have succumbed to more pests and diseases, including new pests. Interviewees explained that the area has good irrigation measures but that every time floods occur, rice production falls significantly. Floods in 2015 reduced rice production by 50%.

Table 4: Percentage of surveyed households reporting climate-related changes in Guangxi and Yunnan over the past ten years and before

Climate-related change	Percentage of households (average for both provinces)
Decline in rainfall	92.15
Temperature (summer/winter)	70.06
Insects/pests	66.86
Drought	62.79
Diseases (animal and crop)	44.48
River water flow	39.53
Flood	36.05
Sunshine	29.36
Wind strength	25.58
Mud-rock flow, landslide	1.45

Source: Song et al. (2016)

Community interviewees and project implementing partners were clear that the participatory plant breeding project had improved the resilience and adaptive capacity of local communities and reduced their vulnerability to climate change. Song et al. (2015) also affirm that the technical, institutional and market innovations developed under the participatory plant breeding project "have contributed to strengthened livelihoods, agrobiodiversity and social capital, thereby enhancing resilience to climate and socioeconomic change, and strengthening capacity for further innovation". Song et al. (2016) reiterate that project activities have enhanced climate resilience. Interviewees provided the following explanations and details:

- ***Diversification improved the resilience of the local agricultural system***. Swiderska et al. (2011) also explain that farmers grow different varieties together to reduce the risk of crop loss and ensure some varieties survive even if crops fail completely in some areas. Song et al. (2015) add "the wider variety of crops allow farmers to maintain productive fields through unstable weather patterns". For example, a shift away from water-intensive rice production to less water-intensive traditional crops such as maize and walnuts has occurred in the Yunnan Stone Villages (Song et al. 2016). The Stone Village community seed bank has 108 varieties, which provides options for adaptation and enables recovery from extreme events (Reilly and Swiderska 2016).
- ***Knowledge and capacity for conservation and sustainable use of biodiversity was improved.*** The project helped the local community understand the importance of ecosystems, and inspired them to protect and restore them. New knowledge of, and awareness-raising on, conservation and sustainable use of biodiversity helps farmers and local communities adapt and respond to changes. Different communities were encouraged and given support to share experience and knowledge amongst themselves to build up their capacity to respond to various changes and challenges, and therefore increase their resilience. They shared traditional practices relating to conservation and sustainable use of agrobiodiversity. They also exchanged resources, such as seed varieties. Local village residents now have more confidence in dealing with climate change.
- ***Knowledge and capacity to manage and respond to specific local hazards was improved***. The project helped villagers and local leaders to understand how changing environmental, economic and cultural circumstances affect their lives. It helped them identify challenges and opportunities and organise activities to improve or maintain their wellbeing, for example by introducing preventive measures to address the hazards. Song et al. (2015) add that "farmers were able to maintain, and in some cases even improve, productivity despite drought conditions" by planting crops that were resistant to drought and selecting varieties for a diversity of planting times to adapt to late or absent rainfall (Song et al. 2016). Local landraces and improved varieties introduced by the participatory plant breeding project can be far more resilient than modern varieties; for example, maize landraces survived the 2010 drought in Guangxi, but hybrids did not (Song et al. 2016; Swiderska et al. 2011).

- ***Traditional knowledge, practices and joint collective governance can help climate change adaptation.*** The Stone Village in Yunnan, for example, has a 1,000 year-old irrigation system that has lessened the impacts of climate change, particularly drought, compared to villages without a traditional water management system (Swiderska 2016a). Meanwhile, the Stone Village uses customary laws to ensure fair water allocation to all households. This system has prevented water scarcity and conflict despite recurring drought.
- ***Income increased and improved the health of community members was improved.*** Participatory plant breeding help improve more nutritional and farmer-preferred local crops and varieties, for example, and also helped build market linkages, adding further value. This contributes to adaptive capacity.
- **Seed conservation was improved and crop resistance to drought, insects and temperature increases due to climate change was strengthened**. DNA analysis of 191 maize landraces in Southwest China shows that these are far more genetically diverse and resilient to drought and insects than the same lines held *ex situ* for 20-30 years (Swiderska 2016b). Song et al. (2016) add that new maize varieties developed through participatory plant breeding processes have 15–30% higher yields than landraces, and have higher drought and pest resistance.
- ***Harmony between the local farmers' needs, ecosystem adaptation and sustainable development*** was achieved by the joint participatory plant breeding initiative. Activities were very effective and achieved a balance between all goals. This reduced vulnerability.

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

Most interviewees explained that women and the elderly experienced the most significant improvements in resilience and adaptive capacity (or reductions in vulnerability) as a result of the project. This was because the project specifically targeted women and the elderly, particularly those between the ages of 50 and 70, who are particularly affected by the changes observed and who are now the main labour force in agriculture, especially in remote mountain areas. If their husbands go to work in big cities, women form part of the main labour force in farming work in some local communities. Young men are "better able to take advantage of urban incomes" and thus migrate to cities, leaving the women behind, so "[i]n most villages, agriculture has become the work of women and elders" (Song et al. 2015). Middle-aged farming women and the elderly are the social groups most experienced in farming. Women are traditionally the seed guardians in China (Reilly and Swiderska 2016), and therefore they gain more knowledge and experience from project activities than others. Some play leading roles in community decision making and are involved in grassroots-level policymaking processes. They are therefore more informed and better educated than others and have benefitted from project empowerment processes (Song et al. 2015; Swiderska 2016b).

One community interviewee also felt that the poor accrued more adaptation gains due to specific project targeting.

