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EVIDENCE SUMMARY

Ecosystem-based Adaptation and Extreme Events

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Extreme weather and other climate events, such as floods, droughts, storms and heat waves, pose considerable risks to communities and reverse development gains. As the climate warms, these events are likely to increase in frequency and intensity. Because extreme events often have greater impacts on the most vulnerable populations, there is an urgency to implement strategies that will improve resilience. Ecosystem-based adaptation (EbA) is a nature-based method for climate change adaptation that can reduce the vulnerability of societies and economies to extreme events. EbA provides flexible and cost-effective approaches that enhance resilience through the improved management and conservation of ecosystems. EbA can be an effective adaptation strategy alone or as an element of broader national, regional and community adaptation plans.

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Background

Annual losses from extreme weather and climate-related disasters — such as droughts, heavy precipitation and heat waves — have increased from several billion dollars in 1980 to $200 billion in 2010. Loss of life and economic losses (as a percentage of gross domestic product) from natural disasters are significantly higher in developing countries; 95 percent of deaths from these events between 1970 and 2008 took place in developing countries (Seneviratne et al. 2012).

EbA uses biodiversity and ecosystem services to help communities adapt to the negative impacts of climate change (UNEP 2016). Specific EbA approaches that can help communities adapt to extreme events include: restoring and replanting upland forests and coastal mangroves to reduce landslide risk and coastal erosion from strong storms, conserving natural infrastructure such as coral reefs to buffer against damaging waves and creating riparian buffers to decrease flood risk (Munang et al. 2013). EbA approaches can be implemented alone or in coordination with a broader adaptation strategy. Specific advantages of EbA may include additional benefits provided by ecosystems such as carbon sequestration, biodiversity conservation and the provision of wild foods, fuel and clean water; cost-effectiveness; and sustainability (Munang et al. 2013, Nel et al. 2014).

Studies on EbA have found that these nature-based approaches may offer significant cost savings compared to other climate change adaptation strategies, such as the construction of hard infrastructure. For example, in the Maldives, researchers estimated that the cost of replacing the coastal protection offered by coral reefs and other marine ecosystems with infrastructure such as seawalls and breakwaters would range from $1.6 to $2.7 billion, compared with $34 million initially and $47 million annually to protect and maintain these ecosystems (Munang et al. 2013). Coastal ecosystems also generate a number of additional benefits — such as the conservation of fisheries and sites for recreational activities — that contribute an estimated $10 billion annually to the economy. In Mindoro Oriental Province in the Philippines, the International Union for the Conservation of Nature and others conducted an economic analysis of the costs associated with building a seawall versus those associated with mangrove restoration and protection. They found that over a 20-year period, the costs of mangrove protection and restoration (~$75,000) were significantly less than the costs of building and maintaining the seawall (~$232,000). Mangroves also offered a number of additional benefits, including habitat for fish and sites for ecotourism. However, the seawall construction would offer immediate coastal protection (after a one- to two-year construction period), while the newly planted mangroves would take four years to mature before providing comparable results (Baig et al. 2015).

EbA interventions like mangrove restoration in the Philippines can strengthen the protection provided by coastal ecosystems. In some estimations, 100 meters of mangroves can decrease wave heights by 13 to 66 percent (Spalding et al. 2014).

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How Can Ecosystem-based Adaptation Support Resilience to Extreme Events?

As the climate warms, extreme weather events are likely to increase in frequency and intensity and can interact with other climate stressors like sea level rise, permafrost melt and rainfall variability. EbA can help communities adapt, as described below:

Coastal flooding and storm surges: Healthy coastal ecosystems like mangroves, coastal marshes and coral reefs can provide resilience to floods, storm surges and increased sea levels by serving as physical buffers that retain excess water, dissipate wave energy and stabilize shorelines (Baig et al. 2015). In the absence of these types of natural systems, costly infrastructure such as seawalls, levees and breakwaters would need to be built to absorb the impact of waves, reduce erosion and decrease saltwater intrusion (Bertule et al. 2014, Brown et al. 2014). For more information, see the **Coastal Vulnerability Summary.**

Non-coastal flooding: Intact inland ecosystems, such as riparian forests and wetlands, can reduce the impact of floods by serving as buffers that retain excess rainwater and prevent runoff (Baig et al. 2015). For example, a study that compared climate change adaptation approaches in two districts of Fiji found that ecosystem-based approaches such as planting riparian buffers had a better cost-benefit ratio compared to more traditional infrastructure approaches for flooding, such as reinforcement of riverbanks (Brown 2014).

