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SERIES SYNTHESIS

Ecosystem-based Adaptation


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Ecosystem-based adaptation (EbA) is a nature-based approach that uses biodiversity and ecosystem services to help people adapt to the adverse impacts of climate change (UNEP 2016). In addition to improving climate resilience, EbA interventions can provide biodiversity conservation and other human well-being co-benefits, including habitat for food species, non-timber forest products for household use, carbon sequestration for climate mitigation and pollination for agricultural productivity. This document provides an introduction to EbA and common EbA approaches; summarizes evidence related to EbA and food security, water security, coastal populations and extreme events; and discusses cost-effectiveness, elements of a successful EbA approach and enabling conditions. It draws from a series of evidence summaries and case studies generated by USAID highlighting the potential role of EbA in addressing climate vulnerabilities and contributing to development results, which can be found at rmportal.net/usaideba.

I. Introduction

Addressing climate change is critical for safeguarding the world's poor and vulnerable populations while also reducing risks to economic growth and enhancing global security. Strategies to reduce climate vulnerability are typically classified into three categories: hard solutions, such as engineered infrastructure like levees; soft solutions, including insurance and early warning systems; and nature-based solutions such as EbA (Field et al. 2012). EbA is a people-centric concept that recognizes ecosystem integrity as critical for human resilience to climate change (Bertram et al. 2017). The use of biodiverse ecosystems, such as wetlands, forests and mangroves, represents a proven strategy for building resilience to climate change. These natural systems can reduce the impact of floods and droughts, decrease hillside erosion and protect lives and property against storm surge and high waves.

Healthy ecosystems also provide a wide range of life-sustaining co-benefits, from clean water for drinking, fertile soils for agriculture and habitat for fish, to other natural products that support economic growth, food security and human well-being. EbA approaches support USAID's mission by sustaining the natural resource base upon which communities depend and lowering climate risk, which promotes more stable, resilient and self-reliant societies.

Combining several climate adaptation strategies is often an effective way to build resilience. For example, the Government of Bangladesh is increasing the country's resilience to rising sea levels and cyclones by constructing coastal embankments and cyclone shelters (hard solution), instituting a cyclone early warning system in coastal areas (soft solution) and planting trees to stabilize "chars" or river delta islands (EbA solution). In addition to improving climate resilience, these EbA interventions provide biodiversity and human well-being co-benefits, including habitat for food species, pollination for agricultural production and non-timber forest products for sale to generate household income.


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EbA approaches can also address problems associated with maladaptation (i.e., development efforts that inadvertently increase climate risks). For instance, replacing a natural system, like coastal dunes or salt marshes, with a sea wall can inadvertently increase climate vulnerability through the loss of ecosystem services that contribute to resilient livelihoods. Although sea walls can offer effective shoreline protection, they can also have negative consequences if their design does not incorporate landscape-level hydrological processes and account for the economic value of the healthy ecosystems replaced and the ecosystem services lost.

The integration of EbA approaches into community-based adaptation strategies can address many of the priorities identified by vulnerable countries and people, such as reducing disaster risk and improving natural resource conditions. As natural buffers, ecosystems are often less expensive to maintain and can be more effective than physical structures, such as dikes or concrete walls (Colls et al. 2009). The potential benefits and challenges of EbA outlined in this document can help decision-makers and development practitioners consider and identify where EbA is likely to be a relevant adaptation strategy.

II. Common Ecosystem-based Adaptation Activities

EbA approaches build resilience by improving the management of ecosystems and minimizing impacts on them, which enhances the ability of these ecosystems to protect people from the adverse effects of climate change. Depending on the type of intervention, EbA approaches may provide protection at different scales. For example, substituting conventional crop varieties with wild seeds may provide benefits at the individual farm or household level, while improving land-use planning for a river basin can benefit multiple communities. Six common categories of EbA activities are:

Supporting integrated land-use planning: Land-use planning can help to regulate development in sensitive areas, reduce pressures on ecosystems and minimize climate risks. In coastal areas, for instance, land-use plans can restrict human settlement in areas at high risk for storm surge and flooding associated with extreme weather events (USAID 2015). Similarly, land-use planning for settlements located further inland can allocate space designated as freshwater recharge zones to help offset the impacts of drier conditions and drought. In general, long-term, institutionalized and iterative land-use planning can support sustainable natural resource management that increases human resilience to climate change (Christie et al. 2005).

