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EVIDENCE SUMMARY

Ecosystem-based Adaptation and Coastal Populations

Coastal areas are some of the world's most biologically and economically productive zones and provide critical access for trade and commercial fisheries. They are home to many of the world's growing populations, including megacities like Manila and Jakarta. 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, climate stressors such as sea level rise, increasing ocean temperatures and ocean acidification threaten the well-being and livelihoods of coastal populations by degrading water supplies, increasing incidences of waterborne disease, damaging coastal infrastructure and disrupting coastal ecosystems and fisheries (Ferrario et al. 2014, USAID 2015). Ecosystem-based adaptation (EbA) is a nature-based method for climate change adaptation that can increase the resilience of coastal populations by strengthening and maintaining natural systems and the goods and services they provide. EbA can also provide additional benefits for health, food security, biodiversity conservation and sustainable economic growth.

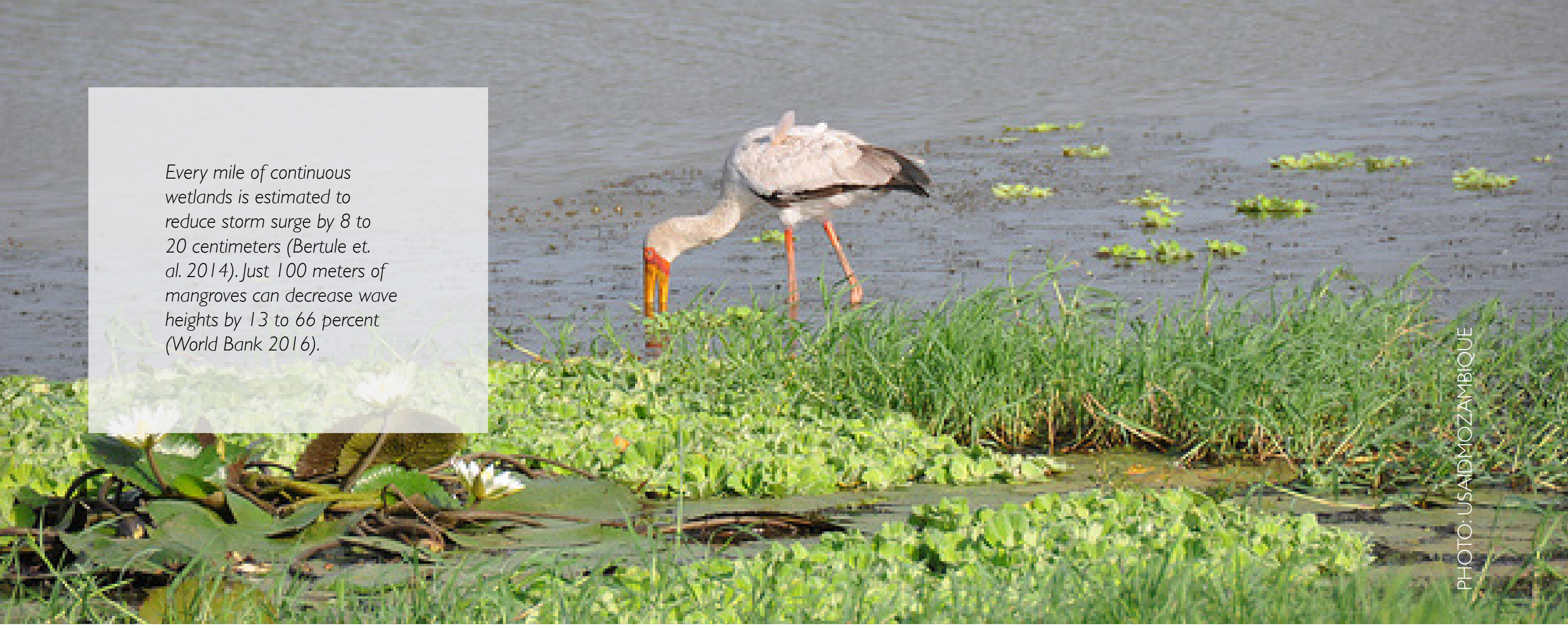
Background

Coastal areas are vitally important economic and cultural centers, which provide a home to more than 40 percent of the world's population and contribute an estimated 61 percent of the world's gross national product (UNEP 2016). Coastal zones are particularly important for developing countries that are heavily reliant on coastal resources for their livelihoods. For example, the fisheries sector alone can account for more than half of the total value of all traded commodities in some developing countries (FAO 2016). Ongoing migration to urban centers and global tripling in the volume of seaborne trade over the past 30 years means that port cities, such as Ho Chi Minh, will continue to expand and contribute significantly to national and global economies (Hanson 2011). Coastal communities have flourished because of their ready access to shipping and trade as well as their proximity to a rich natural base, including mangroves, coral reefs and seagrass beds that support coastal fisheries (Scialabba 1998).

While the location of coastal communities at the intersection of marine and land systems strongly contributes to economic growth, these communities are also highly exposed to climate stressors. Sea level rise, increases in ocean temperature, ocean acidification, coastal flooding and increasing intensity and frequency of extreme weather events all pose significant risks to human and natural systems in coastal areas (Wong et al. 2014). Increasing sea temperatures and ocean acidification also affect the frequency, intensity and impacts of coral bleaching events (Wong et al. 2014).

In many cases, climate stressors are already impacting coastal communities. Average sea surface temperatures–which have increased over the past 30 years along more than 30 percent of the world's coastlines–have shifted the location of fishery resources (Lima and Wethey 2012). These increased ocean temperatures also caused three global bleaching events in 1998, 2010 and 2015, resulting in catastrophic loss of the world's coral reefs with associated impacts on food security and coastal livelihoods (Hughes et al. 2017). Similarly, seawater has become more acidic because the ocean is absorbing