Ecosystem-based adaptation to climate change: Lessons learned from a pioneering project spanning Mauritania, Nepal, the Seychelles, and China

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Societal Impact Statement
Ecosystem-based adaptation (EbA) is increasingly being used to reduce the impacts of climate change on vulnerable people and landscapes. The international EbA South project implemented EbA interventions across three countries (Mauritania, Nepal, the Seychelles), piloting the restoration of mountain, desert and coastal ecosystems to enhance the climate resilience of local communities. The experiences of the EbA South project across these distinct ecosystems and socio-economic environments provide unique insights into the adaptive management invariably required within EbA initiatives. This analysis also provides lessons on how to share knowledge among different stakeholders and countries to advance South-South cooperation.

Summary
Climate change is having an increasingly negative impact on the world's most vulnerable societies. Ecosystem-based adaptation (EbA) uses biodiversity and ecosystem services to help local communities adapt to the adverse impacts of climate change. This approach, which has the potential to be implemented across a wide range of ecosystem types and scales, is increasingly being adopted by governments and international donors within climate change adaptation initiatives. The objective of the EbA South project was to enhance the climate resilience of communities in Mauritania, Nepal, and the Seychelles by building institutional capacity, mobilizing knowledge and transferring EbA technologies based on China's experience in successfully implementing restoration. The project implemented EbA interventions in the drylands of Mauritania, Himalayan forests in Nepal, and the coastal zone of the Seychelles. All interventions were carefully monitored by researchers to generate scientific evidence of the impacts of EbA. Here, we provide implementers of EbA with the major lessons learned from the EbA South project, namely: (a) quantifying the full suite of ecosystem goods and services generated through EbA at a landscape scale; (b) budgeting in
INTRODUCTION

Even optimistic scenarios for greenhouse gas emissions show the average global temperature increasing by at least 2°C from preindustrial levels before 2100 (IPCC, 2018). This will have multiple, far-reaching consequences for ecosystems and human populations. Such consequences include declines in agricultural productivity, negative impacts on human health, increased rates of species extinction, shifts in biomes, and flooding of large tracts of land as a result of sea-level rise (Scarano, 2017). The world’s poorest communities are most at risk from these impacts, making implementation of adaptation strategies in vulnerable areas to improve the resilience of affected communities of critical importance (Scarano, 2017).

One option for markedly increasing the resilience of vulnerable communities is ecosystem-based adaptation (EbA)—an approach that uses ecosystems and their associated services to assist communities in adapting to climate change (Reid et al., 2019). As a nature-based solution to climate change, EbA is increasingly being recognized by governments, donors, and academia as an effective approach to adaptation which also provides considerable co-benefits relating to climate change mitigation and conservation of biodiversity. There are, however, various gaps in our knowledge and understanding of the implementation of EbA (Munroe et al., 2012). First, because it is a relatively new approach, there are relatively few projects providing long-term information and lessons learned on EbA. Second, since EbA is multidimensional with a broad range of applications in different ecosystems and takes place at a wide variety of temporal and spatial scales, approaches used in one project may not be transferrable to another. Third, EbA projects often take many years, if not decades, to produce substantial results, which prevent rapid generation of knowledge on how to implement EbA effectively. Lastly, EbA benefits are often difficult to quantify, making it challenging to assess the full socioeconomic impact of EbA on communities. As a result, information on successes and failures in EbA projects needs careful documentation.

In the sections below, we analyze the lessons learned during a ground-breaking EbA project in the Global South. This project, known as EbA South, brought together governments, communities, researchers, and restoration practitioners from Mauritania, Nepal, the Seychelles, and China to undertake EbA in dryland, mountain, and coastal ecosystems. Different EbA approaches were piloted in three distinct ecosystems and cultural settings, providing an opportunity to inform a diverse array of future EbA initiatives.

WHAT IS ECOSYSTEM-BASED ADAPTATION?

