Ecosystem-based Adaptation:

A natural response to climate change

Published by: IUCN, Gland, Switzerland

Citation: A. Colls, N. Ash, and N. Ikkala (2009). *Ecosystem-based Adaptation: a natural response to climate change*. Gland, Switzerland: IUCN. 16pp.

ISBN: 978-2-8317-1215-4

Acknowledgements: We would like to thank the following people for contributing and reviewing case studies: Angela Andrade, Senja Väätäinen, Excellent Hachileka, Annita Annies, Jerker Tamelander, Minna Epps, Katharine Cross, Claire Warmenbol, Mark Smith, Stefano Barchiesi and Trevor Sandwith. We would also like to thank Lorenzo Guadagno for helping to edit and produce this publication.

Photo cover: © Ron Giling/Lineair/Still Pictures

Design and layout by: L'IV Com Sàrl

Printed by: Polygravia arts graphiques

Available from: IUCN (International Union
for Conservation of Nature)
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Ecosystem-based Adaptation: a natural response to climate change

What is "Ecosystem-based" Adaptation?

Ecosystem-based Adaptation (EbA) integrates the use of biodiversity and ecosystem services into an overall strategy to help people adapt to the adverse impacts of climate change. It includes the sustainable management, conservation and restoration of ecosystems to provide services that help people adapt to both current climate variability, and climate change[1]. Ecosystem-based Adaptation contributes to reducing vulnerability and increasing resilience to both climate and non-climate risks and provides multiple benefits to society and the environment.

Many recent climate change adaptation initiatives have focused on the use of technologies and the design of climate-resilient infrastructure. However, there is growing recognition of the role healthy ecosystems can play in helping people adapt to climate change. Healthy ecosystems provide drinking water, habitat, shelter, food, raw materials, genetic materials, a barrier against disasters, a source of natural resources, and many other ecosystem services on which people depend for their livelihoods. As natural buffers, ecosystems are often cheaper to maintain, and often more effective, than physical engineering structures, such as dykes or concrete walls. Ecosystem-based Adaptation, therefore, offers a means of adaptation that is readily available to the rural poor; it can be readily integrated into community-based adaptation and addresses many of the concerns and priorities identified by the most vulnerable countries and people. In addition, healthy ecosystems, such as forests, wetlands, mangroves, and coral reefs, have a greater potential to adapt to climate change themselves, and recover more easily from extreme weather events.

Ecosystem-based Adaptation in practice

Ecosystem-based Adaptation involves a wide range of ecosystem management activities to increase resilience and reduce the vulnerability of people and the environment to climate change. These activities include:

- Sustainable water management, where river basins, aquifers, flood plains, and their associated vegetation are managed to provide water storage and flood regulation services;
- Disaster risk reduction, where restoration of coastal habitats such as mangroves can be a particularly effective measure against storm-surges, saline intrusion and coastal erosion;
- Sustainable management of grasslands and rangelands, to enhance pastoral livelihoods and increase resilience to drought and flooding;
- Establishment of diverse agricultural systems, where using indigenous knowledge of specific crop and livestock varieties, maintaining genetic diversity of crops and livestock, and conserving diverse agricultural landscapes secures food provision in changing local climatic conditions;
- Strategic management of shrublands and forests to limit the frequency and size of uncontrolled forest fires; and
- Establishing and effectively managing protected area systems to ensure the continued delivery of ecosystem services that increase resilience to climate change.

This report presents 10 examples of Ecosystem-based Adaptation taking place in both developing and developed countries, at national, regional, and local scales, and in marine, terrestrial, and freshwater environments. The case studies demonstrate how Ecosystem-based Adaptation is being implemented at project and programmatic levels.

1 A full description of Ecosystem-based Adaptation is provided in the report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change under the Convention on Biological Diversity (CBD), CONNECTING BIODIVERSITY AND CLIMATE CHANGE MITIGATION AND ADAPTATION.

Multiple benefits of Ecosystem-based Adaptation

Ecosystem-based Adaptation reduces vulnerability to both climate and non-climate risks and provides multiple economic, social, environmental and cultural benefits, including:

Disaster risk reduction
Ecosystem-based Adaptation measures frequently complement disaster risk reduction objectives. Healthy ecosystems play an important role in protecting infrastructure and enhancing human security, acting as natural barriers and mitigating the impact of (and aiding recovery from) many extreme weather events, such as coastal and inland flooding, droughts, extreme temperatures, fires, landslides, hurricanes and cyclones.

Livelihood sustenance and food security
By protecting and restoring healthy ecosystems to be more resilient to climate change impacts, Ecosystem-based Adaptation strategies can help to ensure continued availability and access to essential natural resources so that communities can better cope with current climate variability and future climate change. In this context, Ecosystem-based Adaptation can directly meet the needs of Community Based Adaptation and poverty-reduction initiatives.