excess carbon from the atmosphere. The tropical Pacific Ocean has already experienced measurable increases in average acidity levels, with negative impacts on the coral reefs, plankton and shellfish that support communities' food security and economic growth. Climate risks posed to coastal communities include land loss due to erosion and submergence leading to relocation, damage to the built environment from extreme events like typhoons, increased incidence of food- and water-borne disease, reduced water availability and loss of cultural heritage (Hunt and Watkiss 2011).

Climate stressors also interact with unsustainable development practices like coral mining, overfishing and the construction of infrastructure in ecologically sensitive areas. For decades, these unsustainable practices have negatively impacted coastal areas, resulting in environmental degradation, habitat fragmentation and loss, pollution and erosion. As a result, coastal ecosystems are among the most threatened natural systems globally. For example, the rate of loss of mangroves–which are critical for coastal protection and economic development–is three to four times the rate of global deforestation (Spalding et al. 2014). The combined impacts of climate change and degradation of natural systems are of particular concern for poor coastal populations who are highly dependent on ecosystem goods and services to meet their basic needs (Spalding et al. 2014).



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Every mile of continuous wetlands is estimated to reduce storm surge by 8 to 20 centimeters (Bertule et. al. 2014). Just 100 meters of mangroves can decrease wave heights by 13 to 66 percent (World Bank 2016).

Ecosystem-based Adaptation Approaches for Building the Resilience of Coastal Populations

A range of EbA approaches can build resilience by improving the conservation, protection and management of biodiversity and ecosystem services in coastal areas (UNEP 2016). EbA approaches maintain and strengthen natural systems to enhance their ability to protect coastal populations from the adverse effects of climate change. While each of these actions can be implemented to achieve goals other than climate change adaptation, they can be described as EbA when they are used with the explicit intention of decreasing coastal vulnerability to climate risks. Specific EbA approaches include:

Integrated coastal zone management and planning: Integrated coastal zone management is a long-term, institutionalized and iterative planning process that promotes integration of coastal activities across sectors with a view to using natural resources in a sustainable way (Christie et al. 2005). Integrated coastal zone management regulates development in sensitive or vulnerable areas (e.g., coastal sand dunes) to reduce pressure on coastal ecosystems. Integrated coastal zone management plans can specify areas left as open space for freshwater infiltration to reduce the impacts of saltwater intrusion and drought, as well as designate no-go zones where habitation is prohibited due to high flood risk (USAID 2015). Integrated coastal zone management may also include the removal or modification of shoreline-hardening structures, like seawalls, that provide coastal protection in some areas but create problems in others by displacing sedimentation and causing erosion (European Commission 2014).