In the context of this paper, we define ecosystem-based adaptation (EbA) as “the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change” (CBD, 2009). Some of the ecosystem services harnessed through EbA include hydrological regulation, soil retention, climate regulation, and the provision of food, building materials or medicinal plants (de Groot, Wilson, & Boumans, 2002). These ecosystem services provide a multitude of benefits to local communities, such as improved and diversified livelihoods, disaster risk reduction, food security, and health improvements (Reid et al., 2019). As a result, EbA is often more cost-effective than alternative adaptation options involving hard infrastructure. For example, restoration of mangroves to reduce coastal erosion is, in certain contexts, more cost-effective than constructing seawalls (Munang et al., 2013; Newsham et al., 2018).

EbA can be implemented in multiple different ways and is applicable to a range of ecosystems across a diversity of geographical scales. Examples of EbA interventions that have been used successfully around the globe include mangrove restoration for protection from storm surges, catchment management to mitigate against droughts and flash floods, rangeland management to prevent desertification, and sustainable management of forests to improve food security (Chong, 2014). The principles of EbA can be applied to initiatives as small as an individual family’s multiuse home garden of a few hundred square meters (Harvey et al., 2017) to large-scale rehabilitation or restoration projects covering hundreds of thousands...
of hectares (Mills et al., 2015; Reid et al., 2019). The potential for EbA to be implemented over vast landscapes makes it of particular relevance to the upcoming United Nations Decade on Ecosystem Restoration planned for 2021–2030 (United Nations Environment Programme, 2020).

3 THE EbA SOUTH PROJECT

The EbA project entitled “Ecosystem-based Adaptation through South-South Cooperation,” also known as “EbA South,” was officially launched in 2013 and concluded in 2019. Funding for the project was provided through the Global Environment Facility’s (GEF) Special Climate Change Fund, implementation was conducted by the United Nations Environment Programme (UNEP), and execution was performed by the National Development and Reform Commission of China through the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, and managed by the UNEP-International Ecosystem Management Partnership (UNEP-IEMP) through the Chinese Academy of Sciences (CAS). EbA South promoted the concept of South–South Cooperation, which refers to technical cooperation among low-income countries in the Global South (GEF, 2012).

In recent years, China has taken a leadership role in South–South Cooperation, promoting capacity building, knowledge sharing, and technology transfer among low- and middle-income countries. EbA South aimed to share China’s experience in ecosystem monitoring, ecological restoration, and climate change adaptation with countries that are vulnerable to climate change. The overall objective of the project was to build climate resilience by increasing institutional capacity, mobilizing knowledge, and transferring appropriate EbA technologies to Mauritania, Nepal, and the Seychelles. Multiple factors contribute to the climate vulnerability of the pilot countries, including poverty, dependence on rain-fed agriculture, and limited capacity to plan and implement the necessary adaptation technologies and practices at a local or national level. Each of these countries is also home to different ecosystems vulnerable to climate change, namely dryland, mountain, and coastal ecosystems, respectively.

EbA South also sought to benefit low- and middle-income countries and people outside of the pilot countries through the involvement of regional networks in Africa and Asia as well as the generation of knowledge resources relating to EbA, which are available on the project website (www.ebasouth.org). Some of these knowledge resources include the planning tool “ALIVE: Adaptation, Livelihoods and Ecosystems” (UNEP-IEMP & IISD, 2018), the EbA Handbook “Ecosystem-based adaptation: a handbook for EbA in mountain, dryland and coastal ecosystems” (Swiderska, King-Okumu, & Islam, 2018), Guidelines on EbA Research entitled “Research on ecosystem-based adaptation: a reference guide” (Llieva, 2019), and a range of video documentaries, including three from the EbA South team and one by UNEP (EbA South project team, 2019).

Lessons learned from existing large-scale ecosystem management projects in the Global South, such as China’s “Grain for Green Program” and South Africa’s “Working for Water” program (Delang & Yuan, 2015; McConnachie, Cowling, Shackleton, & Knight, 2013) were used to inform many of the EbA South approaches. Under the Grain for Green Program, the Loess Plateau in China was transformed into high-quality farmland, vegetation was rehabilitated, grazing was reduced, soil erosion was reduced, and commercial forests were planted, while through the Working for Water program invasive alien plant species were cleared from thousands of hectares to increase water yield and create jobs.