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

Most interviewees felt that there were no trade-offs in terms of *who* experienced changes in resilience, adaptive capacity or vulnerability, with reasons given including the fact that communities themselves decided on project actions and that the local partners were collective farms, so any extra income gained due to ecosystem improvements was a collective benefit. Communities make informed decisions about how best to maintain and improve their collective adaptive capacity using scientific information (for example, climate forecasts and water flow modelling). Furthermore, adaptation gains from ecosystem improvements benefit those beyond the local village residents, reaching urban dwellers too.

Some trade-offs in terms of *who* benefits may have emerged. Adopting a community-based landscape level approach, however, allowed these trade-offs to be dealt with based on customary laws (for example, relating to water usage). The local authority interviewees suggested that policy changes could potentially harm the interests of some groups. For example, better ecosystem conservation reduces

opportunities for local residents to benefit from logging, some types of cultivation, grazing and road construction that are forbidden as a result.

Project implementing partners felt there were no trade-offs in terms of *where* changes in resilience, adaptive capacity or vulnerability were experienced, but other interviewees did not concur with this view. A landscape-level approach to project planning reduced trade-offs, which when apparent were again dealt with based on customary laws.

Most interviewees felt that there were no trade-offs in terms of *when* changes in resilience, adaptive capacity or vulnerability were experienced. The project was designed to ensure long-term improvements in adaptive capacity and resilience, and one implementing partner described how strong levels of participation built capacity for the long term.

Social co-benefits from the EbA initiative

Interviewees listed a number of social co-benefits resulting from the participatory plant breeding project. Many of these also contribute indirectly to improvements to resilience, adaptive capacity and vulnerability:

- ***Secure sustainable water provision***, for example through customary landscape use and the revival of sustainable community water management systems.
- ***Improvements to bio-cultural heritage systems*** and related biodiversity management. Traditional eco-cultural knowledge is increasingly comprehensive. Conventional village varieties and resources are protected. Song et al. (2015) also note that traditional varieties and knowledge have been maintained or even increased in villages that have been practicing participatory plant breeding and community-supported agriculture for several years. Elsewhere, diversity is decreasing and the genetic basis for plant breeding is narrowing. For example, the seven project villages in Yunnan had lost 50 local food crop varieties, including 13 rice varieties, 10 maize varieties and 6 bean varieties, before the project began there. Traditional knowledge on farming and food related to those crops had also disappeared (Song et al. 2015). Villagers in Yunnan are setting up a 'Seed Park' biocultural heritage territory and a community-based seed bank (Swiderska and Malmer 2016). Building on traditional knowledge and customary systems, the project also diversified the local community's livelihoods and ensured food security.
- ***Raised awareness*** of the environment, ecosystems, conservation, sustainable development and the sustainable use of biodiversity. New knowledge was acquired on these issues.
- ***Improvements in health*** amongst farmers and villagers due to higher crop diversity. Swiderska (2016b) also reports that the project has put an end to health problems related to pesticide use in Guangxi Province.
- ***Increases in income*** from collective farms. Positive impacts on farmers' living. Song et al. (2015) also note that villages practicing participatory plant breeding and community-supported agriculture have seen farming income increase rapidly over the last ten years. Crop staple food yields have experienced productivity increases of 15–20%, and incomes have increased by around a factor of three.
- ***Strengthened capacity*** for local community farmers, relating to organisational skills and agricultural technologies.
- ***Improved market access***. There are now closer relationships and more interactions between consumers and farmers. A market-driven approach has helped recover plantations of old local varieties favoured by farmers. Traditional varieties are marketed as organic products with historical significance and can thus secure premium market prices despite small production quantities. Song et al. (2015) explain how "farmers are finding new market channels for their goods … notably urban farm-direct restaurants and farmers' markets".
- ***Strengthened social capital***, due to more stable community relations and reduced conflict over resources. Drought is inducing conflicts over water resources, but a renewed emphasis on customary law helps mitigate this. Ties and trust between minority groups has been built. Song et al. (2015) note that more young people are going back to work in project villages that have been

practicing participatory plant breeding and community-supported agriculture for several years, bucking the general trend for out-migration. They also note that as a result of project activities in Guangxi Province, women leaders have established informal women's groups to support each other's efforts to conserve landraces and strengthen communication and bonds. These groups have gradually expanded and grown into five registered farmer's cooperatives (Song et al. 2015). The project links farmers with breeders, scientists, market people and others, which enhances farmer capacity and links them to a larger world with more information and opportunities (Song et al. 2015). Vegetable groups, folk music and dancing groups, and the revival of traditional community organisations and seed exchanges, has occurred (Song et al. 2016). The concept of bio-cultural farming is not only about farming technologies, but incorporates the spiritual world, culture and traditions. These are embedded in the long farming history and are the essential basis for sustainable development (Swiderska 2016a).

- ***Improved governance.*** Various organisations now have better rules, regulations and agreements in place. Customary law is better supported and governance has improved. For example, Song et al. (2015) explain how customary laws have been brought back and combined with some new rules for water management and distribution in times of scarcity. Opportunities for policy improvement have also emerged; for example, scientific and traditional knowledge combine to provide positive inputs to policy and law formulation or revision. When these policies and laws materialise, everyone will benefit. Improved policies can consider and value traditional knowledge.
- ***Strengthened intellectual property rights*** (Song et al. 2015). The project has worked to secure the formal recognition and protection of farmers' rights to different plant varieties, and to ensure farmers are rewarded. For example, project activities have contributed to the implementation of the Food and Agriculture Organization Treaty on Plant Genetic Resources, which entered into force in 2004, and the head of China's maize breeding programme recently proposed a revision to China's seed law to include protection of farmers' rights and seed systems (Song et al. 2015).
- Significantly ***higher food self-sufficiency*** in villages with organic farmer groups, compared with neighbouring villages (Song et al. 2016). This is important in remote areas a long way from markets or agricultural extension services, where dependence on modern varieties means seeds have to be bought each season, are often protected by intellectual property rights and require costly inputs such as fertilizers and pesticides (Swiderska et al. 2011).

