EVIDENCE SUMMARY

Ecosystem-based Adaptation and Extreme Weather and Climate Events


PHOTO © CONSERVATION INTERNATIONAL / LUCAS BUSTAMANTE

In many places, climate change is projected to increase the frequency and intensity of extreme weather events, such as floods, droughts, storms, and heat waves, which can pose considerable risks to communities and reverse development gains. These extreme events often exert greater impacts on the most vulnerable populations and there is an urgency to implement strategies that will improve their resilience. In some cases, ecosystem-based adaptation (EbA), a nature-based approach for climate change adaptation, can reduce the vulnerability of societies and economies to extreme events by providing 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.

Background

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, heavy precipitation, and heat waves (Nel et al. 2014). The Intergovernmental Panel on Climate Change estimates that annual losses from extreme weather and climate-related disasters 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% 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 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 in construction costs compared with $34 million initially and $47 million annually to protect and maintain these ecosystems (Munang et al. 2013). In addition, coastal ecosystems 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, IUCN 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 associated with mangrove protection and restoration were significantly less than with building and maintaining the seawall (~$75,000 for the former vs. ~$232,000 for the latter). Mangroves also offered a number of potential co-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. It has been estimated that just 100 meters of mangroves can decrease wave heights by 13 to 66% (Spalding et al. 2014).

PHOTO: © CONSERVATION INTERNATIONAL / NANDINI

How Can Ecosystem-based Adaptation Support Resilience to Specific Extreme Weather and Climate Events?

Climate change is projected to increase the frequency and intensity of some extreme weather events. EbA can help communities adapt to their impacts, as described below:

Coastal flooding and storm surges: Climate change is projected to increase coastal flooding and storm surges in some places through sea level rise and more intense and more frequent extreme events, such as hurricans and cyclones. Healthy 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 Ecosystem-based Adaptation and Coastal Populations evidence summary.

Non-coastal flooding: In some areas, climate change is projected to increase the frequency and intensity of heavy precipitation events, leading to higher incidence of local flooding (Kundzewicz et al. 2014). Intact 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: Climate change is projected to increase rainfall intensity and frequency and permafrost melting in some regions, which can lead to more 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 including floods (Doswald and Estrella 2015).

Fires: Climate change is expected to increase the intensity and incidence of wildfires in some places due to drier forest conditions, increased temperatures, and drought. 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 been engaged to implement traditional fire-management strategies in areas that were experiencing an increase in wildfires; these efforts have been successful in limiting their occurrence, intensity, and spread. Co-benefits for Aboriginal communities include biodiversity conservation and protection of areas with culturally significant rock art (Colls et al. 2009).

Droughts: Climate change is projected to increase the incidence of drought in some regions due to higher temperatures and varying rainfall patterns, leading to reduced availability of water for household and agricultural use. 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. EbA solutions such as the establishment of protected areas important for water recharge were combined with non-EbA approaches, including the construction of hard infrastructure for water collection, storage, and distribution (Doswald and Estrella 2015).

Heat waves: In some areas, climate change is projected to increase the severity and frequency of extreme heat events. This is of particular concern as cities 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	Potential Co-benefits of EbA Approaches
Coastal Flooding	• Restore mangroves • Establish and manage marine protected areas	• Conservation of fisheries • Preservation 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 • Preservation of recreational sites

The Role of Ecosystem-based Adaptation in Urban and Rural Resilience to Extreme Weather 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 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).