Establishing and managing protected areas: The protection of floodplains, coral reefs and other ecosystems can attenuate storm surge and floods and reduce damage to infrastructure, among other climate adaptation benefits (Beck et al. 2012). In addition, protecting these habitats provides biodiversity conservation co-benefits, including resting areas for migratory bird species, and spawning and nesting areas for various species. In many cases, healthy ecosystems can provide similar benefits for climate change adaptation as conventional hard solutions, such as dikes and levees (European Commission 2016). Healthy ecosystems can also protect communities from erosion and inundation during large storms (UNEP 2014). For example, in the Caucasus Mountains in the Republic of Georgia, forests reduce landslide potential and slow water runoff to streams that flow past population centers, reducing flood risk to downstream villages and agricultural fields, particularly during the rainy season (IUCN 2012).

Restoring ecosystems: Ecosystems must be intact and well-functioning to provide effective protection against climate stressors. For this reason, ecosystem restoration is an important EbA approach. The restoration of Vietnam's mangrove forests is a prime example. After Vietnam lost over 80 percent of its mangroves, mostly through conversion for agriculture and aquaculture, the country implemented a program to replant mangroves. These restored mangroves helped to reduce wave height from Tropical Cyclone Damrey in 2005 from four meters to 0.5 meters and prevented damage to a network of sea walls in northern Vietnam (Powell et al. 2011).

Supporting ecosystem-based livelihoods: Livelihood activities, such as agriculture, fishing, aquaculture and the collection of non-timber forest products, are particularly vulnerable to climate stressors, including ocean acidification, shifts in temperature and extreme weather events like droughts. At the same time, these activities can lead to ecosystem degradation. By improving the management of natural resources on which livelihoods depend, communities can reduce pressure on the resource base (e.g., fish stocks), making it more resilient to climate stressors (e.g., warming of freshwater lakes). As an illustration, the USAID/Malawi Fisheries Integration of Society and Habitats (FISH, 2014-2019) project increases social, ecological and economic resilience to climate change and improves biodiversity conservation through sustainable fisheries co-management. Through the project, communities and local governments are protecting four of Malawi's main lakes, which is anticipated to improve household food security and income and build resilience to water and food shortages.

Building green infrastructure: The use of green infrastructure—defined in USAID's 2017 Green Infrastructure Resource Guide as "any engineered intervention that uses vegetation, soils and natural processes to manage water and create healthier built environments for people and the natural resources that sustain them"—can help moderate extreme events and increase water storage capacity (USAID 2017). Examples include urban parks that allow for water recharge zones, green roofs that reduce temperatures and capture water runoff, and constructed wetlands to treat domestic and industrial wastewater (WWF 2016, Bertule et al. 2014). For instance, USAID/Peru has supported cost-effective green infrastructure to manage climate-related rural water insecurity, including the restoration of pre-Incan ***amunas*** (i.e., water conservation systems that capture and channel rainwater during the rainy season to recharge aquifers) that provide dry season water supplies. More information on these projects can be found at rmportal.net/usaideba.