Biodiversity conservation
Protecting, restoring, and managing key ecosystems helps biodiversity and people to adjust to changing climatic conditions. Ecosystem-based Adaptation can safeguard and enhance protected areas and fragile ecosystems. It can also involve restoration of fragmented or degraded ecosystems, or simulation of missing ecosystem processes such as migration or pollination.

Carbon sequestration
Ecosystem-based Adaptation strategies can complement and enhance climate change mitigation. Sustainable management of forests can store and sequester carbon by improving overall forest health, and simultaneously sustain functioning ecosystems that provide food, fibre and water resources that people depend on. Conservation and, in some cases restoration, of peatlands can protect very significant carbon stores. Additional mitigation efforts can be realized through land and water management practices that sustain essential natural resources while minimizing additional greenhouse gas emissions.

Sustainable water management
Managing, restoring and protecting ecosystems can also contribute to sustainable water management by, for example, improving water quality, increasing groundwater recharge and reducing surface water run-off during storms. About one third of the world's largest cities obtain a significant proportion of their drinking water directly from forested protected areas (Dudley and Stolten, 2003).

1. Integrated approach to Ecosystem-based Adaptation in high mountain ecosystems in the Colombian Andes

© Klaus Shutze

Vulnerability

In the Colombian Andes, the high mountain ecosystems of Chingaza Massif, which are located above 2740 metres, are very vulnerable to the anticipated impacts of climate change. Models have predicted that 78% of glaciers and 56% of moorlands could disappear by 2050. These changes would mean the loss of many of the ecosystem services provided in the region, especially soil protection, food and water supply, water flow regulation, and associated hydropower potential. 80% of the population that live in the surrounding ecosystems of the Capital city of Bogotá rely on the water from the Chingaza Massif.

Ecosystem-based Adaptation activity

Colombia is implementing an Integrated National Adaptation Plan (INAP) using Ecosystem-based Adaptation activities and policy interventions to proactively address the impacts of climatic change across the country. In the Chingaza Massif, these adaptation measures include:

- Restoration of the high mountain ecosystems. The Colombian National Parks Strategy for Participatory Ecological Restoration has been updated to take climate change into account in order to ensure water regulation and increase carbon sequestration. The strategy was developed with participatory agreements with local communities.
- Incorporation of Ecosystem-based Adaptation in land use and territorial planning models to guide adaptation beyond biodiversity conservation towards the maintenance of structure and functioning of ecosystems.
- Improvement of productive agro-ecosystems to reduce their vulnerability to climate change impacts. Sustainable management practices have been proposed for different farming systems and adopted through farm plans developed by local farmers.
- Assessment and dissemination of climate information to determine the functioning of the Chingaza Massif under different Climate Change scenarios and to facilitate adoption of adaptation measures and policies.
- Water and carbon cycle modeling and monitoring, including the establishment of several hydro-meteorological stations.

Evidence of success

Implementation of the Integrated National Adaptation Plan in Chingaza Massif has resulted in an integrated, ecosystem-based vision of the territory. The project has improved governance of the region by incorporating Ecosystem-based Adaptation into regional planning processes, including municipal and watershed management plans. It has also contributed to the National Adaptation Policy which aims to integrate sectoral actions towards climate change adaptation and sustainable development. Currently, there are 27 restoring processes being implemented out of 200, which is the target objective, including upper watersheds, riversides and landslides areas. Native plants are selected with the local communities, who are also using climate information to develop early warning systems for fires, landslides and floods. Baseline data has been established for land cover and land use, water and carbon cycles, farming systems, and risk zoning.

Key message

Ecosystem-based Adaptation can be embedded into national, regional and local policy and practice by adopting an integrated, participatory and ecosystem-based approach to territorial planning.

Source: Pérez, A., Muñoz, M.M.M., Páez, K.S., and Triana, J.V. The Ecosystem Approach and Climate change adaptation: lessons from the Chingaza Massif, Colombia.

2. Identifying opportunities for Ecosystem-based Adaptation in Eastern Africa

Vulnerability

Many parts of Eastern and Southern Africa are already being affected by climate change, and will be hit hard by its impacts on agriculture, water availability and quality, ecosystem services, biodiversity, and health, all of which will impact local livelihoods, and especially the poorest part of the population.

Ecosystem-based Adaptation activity

IUCN's Climate Change and Development project in Eastern and Southern Africa is being implemented in Mozambique, Tanzania and Zambia, to ensure that climate change-related policies and strategies lead to adaptation activities that emphasize the role of forests and water resources in supporting people's livelihoods. It is a three year project, which started in 2008 and is funded by the Finnish Ministry of Foreign Affairs.

The project has focused on risk screening and scoping of adaptation activities at the community level using participatory approaches that have included CRiSTAL[1] to conduct vulnerability assessments. The assessments were applied on different livelihood systems (farmers, agro-pastoralists, fishermen), in different ecological zones such as arid, coastal and sub-humid zones – each faced with extreme climatic events with increasing incidence and intensity (droughts, floods and hurricanes).