The Grain for Green Program was particularly relevant for EbA South given its scale. Between 1998 and 2008 the Chinese Central Government invested ~US$29 billion in the restoration of ~30 million hectares of highly degraded land, including former agricultural land, to forests and grasslands. This investment reduced the annual input of sediment into the Yellow River from 1.6 billion tonnes to 300 million tonnes (Feng, Fu, Lu, Zeng, & Wu, 2013; Li, Du, & Liu, 2016; Lü et al., 2012). In landscapes where agricultural land was taken out of production, farmers were provided with food, living allowances, saplings, and the ownership of forests and pastures planted on their land. They were also trained on improved agricultural production techniques, which ultimately resulted in a 18% increase in grain production across the Loess Plateau between 2000 and 2008, despite large areas of agricultural land being taken out of production (Lü et al., 2012). This indicates that in-depth planning on compensation and incentivization among local communities for land taken out of agricultural production during the restoration process is of critical importance.

EbA interventions implemented by the EbA South project had similar objectives to the Grain for Green and Working for Water programs in that ecosystems were restored to improve the supply of ecosystem goods and services to vulnerable communities, thereby improving their livelihoods (GEF, 2012). In Mauritania, 150 hectares of multiuse greenbelts were planted to restore degraded desert, dune and savanna ecosystems (Figure 1). These greenbelts reduce erosion of soils and will in time provide livelihood options—including harvesting of fruit, collection of gum arabic, and the processing of plant products to produce cosmetics—for poor rural communities living near the intervention sites. In Nepal, the project focused on the restoration of degraded mountain ecosystems in several watersheds to build the climate resilience of local communities. These communities are increasingly facing food insecurity as a result of crop losses from droughts, floods, and soil erosion. Plant species were selected based on the needs of communities, including fodder production, food production, water generation, and biodiversity conservation. A total of ~840,000 tree and shrub seedlings were planted (Figure 2). Lastly, in the Seychelles, EbA South focused on the restoration of 400 hectares of degraded wetland ecosystems, including mangroves, to protect ecosystems and local communities from the impact of sea-level rise and flooding (Figure 3).

The total area of land restored in the EbA South project was less than 1,000 hectares—a small amount compared with national and global restoration needs. The long-term effects of the project could, however, be significant by assisting the project’s countries and
other countries with similar environments to catalyze the upscaling of EbA. At the end of the EbA South project, lessons learned from the successes and challenges experienced throughout the project were compiled by all stakeholders involved. The following sections describe the main conclusions from these consultations and provide examples from each pilot country.

4 | QUANTIFICATION OF ECOSYSTEM GOODS AND SERVICES AT A LANDSCAPE SCALE

The EbA South stakeholders frequently deliberated on how the relatively small ecosystem restoration initiatives within the project could be used to catalyze the restoration of hundreds of millions of hectares of degraded land globally. Restoration at this scale, which will require investments of hundreds of billions of US dollars, is needed to make meaningful inroads into climate change adaptation and mitigation global goals (Gann et al., 2019). The stakeholders noted that innovative public–private partnerships (PPP) underpinned by sophisticated analyses of the economic returns would be required for such investments and that conventional Payment for Ecosystem Services (PES) approaches would in all likelihood be inappropriate for many EbA projects. It was agreed that new approaches for building sophisticated economic cases for restoration initiatives over millions of hectares using granular data on a diverse range of ecosystem goods and services would be required. New technology will be critical for the initial modeling to build the economic case and then ultimately monitoring the ecosystem goods and services during implementation of the investment (Vihervaara, Mononen, Nedkov, & Viinikka, 2018). High-resolution data collected by drones could, for example, assist in modeling ecological processes at a regional scale as well as inform appropriate adaptive management of large EbA initiatives. This information could then be made more available to a wide variety of stakeholders, including for example local communities, restoration practitioners, investors, academics, buyers of ecosystem goods and services, and government decision-makers who will benefit from the interventions and information provided. Smartphone applications could be developed to distribute the outputs of aerial survey data to stakeholders and to collect data in the field to ground truth data collected by drones, aeroplanes, or satellites. Such technological advances hold promise for resolving potential conflict between stakeholders in this and future EbA projects by providing objective assessments of the ecosystem goods and services being derived from the EbA interventions. They could also
be used to channel payments for ecosystem goods and services directly from the buyer or donor to the practitioners on the ground.