Landslides: Healthy ecosystems have intact vegetation that can limit soil erosion and stabilize slopes, which helps to prevent landslides while also maintaining soil fertility for agriculture. Studies have shown that EbA approaches like forest and grasslands management and restoration can reduce the landslides triggered by major weather events. EbA approaches such as revegetation and reforestation have been implemented in countries like Nepal and Colombia to help prevent landslides as well as other hazards (Doswald and Estrella 2015).

Fires: EbA approaches that maintain healthy ecosystems can help protect nearby communities from the effects of fires (Nel et al. 2014). For example, indigenous communities in Australia have implemented traditional fire-management strategies in areas that were experiencing an increase in wildfires; these efforts have been successful in limiting wildfire occurrence, intensity and spread. Additional benefits for Aboriginal communities include biodiversity conservation and protection of areas with culturally significant rock art (Colls et al. 2009).

Droughts: Intact ecosystems can protect water sources and help communities adapt to drought. For example, healthy forests can serve as sponges for rainfall by absorbing water and recharging groundwater supplies; they also provide a number of additional benefits including water filtration, provision of forest products and carbon sequestration (Talberth et al. 2012, Bertule et al. 2014). In Bolivia, the Swiss Development Cooperation worked with local communities to improve their resilience to repeated droughts through a combined EbA and hard infrastructure approach, which included the establishment of protected areas important for water recharge and the construction of hard infrastructure for water collection, storage and distribution (Doswald and Estrella 2015).

Heat waves: Extreme heat events are of particular concern in cities, which can become "heat islands" where temperatures are higher than in surrounding rural areas, leading to increases in heat-related morbidity and mortality. EbA approaches in cities — including the conservation of natural systems and green spaces like parks and gardens — can provide cooling benefits. For example, a study in Portugal found that urban gardens are significantly cooler than surrounding areas, and the cooling effect can extend out for at least 200 meters (Olivieri et al. 2011). Green roofs are another natural solution that can help buffer against extreme temperatures while supporting local biodiversity, particularly birds and insects (Bertule et al. 2014).

Extreme Event	Examples of EbA Approaches	Additional Benefits from EbA Approaches
Coastal Flooding	• Restore mangroves • Establish and manage marine protected areas	• Conservation of fisheries • Protection of ecotourism sites
Non-Coastal Flooding	• Plant riparian buffers • Conserve forests	• Provision of forest products • Sequestration of carbon
Landslides	• Restore forests • Protect grasslands	• Conservation of pastureland • Maintenance of soil fertility
Fires	• Implement indigenous fire management techniques • Improve forest management	• Conservation of forest biodiversity • Preservation of indigenous knowledge
Droughts	• Conserve watersheds • Implement agroforestry practices	• Improvement in crop yields • Conservation of pollinator habitat
Heat Waves	• Conserve urban green spaces • Build green roofs	• Reduction in air pollution • Protection of recreational sites

The Role of Ecosystem-based Adaptation in Urban and Rural Resilience to Extreme Events

EbA approaches can play an important role in helping both rural and urban communities strengthen their resilience to extreme events. Rural communities are often highly dependent on ecosystem services to meet their basic needs; they also tend to have higher poverty rates and can be geographically isolated. For these communities, EbA approaches for climate change adaptation are often more cost-effective, feasible and sustainable compared with hard infrastructure, while also providing important additional benefits that contribute to food security, health and economic growth (Long 2013).

Urban areas may perceive less of a direct dependence on ecosystems compared with rural areas; however, EbA approaches can also improve climate resilience for city populations. Specifically, strategies such as creating green spaces; maintaining urban forest fragments, wetlands and riparian buffers; protecting or restoring watershed forests; and planting trees can help urban communities to better cope with the impacts of extreme events such as floods and heat waves (Brink et al. 2016). In addition, many of the world's largest cities are in coastal areas and along river banks; EbA can play a significant role in helping them build resilience to extreme events such as storm surges. For more information, please see the **Coastal Vulnerability Summary.**