1 CRiSTAL (Community-based Risk Screening Tool – Adaptation and Livelihoods) is a project-management tool, developed by the International Union for Conservation of Nature (IUCN), the International Institute for Sustainable Development (IISD), the Stockholm Environment Institute (SEI-US) and Intercooperation, to help integrate risk reduction and climate change adaptation into community-level projects.

Evidence of success

The project has improved the capacity for undertaking vulnerability assessments at local level and steps have been taken to develop Ecosystem-based Adaptation practices at community level, including re-vegetation and reforestation of dunes along the Mozambique coast, tree enrichment along flood-prone areas in Tanzania, and use the of non-timber forest products in Zambia.

Key message

Ecosystem management and restoration can significantly reduce community vulnerability to climate stress. Similarly, policies and development interventions that secure the local natural resource base can, in many cases, increase community resilience to a range of threats, including climate change.

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In Zambia, CRiSTAL has been applied in three communities: Kapiri Mposhi, Sesheke and Mwansabombwe. The community-based vulnerability assessments revealed that farming and human health were particularly vulnerable to drought, as well as rainfall variability and occasional intense rainfall events. The project has identified possible coping strategies for the communities, including water harvesting, conservation farming methods, increased access to meteorological information and improved sanitation. The communities will make final decisions about the priority adaptation measures which will be implemented in order to enhance their adaptive capacity to the impacts of climate change.

3. Ethiopia's National Adaptation Programme of Action (NAPA)

Vulnerability

Low levels of socio-economic development, limited infrastructure, lack of institutional capacity and a higher dependency on natural resources result in Ethiopia being highly vulnerable to climate variability and extreme climate events. Recurrent drought events and political instability in the past have resulted in famines and migration of people. The country is also vulnerable to severe flooding and associated soil erosion of the fertile Ethiopian highlands.

Ecosystem-based Adaptation activity

Ethiopia has included a significant number of Ecosystem-based Adaptation activities within its National Adaptation Programme of Action, published in June 2007. The UNFCCC developed National Adaptation Programmes of Action to provide a process for Least Developed Countries (LDCs) to identify urgent and immediate needs for adaptation to climate change. Community-level input is an important part of the NAPA process, recognizing that grassroots communities are the main stakeholders.

The Ethiopian NAPA presents 37 potential adaptation options, of which 19 are ecosystem-based activities. As part of the NAPA process, priority adaptation projects are identified using multi-criteria analysis to assess their poverty and climate risk reduction potential; synergy with national and sectoral plans and Multilateral Environmental Agreements (MEAs); and cost-effectiveness. Four of the final eleven priority projects identified and proposed in Ethiopia's NAPA are Ecosystem-based Adaptation activities:

- Improving and enhancing rangeland resource management practices in the pastoral areas of Ethiopia;
- Community based sustainable utilization and management of wetlands;
- Community-based carbon sequestration in the Ethiopian Rift Valley; and
- Promotion of on farm and homestead forestry and agroforestry practices in arid, semi-arid and dry, sub-humid parts of Ethiopia.

Key message

Ecosystem-based Adaptation is recognized by many Least Developed Countries as a cost-effective, accessible way of reducing poverty and climate risk.

Source: http://unfccc.int/resource/docs/napa/eth01.pdf

ECOSYSTEM-BASED ADAPTATION IN OTHER NAPAS

Many other Least Developed Countries have prioritised Ecosystem-based Adaptation activities within their NAPAs including, for example: community-based coastal afforestation (Bangladesh), watershed restoration (Haiti) and conservation and rehabiliation of degraded wetlands (Lesotho).

4. Livelihood enhancement and diversification in Sri Lanka

Vulnerability

Kudawa is a rural fishing village located near the Kalpitiya peninsula in north-western Sri Lanka. The community is highly dependent on the Bar Reef Marine Sanctuary, an area of high marine biodiversity that suffers from over-fishing and illegal exploitation. The reef system experienced a mass coral bleaching event in 1998 and remains vulnerable to the impacts of climate change. Arrangements are currently being made by the authorities to demarcate the core area of the Bar Reef Marine Sanctuary with the agreement of the local community. While, in the longer term, this will help sustain natural resource dependent livelihoods, reduced access to the reef's natural resources will in the shorter term pose a challenge for the community.

Ecosystem-based Adaptation activities

Sustainable Livelihoods Enhancement and Diversification (SLED, IMM 2008) is a tool developed by IUCN and partners that can facilitate adaptation among communities dependent on climate change sensitive resources. It works by helping communities make informed choices about their livelihood options. The SLED tool was applied in Kudawa village, in partnership with local organizations and the NGO Community Help Foundation (CHF). It was implemented in three phases through a combination of fieldwork and community workshops:

- Phase 1 involved mapping existing livelihoods and understanding the community's dependency on the coral reef resources;
- Phase 2 assessed the community's aspirations, adaptive capacity and potential adaptation strategies;
- Phase 3 implemented the adaptation strategies.