5 | FINANCIAL AND TIME BUDGETS SHOULD ACCOUNT FOR THE COMPLEXITY OF EbA INTERVENTIONS

The EbA South project found that full-time project management support is necessary even in landscapes where the EbA interventions are only implemented over relatively small landscapes covering tens of hectares. This was only evident in hindsight once the considerable amount of socioeconomic and biophysical complexity had emerged from the project’s landscapes. The project stakeholders also agreed in hindsight that managing such complexity effectively requires thorough socioeconomic analyses before the project starts and nimble adaptive management during project implementation.

At the outset, the EbA South project did not assign full-time project managers to implement the interventions because it was assumed that government staff within each country could undertake the management of the relatively small project areas in a part-time capacity. It was, however, soon evident that the government staff deployed by the project were unable to devote sufficient time to the analysis and management of unanticipated complexities. This led to considerable project delays. Examples of the complexities encountered for each participating country are described below.

Within Nepal, the project encountered two main challenges, namely securing land for long-term EbA interventions and disbursing funds to local implementing entities. Identifying appropriate project sites was challenging because, although local communities initially expressed support for the project, debates around the appropriateness of the EbA interventions compared with alternative land-use options emerged. This occurred after considerable time and funding had been spent on propagating seedlings in nurseries. A potential trade-off existed between planting trees providing products such as fruit, medicine, and timber and keeping land as grazing ground for cattle. This complication was also encountered in Mauritania, where entire sites were abandoned several years into the project because of land-use conflict within affected communities. In both Nepal and Mauritania, some community members took the view that using certain degraded ecosystems for existing livelihoods was more beneficial than restoring the ecosystems, which would only result in benefits in the future. Similar resistance to EbA interventions has been documented in other regions (Baig & Iftikhar, 2005; Mavrogenis & Kelman, 2013; Reid et al., 2019; Sieber, Biesbroek, & de Block, 2018).

Irrespective of the size of the EbA interventions, if there are complex economic trade-offs and social dynamics, progress on implementation of EbA will invariably require considerable investments of

FIGURE 2 Nursery of indigenous trees and shrubs used in the restoration of degraded Himalayan forests in Nepal
time, highly skilled management and deft decision-making by project managers, government and community members. The EbA stakeholders agreed on reflection that preparation for an EbA project should include detailed analyses of the potential benefits and trade-offs of EbA at the project sites, in-depth stakeholder consultations, and agreement of how community members are compensated in the short-term for loss of benefits from land taken out of production (Bubeck et al., 2019; Lo, 2016).

Effective EbA interventions by government usually require strong technical and managerial capacity at local and national levels, with considerable internal cross-sectoral collaboration between departments and ministries (Reid et al., 2019). The up-skilling and re-training of staff that is required to achieve this capacity is usually greater than that required in other development projects. In the case of EbA South, changes in government structures and policies in Nepal during the project resulted in the management of project funds being considerably more time-consuming than initially anticipated. This was particularly the case with regard to flow of project funds between government departments, a delay that has been encountered by other EbA projects (Mills et al., 2015). Further challenges occurred in Nepal when policy changes led to payment delays of several months because government staff were unfamiliar with newly developed protocols for transferring funds. To expedite payments, staff had to receive intensive, time-consuming training on the new protocols. Similar delays from changes in government policies were experienced in the Seychelles. In this case, as a result of changes to the Seychelles government’s procurement policy, the contracting process for teams to remove invasive alien vegetation from riverine forest and mangrove restoration sites took months longer than anticipated. This resulted in seedlings in the project’s nurseries becoming root-bound, which in turn caused further delays in the implementation of the EbA interventions.