Establishment and management of protected areas: The establishment and management of protected areas help maintain healthy coral reefs and other coastal ecosystems (Spalding et al. 2014). Protected areas also confer important economic, food security and biodiversity co-benefits, including habitat for sustaining fish populations and resting areas for migratory bird species. Marine protected areas, for example, can protect coral reefs that provide important shore protection and wave attenuation benefits.

Ecosystem restoration: Approaches include the restoration of coastal ecosystems (e.g., wetlands, salt marshes, rivers, reefs) to re-establish natural functions that have been degraded by human activities. Restoration activities include removing dams, allowing wetland plants to re-colonize and modifying erosion processes that degrade wetland areas. EbA practices such as reforestation within riparian buffers and reconnecting rivers to floodplains can help maintain the viability of temperature-sensitive fish habitats in coastal wetlands. For example, restoring shade trees near streams can cool water temperatures that are subject to increase under warmer climates, which can help fish and other species adapt and contribute to food security and local livelihoods. The Reef Rescuers project is an example of the application of ecosystem restoration as an EbA approach in the Seychelles.

Managed realignment and coastal setbacks: In many coastal areas, the installation of levees has led to the constriction of waterways, which in turn can increase flow velocity and soil erosion. EbA approaches, such as relocating levees further away from the side of river channels and restoring floodplains, can allow for the reestablishment of coastal ecosystems such as salt marshes that provide flood control and other economic and environmental benefits (Colls et al. 2009, Spalding et al. 2014). Preventing development close to the shoreline also allows mangroves to migrate landward as sea levels rise and natural wetlands to re-establish, improving their ability to provide ecosystem benefits, such as the attenuation of coastal erosion and storm surge (Spaulding et al. 2014).

Sustainable fisheries management: Climate change will affect fisheries and aquaculture via ocean acidification, changes in sea temperatures and circulation patterns, and habitat loss (Shelton 2014). As such, climate stressors impact fish range and viability and pose risks to fishing community livelihoods, food security and safety as community members travel to new or more distant fishing grounds (Badjeck et al. 2009). By practicing sustainable fisheries management, communities engaged in fisheries and aquaculture can reduce pressures on fish stocks, making them more resilient to climate stressors like higher water temperatures.

Green infrastructure: Green infrastructure uses natural or semi-natural systems for water resources management with similar benefits to conventional "grey" water infrastructure (Bertule et al. 2014). Green infrastructure can help moderate the impacts of extreme events, such as drought and floods, and increase water storage capacity, particularly in urban areas. Examples include urban parks that allow for water recharge zones, green roofs that reduce temperatures and capture water runoff, constructed wetlands for treating domestic and industrial wastewater, and permeable pavements (Bertule et al. 2014).

EbA approaches can be implemented alone or as part of a broader adaptation strategy. In some situations, a combined engineering and EbA approach may be the most effective strategy for coastal resilience (van Slobbe et al. 2013, Spalding et al. 2014).

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Adopting EbA approaches in coastal areas can reduce climate risks to food security, health, infrastructure, livelihoods and economic growth, and water supply and sanitation. The table below highlights specific EbA approaches to address climate risks to these coastal development sectors.