Micro-projects were piloted that focused more on using local resources without over-extracting natural resources and remaining consistent with the social environment. For example, shifting from fishing and sea cucumber collection, to support sustainable livelihood diversification activities such as seaweed and sea bass culture and home garden improvement.

Evidence of success

Application of the SLED tool has helped community members in Kudawa to realise the importance of diversifying their livelihood options, both to cope with current pressures and increase their capacity to adapt to future change. Based on the success of this pilot study, a new institution, The Marine and Coastal Resource Conservation Foundation (MCRCF) has been established to apply the SLED approach to other coastal villages in Sri Lanka. Livelihood enhancement and diversification, including into activities dependent on well-managed ecosystems, will help reduce coastal communities' dependency on vulnerable, climate-sensitive resources, relieving pressure on ecosystems and increasing resilience to climate change.

Key message

Livelihood enhancement and diversification can encourage people to move away from unsustainable exploitation and degradation of natural resources and thereby increase social and environmental resilience to climate change.

Source: Sustainable Livelihoods Enhancement and Diversification (SLED): A Manual for Practitioners. Available at: http://www.iucn.org/about/work/programmes/marine/marine_resources/marine_publications/?2653/SLED

THE VALUE OF NATURAL COASTAL PROTECTION IN THE MALDIVES

In the Maldives, a study by The Atoll Ecosystem Conservation Project has looked at the value of the physical protection services which are provided by coastal and marine ecosystems. It found that the total costs of constructing seawalls, breakwaters and other structures to replace the barriers currently provided by coral reefs would be between USD 1.6 – 2.7 billion. The costs of the damages that would be caused to towns, villages, hotels, and other infrastructure and industries, should the physical protection afforded by coral reefs be degraded or lost would be even higher than this (The Economic Value of Marine and Coastal Biodiversity to the Maldives economy, IUCN (2008)).

5. Community-based coastal habitat restoration in tsunami-affected coastal areas of Indonesia, Sri Lanka, India, Thailand, and Malaysia

Vulnerability

Coastal areas around the world are vulnerable to the impacts of climate change, including storms, associated coastal flooding, salt-water intrusion and erosion.

Ecosystem-based Adaptation activity

Green Coast is a coastal rehabilitation programme helping restore and manage damaged coastal ecosystems in the tsunami-affected areas in Indonesia, Sri Lanka, India, Thailand, and Malaysia. Adopting a community-led approach, the Green Coast programme seeks to improve local livelihoods via four main activities: (1) Coastal ecosystem rehabilitation; (2) Building environmentally-sustainable livelihoods; (3) Developing village regulations that support environmental conservation efforts; (4) Environmental education campaigns. Green Coast is funded by Oxfam Novib (Netherlands) and has been developed by Wetlands International, together with WWF, IUCN, and Both ENDS. In practice, Green Coast provides financial and technical support for communities for livelihood activities and engages community participation in planting mangroves or other coastal vegetation. In this way, communities can participate in the restoration of coastal ecosystems, while enhancing their livelihoods and increasing their resilience to the impacts of climate change.

Evidence of success

Green Coast has proved to be a successful approach to rehabilitate coastal ecosystems. In Indonesia, for example, Green Coast has facilitated 60 local NGOs and Community Based Organizations (CBOs) to train and assist Tsunami victims in rehabilitating the coastal ecosystem and at the same time restoring or creating alternative livelihoods in Aceh and Nias. Local inhabitants were involved directly in the planning, preparation, planting, and nursing of the seedlings. By March 2009, 893 ha of Aceh's and Nias' coastland had been rehabilitated through the planting of mangroves (1.6 million seedlings) and beach plants (250,000 seedlings), and the conservation of the coral reef. In addition to the direct benefits from the restoration itself, the community's active participation in this rehabilitation effort was rewarded in the form of collateral-free, interest-free loans of business capital to the CBOs involved, which could then be used to build alternative livelihoods.

Key message

Restoring healthy coastal ecosystems, such as mangroves and coral reefs, helps protect coastal communities from some of the impacts of climate change including storms, associated coastal flooding, salt-water intrusion and erosion.

Source: http://global.wetlands.org/Portals/0/Major%20Projects/WLP/Lessons%20Learnt%20in%20Aceh%20(English)-GC%202.pdf

Mangroves dissipate the energy and size of waves as a result of the drag forces exerted by their multiple roots and stems. The extent to which wave energy is reduced depends on many factors including coastal profile, water depth and bottom configuration. One study found mangrove forests reduce wave heights 5 – 7.5 times more than unvegetated beach surfaces (Quartel *et al*., 2007).