In Mauritania, extreme climatic conditions as well as operational challenges occurred throughout the project. Both these aspects required continuous reassessment, and often delays, of implementation plans. For example, many project sites experienced extreme winds and average monthly temperatures before the rainy season of ~35°C. These conditions resulted in the mortality of approximately half of the planted seedlings at some sites (Soule et al., 2018). They also reduced the amount of time staff could spend in the field, which greatly delayed planting operations. This in turn led to seedlings being planted at the end of the rainy season and additional laborers being employed and
harsh environmental conditions had not been anticipated at the permanently stationed onsite to irrigate seedlings several months into the dry season. Many of the knock-on effects of unexpectedly high rainfall and insufficient irrigation led to inefficiencies and major delays in implementation. The lesson learned from this experience was that rigorous scenario planning at the outset of the project, taking potentially extreme climatic events into account, is a critical part of the advanced planning required for EbA projects. Careful planning for desert environments in particular is of fundamental importance (Hardegree et al., 2018).

Implementation of EbA in Mauritania was also delayed substantially as a result of private subcontractors conducting work of insufficient quality. Rectifying the inadequate work, which related predominantly to poor fence construction and planting methods, required significant alterations to implementation plans and a large amount of the project manager’s time. Similar problems have been encountered in EbA implementation in South Africa’s subtropical thicket, where private contractors were not incentivized to focus on the successful establishment of plants, but rather on achieving a certain planting density within a specified time period (Mills et al., 2015).

Lastly, in the Seychelles, decisions on the appropriateness of certain EbA interventions were found to be more complex than initially anticipated. Stakeholders with different professional backgrounds prioritized EbA and grey infrastructure interventions differently depending on their expertise. For example, stakeholders with an engineering background focused primarily on the benefits of hard infrastructure such as seawalls to protect coastline ecosystems from storm surges, whereas those with an ecological background promoted the use of vegetation for the stabilization of dunes, riverbanks, or mudflats.

The lesson learned in the Seychelles was that EbA initiatives can trigger more debate among stakeholders than would be typically expected for standard development projects. Compromises between the hard engineering and soft ecosystem approaches had to be forged over several years during the implementation of the project. A similar experience occurred in an EbA project in Thailand, where many stakeholders favored visible and familiar hard infrastructure of weirs for managing floods, as opposed to the EbA approach of constructing natural pool sediment traps (Sieber et al., 2018). The lesson learned in this project was that government staff required training on EbA in order to raise awareness and facilitate informed decision-making among local communities. Without such engagement with stakeholders, friction between groups is likely (Sieber et al., 2018).

The debates on EbA versus hard infrastructure in the Seychelles led to significant delays in implementation and required substantial amounts of the project manager’s time to facilitate debates across government departments, among university staff and between technical experts within the project team. In hindsight, the stakeholders agreed that decision-making on the use of EbA or non-EbA alternatives should have been finalized before the start of the project. It was, however, also noted that debates during implementation were inevitable because of the contentious nature of the interventions and the lack of understanding among stakeholders on the benefits of EbA. It is therefore advisable that funding is set aside for awareness raising and protracted decision-making in EbA projects.

The project’s stakeholders also noted that relatively large contingency budgets for managing unforeseen setbacks (Clewell, Rieger, & Munro, 2005) and for managing the “planning fallacy” (i.e., underestimating the amount of time needed to complete a task; Buehler, Griffin, & Ross, 1994) should be allocated to EbA projects. To address the planning fallacy, stakeholders suggested that external third parties should be employed to evaluate costs and time frames. The estimates provided by such parties are usually more accurate than those provided by stakeholders involved directly in implementation (Mills et al., 2015).

6 | SOWING THE SEEDS OF LONG-TERM RESEARCH ACROSS MULTIPLE PLATFORMS AND INSTITUTIONS

Upscaling of EbA to meet global climate change challenges will require major adjustments in current government policies, with such adjustments being informed by extensive socioeconomic and ecological data (Rizvi, Baig, & Verdone, 2015). A conundrum in this regard, that needs urgent attention from the global community, is that such data take decades to materialize because the full suite of benefits from EbA usually only manifests over such time periods. This is particularly the case in systems where tree seedlings take several decades to fully mature. Governments, donors, private sector companies, and research institutions typically do not plan and fund projects over such time frames (Cornell et al., 2013). As a result, there is seldom sufficient information generated from EbA projects to enable policymakers to take well-informed decisions (Druce, Moslener, Gruening, Pauw, & Cornell, 2016).