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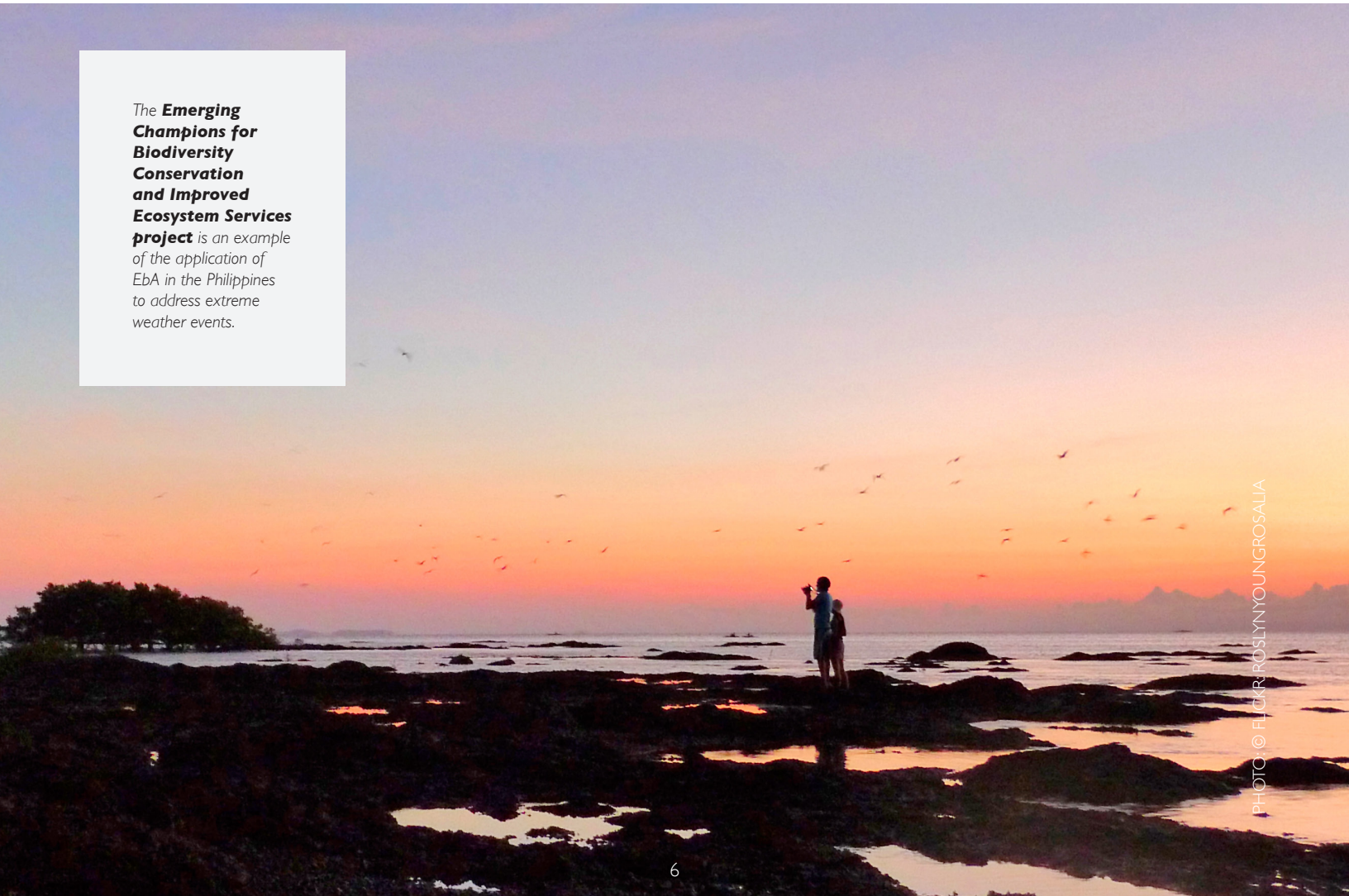
How Does Ecosystem-based Adaptation Differ From Ecosystem-based Approaches to Disaster Risk Reduction?