Distribution and trade-offs relating to social co-benefits

Interviewees felt that some groups accrued more of these social co-benefits than others, but no interviewees gave examples of how social co-benefits for some came at a cost for others. One explained that whilst it is unavoidable that some will benefit more than others, the communities are satisfied with the current situation, as co-benefits are shared and conflicts dealt with based on customary laws. Those felt to accrue more social co-benefits than others included:

- Youth and children, who will benefit in the future from eco-conservation activities today.
- Villagers, who can increase their incomes and have more choices as a result of improvements in biodiversity. Swiderska (2016b) adds that participatory plant breeding has empowered poor farmers and improved their nutrition and health.
- Women, who are targeted by project activities so also receive more social co-benefits emerging from project activities.
- Consumers (urban and others), who can access healthier food.
- Social enterprises that support ecological smallholders.

The role of participatory processes and local/indigenous knowledge

Most implementing partner interviewees felt that the participatory plant breeding project incorporated local knowledge or practices. These helped improve crops and protect crop species diversity, for example by using local drought-resistant crops and crop varieties; preventing or controlling crop diseases and pests using biological and physical methods; informing farming methods as they change to eco-planting; keeping and saving local seeds to make them viable for longer (using traditional

methods); managing water distribution amongst villages and households, and between crop seasons, using customary laws; and informing seasonal sowing or harvesting work (using related customary ritual activities). Some local varieties currently used feature in legends and fairy tales.

Implementing partner and community interviewees described a number of ways that communities participated in the project. Participation in plant breeding was mentioned most, whereby community members selected varieties and engaged in a Participatory Guarantee System. Under this system, organic farmers regain control over the certification process and are able to produce a far more credible and effective system of quality assurance compared to third-party certification systems. Although only recently adopted, the system has been recognised all over the world. Community participation was also a component of seed bank-related activities and community-supported agriculture, including eco-friendly plantations and husbandry. Farmers were given opportunities to travel and exchange experiences with communities elsewhere, which improved their knowledge. Consumer participation in community events boosted farmers' enthusiasm for participation.

Those that characterised the participatory processes used according to the typology supplied[2] categorised them towards the latter end of the spectrum. Three felt that participation could be characterised as self-mobilisation, with one adding that communities have decision-making power over how to use their own resources. Song et al. (2015) support this perspective, detailing how farmers have led a number of biocultural innovations and established their own local organisations. Swiderska (2016b) describes 500 'innovations' in 18 communities, most of which are technological innovations, but also some market and institutional innovations, and many of which are based on indigenous knowledge. Participation could also be characterised as being for material incentives, functional and interactive, because engagement in eco-agriculture farming work brought economic benefits from higher income or lower input costs.

All implementing partner and community interviewees agreed that the use of participatory processes supported EbA project implementation and built adaptive capacity. They provided the following explanations for this: local community ownership was enhanced; independence from the biotech industry was enhanced; community environmental awareness levels had improved; levels of scientific understanding were heightened; improvements to the ecosystem had enhanced its ability to cope with pests; the focus on old local seed varieties had been renewed; participation had improved local capacity, for example on the breeding techniques used by farmers; and participation had brought additional economic and reputational benefits. This mirrors experience from mountain communities elsewhere in the world showing that biocultural heritage is critical for adaptation (Swiderska and Malmer 2016).

One interviewee added that new farming methods help villagers cope with climate change and provide additional benefits, so they will willingly adopt them and little promotion is needed. The local authority interviewees added that gains in adaptive capacity occurred because the project had identified something of interest to the local community as its entry point, and this had encouraged people to participate.

[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).

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

Interviewees listed a number of threats to local ecosystem resilience and services provision:

- Climate change and related changes to temperature, soil water, and so on. Climate change brings more droughts and higher temperatures, which significantly affects agricultural production and pest populations as well as biodiversity, agro-biodiversity (by reducing the varieties of food crops available), water availability and local ecosystems. Extreme climatic conditions bring more risks and unpredictability in terms of water provision and the farming system, for example extreme drought combined with extreme floods can cause soil erosion.
- Natural disasters, including floods, rainfall changes, drought, wind damage and insect plagues destroying local ecosystems. For example, pest plagues hinder the growth of local crops and might bring about a total loss of the crop yield. Using pesticides can address pest-related crop losses, but will harm the environment.
- Government policies and implementation. Local governments sometimes enact measures in pursuit of political gains, or for performance appraisal, that are not necessarily compatible with local lifestyles, and this can have a negative effect on the local environment. Similarly, national policymaking is often unable to comprehensively take into account every situation in the entire country, and might go against local customs in some places.
- Overexploitation of resources, brought about by economic development. Local residents choose high-yielding crop varieties that require less labour input but lead to the gradual disappearance of some traditional crops and traditional varieties. Song et al. (2015) also explain how labour-saving chemical-intensive mono-cropping has led to degradation and loss of agrobiodiversity, traditional knowledge, culture and community cohesion.
- Market-related factors.
- Urban development, which decreases the area of arable land and weakens the ability of wetlands to provide ecosystem services.
- The ploughing up of hilly land and planting of single species, for example fast-growing eucalyptus, which replaces existing vegetation and animal diversity and lowers the ecosystem's ability to deal with natural disasters. Short-term earnings are higher, but the soil ecosystem is destroyed and it is hard to recover species diversity.
- Excessive and poorly managed coal extraction affects groundwater, and thus rivers and their associated ecosystems.
- Burning the mountain to reclaim wasteland, which leads to the disappearance of many species.