To address the need of project interventions needing long-term monitoring and evaluation for decades (Lindenmayer et al., 2012), the EbA South project developed Memoranda of Understanding (MoUs) which institutionalized cooperation between government departments and national universities. Although these MoUs did not result in long-term funding commitments, they did emphasize the importance of long-term monitoring of the project’s EbA interventions by the institutions involved. The agreements also highlighted the commitment of the universities to build monitoring of the EbA interventions into their ecology curricula and field work. In the Seychelles, for example, the Ministry of Environment, Energy, and Climate Change signed an MoU with the University of Seychelles to develop a long-term research program focused on climate change adaptation. This collaboration has led to university staff developing training courses and establishing a nursery for coastal plants used in the restoration of wetland channels.

Other MoUs signed in the EbA South project were between Tribhuvan University and the Government of Nepal and between École Normale Supérieure de Nouakchott and the Government of Mauritania. The spirit of these agreements was for the collaborations to lead to innovation on EbA protocols and technologies.
and development of critical EbA skills. The importance of forging partnerships between government and universities for effective development as well as management of climate change has been highlighted by other authors (Cornell et al., 2013; Guimon, 2013). The EbA South project demonstrated how this is particularly relevant for projects involving management of ecosystems.

One drawback of the MoUs identified by the project’s stakeholders was the reliance on individual university departments to undertake the research over decades. The long-term sustainability of this approach was questioned. Would the research stop, for example, as a result of staff turnover, leading to a loss of institutional memory of the project. It was noted that collaborations should ideally have been sought with several other universities in each country, as well as research organizations such as the International Long-Term Ecological Research (ILTER) Network—a federation of independent national research networks with the objective of coordinating international ecological research. The ILTER Network is of particular relevance because it facilitates sharing of data and collaboration between researchers working in similar ecosystems (Vanderbilt & Gaiser, 2017).

The EbA South stakeholders also noted the importance of safe storage and accessibility of data collected during the long-term research. This could be achieved initially by storing data in several locations, preferably on platforms such as university servers where databases are adequately backed up. Ultimately, however, one central online repository for the long-term datasets which is well-organized and easily accessible to the international research community would be preferable. Other general principles for good data management practices that were raised by stakeholders included: (a) making publicly funded research data available with as few restrictions as possible; (b) enabling research data (including metadata) to be used by other researchers by providing information on how to access supporting data in publications; (c) implementing policies that include legal, ethical, and commercial considerations for the release of data at all stages of the research process; (d) ensuring that all sources of data are acknowledged; and (e) maximizing the benefit from limited budgets by increasing the use of public funds for the management and dissemination of research data (Corti, van den Eynden, Bishop, & Woollard, 2014). It was also noted that monitoring and evaluation approaches should recognize the potential for variations in the interests of stakeholders through time, and that at the outset of the long-term research of any EbA project some flexibility would need to be built into how the research is funded and what research protocols are followed (Rubin, Kondolf, & Rios-Touma, 2017; Stem, Margoluis, Salafsky, & Brown, 2005).

7 | PROFESSIONAL SCIENTIFIC INTERPRETERS AND TARGETED JOINT RESEARCH FOR LONG-TERM SOUTH–SOUTH COLLABORATION ON THE SCIENCE OF EBA

The EbA South project generated significant engagement between EbA practitioners, government officials, and scientists from China, Nepal, the Seychelles, and Mauritania. Data, findings, ideas, and experiences from a wide range of ecosystems were shared during field trips and workshops in all four countries. Communication in these engagements was, however, often greatly constrained by the language barrier, with English used as the medium of collaboration despite it being a second or third language of most participants. The language barrier also limited collaboration after workshops. Knowledge exchange in a workshop setting is a relatively short-lived experience unless personal relationships and professional collaborations are initiated. EbA South stakeholders noted that the hiring of professional interpreters with scientific knowledge during expeditions as well as in workshops would have increased the benefits of collaboration by improving the flow of knowledge and learning during implementation of the project.