Implementing agroforestry and conservation agriculture: Sustainable agricultural practices can minimize disruptions to the natural environment, increase economic and social benefits for farmers and other users, and enhance resilience to climate change. Key examples include agroforestry, conservation agriculture and the propagation of wild species. Agroforestry can protect crops from storms and reduce demand for water by integrating trees and shrubs into crop and animal farming systems. Conservation agriculture increases climate resilience by minimizing disruptions to the soil's structure, composition and natural biodiversity. Finally, wild species' propagation can enhance resilience by providing farmers with a wide variety of alternatives when crops fail or climate conditions shift, particularly because many wild species have evolved to be better suited to fluctuations in local conditions than commercial varieties (Colls et al. 2009, UNDP 2015). For instance, USAID's Mekong Adaptation and Resilience to Climate Change (ARCC, 2011-2016) program supported farmers in Thailand to build their resilience to projected increases in mean temperature by raising more heat-tolerant native black pigs.

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III. Ecosystem-based Adaptation Can Protect and Enhance Development Programming and Reduce Climate Risks

Climate change poses severe risks to a range of development objectives from improved health to food and water security. The appropriate application of EbA approaches can reduce many of these risks while helping to achieve those development objectives. Following is a summary of evidence on the ways in which EbA can address threats to food security, water security and coastal populations, as well as how EbA can increase resilience to extreme weather events.

Food security: Chronic food insecurity affects an estimated 12.9 percent of the population in the developing world, with over 800 million people undernourished globally (UN 2016). When people lack sufficient food, they are more likely to suffer from reduced physical and mental capacity, increased risk of chronic disease and decreased productivity. The collective impacts of food insecurity can decrease a country's gross domestic product by about 10 percent annually (Brown et al. 2015). Climate stressors often magnify risks to food security, further threatening human health and economic productivity. For example, higher temperatures and lower levels of rainfall can decrease crop yields, shift planting windows, increase stress on livestock and change the prevalence of pest infestations.

EbA approaches can increase the resilience of food production and improve agricultural productivity. EbA activities that strengthen food security include planting shade trees to improve soil fertility and support pollinators, restoring and managing watersheds to maintain water supply for irrigation and intercropping to improve resistance to pest outbreaks (Colls et al. 2009, Vignola et al. 2015). For fishing communities, protecting marine and freshwater habitats and strengthening fisheries management help to ensure that fish stocks do not fall below minimum viability levels and are more likely to withstand challenging climate conditions. Healthy ecosystems are also critical for the diversification of food sources, such as wild plants and indigenous crops, which can serve as safety nets in times of food shortages (Powell et al. 2011, Ahenkan and Boon 2011). Additional information on EbA and food security, and a case study from Bangladesh that illustrates the use of EbA to strengthen food security can be found at rmportal.net/usaideba.

Water security: Water insecurity hinders sustainable development and poverty reduction. Nearly four billion people experience severe water scarcity at least one month per year and about 500 million people face severe water scarcity year-round (Mekonnen and Hoekstra 2016). Sustainable access to good-quality water is necessary for livelihoods, human well-being and socioeconomic development. Clean and sufficient water resources protect against water-borne pollution and diseases (UN-Water 2014). Climate change poses a challenge to water security by altering the timing, quantity and quality of precipitation and water flows, leading to impacts on health, agriculture and infrastructure. For example, prolonged drought reduces water stores in reservoirs, streams and spring catchments. As water sources dry up, the level of effort needed for water collection goes up, thereby increasing the burden on women and girls, who are disproportionately responsible for water collection in much of the world (UN 2014).

EbA approaches can be a cost-effective adaptation strategy to maintain and increase the quantity and quality of water by recharging aquifers and improving water storage (Talberth et al. 2012, Bertule et al. 2014). Forests, wetlands and riparian buffers all play important roles in filtering runoff, preventing erosion and slowing sedimentation. Agroforestry and conservation farming can reduce agricultural water demand and help increase farmers' resilience during droughts (Vignola et al. 2015). Additional information on EbA and water security, and case studies from Mongolia and Peru that illustrate the use of EbA to improve water security can be found at rmportal.net/usaideba.