Coastal development sector	Climate risks	EbA approaches to address climate risks
Food Security	• Decreased availability of fish for consumption from warming ocean temperatures and ocean acidification impacts on fish populations • Crop failure from drought and extreme weather events	• Establish and manage marine protected areas to improve fisheries' resilience • Promote conservation agriculture to increase agricultural resilience
Health	• Direct injury from extreme weather events • Waterborne diseases from standing water related to floods • Decreased water for consumption and food production from drought • Displacement and forced migration due to coastal submersion and crop failure	• Plant riparian and coastal buffers to protect against high winds • Implement integrated coastal zone management to strengthen ecosystems that serve as physical barriers and to help ensure that populations do not settle in coastal areas vulnerable to sea level rise and storm surge • Conserve and restore upstream forests to stabilize slopes • Protect open spaces to absorb flood water
Infrastructure	• Wind damage from extreme weather events • Water damage from floods and rising sea levels • Heat damage from increases in the number of hot days and heat waves	• Conserve wetlands and floodplains to attenuate floodwaters • Protect coral reefs and create living breakwaters to attenuate wave energy • Implement land-use zoning to protect local ecosystems from infrastructure development in vulnerable areas • Create green spaces and construct green roofs to reduce temperatures in urban areas
Livelihoods and Economic Growth	• Decline in the abundance and shifts in the range of commercially important marine species due to ocean warming and acidificatio • Loss of fishing days from extreme weather events • Decline in ecotourism revenue due to decreased visitation to degraded coastal areas	• Improve management of coastal fisheries to help ensure adequate fish stocks • Protect coastal marshes to decrease salt water intrusion of coastal agricultural lands and help maintain their productivity • Conserve and restore coastal ecosystems to protect nursery grounds for fish and sites for ecotourism
Water Supply and Sanitation	• Damage to water systems from extreme weather events • Changes in groundwater recharge rates due to shifts in the timing, quantity and quality of precipitation • Contamination of water systems due to saltwater intrusion from sea level rise and from storm surge • Decreased water for consumption from drought	• Implement rainwater harvesting to improve water retention and reduce pressure on groundwater resources during dry seasons • Protect upstream watersheds to secure spring water catchments and augment coastal groundwater sources • Remove invasive, non-native vegetation from river margins, estuaries and coastal wetlands to increase absorptive capacity

How Does Ecosystem-based Adaptation Compare to Hard Infrastructure in Coastal Zones for Cost-effectiveness?

EbA approaches can effectively address a range of climate risks and are more cost-effective than the construction of hard infrastructure in some contexts. For example, the natural infrastructure provided by EbA approaches such as restoring coral reefs and planting riparian buffers may be more resilient to climate change and less expensive to maintain over the long term compared to engineered infrastructure such as seawalls and bulkheads. Furthermore, the enhancement of natural coastal ecosystems will provide more co-benefits such as the provision of fish and sites for ecotourism, increasing the cost-effectiveness of EbA beyond just its benefits for climate adaptation. While engineering options often have a role in reducing risk, they also have drawbacks such as the relatively high cost of construction, need for regular maintenance and potential damage to local ecosystems.

The following examples highlight the economic benefits of investing in EbA approaches for coastal protection from climate change:

- In Fiji, researchers undertook an economic analysis comparing EbA approaches, such as replanting mangroves and decreasing coral extraction, and hybrid approaches to protect a major coastal city from climate change impacts. They found that the EbA approaches yielded the highest benefits for each dollar spent on implementation (Rao et al. 2013).
- A study by the Atoll Ecosystem Conservation Project in the Maldives estimated that the cost of constructing seawalls, breakwaters and other structures to replace the protection currently provided by coral reefs would be between US$1.6-2.7 billion compared with less than $50 million annually to prevent ongoing reef degradation. Furthermore, the economic impacts of coral reef degradation would be even higher due to the loss of other ecosystem services such as the provision of fish and sites for tourism (Munang et al. 2013).
- In Vietnam, an investment of $1.1 million to plant 12,000 hectares of mangroves has led to a savings of $7 million annually in costs to maintain sea dikes while also providing livelihood benefits for over 7,500 families through the sale of shrimp, crabs and mollusks that live in the mangrove forests (IFRC 2012).