Boundaries influencing ecosystem resilience

One interviewee explained that the level of the watershed or catchment area was useful for considering ecosystem resilience because the landscape contains different ecosystems, such as forests and agricultural land, which interact with each other.

Thresholds influencing ecosystem service provision

Implementing partner and local authority interviewees felt that without sufficient local water availability (due to changes in temperature and droughts), rivers, lakes and all their associated wildlife could be damaged irrecoverably and there might not be enough water for irrigated agriculture.

Two implementing partners also described how soil loss and erosion could result from temperature increases and droughts. This could in turn cause biodiversity loss.

One interviewee described potential thresholds relating to degradation and forest loss, and also the loss of traditional knowledge systems, which could mean managing trade-offs and dealing with conflicts sustainably becomes impossible, and ecosystem service delivery will be affected as a result.

EbA initiative impacts on ecosystem resilience and services provision

Interviewees were unanimous in their view that the participatory plant breeding project had enhanced ecosystem resilience and supported ecosystem services provision. Examples given included:

- Diversification and proliferation of local genetic resources through crop breeding. With more crop species, the ecosystem has become more stable.
- New ecological farming and husbandry methods, which have increased species diversity and helped preserve the local environment. Ecosystem harm by pesticide use has decreased.
- Improvements to the wetland ecosystem and biodiversity. Wetland ecosystems have improved, and there are richer living resources.
- Improvements in water provision in the form of improved community water resources management and protection of water resources. The ‘eco-planting’ model conserves the environment (including land and water resources).
- Improved forest resources management. There are now more bamboos and trees on the village mountains, which has improved the environment.

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

The participatory plant breeding project operated at the landscape level. It included land used by the village for farming activities, and also forested land and water resources. No interviewees could list any trade-offs in ecosystem service delivery between different scales, but three felt there might be synergies. For example, different communities may have different capacities, so building networks for knowledge and resource sharing and exchange between communities can lead to improvements in ecosystem service delivery in other areas, for example through seed exchange.

One community member interviewee mentioned, however, that some biodiversity improvements, such as an increase in the numbers of monkeys and birds, will harm agriculture.

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

Implementing partner and community interviewees listed a range of timescales over which they expected ecosystem services improvements to be maintained, restored or enhanced. The minimum was at least one year (for water provision), then three years (for improvements to farmland and forested land), with benefits extending up to eight years (according to two interviewees) or at least ten years (according to two more). One interviewee felt it would take at least ten years for ecosystem services to be restored and enhanced.

Interviewees were unclear on whether there were trade-offs (or synergies) between the delivery of different ecosystem services at different timescales.

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

How cost-effective is the EbA initiative?

Four implementing partners felt there was evidence related to the costs and benefits of the 'Participatory plant breeding and community-supported agriculture’ project. This came from studying the

village's books and assessing the improvements in income generated by the community from food production and the sale of 'green' products.

Although no formal cost-benefit analysis has been conducted, published literature reinforces the perception that the project is cost-effective. Song et al. (2015) explain that organic rice commands a price three to four times greater than regular rice, while for maize overall incomes are 30% higher in project villages than in non-project villages growing hybrid maize. Community-supported agriculture has thus tripled farm incomes amongst some participating households. A household survey showed that incomes from crop production and sale in Guangxi had increased between 2007 and 2012, reversing the downward trend of the previous five years (Song et al. 2015; 2016).

Meeting 'economic and market needs' was by far the greatest reason for developing innovations under the participatory plant breeding project, followed by meeting social and cultural needs and the need to reduce labour inputs (see Table 5). Ecological risk/change and major climatic events were the least cited reason to adopt the innovations developed. Clearly, economic concerns are the main driver of project activities, which suggests that they must be cost-effective if adopted and can thus meet both resilience and market needs (Song et al. 2016).

Table 5: Reasons for developing innovation amongst Yunnan and Guangxi households

Reason	Number of households giving this reason
Ecological risks/changes	1
Major climatic event that led to crop failure/scarcity	4
Economic and market needs	356
Social and cultural needs	74
Labour saving	73
Repatriation/collaboration with scientists (= supporting factor)	38
Experiment and exploration (= supporting factor)	29
Other (health, hobbies, etc)	56

Source: Song et al. (2016).

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

Interviewee responses were mostly unclear on whether the participatory plant breeding project has been compared to other adaptation approaches. One said it had not, as EbA was assumed to be the best solution. One implementing partner felt it was slightly more cost-effective than other approaches.

Participatory plant breeding has been compared to conventional plant breeding, however, and is more cost-effective (Krystyna Swiderska pers. com. 2018). This is because the resulting varieties are adopted more readily by farmers, so less investment is needed to promote the adoption and dissemination of new varieties, and also because farmers do some of the work that scientists would otherwise do (ie field testing) (Ceccarelli et al. 2009). The participatory plant breeding varieties developed in Guangxi Province spread spontaneously to neighbouring villages, and farmers conduct on-farm research and give their time for free. All of these lower the cost of participatory plant breeding compared to conventional breeding, and also reduce the time taken to adopt new approaches (Song et al. 2016). Volunteers (ie agroecology students) also undertake community capacity building to promote sustainable practices for free. One participatory plant breeding maize variety, however, is a hybrid and this has brought financial benefits for the communities as they are allowed to sell it locally and retain the profits (due to a benefit-sharing agreement with communities, because participatory plant breeding varieties can only be registered by breeders not communities) (Krystyna Swiderska pers. com. 2018).