Coastal populations: Coastal areas are some of the world's most biologically and economically productive zones, providing critical access for trade and fisheries. They are also home to many of the world's growing populations, including megacities like Manila and Jakarta (Spalding et al. 2014). They also support the livelihoods of millions of rural households through coastal resources such as wild fisheries, mangroves and coral reefs. At the same time, coastal areas are highly vulnerable to climate stressors, such as sea level rise, increasing ocean temperatures and ocean acidification (Wong et al. 2014). These stressors pose significant risks to the well-being and assets of coastal populations. Extreme weather events, such as typhoons, drought and coastal flooding, are expected to worsen in many coastal areas as a result of climate change. A combination of sea level rise, strong storms and increased rainfall can also lead to the submergence of coastal areas.

EbA approaches can often help coastal populations adapt to the adverse impacts of climate change (UNEP 2016a). For example, restoration of mangroves, coral reefs and other natural systems can help attenuate coastal erosion and storm surge. Healthy coastal ecosystems can also act as barriers against extreme events, capture sediment and slow destructive wave energy (Spalding et al. 2014). Additional information on EbA and coastal populations, and a case study from the Seychelles that illustrates the use of EbA to protect coastal populations can be found at rmportal.net/usaideba.

Extreme events: A growing body of research finds that climate change is projected to increase the frequency and intensity of some extreme weather events such as droughts, typhoons, hurricanes, heavy precipitation and heat waves (Nel et al. 2014). Over the last 40 years, the frequency of natural disasters has increased almost three-fold, from over 1,300 events between 1975 and 1984 to over 3,900 between 2005 and 2014 (Lopez et al. 2015). Damages from extreme events have grown from several billion dollars in 1980 to an estimated $200 billion in 2010 (Field et al. 2012). In addition, climate change is projected to increase rainfall intensity and frequency and permafrost melting in some regions, which could lead to more landslides and damaging localized flooding.


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A number of EbA approaches can help communities become more resilient to extreme events. For example, restoration of upland forests and coastal mangroves can reduce landslide risk and erosion from strong storms. Protection of coral reefs can provide a buffer against damaging waves and riparian buffers can decrease flood risk (Munang et al. 2013). Intact ecosystems, such as healthy forests, can protect against drought conditions by absorbing water and recharging groundwater supplies. Green spaces and roofs and vegetated riparian buffers in urban areas can mitigate extreme heat waves by decreasing daytime temperatures and contributing to cooler water temperatures. Restoring natural fire regimes to dry forests can reduce the impacts of uncontrolled wildfires. Additional information on EbA and extreme events, and a case study from the Philippines that illustrates the use of EbA to protect communities from extreme events can be found at rmportal.net/usaideba.

IV. Cost-Effectiveness of Ecosystem-based Adaptation Approaches

The United Nations Environment Program estimates that the cost of climate change adaptation by developing countries could rise to between $140 and $300 billion per year by 2030, and between $280 and $500 billion annually by 2050 (UNEP 2016b). In the Lower Mekong region alone, climate change is estimated to pose economic risks valued at $16 billion per year (Talbreth and Reytar 2014). While estimates vary, these figures underscore the increasing cost of adaptation.

EbA approaches can be a cost-effective strategy for addressing climate risks, particularly when considering the relative costs and benefits of adaptation interventions. Adaptation costs typically include the "costs of planning, preparing for, facilitating and implementing adaptation measures, including transition costs"; adaptation benefits comprise "the avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures" (UNFCCC 2011). A study examining the cost-effectiveness of EbA to address erosion and landslides in mountainous regions of Nepal and Peru found that EbA interventions were nine times more cost-effective than business-as-usual (BAU) scenarios in Nepal and two times more cost-effective than BAU scenarios in Peru. BAU scenarios increased the risk of erosion and landslides because they involved production practices — such as overgrazing and cultivation of short grasses on degraded lands — that destabilized slopes. The alternative EbA interventions supported adoption of sustainable grassland management for grazing livestock and the cultivation of commercially valuable, deep-rooted native grasses that better stabilized slopes (UNDP 2015). Additional information on the economics of EbA can be found at rmportal.net/usaideba.