Another important economic factor when considering an EbA approach is the potential for the initial return on investment to increase over time. For example, an investment in wetland rehabilitation for shoreline protection can result in stabilization and expansion of the wetlands under good management, which potentially leads to the generation of ecosystem services that contribute to sustainable development. In contrast, hard infrastructure tends to depreciate in value over time as maintenance costs increase (Bertule et al. 2014). Additionally, EbA approaches that maintain coastal ecosystems often protect sites with social and cultural significance for local communities, a benefit that is difficult to quantify.

In Kenya, the program titled "Livelihood Sustainability through Raising Community Capacity for Fisheries/Coastal Management in Lamu Archipelago" strengthened local community-driven institutions to reduce destructive fishing practices. The program also helped to build trust in management authorities and improve self-policing of the fishery to reduce pressure on fish stocks and strengthen the fishery's resilience (Shelton 2014).

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What Factors Make Ecosystem-based Adaptation an Effective Approach for Coastal Populations' Resilience?

EbA is an important strategy for strengthening coastal resilience; however it should not be seen as a panacea for every instance of climate vulnerability. Additionally, experience has shown that there are a number of critical actions necessary to ensure the success and sustainability of EbA approaches, including the following:

Provide incentives for local community, government and private sector stakeholders. Coastal populations need incentives to shift development away from practices that increase vulnerability (e.g., sand and coral mining) towards more sustainable practices that increase resilience (e.g., coastal dune protection for erosion control). Incentive programs, like payment for environmental services and tax reductions, help encourage landholders to take actions that protect ecosystems over the long term. The design and due diligence of EbA activities should consider how best to ensure that sufficient funding is available for proper implementation and maintenance of EbA strategies.

Assess the extent to which the ecosystem itself is being impacted by climate stressors, which may impair its ability to provide enhanced protection against climate risks. For example, if coastal communities rely on coral reefs as breakwaters for storm surge and the reefs suffer high levels of mortality from coral bleaching and typhoons, their ability to reduce wave action will be diminished.

Consider an integrated approach that mainstreams EbA in poverty reduction and development strategies, which can be more effective than single-objective projects. For example, a food security project that includes mangrove restoration will generate multiple benefits, including the protection of fisheries habitat to increase protein available for diets and shoreline protection against storm surge.

Consult and coordinate with cross-sectoral stakeholders. Coastal areas tend to be some of the most heavily populated zones with competition for natural resources among multiple uses such as tourism, industrial activities and local livelihoods. For this reason, successful EbA requires creating stakeholder awareness and buy-in for the EbA concept across various coastal constituencies (Colls et al. 2009).

Take into account the time horizon for EbA approaches to be effective. EbA approaches such as the replanting of coastal forests may take several years before they can provide sufficient coastal protection. EbA time horizons must be compared with the time it takes for hard infrastructure to be designed and constructed. In some cases, the EbA approach will be equivalent and in other cases, it may be longer. There may also be situations where EbA project designers and local communities lack sufficient information to correctly design the intervention, in which case additional time for community capacity building and analysis is required before initiating project design.

Conclusion

Development programming that protects and restores coastal ecosystems can reduce the vulnerability of coastal zones to climate change while also providing important ecosystem goods and services that contribute to improved health, food security and sustainable economic growth. A range of EbA approaches can build the resilience of coastal populations, including the establishment and management of protected areas, effective coastal land use planning, ecosystem restoration, sustainable fisheries management and the use of green infrastructure, among others. In many cases, natural infrastructure provided by EbA approaches, such as mangroves and coral reefs, will be more resilient to climate change—and more cost-effective—than engineered infrastructure such as seawalls and bulkheads. Several elements are necessary to ensure the success and sustainability of EbA approaches. Of particular importance are the need to incentivize coastal populations to consider EbA, the extent to which the ecosystem itself is impacted by climate change and the need for broad stakeholder buy-in and coordination. In the face of growing climate risks, EbA approaches are an increasingly important method to strengthen the resilience of coastal populations.

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