Broader economic costs and benefits from the EbA initiative

Three out of five implementing partners felt that there were no broader economic costs and benefits from the participatory plant breeding project. Community-supported agriculture has, however, enabled

communities involved with participatory plant breeding to generate income on an ongoing basis, thus generating sustained economic benefits (Krystyna Swiderska pers. com. 2018).

Financial and economic trade-offs at different geographical scales

Although one implementing partner felt there were trade-offs, three did not and explained that communities made their own decisions about what crops to grow, whether to enter the market, and hence where financial/economic benefits and costs accrue. One added that areas closer to daily village life in the context of forest or water resources management received more investments. Economic benefits at wider scales may accrue as other farmers not involved in participatory plant breeding receive seeds from participatory plant breeding through seed exchanges in both the target region and more widely through the National Farmer Seed Network (Krystyna Swiderska pers. com. 2018).

Changing financial and economic benefits and costs over time

Implementing partner interviewees all agreed that financial and economic benefits from the participatory plant breeding project had changed over time. In the short term, human resource inputs are higher and investments outweigh earnings as a result of the need to cooperate with multi-disciplinary experts, but this situation is reversed in the long term, when benefits from diversification (food crops and plantations), eco-tourism business and community-supported agriculture have grown and the significant potential increase in earnings realised. For example, Krystyna Swiderska (pers. com. 2018) explained that some investment was needed to establish community-supported agriculture activities to enhance farmer incomes and provide incentives to continue the participatory plant breeding work, but that after one restaurant had been established, another eight were established using the profits from the first, so no further capital was required. Community-supported agriculture and the links to ecological restaurants can potentially generate long-term financial benefits for farmers, but initial investment is needed to develop a participatory guarantee scheme to sustain benefits and provide quality guarantees to consumers (Krystyna Swiderska pers. com. 2018). Some interviewees also pointed out that 'eco-planting' under the project resulted in short-term drops in productivity, so even though this resulted in longer-term improvements to the ecosystem, young farmers under economic pressure often reject 'eco-planting' in favour of higher short-term earnings, and it is older farmers who adopt the 'eco-planting' models. Interviewees explained, however, that short- and long-term financial benefits would be impossible to estimate, and that evaluating broader economic costs and benefits would take longer than the project timeframe. Operational costs and income from activities also fluctuate according to the market.

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

Interviewees listed a number of local-level barriers to implementing EbA. The most important of these was a lack of government support, in terms of recognition, policies or subsidies. Policies and institutions should be suited to local conditions and based on local culture and expertise, but interviewees provided a number examples of how this was not the case:

- One community-level interviewee described how current policy states that only farmers with vegetable fields of at least 50 mu (about 3.33 hectares) in one continuous area will receive local government support, but this interviewee's village is small and does not have such big fields.
- Similarly, a cooperative cannot apply for a government subsidy for a pig husbandry facility because government policy requires such facilities to be 500 metres from residential areas, which is impossible in such a small village.
- Local government also 'blindly' promotes tourism without considering traditional knowledge and local context. For example, mass tourism is encouraged, but this needs considerable amounts of

infrastructure and exceeds the carrying capacity of local ecosystems. Tourism policies are extremely exploitative and designed to benefit big tourism companies rather than local communities.

- Cooperation with local government is important, but government usually operates in a top-down manner and meaningful exchange with local communities is minimal. Incentives are needed to facilitate consultation between government and local communities.
- Local government mostly pursues performance-oriented results when implementing policies, so it is difficult to get its support for initiatives or projects, or have lessons from such projects incorporated into policy, if they cannot deliver outcomes that can be identified as meeting government performance indicators.
- Urban development driven by local government reduces available farmland, damages wetland ecosystems, ignores farmers' traditional knowledge and encourages the use of chemical inputs to boost agricultural production.
- Lastly, a lack of official marketing is problematic. Local government should actively market the project and provide financial subsidies to farmers adopting eco-planting.

Other local-level barriers to implementing EbA listed by interviewees were:

- Low levels of understanding amongst the local community, and also local leaders. Low local awareness levels need to be addressed and more communication with local communities is needed.
- The multi-disciplinary skills needed to meet community needs. Capacity building for specific implementers is needed.
- A lack of support from local leaders.

Provincial-level barriers to implementing EbA

Interviewees described the importance of government support, coordination and cooperation at this level, and the need for multi-disciplinary skills, enhanced capacity and communication, a better understanding of the project, and more investment. EbA activities needs to be developed along with those focused on agricultural cultural heritage, tourism and the reduction of chemical pesticide and fertilizer usage. EbA policies need to be transparent. The government does not consult with traditional communities about water management, however, and prioritises dam building along the Yangtze River even when communities want to use ecosystem-based approaches. There is also a lack of safeguarding measures to implement good eco-development strategies, and inadequate recognition of EbA. The challenges described in the section above relating to top-down local government operating modalities and whether projects meet government performance-related targets are also relevant at this level and, as above, incentives are needed to facilitate consultation between government at this level and local communities.