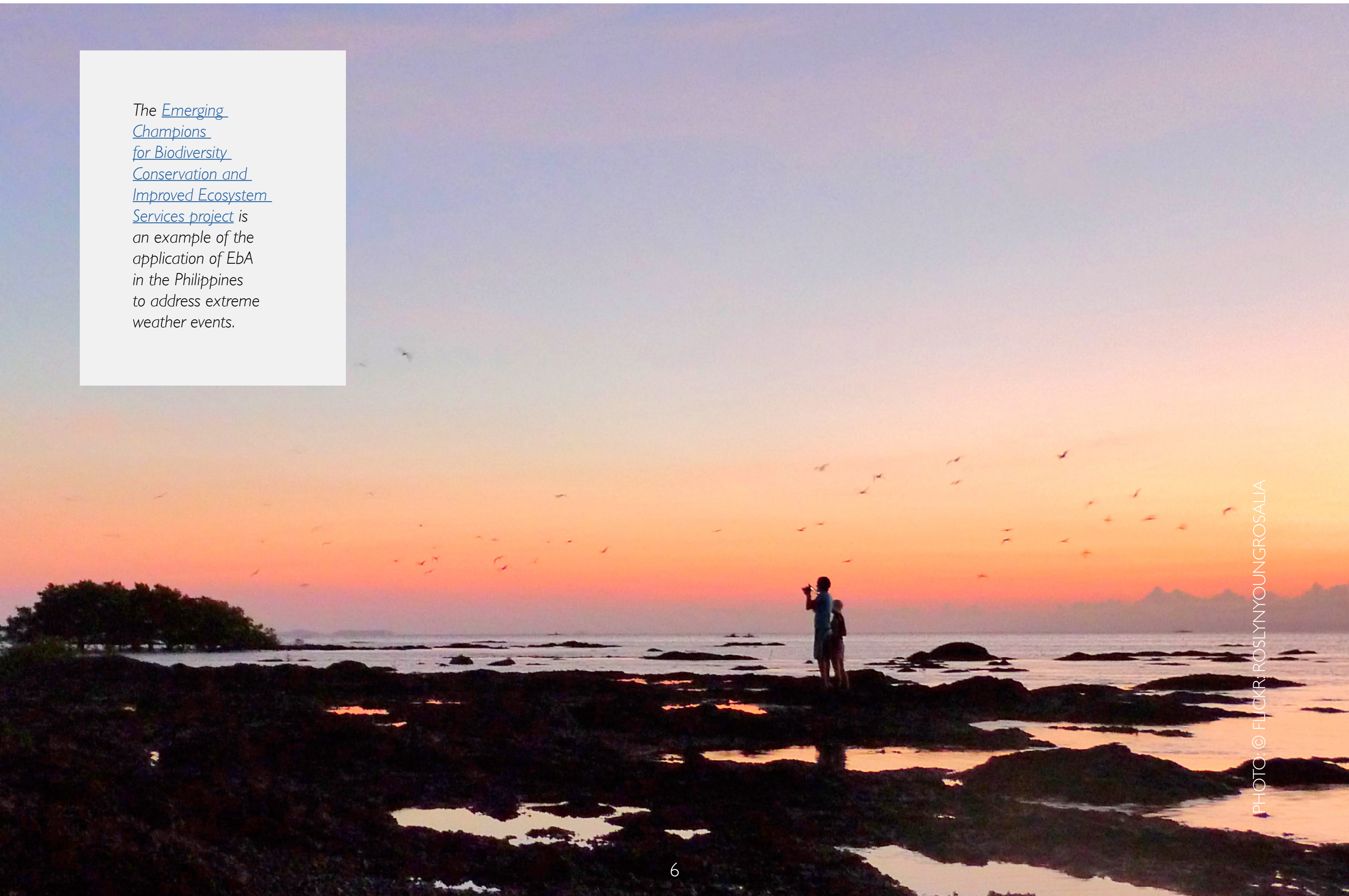
Urban areas may perceive less of a direct dependence on ecosystems compared with rural areas; however EbA approaches can also improve climate resilience for city populations. Specifically, strategies such as creating green spaces, maintaining urban forest fragments, wetlands and riparian buffers, protecting 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, see the Ecosystem-based Adaptation and Coastal Populations evidence summary.

PHOTO: © CONSERVATION INTERNATIONAL / DAVID EMMETT

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 hazards resulting from climate change 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 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 impact of extreme weather events and other disasters while optimizing opportunities to increase community resilience. In a recent discussion paper from UNEP, researchers reviewed 38 EbA and Eco-DRR projects, including a number of hybrid projects, and identified several steps during project design and implementation for EbA and Eco-DRR integration 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.

PHOTO: © FLICKR: ROSLYNYOUNGROSALIA

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

EbA and hard infrastructure approaches offer different advantages and disadvantages for climate change adaptation to 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. 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. Furthermore, some infrastructure projects may have negative impacts on local ecosystems and compromise their function and productivity (Munang et al. 2013, Rizvi et al. 2015, European Commission 2013).

In contrast, EbA approaches can often be cheaper than built infrastructure for 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 hazards like storms and flooding. 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 option given their geographic isolation, and lack of funding for other adaptation strategies. Challenges to expanding the use of EbA include the time required to see results for some approaches 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 events, either alone or as a part of a broader strategy depending on the context.

Sources

Baig, Saima, Ali Rizvi, Maria Pangilinan, Rosalina Palance-Tan. "Costs and benefits of Ecosystem Based Adaptation: the case of the Philippines." IUCN, 2015. Accessed September 9, 2016. https://portals.iucn.org/library/sites/library/files/documents/2016-009.pdf

Bertule, M., G. J. Lloyd, L. Korsgaard, J. Dalton, R. Welling, S. Barchiesi, M. Smith et al. "Green Infrastructure Guide for Water Management: Ecosystem-based management approaches for water-related infrastructure projects." UNEP, UNEP-DHI, IUCN, TNC, and WRI, 2014. Accessed August 9, 2016. http://web.unep.org/ecosystems/resources/publications/green-infrastructure-guide-water-management

Brink, Ebba, Theodor Aalders, Dóra Ádám, Robert Feller, Yuki Henselek, Alexander Hoffmann, Karin Ibe et al. "Cascades of green: a review of ecosystem-based adaptation in urban areas." Global Environmental Change 36 (2016):111-123.