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EbA approaches also provide biodiversity conservation and other human well-being co-benefits, another factor that can contribute to EbA's cost-effectiveness compared with other adaptation approaches. For example, a cost-benefit analysis comparing mangrove restoration with construction of an earthen dike in Mozambique to protect a coastal city from frequent flooding and high storm surges found that mangrove restoration had positive financial and economic net present values (a measure that reflects return on investment) that exceeded the earthen dike alternative. The primary reason for this was that mangrove restoration provided additional benefits that the earthen dike did not, particularly carbon sequestration and fish production (Narayan et al. 2017).

V. Elements of a Successful Ecosystem-based Adaptation Approach

EbA is an important strategy for strengthening human resilience to climate change and achieving co-benefits; however, it should not be seen as a panacea for every type of climate vulnerability. There are a number of critical elements necessary to ensure the effectiveness and sustainability of EbA approaches, including the following:

Investment and financial incentives: To be sustainable, EbA approaches should include financial plans that identify near-term and long-term funding sources for EbA design, implementation and maintenance. While the cost of implementing and maintaining EbA activities is typically lower than for hard infrastructure approaches, EbA activities typically require some investment in longer-term maintenance and monitoring. For example, reforestation on stream banks to reduce erosion, cool water temperatures and ensure the suitability of fish habitat requires monitoring to make sure trees are not cut down and resources to replant trees that do not survive. However, a major advantage of EbA is that natural systems can potentially repair themselves in comparison with hard infrastructure that requires periodic investments in repairs, such as seawalls that degrade from continuous wave energy. Incentivizing community, government and private sector stakeholders is another important element of sustainable EbA approaches. Examples range from tax incentives for adopting EbA approaches to payment for ecosystem services programs that incentivize farmers or other groups to manage their land in ways that improve environmental benefits (USAID 2009).

Effective institutions: Appropriate governance and legal structures must be in place and well-functioning to ensure ecosystems can continue to provide climate resilience and other benefits. Successful EbA requires consultation and coordination with diverse government institutions and other stakeholders as well as raising awareness of the value of ecosystems for reducing climate risks (Colls et al. 2009). In Mongolia, for instance, the Ecosystem-based Adaptation Approach to Maintaining Water Security in Critical Water Catchments project funded by the United Nations Development Program and the Adaptation Fund built capacity among government officials to promote EbA approaches and supported the establishment of river basin councils to improve coordination of district activities at the basin scale.

Policy support: National and local policies are instrumental in the systematic implementation and scaling up of EbA approaches. Also, coordinated action across government institutions is critical to reinforce the importance of EbA and provide funding for its implementation. For instance, many countries prepare national adaptation plans or development policies that prioritize specific interventions. Ideally, these plans and policies would consider the potential role of EbA within sectors like water and agriculture. The inclusion of EbA in national and local policies also ensures that EbA is considered within the broader context of national and local priorities, rather than used as part of a stand-alone, project approach. For example, the GIZ-funded program, Strategic Mainstreaming of Ecosystem-based Adaptation in Vietnam (2014-2018), worked to strengthen stakeholder capacity at national and provincial levels to mainstream ecosystem-based measures in Vietnam's adaptation policy framework.

Ecosystem viability: A critical element of EbA is the extent to which the ecosystem itself is being impacted by climate and other stressors, which may impair its ability to protect against climate risks. For example, if coastal communities rely on coral reefs as breakwaters for storm surge, and those reefs become degraded from bleaching and ocean acidification, their ability to reduce wave action may be diminished. Similarly, an approach that focuses on the management of specific fisheries may not be effective if the location of that fishery is shifting as a result of changes in ocean temperatures.

