In this presentation we will learn about Ecosystem-based adaptation (EBA)
Ecosystem-based adaptation has several definitions. But they all have one element in common: the use of ecosystem services for the adaptation of people. EBA is a human-centered concept (i.e. it does not focus on the protection of nature for nature’s sake), but it seeks nature-based solutions for the climate change and other challenges that people face. However, it also targets the adaptation of ecosystems (increasing their resilience to climate change), to ensure that they will continue to provide services for the adaptation of people (as shown in the next slide)...
Sustainable and adaptive management is thus needed for the continuous provision of ecosystem services. But in many cases, processes of degradation and other anthropogenic pressures on ecosystems must be addressed first, before any adaptive management can be considered or planned.
The term ecosystem based adaptation (EBA) was popularized by international Non Government Organizations and the Convention on Biological Diversity (CBD). Several countries have also made submissions to the United Nations Framework Convention on Climate Change (UNFCCC), stressing the necessity for EBA and calling for EBA funding, capacity-building and implementation. But how is this term used by national policymakers and scientists?
The objectives of this section is to present the scientific evidence on the effectiveness of EBA from an analysis of peer-reviewed papers and discuss the opportunities and challenges that arise with regard to the design and implementation of EBA policies and interventions.
As there has been strong advocacy on EBA from international and nongovernmental conservation and development organizations, there was a need to assess the scientific evidence on its effectiveness. We must discover and analyze the factors leading to
EBA effectiveness under different conditions in order to move EBA from concept and theory to action and practice.

As EBA is not a term that is widely used in science, the analysis was made based on studies linking ecosystem services to climate problems that people faced, such as extreme events, hazards, variability and changes in the onset of seasons etc.
Six cases linking forest and tree ecosystem services to adaptation can be distinguished from the analysis: (1) Forests and trees providing goods to local communities coping with climate variability; (2) Trees regulating water, soil and microclimate in agricultural fields for increased resilience; (3) Forests regulating water and protecting soils in watersheds for increased resilience; (4) Forests protecting coastal areas from climate related threats; (5) Urban forests and trees regulating temperature and water for resilient cities; and (6) Forests regulating atmospheric pressure and moisture, thus influencing rainfall at the regional scale.
1. Products

- Forests and trees
  - Provide safety nets for local communities coping with climate shocks
  - Increase livelihood diversification (anticipatory strategy)
- Examples:
  - Indonesia (Kalimantan) – the most heavily affected, the poorest and the least-educated relied more on forests for their coping strategies after a flood (Liswanti et al. 2011)
  - Honduras – smallholders sold timber to recover from asset loss due to Hurricane Mitch (McSweeney 2005)
- Issues:
  - Poverty trap? (out of the forest, out of vulnerability?)
  - Sustainability of natural resources for adaptation
  - Property rights and access

Forest and tree products, such as timber, charcoal, fuelwood, wild fruits, mushrooms, roots and fodder, constitute important safety nets and income diversification strategies for many communities in developing countries that face climate variability and climate
hazard risks.

In Indonesia for example, people impacted by floods sold and consumed forest products such as bushmeat to supplement their livelihoods and food intake. In Honduras, poor rural households sold timber to self-insure after being unable to recoup lost landholdings due to Hurricane Mitch.

It is important to differentiate between products as safety nets for coping strategies (short-term, usually after a disaster strikes) and
products as a major source of livelihood diversification for adaption strategies (proactive management of resources in anticipation of disasters). The poorest of the poor might turn to the forest during or after a disaster in order to survive, but many agrarian communities also use forest and tree products as an integral income diversification strategy for dealing with climate variability on a constant basis. Many of these communities maintain trees on their farms for this purpose. When harvests are decreased due to climate events, people can sell fuelwood, fodder, or other forest products from their
farms to supplement their income. Fodder from trees is also used to directly feed livestock when there is no other feed available.

With coping strategies like the ones encountered in Honduras, a high dependence on forest products for dealing with climate events can be a source of vulnerability when the ecosystem is degraded or mismanaged, when conflicts arise between different forest users, or when access becomes restricted.
Trees in agricultural fields have been found to help maintain production under a variable climate and protect crops against climate extremes. Trees regulate the microclimate in farms and protect crops from excessive sun radiation and heat. With their...
deep root systems, they can explore larger soil depths for water and nutrients which will be beneficial to crops in times of drought. Their contribution to increased soil porosity, reduced runoff and increased soil cover leads to increased water infiltration and retention, and reduction of moisture stress during low rainfall. Excess water is pumped out of the soil profile more rapidly in agroforestry plots due to their higher evapotranspiration rates.