6. Integrated water resources management in Tanzania

Vulnerability

Climate change is expected to exacerbate water scarcity in the Pangani River Basin, in Tanzania, where water demand is already exceeding supply. The ice cap of Mount Kilimanjaro has melted considerably and is projected to disappear completely by 2025. Flows in the basin have been reduced from several hundred to less than 40 cubic metres per second. The shortage of water is already leading to tensions between different water users – farmers, hydropower, fishers, residents. Around 80% of the 3.4 million people who live in the basin depend on agricultural livelihoods. The Pangani Basin Water Board, which allocates water permits, has little data on which to base its decisions and needs to take climate change, reducing water supplies and the water needs of the natural environment into account.

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PROTECTING WATER SUPPLIES

In Burundi, a project has been proposed in the country's National Adaptation Programme of Action to protect buffer zones of marshes in the Lake Tanganyika floodplain and around the lakes of Bugesera, in order to protect water supplies. Un-managed exploitation of the marshes reduces available water supplies, which are already vulnerable to drought. Watershed management can further regulate flooding by allowing natural processes of erosion and deposition to continue and ensuring rivers and coasts have space to develop.

Ecosystem-based Adaptation activity

In response, the Pangani River Basin Management Project[1] was initiated to reduce conflict and prepare water users and managers in the Pangani River Basin for future reductions in water availability. The project, which started in 2006 and will end in 2011, aims to improve the management of the basin's water resources, taking into account the impacts of climate change and freshwater needs of the environment. Key activities include:

- Environmental flow assessment (EFA) to evaluate the ecological, social and economic impacts of alternate flow regimes to build an evidence-base for water allocation decision options;
- Multi-stakeholder consultation and legal reviews to improve management planning and implement rational systems of water allocation;
- Establishing catchment forums for community participation in water management decisions;
- Climate change vulnerability assessments which raise awareness

1 The Pangani Basin Water Office is implementing the project with technical assistance from IUCN (International Union for Conservation of Nature), the Netherlands Development Organization (SNV) and the local NGO PAMOJA. The project is financially supported by the IUCN Water & Nature Initiative, the Government of Tanzania, the European Commission through a grant from the EU-ACP Water Facility, and the Global Environment Facility through UNDP.

about climate change impacts and adaptation strategies;

- Implementation of climate adaptation strategies as prioritised by communities and local government; and
- Integrated Water Resource Management planning at the basin level.

Evidence of success

Stakeholders are gaining understanding of the social, economic and environmental trade-offs for different water allocations under different future scenarios, (e.g. maximising hydropower, maximising water for agriculture use). The Pangani Basin Water Office is using this information for a new, and flexible, approach to informed decision-making. They are learning to allocate water within the limits of the river's flow, including to ecosystems in the basin that store water, regulate flows and support livelihoods.

Key message

Water is at the centre of many climate change impacts, and is therefore key to many adaptation policies, planning and action. The allocation of water to sustain natural infrastructure, such as wetlands and estuary habitats, and the adoption of adaptive governance build adaptive capacity to respond to an uncertain future climate.

Source: The Water and Nature Initiative:
www.iucn.org/about/work/programmes/water/
www.panganibasin.com/project/index.htm

Table 1: Pangani outcomes

Prior	Current	Future
• Water scarcity driving conflict • Aquatic biodiversity declining • Loss of ecosystem services • Weakening livelihoods • CC vulnerability	• Shared recognition of resource limits • Ecosystems 'at the table' • Governance of allocation decisions agreed • Empowerment to take action, solve problems and negotiate • Visible results • National EFA team & Pangani a national benchmark	• Agree flow scenarios • Negotiate flow allocations • Flow allocation to aquatic ecosystems based on cost/benefits for ecosystem services • Monitor and implement adaptive management

7. Community-based fire management in Australia


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Vulnerability

West Arnhem Land is a remote, tropical savanna region in Australia's Northern Territory. The region contains large areas that were once inhabited but are now almost empty, and thus largely unmanaged. In the absence of fire management, fires can burn over tens of thousands of kilometers, causing considerable damage to the extensive patches of rainforest ecosystems found in the region. Uncontrolled wildfires also threaten adjacent land managers and globally-significant rock art sites. By contrast, the incidence of wildfires in those parts of Arnhem Land actively managed by Aboriginal people is markedly less. Climate change impacts are expected to increase the size, intensity and frequency of wildfires in Australia, and extend the fire season.