The lesson learned within EbA South was that overcoming language barriers should be a priority in projects which involve a diversity of stakeholders—particularly where international collaboration for long-term research is required (Cornell et al., 2013; Goring et al., 2014). Indeed, the exclusive use of English should be considered a significant risk to the effectiveness of interventions, and researchers should not assume that all relevant data are available in English (Amano, González-Varo, & Sutherland, 2016), particularly with regard to traditional and indigenous knowledge.

To encourage the scientific communities in each country to embark on long-term EbA research (including at the project sites), the EbA South project gave participating scientists considerable leeway with regard to research topics and which journals were used for publication of results. This was arguably appropriate for ensuring the commitment of researchers for a project with a relatively limited research budget of about US$40,000 per country over 5 years. There were, however, drawbacks with this approach, particularly because critical gaps in EbA knowledge, which could have been addressed on a small budget, were not systematically studied by the researchers on the project. Such gaps included: (a) the costs and benefits of different EbA implementation protocols; (b) the rate of production of non-timber forest products from the tree species planted by the project; (c) appropriate financial mechanisms for upscaling EbA given the social and economic forces around the project sites; and (d) identifying how technology could be used to model and quantify the ecosystem goods and services within the EbA intervention sites.

The EbA South stakeholders noted that in hindsight more value could have been obtained from the small research budget by providing detailed terms of references for researchers that provide some flexibility in the topics of research but stipulate a few core deliverables that are strongly aligned with the project’s overarching objectives. In addition, it was noted that fostering long-term scientific relationships between individual scientists as well as the institutions they have been achieved by having the project’s research outputs, such as peer-reviewed publications, a joint responsibility of the Chinese research institutions and the universities in the pilot countries.
Exit strategies for EbA projects detail how the ecological infrastructure developed during the project will be maintained through time (Agol, Latawiec, & Strassburg, 2014; Clewell et al., 2005). The EbA South stakeholders noted how the financial and operational arrangements for such post-project maintenance vary according to the social, economical, and biophysical contexts of a particular site and that the nuances of these contexts are invariably not known at the start of an EbA project. Regular revision of the exit strategy throughout the implementation of the project was consequently deemed by the stakeholders to be a critical activity for EbA projects. This insight emerged from a diverse range of experiences in the individual countries, as documented below.

In the Seychelles, mangrove and riverine vegetation were restored by planting tree seedlings at 10 sites on three different islands. At the outset of the project, it was not anticipated that major investments of time and resources would be required after the seedlings had been planted. The assumption was that restored areas would not need supplementary follow-up or active protection as long as direct damage to trees from wood harvesting did not occur. The risk of wood harvesting at the project sites was deemed negligible and consequently an exit strategy focusing on continued protection of restored areas beyond the project period was not prioritized. Unfortunately, this approach was in hindsight not appropriate. Unanticipated long-term threats emerged in the last year of the project. At one site, landscaping and road maintenance contractors cut down several hundred of the project’s seedlings during road work, despite the seedlings being more than 10 m away from the roadside. At other sites, invasive alien plants, mangrove crabs, and giant tortoises damaged the project’s tree seedlings more extensively than had been expected. In retrospect, the exit strategy for the Seychelles interventions should have included enhanced communication protocols between government and the Landscape and Waste Management Agency to prevent damage to the trees by roadside maintenance teams. It also should have included long-term agreements with government and nongovernmental organizations to safeguard the project’s tree seedlings until the trees are large enough to withstand pressures from alien plants, crabs, and tortoises.

In the case of Mauritania, the extent of adaptive management required during the project implementation was not anticipated. For example, local politics necessitated the changes in project sites, with some of the new sites needing fencing to protect tree seedlings from livestock (Soule et al., 2018). The shift in project sites also meant that planting of tree seedlings continued right up until the closure of the project instead of a year before. As a result, a verbal commitment from the government to maintain the project’s fences and to water seedlings for several months after project closure was obtained. It is likely that the government of Mauritania will undertake these actions because the project sites are on state-owned land and the government recognizes the value of the EbA investment. In retrospect, it would, however, have been preferable to invest the time and resources well in advance of the closure of the Mauritania interventions to obtain a written agreement with the government, specifying the required maintenance costs over a period of 5 to 10 years in relation to the expected long-term benefits from the project’s interventions.