In Indonesia, cacao grown under tree shade was found to cope better with drought compared to
unshaded cacao systems. In Chiapas, Mexico, research in coffee systems showed that shade decreases temperature and humidity fluctuations and reduces vulnerability to water stresses. Similarly, farmers who grew their crops under *Faidherbia* and *Gliricidia* in Malawi suffered significantly less losses than farmers who were not practicing agroforestry (many of which experienced completed crop failure).

However, trade-offs can occur between the different effects of trees on agriculture e.g. dense tree
cover protects soils, but competes with crops for light. Because of the diverse interactions between trees and crops, it is difficult to be conclusive about the relationship between shade cover and yield. The position of the trade-off point, where the positive effects of shade cover are maximized, is context-specific. Trees can buffer crops against climate events, but decrease average yields in the absence of climatic and other disturbances. Nevertheless, the value of trees for agriculture is high in environments characterized by high climatic risk (e.g. in drylands) and areas with low soil fertility and agricultural inputs (i.e. where
chemical fertilizers or irrigation cannot buffer soil degradation and climatic events).
Forests influence rainfall interception, evapotranspiration, water infiltration and groundwater recharge. They contribute to regulating base flows during dry seasons and peak flows during rainfall events, both of which are important services for the
adaptation of people to climate variability and change. They also stabilize soil and prevent erosion and landslides, reducing further the negative impacts of climate hazards on infrastructure, settlements, and water users.

In Flores, Indonesia, tropical forested watersheds have been shown to increase base flow (i.e. the proportion of stream flow coming from groundwater in the absence of rainfall) and reduce the impacts of drought on downstream agrarian communities. Under irregular rainfall, agricultural households near forested
watersheds showed higher profits than other households.

However trade-offs can also occur between services. For example, a reforestation project targeting the reduction of storm runoff through increased infiltration can conflict with increased water needs during dry seasons in downstream areas.

In general, evidence is scarce on the role of watershed regulating services for the adaptation of people, although the literature on the relationship between forests and water can inform decisions on
EBA. It is important to underline that EBA implementation should not be planned based on conventional beliefs, for example the belief that natural and planted forests increase total water flow. The effects of forests on water flows are not as clear as it is commonly believed, they are highly context-specific, and thus inappropriate generalizations should be avoided.
Coastal forests such as mangroves protect coastal zones from tropical storms, sea level rise, floods and erosion due to their ability to absorb and dissipate wave energy, increase peat production and stabilize coastal land.
In Orissa, India, villages that were protected by mangroves suffered less losses of life and property in comparison to villages that were not during the 1999 cyclone. In Vietnam, economic valuations showed that planting mangroves on the seaward side of sea dikes reduced the costs of maintaining these defenses, as mangroves dissipate destructive wave energy, stabilize the sea floor and its slope, and trap sediment. The annual benefits of mangrove restoration for dike protection were estimated to be US$70–130 per hectare per year.
While the benefits from the protection services of coastal forests are broadly recognized, there has been little emphasis on the specific characteristics influencing their effectiveness in different contexts. For example, how much mangrove forest is needed to reduce the vulnerability of a particular area? Other open questions are also – how much pressure forests can withstand before they discontinue providing services, and whether it is the structure and health of the ecosystem barrier that is key for protection, or the species and ecosystem type. It is also difficult to determine how much protection
mangroves provide and when other measures (such as infrastructure) will be needed.
Urban forests and trees can provide shading, evaporative cooling, and rainwater interception, storage and infiltration services in cities and towns. They can play a significant role in urban adaptation to climate variability and change.
Due to their altered surface covers, where built areas have replaced vegetation, urban areas face increased rates and volume of surface runoff. Modelling has shown that adding green cover in Manchester, UK, has the potential to reduce runoff during rainfall events.

Urban heat islands occur due to urban surfaces, such as concrete, brick, asphalt and stone which absorb short-wave solar radiation and then re-radiate it as long-wave radiation. In New Jersey, USA, urban trees are shown to reduce
both the direct (e.g. heat stress) and indirect impacts of urban heat islands (e.g. health impacts from air pollution). Areas with mature tree canopies can be 2.7–3.3°C cooler than areas with no trees.