Bhutan, Guinea, Mali, Gambia and Samoa have all prioritised community-based fire management projects in their National Adaptation Programmes of Action (NAPAs)

Ecosystem-based Adaptation activity

The West Arnhem Land Fire Abatement Project is an initiative enabling Indigenous fire managers to work with the broader community to reduce unmanaged wildfires across 28,000 km^2 of Western Arnhem Land. The fire management includes early dry-season burning that breaks up the landscape and makes it more difficult for wildfires to spread across the fire breaks later in the year. Field studies and remote-sensing data have shown that early dry season fires emit less greenhouse gases (CO_2, nitrous oxides and methane) per area affected than the more intense, late dry season fires (Russell-Smith et. al. 2004). If the wildfires that burn across northern Australia can be changed so that there are less frequent intense wildfires in the late dry season, then less smoke and greenhouse gases will be emitted. Limiting wildfires in this way also stops the degradation of different plant communities and helps conserve environmental and cultural values of the Arnhem Land Plateau.

The project, which started in 2005, is a partnership between private and public institutions and the civil society. As part of the agreement, Darwin Liquefied Natural Gas will provide around US$ 1 million every year for the next 17 years to Aboriginal Traditional Owners of Western Arnhem Land, to implement the fire burning strategy and offset an estimated 100,000 tonnes of CO_2-equivalent per year.

Evidence of success

Since the project started, the incidence of destructive wildfires has been reduced. This has reduced the degradation of ecosystem services, and helped protect culturally-significant rock art sites. By limiting wildfires, the project is also reducing greenhouse gas emissions (an estimated 488,000 tonnes of CO_2-equivalent were abated during the first four years). The project has generated economic benefits including increased employment and economic participation of aboriginal communities and the avoided costs of destructive wildfires and the associated loss of biomass and ecosystem services. Because fire management in Arnhem Land is based largely on Aboriginal practices, the project has also supported the transfer of indigenous knowledge between generations as elders work with young people.

Key message

Community-based forest fire management is an example of ecosystem-based adaptation combined with mitigation efforts that generate multiple environmental, economic and social benefits. Strategic fire management needs to be repeated every year, so success is dependent upon ongoing ecosystem management.

Source: Prepared by Tropical Savannas CRC, Australia, for the report "The Role of Environmental Management and Eco-Engineering in Disaster Risk Reduction and Climate Change Adaptation" (ProAct Network 2008), available at www.proactnetwork.org

8. Restoration of saltmarsh through managed realignment of coastal defences along the North Sea coast of the UK

Vulnerability

Coastal communities on the low-lying coastal zone surrounding the shallow North Sea Basin are vulnerable to storm surges and coastal flooding. Rising sea levels are increasing this vulnerability. Although coastal defences, such as sea walls, can protect coastal settlements, it is now increasingly recognised that these defences are unsustainable. Furthermore, they can contribute to the loss (or 'coastal squeeze') of natural sea-defence capacity provided by intertidal habitats such as mudflats and saltmarshes.

Ecosystem-based Adaptation activity

An alternative to maintaining 'hard' engineered, coastal defences to protect land from rising sea levels is "managed realignment", a process that involves deliberately breaching the sea walls in order to allow the coastline to recede to a new line of defence further inland. This creates space for intertidal habitat, such as mudflats and saltmarsh, to develop. Once saltmarsh has stabilized and become vegetated, it can help reduce flood risk by increasing flood water storage and reducing wave height and energy in the short to medium term. Recent estimates suggest wave heights can be reduced by up to 50% over the first 10-20 m of vegetated saltmarsh surface (Moller, 2006).

Freiston Shore, Lincolnshire, UK, was selected as a trial site for managed realignment in 2002, because erosion rates at the base of the sea wall were increasing, with escalating repair and maintenance costs. The existing sea defence was breached in three places and a new landward lying secondary defence was strengthened. This created 66ha of saltmarsh habitat and 15ha of saline lagoon between the sea and the communities inland.

Evidence of success

The managed realignment at Freiston Shore is considered a success; saltmarsh vegetation is establishing more quickly than at many other managed realignment sites in the UK. By all accounts, the project is a successful example of cooperation between a number of Government and voluntary organisations.

Key message

This case study demonstrates how Ecosystem-based Adaptation can be successfully implemented alongside other adaptation measures – in this case hard coastal sea defences – to reduce vulnerability to coastal flooding, while also helping to meet national and international targets for the maintenance and creation of key coastal habitats.

Source: Based on the case study prepared by Daniel Friess, Dr Iris Möller, Dr Tom Spencer, CCRU, Cambridge University, UK, for the report "The Role of Environmental Management and Eco-Engineering in Disaster Risk Reduction and Climate Change Adaptation" (ProAct Network 2008), available at www.proactnetwork.org

COST EFFECTIVENESS

The capital costs to implement managed realignment at Freiston Shore were estimated at £1.98 million. Alternative cost estimates were £19 million under the 'do nothing' scenario (where there is no further investment in providing or maintaining current defences) and £2.06 million over 50 years to 'hold the line' (maintain or upgrade the level of protection provided by current defences) (Nottage and Robertson 2005). The wave attenuation function of saltmarsh vegetation is predicted to decrease the overall costs of sea defence structures, so could contribute to lowering the cost of coastal defence. The Environment Agency (1996) estimated that, under typical wave conditions, an 80m wide saltmarsh margin could reduce a sea defence height from 12m to 3m, with a financial saving greater than an order of magnitude.