National-level barriers to implementing EbA

Three interviewees explained that national policies, laws and development strategies (or a lack of thereof) were a key barrier to implementing EbA. In some instances, national policies and development strategies can make it difficult to implement EbA, and existing development strategies need to be transformed. Examples given include:

- Many interviewees commented on the fact that policy implementation is very top-down in China, with local policies subject to influence and pressure from above. Relevant government departments will only provide support and investment if projects reflect local development strategies and higher-level policy support is available.
- Government agriculture subsidies favour non-traditional modern crop varieties, which dominate the market. Song et al. (2016) reiterate this point, explaining that long-existing traditional farming and local seed and innovation processes are threatened by modern farming policies and subsidies and that spikes in crop variety loss coincide with external policy signals, such as when China joined the World Trade Organisation in 2000 and less resilient hybrid seeds were popularised and subsidies for intensive agriculture grew. Although there are some new laws and strategies that protect farmers' rights, Song et al. (2015) add that "national policies on plant variety registration have only

recognised breeders' rights over high-yielding hybrid seeds, and only provide subsidies for hybrid seed production and for inputs such as fertilisers and machinery". These policies "do not protect the rights of smallholder farmers over the landraces they have domesticated, improved and conserved, or support their local seed systems" (Song et al. 2015). Many local landraces have been lost as a result (Song et al. 2016). For example, one maize hybrid, developed through a joint venture with a foreign company, has wiped out half the remaining maize landraces in Guangxi Province since its introduction in 2002 (Swiderska 2016b). Mandates or policies from government at this level are needed, but the government doesn't sufficiently prioritise biocultural heritage.

- The state-owned conservation area (which is part of the project site) does not encourage community participation, and this results in conflicts with communities who undertake illegal activities.
- The financial and taxation incentives provided to those protecting ecosystems and practicing eco-agriculture are insufficient, and there is inadequate protection for traditional species.
- China has a number of strategies and policies addressing climate change, but EbA does not feature strongly in these and needs to be integrated better into policymaking. Agriculture has received less attention in the climate change context than issues like energy or forestry, and technical issues relating to the economic and ecological aspects of adaptation have received more attention than EbA approaches. More support is needed for agriculture and the role it plays in adaptation. The National Climate Change Adaptation Plan is too general and needs more specific targets and allocated funding to support concrete action. Policies and strategies relating to the Convention on Biodiversity are also not strong on climate change.

Awareness levels amongst high-level government officials need to be improved. Further capacity building on EbA for policymakers and leading government stakeholders is needed, along with more collaboration between ministries. Interviewees explained how competent support and cooperation from the relevant government department was important at the national level, as at other government levels. One interviewee explained that government could do more to encourage public scientific research institutes at every level to conduct research and experiments at the community level, and that resources should be invested in translating scientific research findings that can benefit the environment and build the capacity of farmers and those in the market chain. Song et al. (2016) add that "limited scientific investment in improving local varieties leads to the frequent replacement and disappearance of more resilient and diverse local varieties".

Three interviewees said that donors also need to provide more support and attention to EbA, community-based adaptation and biocultural heritage innovation. One added that donors need to understand and support local community needs better.

Local-level opportunities for implementing EbA

Interviewees listed the following local-level opportunities for implementing EbA and supporting ongoing bio-cultural heritage innovation and adaptation.:

- Competent support and cooperation from relevant government departments, such as the Agricultural Department or the Forestry Department. EbA implementation by local governments can be combined with activities on agricultural cultural heritage. Policy design should be open and transparent.
- Cooperation from project and community participants.
- Demand for ecological products from consumers, which motivates farmers to reduce chemical use in production.
- Advocacy already undertaken on EbA. This should be kept up, with actions taken to adapt initiatives to local conditions.
- Marketing of EbA, which has already occurred and could be strengthened. Song et al. (2016) add that China's experience shows that participatory plant breeding needs to be accompanied by market incentives to sustain farmers' active involvement.

- Existing EbA and community-based adaptation 'champions'. Song et al. (2015) comment that "[t]he existence of a capable and committed leader is the most important factor in starting collective action and institutional innovation processes".
- Collaborative research platforms linking farmers and scientists to spur innovation (Song et al. 2015; 2016). These already exist and could be strengthened.

Provincial-level opportunities for implementing EbA

Interviewees explained how competent support and cooperation from the relevant government department (eg the Agricultural Department), and also policy support, was key. For example, Jiangsu Province emphasises water resources management and wetland ecosystem preservation, and it allocates resources to improve and govern the local area. Yunnan Province has specific policies and programmes supporting ethnic groups and minorities and supporting traditional knowledge, language and heritage. One community leader explained that after community involvement in the participatory plant breeding project, county governments learned more about it and started to pay more attention to the project and to provide support. EbA and community-based adaptation 'champions' helped this process. Song et al. (2015; 2016) name the Guangxi Maize Research Institute and the Yunnan Academy of Agricultural Science as key collaborators in this respect and explain that participatory plant breeding practices have become institutionalised in Guangxi through the introduction of a provincial government budget which provides some funding for scientists (but not for communities) doing this work. Furthermore, one interviewee commented on government willingness to provide support and aid to help local poor families, citing a targeted poverty reduction scheme.

Project success has been influenced by a number of factors, including a growing urban middle class in provincial cities, a strong dining-out culture, rising demand for healthy ecologically produced food, and the facilitation role played by the non-government organisation Farmers' Friend, which has established a number of restaurants linking farmers directly with urban consumers (Song et al. 2016).