EbA and ecosystem-based approaches to disaster risk reduction (Eco-DRR) are interrelated but different approaches to help communities respond to extreme events. One difference is that EbA focuses on climate stressors and associated risks while Eco-DRR covers a broader range of disasters. Other differences are that Eco-DRR projects may place less emphasis on biodiversity conservation compared with EbA and more often have a component of early warning, preparedness, response and recovery from disasters, although EbA doesn't exclude these types of activities. Both Eco-DRR and EbA projects can result in strengthened natural systems, and an EbA project can have benefits for disaster risk reduction and vice versa. For example, the University of Lausanne and IUCN are implementing an Eco-DRR project in Nepal that focuses on revegetating slopes with native species to prevent landslides caused by road construction; this approach would also be expected to reduce landslides linked to climate change (Doswald and Estrella 2015).

While the two approaches often operate under different policy frameworks and institutions, researchers have identified more similarities than differences, primarily because both approaches utilize sustainable ecosystem management to achieve objectives. By designing interventions with both EbA and Eco-DRR in mind, projects can better reduce the impacts of extreme weather events and other disasters while optimizing opportunities to increase community resilience. In a recent discussion paper from the United Nations Environment Program, researchers reviewed 38 EbA and Eco-DRR projects, including a number of hybrid projects, and identified several steps during project design and implementation where EbA and Eco-DRR could be integrated, including conducting joint assessments and engaging the same institutions to influence policy (Doswald and Estrella 2015).



*The **Emerging Champions for Biodiversity Conservation and Improved Ecosystem Services project** is an example of the application of EbA in the Philippines to address extreme weather events.*

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How Do Ecosystem-based Adaptation Approaches Compare with Built Infrastructure?

EbA and hard infrastructure approaches offer different advantages and disadvantages for addressing the impacts of extreme events. For example, some advantages of hard infrastructure interventions are that they often provide a high degree of protection against a particular hazard, their benefits start immediately after construction and if maintained properly, they can be effective long-term. A disadvantage of large-scale, hard infrastructure interventions is the cost of construction and maintenance; in addition, they are often single-purpose solutions that may only address one type of climate stressor, such as increased storm surge. Smaller-scale infrastructure projects, while less expensive, still require maintenance and may not be optimal in rural areas where populations are spread out over a large geographic range (Munang et al. 2013, Rizvi et al. 2015, European Commission 2013). Furthermore, some hard infrastructure projects may have negative impacts on local ecosystems and compromise their function and productivity, both through immediate damage as well as knock-on impacts, such as restriction of water flows, which can further decrease ecosystem resilience over time (Auerbach et al. 2014).

In contrast, EbA approaches can often be cheaper than built infrastructure for climate change adaptation while also yielding long-term results, capitalizing on local knowledge and supporting other benefits for local communities. For example, a recent meta-analysis on the effectiveness of coral reefs in coastal adaptation found that they provided significant protection against climate stressors like storms and floods. The researchers found that among the projects they studied, the median cost of constructing a tropical breakwater was $19,791 per meter compared with $1,290 per meter of coral reef restored. Furthermore, coral reef restoration provided additional benefits including habitat for fish and recreation sites (Ferrario et al. 2014). Disadvantages of EbA projects are that they generally take longer to implement and may take time for communities to experience results, while the benefits from built infrastructure are immediately felt post-construction. Moreover, the majority of studies on the role of ecosystems in mitigating extreme events are geographically specific and difficult to generalize to broader contexts (Carabine et al. 2015).

In some cases, traditional hard infrastructure projects may best respond to community needs, especially in situations when an immediate intervention is required. In other situations, EbA can be combined with hard infrastructure options to more fully meet a community's needs; in the Bolivia example mentioned earlier, hard infrastructure for water storage and distribution and EbA approaches were used together to make communities more resilient to drought. Each situation is unique and project designers should consider the full spectrum of factors when developing an adaptation strategy, including costs and benefits associated with each approach, length of time to experience results, availability of resources and technology to implement the intervention, community priorities and sustainability of the intervention.

Conclusion

EbA supports socio-economic resilience to extreme events through the management and conservation of ecosystems while providing additional benefits that contribute to sustainable development. For poor, rural communities in developing countries, EbA approaches are often the most feasible and sometimes the only options given communities' geographic isolation and lack of funding for other climate change adaptation strategies. Challenges to expanding the use of EbA include the time sometimes required to see results and difficulty in generalizing findings from specific EbA projects to the broader context. However, the evidence base supports the consideration of EbA approaches for extreme weather and other climate events, either alone or as a part of a broader strategy.

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About This Series

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