9. Ecosystem-based Adaptation by small-holder farmers in Sweden

Vulnerability

Small-holder farmers in Roslagen, east-central Sweden, face ongoing challenges in sustaining food production in uncertain climatic conditions and disturbances such as droughts, pests and diseases. Climate change is set to exacerbate these challenges. Typically, the farms are small-scale, integrated livestock and crop production systems, and depend on the limited use of chemical fertilizers and pesticides.

Ecosystem-based Adaptation activity

An informal network of small-holder farmers in Roslagen has found a niche in low-input agriculture, producing high-quality and organic products. They have developed a range of ecosystem-based practices that help manage change and adapt to uncertain conditions and disturbances. The farmers use local networks to share best practice and local ecological knowledge. Table 1 summarises the management practices used to buffer the impacts of climate variability and increase overall resilience.

Evidence of success

A series of mild winters during the 1990s increased the intensity and severity of pest outbreaks, especially the fungal infestation of crops. This led to experimentation with both new and old crop varieties to test their pest resistance. Farmers found that the multiple-species cropping systems common in the past could produce a more reliable harvest during varying climatic conditions. Such ecosystem-based practices enable the small-holder Roslagen farmers to adapt to a dynamic environment.

By diversifying and adjusting ecosystem management practices, farmers can increase their resilience to climate variability and change, while also enhancing local and regional biodiversity.

Source: Tengo, M., & Belfrage, K. 2004. Local management practices for dealing with change and uncertainty: a cross-scale comparison of cases in Sweden and Tanzania. *Ecology and Society*, 9(3).

Table 2: Ecosystem-based practices that increase resilience to climate change and other disturbances

	Management practices
Climate-buffering	
Diversification	Crop diversification, intercropping and crop rotation within fields; landscape diversification; multiple sowing dates
Moisture conservation	Nurse crops or trees as shade; early spring harrowing to prevent capillary rise and evaporation
Groundwater regulation	Forest or tree protection; protection of water sources
Flood control	Planting and protection of trees in wetlands to regulate water levels and thus protect nearby fields from flooding.
General resilience measures	
Protection of pollinators	Enhancement of species' habitats; social taboos on pollinator species; beehives; protection of early flowering species
Biological indicators	Indicators for timing of planting and harvest indicators to predict weather indicators of field conditions
Pest control	Social protection of pest-controlling species; enhancing/creating habitat for pest-controlling species; alternating grazing of different livestock species to deter parasites
Weed control	Manual weeding; crop rotation and intercropping within fields; undersown crops and catch crops to deter weeds
Polyculture; local variety improvement	Mixed grains; cereals intercropped with leguminous plants; crop rotation

Use of ecosystem-based farming system called 'Quesungual Slash and Mulch Agroforestry System (QSMAS) gas been credited with increasing the resilience of a group of villages in hilly, southwest Honduras. Thousands of resource-poor farmers have readopted traditional farming techniques, including the practice of planting crops under dispersed native trees, along with terracing and soil conservation measures. The villages have substantially improved their livelihoods and demonstrated resilience to various extreme weather-related events, including the severe droughts and extreme rain during el Niño and la Niña events, as well as Hurricane Mitch in 1998 (FAO, 2009).

10. Adapting the design and management of marine protected areas to sustain biodiversity and human livelihoods in Kimbe Bay, Papua New Guinea

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Vulnerability

Kimbe Bay is situated on the north coast of New Britain Island in the Bismarck Sea, Papua New Guinea. It is characterised by healthy and diverse coral reefs, mangrove forests and sea grass beds, which are important habitats for marine mammals, turtles and fishes (Green *et al*., 2009). The local community, with a population of about 100,000 people, relies on both land and marine resources for its livelihood. There is a growing impact on some resources due to population growth, increasingly destructive fishing and resource harvesting, and the decline of other important cash income. Climate change represents a further serious and increasing threat, with predicted sea level rise and observed coral bleaching likely to increase the vulnerability of the local community.

Ecosystem-based Adaptation activity

The Nature Conservancy worked with local communities, government, NGOs and researchers, to consider ways of designing and implementing a more resilient marine protected area network that would increase social and ecosystem resilience to climate change. A scientific planning process was implemented that included defining objectives and targets, conducting the necessary research and analysis, identification of priority areas and finalizing the design through consultation with local communities and decision makers. The process was informed by adopting specific biophysical and socio-economic design principles, conducting an extensive process of community consultation and engagement at appropriate phases.