National-level opportunities for implementing EbA

Whilst some interviewees felt that national policies, laws and development strategies in China were a key barrier to implementing EbA, the Chinese government does have a number of strategies and policies in place to address climate change (see Box 3) which could provide opportunities to implement EbA in the future, supported by the institutional bodies involved with developing and implementing these strategies and policies. These include the State Council (China's cabinet), which provides a general framework for climate change work at the highest level, the National Development and Reform Commission and various ministries, which have developed their own specific implementation policies and action plans. In 2011, the People's Congress together with 17 ministries established a Climate Change Legislation Working Group, led by the National Development and Reform Commission. This Working Group is developing legislation on climate change adaptation and mitigation, including a draft Climate Change Adaptation Law.

Box 3: Climate change strategies and policies in China

- **China's Agenda 21**, approved by the State Council in 1994, was the first policy to mention climate change adaptation.
- The **State Climate Change Adaptation Plan**, issued by the State Council in 2007, was China's first national climate change adaptation plan and also the first such plan made by a developing country.
- The **China Climate Change Adaptation Plan**, a white paper issued by the State Council in 2008, comprehensively introduced climate change impacts in China and the state's mitigation and adaptation plans and policies.
- The **12th National Plan and Framework for Socio-economic Development**, issued in 2010, integrates climate change mitigation and adaptation considerations in all areas of socioeconomic development, including forestry, agriculture, infrastructure and urban development. Different ministries then made their own specific policies and action plans accordingly.
- **The China Climate Change Adaptation** Plan, Policies and Actions, issued in 2011 by the State Council, described climate change impacts on agriculture during the 11th Five-Year Plan and introduced new adaptation policies, regulations and actions for agriculture.
- The **China Climate Change Adaptation Strategy** was published in 2013 by the National Development and Reform Commission in collaboration with nine ministries.
- The **National Climate Change Adaptation Plan 2014-2020** was published by the National Development and Reform Commission in 2013. The Ministries of Forestry, Urban Construction and Agriculture have made their own specific plans and implementation regulations accordingly. These do not explicitly mention EbA, but they do include ecosystem protection and restoration.
- China's **Intended Nationally Determined Contribution**, submitted to the United Nations Framework Convention on Climate Change in 2015, mentions the importance of the impacts of climate change on ecosystems and how this will affect human development, but it does not specifically mention EbA.
- The **13th Five-Year Plan**, issued by the National Development and Reform Commission in 2016, details how carbon dioxide emissions per unit of GDP will drop by 18% over the next five years.

A number of other policies, laws and strategies support EbA. In 2016, the China Disaster Risk Reduction Commission released its 12th Five-Year Plan, which mentions ecosystem management methods and the importance of increasing investment in protective forest enhancement and anti-flood projects. The government also has strategies related to green and inclusive development. The Green Transformation Policy addresses sustainable transformation for industry and agriculture, and under this there are specific policies such as the Green Agriculture Policy, which promotes traditional and organic crops. Song et al. (2015) explain that whilst some agricultural research policies lead to reduced crop diversity, in recent years the state's new strategic goal of 'ecological civilisation' and other policies on agriculture and farmer co-operatives have supported farmer seed systems and innovation. Although national policies on plant variety registration undermine the rights that smallholder farmers have over their landraces and seed systems, China's national seed law now recognises farmers' rights to save, exchange and sell conventional seeds at the local level (Song et al. 2016). Access and benefit-sharing issues are addressed in China's National Intellectual Property Strategy and National Biodiversity Strategy and Action Plan, and the revised Patent Law (2009) requires disclosure of the origin of genetic resources in patent applications. China also has a Law on Cultural Heritage for Intangible Goods which can be used for traditional knowledge protection (Swiderska 2016a).

There are also national programmes that support farming organisations, for example by providing financial support to registered farmers associations, subsidies and exemption from taxation. The Ministry of Agriculture supports traditional agro-farming villages or sites through certification schemes (under the UN Food and Agriculture Organisation). Those certified receive funding and nationwide recognition, which can help with food crop marketing and ecotourism.

China has had a number of projects addressing adaptation, most notably the Adapting to Climate Change in China project managed by the UN Environment International Ecosystem Management Partnership (UNEP-IEMP) and the National Development and Reform Commission. This focused on developing evidence-based climate change adaptation policy in China, at both the national and provincial level, and supporting the development of Provincial Adaptation Plans accordingly. The Environmental Protection Agency and the Ministry of Agriculture have also jointly implemented in-situ biodiversity conservation plans.

Is the EbA initiative sustainable?

Most interviewees felt there was sufficient local-, provincial- and national-level policy, institutional and capacity support to ensure the initiative could be sustainable over the long term. Despite the lack of local government support in terms of recognition, policies or subsidies, good working relationships existed between local communities and governments at town and county levels. These fostered sustainability, as did the presence of local scientific institutions that support traditional knowledge and community-based approaches, thus ensuring strong links between science and traditional approaches over the long term.

Given the top-down nature of governance in China, relevant national or provincial-level policies and legislation that support EbA are needed to ensure sustainability at lower levels. For example, the presence of EbA in a national five-year plan, green development or agriculture policy, an inclusive development strategy, measures supporting ecological agriculture and ecological recovery, or measures protecting historic villages and agricultural heritage can mean local-level projects are more sustainable. Some of the national and provincial-level policies, legislation, strategies or programmes providing support are described in the sections above.

One interviewee cautioned that there is inadequate evidence to support the project when national policies change. A stronger evidence base for EbA would help address this challenge.

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

Most interviewees felt there were opportunities for replication, scaling up or mainstreaming the participatory plant breeding project, through work with international organisations such as UN Environment, the United Nations Development Programme and other foreign donors and regional banks. Strong collaboration with UN Environment is particularly important for this project, because UN Environment collaborates closely with the Chinese government (including the Ministry of Environment and the National Development and Reform Commission), it is a very important stakeholder in UNEP-IEMP and it has a strong influence over domestic policies. This means that it provides strong potential for scaling up and mainstreaming project activities.