Appropriate time horizons: Another factor when considering an EbA approach is the amount of time before adaptation benefits begin. For instance, it may take several years for re-planted mangroves to provide sufficient coastal protection; when comparing this approach with a hard infrastructure option, the timeframe for mangrove replanting and growth needs to be compared with the time needed to design and construct a seawall or breakwater. From a practical perspective, project designers should also consider the ease of accessing EbA sites during implementation and monitoring. If EbA sites are remote, hard to access and require regular oversight, then an EbA approach may be more difficult to implement.

Expertise and capacity: EbA planning and implementation requires specific expertise, such as in ecological restoration or green engineering. It is important that planning teams incorporate the right technical expertise in addition to knowledge of the local context. Since local communities and government officials will ultimately be responsible for the long-term operation and maintenance of EbA approaches, it may be necessary to strengthen their capacity to take on this responsibility. Integrating local communities early in the project design stage can also support capacity development and create local ownership.

Cross-sectoral integration: Cross-sectoral integration can help to ensure that EbA interventions deliver adaptation and other benefits to different development sectors. EbA can potentially build resilience at multiple scales, from smallholder maize systems in Africa to coastal megacities like Jakarta. When EbA approaches are incorporated into a food security or health program, they can improve adaptation to climate change, contribute to the primary development objective (e.g., food security or improved health) and potentially yield additional benefits, such as natural resource and ecosystem service protection and biodiversity conservation.


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VI. Enabling Conditions

Opportunities exist for integrating EbA within multiple sectors to reduce climate risks and enhance development outcomes. In some cases, an EbA approach may meet a primary resilience objective of a development program, such as a food security project; in other cases, EbA may be a component or co-benefit of a larger water and sanitation, humanitarian assistance or biodiversity program. It is also important to recognize that EbA approaches may not be the best strategy in some contexts. Planners and designers should consider whether EbA approaches actually fit the context in which they are being considered. The table below describes the enabling conditions for EbA to contribute to enhancing resilience and increasing the sustainability of development programming.[1]

		Potential for EbA Effectiveness	
		Low	**High**
Enabling Conditions	**Environmental**	• Degraded ecosystems that have lost their ability to provide services • Ecosystems that are highly vulnerable to climate change	• Healthy, intact ecosystems or good potential to restore degraded ecosystems • Sufficient area of intact ecosystems to contribute effectively to climate adaptation
Enabling Conditions	**Community and Governance**	• Lack of stakeholder engagement and/or interest in EbA approaches • Livelihoods not very dependent on ecosystem services • Lack of coordination among sectors • Lack of government support or an unfavorable policy environment • Unclear responsibilities between administrative levels	• Community understanding of the linkages between ecosystem protection and human well-being, including climate adaptation • Livelihoods closely linked to natural resources and ecosystem services, such as fisheries or forests • Effective coordination between sectors and administrative levels • Civil society advocacy and presence of active champions
Enabling Conditions	**Technical**	• Lack of specialized knowledge on environmental management and ecosystems • Scientific uncertainties about the longer-term costs and benefits of EbA	• Availability of information on the ability of target ecosystems to contribute to climate adaptation • Availability of information on economic costs of EbA versus alternative approaches

[1]Based on literature review, particularly Bertram et al. 2017, Nel et al. 2014, Brown et al. 2014, Colls et al. 2009 and field experience.

USAID Ecosystem-based Adaptation Series
(found at rmportal.net/usaideba)

Evidence Summaries:

- Ecosystem-based Adaptation and Extreme Events
- Ecosystem-based Adaptation and Food Security
- Ecosystem-based Adaptation and Water Security
- Ecosystem-based Adaptation and Coastal Populations
- The Economics of Ecosystem-based Adaptation

Case Studies:

- Improving Ecosystem Management to Strengthen Resilience to Extreme Weather in the Philippines
- Conserving Ecosystems to Support Climate Resilience in Bangladesh
- Maintaining Water Security in Peru Through Green Infrastructure
- Maintaining Water Security in Critical Water Catchments in Mongolia
- Restoring Coral Reefs in the Face of Climate Change in the Seychelles

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About This Series

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