Brown, P., A. Daigneault, D. Gawith, W. Aalbersberg, J. Comley, P. Fong, and F. Morgan. "Evaluating Ecosystem-Based Adaptation for Disaster Risk Reduction in Fiji." Landcare Research, New Zealand, 2014. Accessed August 10, 2016. http://reliefweb.int/report/fiji/evaluating-ecosystem-based-adaptation-disaster-risk-reduction-fiji

Carabine, Elizabeth, Courtenay Cabot Venton, Thomas Tanner, and Aditya Bahadur. "The contribution of ecosystem services to human resilience." ODI, 2015. Accessed September 9, 2016. https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9394.pdf

Colls, A., Neville Ash, and Ninni Ikkala. "Ecosystem-based Adaptation: a natural response to climate change." IUCN, 2009. Accessed September 10, 2016. https://www.iucn.org/content/ecosystem-based-adaptation-natural-response-climate-change

Doswald, N., and M. Estrella. "Promoting ecosystems for disaster risk reduction and climate change adaptation: opportunities for integration". United Nations Environment Programme, 2015. Accessed September 16, 2016. http://www.unep.org/disastersandconflicts/portals/155/publications/Eco_DRR_discussion_paper.pdf

European Commission. "Thematic Issue: Ecosystem-Based Adaptation." Issue 37 (2013). Accessed August 16, 2016.

Ferrario, Filippo, Michael W. Beck, Curt D. Storlazzi, Fiorenza Micheli, Christine C. Shepard, and Laura Airoldi. "The effectiveness of coral reefs for coastal hazard risk reduction and adaptation." Nature Communications 5 (2014).

Kundzewicz, Zbigniew W., Shinjiro Kanae, Sonia I. Seneviratne, John Handmer, Neville Nicholls, Pascal Peduzzi, Reinhard Mechler et al. "Flood risk and climate change: global and regional perspectives." Hydrological Sciences Journal 59, no. 1 (2014):1-28.

Long, V. "Strengthening Community and Ecosystem Resilience Against Climate Change Impacts: Developing a Framework for Ecosystem-based Adaptation in the Greater Mekong Sub-Region: Literature Review." WWF, 2014. Accessed August 10, 2016. http://awsassets.panda.org/downloads/wwf_wb_eba_project_2014_literature_review.pdf

Munang, Richard, Ibrahim Thiaw, Keith Alverson, Musonda Mumba, Jian Liu, and Mike Rivington. "Climate change and Ecosystem-based Adaptation: a new pragmatic approach to buffering climate change impacts." Current Opinion in Environmental Sustainability 5, no. 1 (2013):67-71.

Nel, Jeanne L., David C. Le Maitre, Deon C. Nel, Belinda Reyers, Sally Archibald, Brian W. Van Wilgen, Greg G. Forsyth et al. "Natural hazards in a changing world: a case for ecosystem-based management." PloS One 9, no. 5 (2014):e95942.

Oliveira, Sandra, Henrique Andrade, and Teresa Vaz. "The cooling effect of green spaces as a contribution to the mitigation of urban heat: A case study in Lisbon." Building and Environment 46, no. 11 (2011):2186-2194.

Rizvi, Ali Raza, S. Baig, and M. Verdone. "Ecosystems Based Adaptation: Knowledge Gaps in Making an Economic Case for Investing in Nature Based Solutions for Climate Change." IUCN, 2015. Accessed August 17, 2016. http://cmsdata.iucn.org/downloads/the_economic_case_for_eba.pdf.

Seneviratne, S. I., N. Nicholls, D. Easterling, C. Goodess, S. Kanae, J. Kossin, Y. Luo et al. "Managing the risks of extreme events and disasters to advance climate change adaptation a special report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC)." IPCC, 2012. Accessed August 18, 2016. https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf

Spalding, Mark D., Susan Ruffo, Carmen Lacambra, Imèn Meliane, Lynne Zeitlin Hale, Christine C. Shepard, and Michael W. Beck. "The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards." Ocean & Coastal Management 90 (2014):50-57.

Talberth, J., E. Gray, E. Branosky, and T. Gartner. "Insights from the Field: Forests for Water WRI Issue Brief: Southern Forests for the Future Incentives Series." WRI, 2012. Accessed August 18, 2016. http://pdf.wri.org/insights_from_the_field_forests_for_water.pdf

UNEP, 2016. "Climate Change Adaptation: Building Resilience of Ecosystems for Adaptation." Accessed August 1, 2016. http://www.unep.org/climatechange/adaptation/EcosystemBasedAdaptation/tabid/29583/Default.aspx.

About This Series

This evidence summary is part of a series of products highlighting the potential role of biodiversity and ecosystem-based adaptation in addressing climate vulnerability. This series is produced by USAID's Biodiversity Results and Integrated Development Gains Enhanced (BRIDGE) activity and can be found here: rmportal.net/usaideba.

Disclaimer

U.S. Agency for International Development
1300 Pennsylvania Avenue, NW
Washington, DC 20523
Tel: (202) 712-0000
Fax: (202) 216-3524
www.usaid.gov

June 2017