The Centre for Chinese Agricultural Policy project team is trying to link community assessment data from the Indigenous Peoples' Climate Change Assessment in Yunnan with their macro-level scientific data to create a more complete picture to inform climate change policy responses. This is an emerging area of work (Song et al. 2015).

Interviewees also said that building on solid community-level work to deliver real results which could be shared through public presentations at various fora can also facilitate impacts at a wider scale. The new multi-stakeholder Farmer Seed Network – which brings together farmers from several provinces to exchange knowledge and seeds and talk with policymakers and scientists each year – provides a key opportunity for scaling up participatory plant breeding, farmer networking and policy pilots to enhance support for biocultural innovation in remote farming communities for food security and resilience to climate change (Song et al. 2015; 2016).

The application of various tools or approaches for EbA could help overcome some of the national level barriers to EbA implementation, and support further implementation. For example, tools to support EbA mainstreaming could be applied, or financial flows analysed to understand whether subsidies/finance (such as from China's payments for ecosystem services schemes) does or does not support adaptation or sustainable agriculture, and thus how support could be redirected accordingly.

Summary and conclusions

The 'Participatory plant breeding and community-supported agriculture' project in Yunnan Province, and also Guangxi Province in Southwest China provides an example of how EbA can be an effective approach to tackling climate change.

Effectiveness for human societies

The project has clearly improved the resilience and adaptive capacity of local communities and reduced their vulnerability to climate change. Women and the elderly experienced the most significant improvements in this respect. Few trade-offs in terms of who or where changes in resilience, adaptive capacity or vulnerability were experienced were apparent, and customary laws helped manage these when they did emerge. The project was designed to ensure long-term improvements in adaptive capacity and resilience, but may at times have involved short-term reductions in productivity.

A multitude of social co-benefits resulted from the project: improvements in water provision and the environment; improvements to bio-cultural heritage systems; raised awareness and capacity; health improvements; higher incomes; improved market access; stronger social capital; better rules, regulations, agreements and policies; strengthened intellectual property rights; and food self-sufficiency. Whilst some groups may have accrued more of these social co-benefits, this did not come at a cost for others.

Local knowledge and practices were an integral component of many project activities. Community participation also occurred in many different activities and to different degrees, often extending to 'self-mobilisation' – the most devolved form of participation. The application of participatory processes clearly supported EbA project implementation and built adaptive capacity.

Effectiveness for the ecosystem

Local ecosystem resilience and service provision are threatened by a number of issues, amongst which climate change impacts such as drought are key. Watershed or catchment level management may be important for supporting ecosystem resilience, and there may be thresholds – for example relating to water provision – beyond which ecosystem resilience will fall, but knowledge on this is scarce. What is clear, however, is the contribution of the project to ecosystem resilience and ecosystem services provision. These ecological benefits were apparent at the landscape level, and came with no apparent trade-offs in terms of ecosystem service delivery elsewhere. Improvements to ecosystem services were sustained over the long term, although some may have taken time to materialise. No important trade-offs between the delivery of different ecosystem services were apparent.

Financial effectiveness

The project is cost-effective due to increases in income from agriculture. Indeed, 'economic and market needs' is the most important motivating factor for implementing project activities, far outweighing adaptation or disaster risk reduction. The project was not compared to other adaptation approaches. Unusually for an EbA project, broader economic benefits emerging from the initiative were not significant, especially in the short term. Financial or economic trade-offs at different geographical scales were not apparent, and although investments and human resource inputs are high in the short term, the long-term financial gains make these investments worthwhile.

Policy and institutional issues

The most important local-level barrier to implementing EbA was a lack of government support, in terms of recognition, policies or subsidies. Inappropriate top-down governance was also a barrier at the Provincial level. At the national level, top-down governance and absent or inappropriate policies, laws and development strategies were a key barrier to implementing EbA. These included subsidies for hybrid seeds and intensive agriculture, and minimal integration of EbA into climate change policymaking. Awareness levels amongst high-level government officials need to be improved, along

with further capacity building on EbA for key government stakeholders and more investment in EbA-related research.

A number of local- and provincial-level opportunities exist for implementing EbA and supporting ongoing bio-cultural heritage innovation and adaptation. Competent support and cooperation from government departments was important at both levels. At the national level, the Chinese government has a number of strategies and policies in place to address climate change, as well as institutional bodies to ensure their implementation. Policies and programmes are also emerging in other areas such as disaster risk management, agriculture, intellectual property rights, biodiversity management and cultural heritage protection that support EbA and biocultural heritage.

Most interviewees felt there was sufficient local-, provincial- and national-level policy, institutional and capacity support to ensure the initiative could be sustainable over the long term. Good working relationships between communities and government facilitated this, as did local scientific institutions that support traditional knowledge and community-based approaches. Policy implementation in China is very top-down, however, so relevant national policies are needed to ensure sustainability at lower levels. A stronger evidence base would reduce the risks associated with policy change.

Opportunities for replication, scaling up or mainstreaming the project included working with international organisations such as UN Environment, which has strong ties with government, and also through improving links between local knowledge and scientific data, and sharing project activities with other communities and farmer networking. Further application of EbA tools could support further implementation.

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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 Participatory Plant Breeding and Community Supported Agriculture project, China. 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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International Institute for Environment and Development
80-86 Gray's Inn Road, London WC1X 8NH, UK
Tel: +44 (0)20 3463 7399
Fax: +44 (0)20 3514 9055
www.iied.org

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