In Nepal, where tree seedlings were planted on both private and communal land, the provision of follow-up maintenance service—such as weeding and fertilizing to maximize seed survivorship—was inhibited by the limited project budget. As a result, at the outset of the project, private landowners and communities were selected for participation based on their interest in the project and their commitment to investing in the maintenance of the seedlings. During implementation of the project, however, it became evident that the amount of resources that landowners and communities invested in maintaining the seedlings varied considerably. This variation was far greater than had been anticipated, highlighting the importance of in-depth socioeconomic analyses at each targeted site before undertaking EbA interventions. The variation in investment into maintenance of the EbA interventions by project participants is highlighted by two extreme examples from Nepal.

One landowner in Nepal frequently weeded her hundreds of seedlings and fertilized them with goat droppings collected from her land. This particular woman also encouraged family members to travel from Kathmandu to her rural plot to assist her with maintenance of the seedlings on weekends. Her objective was to leave a green legacy for her descendants and to convert eroding fallow land into a verdant forest of valuable trees which would provide fodder, medicines, fruit, and timber, and would retain an organic-rich topsoil. There was also an economic incentive for the landowner to undertake regular maintenance. This was because her neighbors were legally entitled (without her permission) to graze their cattle on her fallow land, in effect occupying it, if she did not demonstrate an economically viable activity on the land. She was consequently motivated to maintain the seedlings and ensure that they become productive trees because this would protect her land asset.

In contrast to the example above, one of the communities in Nepal that had agreed to have thousands of tree seedlings planted on a piece of their communal land did not follow through with any maintenance of the seedlings, despite having committed to government that they would maintain a multiuse forest on the land in the long term. As relationships were built with the community, it emerged that the lack of maintenance of the seedlings was a result of the security of the land being at risk. A wealthy private landowner had donated the land to the community, allegedly to reduce his tax burden. During the implementation of the project, the community developed suspicions that as the trees matured and the value of the land increased, the landowner would attempt to find a legal route to reverse the donation and reclaim the land. Consequently, it was a calculated economic decision for the community to reduce their investment in maintenance of the seedlings.
The examples from Nepal highlight the likelihood of variation in investments in maintenance even with detailed socioeconomic information available at the outset. This is because socioeconomic conditions change over time and willingness to invest in maintenance may change as a result. There will consequently inevitably be a continuum of success across sites no matter how well the exit strategy is designed and iterated. Unlike other types of infrastructure projects where specific targets of quality and quantity can be reached, there will invariably be considerable variation in the success of EbA interventions across sites as a result of socioeconomic and biophysical factors beyond the control of the project manager. EbA projects investing in interventions spanning tens or hundreds of hectares should arguably therefore be viewed as large experiments, in which project resources are allocated across multiple sites, with the full understanding that not all sites will prove to be viable locations for long-term ecological infrastructure. Crucially, the reasons for failure at certain sites within a project should be well-documented to assist targeting upscaling of EbA at appropriate sites in the future.

9 | CONCLUSION

EbA interventions require urgent upscaling globally at the scale of hundreds of millions of hectares. Lessons learned through the implementation of the EbA South project can inform such upscaling. In particular, EbA South stakeholders emphasized the importance of: (a) quantifying the full suite of ecosystem goods and services generated through EbA at a landscape scale; (b) budgeting in advance for management of time-consuming complexities related to socioeconomic as well as ecology; (c) undertaking long-term research for adaptive management and documenting the project’s successes; (d) providing platforms for effective communication and collaboration amongst stakeholders with different first languages; and (e) regularly adjusting exit strategies for maintenance of the EbA landscapes after closure of the project.

Applying the above lessons learned to future EbA projects will potentially lead to a shift in how societies manage ecosystems to mitigate risks from climate change, ultimately triggering investments at the scale required for meaningful impact at a global scale. Long-term research that quantifies the ecosystem goods and services delivered by EbA over decades will play a particularly important role in this regard. Such quantification will enable sophisticated economic models to be built that convince public and private sector investors of the value of large-scale EbA.

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