Evidence of success

The project resulted in a scientifically designed network of marine protected areas and mechanisms to support the development by communities of management plans and agreements governed by the Papua New Guinea Organic Law for Provincial and Local Governments. The project was one of the first attempts to marry a systematic conservation planning process with an explicitly modelled analysis of climate change at a local level. It proved possible to achieve the principles of resilient design in practice by risk spreading (increasing the representation and replication of conservation targets) and aligning the design with areas where communities were willing to support conservation action and where economic tradeoffs were minimized. Much more work remains to be done to ensure that long-term benefits for ecosystems and communities are realized, and to negotiate the kinds of agreements and institutional arrangements with communities that will support long-term effectiveness.

Key message

Marine protected areas can increase the resilience of vulnerable communities to climate change, provided that planning, analysis, and decision-making are undertaken with the full participation of relevant scientific, institutional, and community stakeholders.

Source: Green, A., S. E. Smith, G. Lipsett-Moore, C. Groves, N. Peterson, S. Sheppard, P. Lokani, R. Hamilton, J. Almany, J. Aitsi and L. Bualia (2009); Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea, Oryx 43: 488-498

Lessons learned: principles of effective Ecosystem-based Adaptation

Early lessons from the case studies profiled here, along with other Ecosystem-based Adaptation projects, suggest there are some fundamental guiding principles for developing effective Ecosystem-based Adaptation strategies. These principles include:

Focusing on reducing non-climate stresses
Reducing ecosystem degradation is a no regrets, win-win approach to adaptation. Ecosystem-based Adaptation strategies should include a focus on minimizing other anthropogenic stresses that have degraded the condition of critical ecosystems, and thereby undermine their resilience to climate change. Such stresses include, *inter alia*, unsustainable harvests, habitat fragmentation, non-native species, and pollution.

Involving local communities
Community participation is an important element in all of the case studies profiled. Ecosystem-based Adaptation measures are more successful when the local population participates in both planning and implementation.

Multi-partner strategy development
Many of the case studies profiled here involve multi-partner funding and cooperation. Ecosystem-based Adaptation presents a tangible opportunity to solve climate change problems by aligning conservation, development, and poverty alleviation interests. Such synergies benefit from collaboration between indigenous and local communities, conservationists, natural resource managers, relevant private sector stakeholders, development specialists, and humanitarian aid specialists

Building upon existing good practices in natural resource management
The most effective Ecosystem-based Adaptation strategies apply established best practices in land, water, and natural resource management to confront some of the new challenges posed by climate change. The application of the ecosystem approach for the integrated management of resources is particularly appropriate to the implementation of Ecosystem-based Adaptation.

Adopting adaptive management approaches
Ecosystem-based Adaptation strategies should support adaptive management options that facilitate and accelerate learning about appropriate adaptation options for the future. Climate impacts and EbA measures should be monitored carefully so that management actions can be appropriately adjusted in response to changing conditions.

Integrating Ecosystem-based Adaptation with wider adaptation strategies
Successful adaptation depends upon integrating Ecosystem-based Adaptation initiatives with other risk management components, such as early warning systems and awareness-raising, and in some cases with physical infrastructural interventions. It is important to encourage and enable technology transfer and dialogue between planners and practitioners with expertise in hard engineering, and in ecosystem management.

Communicating and educating
Successful Ecosystem-based Adaptation depends on knowledge transfer, capacity building, integrating science and local knowledge and raising awareness about climate change impacts and the benefits and potential of sound ecosystem management.

Barriers, limits and knowledge gaps

Unlike some adaptation measures, Ecosystem-based Adaptation can be readily implemented, adopting best practice approaches for the sustainable management of, for example, fisheries, forests, agricultural systems, river catchments, and coastlines. Nevertheless, Ecosystem-based Adaptation initiatives still face a range of barriers, which can include a lack of finance, land use conflict and community opposition. Knowledge gaps can also be a problem; there is a lack of information about the costs and benefits of EbA measures, for example.

As with all adaptation interventions, there are inevitably limits to Ecosystem-based Adaptation. Healthy, resilient ecosystems cannot protect communities from all climate or extreme weather-related impacts. In some situations, engineering solutions will still be required instead of, or alongside, Ecosystem-based Adaptation measures. There will also be ecological limits to Ecosystem-based Adaptation. Opportunities to increase ecosystem resilience to future climate change may only be effective for lower levels of climate change (≤2-3°C), since beyond certain levels of climate change, impacts on ecosystems are expected to be severe and largely irreversible (IPPC, 2007). Indeed, thresholds of resilience for many ecosystems are likely to be exceeded over the longer term unless greenhouse gas emissions are sharply and quickly reduced and temperature rise is kept within a 2ºC limit.

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IUCN works on biodiversity, climate change, energy, human livelihoods and greening the world economy by supporting scientific research, managing field projects all over the world, and bringing governments, NGOs, the UN and companies together to develop policy, laws and best practice.

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