Trees are a better option than grasslands for greening urban areas because they are less sensitive to drought. In general, urban green spaces are very effective in reducing temperatures but cannot act as a stand-alone solution for reducing runoff. Other measures might be needed.
Research on the role of forests and trees in urban adaptation to climate variability and change in developing countries is only now beginning, and evidence is limited. Urban centers in developing countries face more complex challenges as many of them lack adequate “gray” infrastructure (e.g. bridges, sewage systems) and have big proportions of their population living in slums and other high-risk areas that are disaster-prone and ill-equipped for adaptation. They face multiple hazards and risks; multiple measures will be needed in addition to green strategies to address them.
Tropical forests can have a cooling effect at the regional scale, through increased evaporation and cloud cover, and influence precipitation through water pumping and rainfall recycling. Forests can act as a pump of atmospheric moisture, attracting...
moist air from oceans to inland regions, which is something that helps generate rainfall. This influence can be over large distances: land-use change in the humid tropics can influence precipitation in the middle and higher latitudes. For example, maps of atmospheric moisture transport suggest that virtually all water transpired by trees in Eastern Africa will come back as rainfall elsewhere in Africa.

But this role of forests in hydrological processes at the regional scale is still highly debated and more research is needed.
Planning EBA across countries and regions will be difficult due to the involvement of different actors across multiple scales. This is a particular challenge if payment for ecosystem services schemes are to be designed as a financial mechanism for conserving forests. Questions about who benefits – and who should pay – for the rainfall services that forests provide will have to be answered.
The literature provides evidence that EBA, with forests and trees for example, can reduce social vulnerability to climate hazards, but uncertainties and knowledge gaps remain, particularly for regulating services in watersheds and coastal areas.

A lot of empirical evidence already exists on how local communities use forest and trees to adapt to climate change, for example by planting or keeping trees on their fields and having multiple use strategies for forest products. However, the more we go to the regional and global level, the more we face knowledge gaps and controversies.

There is an abundant literature on ecosystem services, and it can be revisited with a climate change lens to partially fill knowledge gaps on EBA. Testing and evaluating different interventions is also needed and pilot projects under implementation could serve as learning sites. And in general, uncertainties should not inhibit action and implementation. There might be uncertainties with regard to some of the costs and benefits of EBA, but there is a lot already known about the co-benefits and other positive effects that can occur with EBA (see opportunities). Lastly, any implementation risks that might result from uncertainties can be dealt with through adaptive management and learning-by-doing, which are essential components of EBA strategies.
EBA is a concept that is increasingly gaining popularity among climate change, development, conservation and disaster risk planners and policymakers. But can EBA be applied in practice as it is described in the concept and framework that was presented earlier? What issues need to be taken into account in relation to both the opportunities and challenges?

(DISCUSSION WITH PARTICIPANTS – Do you know concrete examples of EBA interventions? What makes them interesting? What have been the challenges in implementing them?)
The National Adaptation Programmes of Action (NAPAs) are one of the first adaptation policies established under the UNFCCC. The objective of the NAPA process is to guide the development of national adaptation planning in the least developed countries (LDCs) and to produce ranked priority projects for implementation and funding under the Global Environment Facility (GEF).

EBA as a concept or strategy was not a requirement for completing and submitting to the NAPA. But more than 20% of the NAPAs submitted to the UNFCCC referenced the importance of ecosystem services for human well-being. Several projects also included the management of ecosystem services, often in combination with other measures (e.g. projects targeting the rehabilitation of dams and watershed reforestation as a combined measure to regulate water flows in Cambodia).

Ecosystem services are mostly mentioned for their role in providing basic goods for human well-being (sufficient nutritious food or sufficient livelihoods) and for their role in enhancing security under disaster, e.g. buffering potential adverse impacts of storms and drought. The most important ecosystem services identified are the ones provided by forests and woodlands and coastal and marine ecosystems.
EBA provides many positive opportunities for harnessing during implementation.

Just one EBA strategy, for example a strategy involving forest and tree ecosystems, can benefit a variety of sectors and social segments through the bundle of ecosystem services which it can provide. These services can range from provisioning (e.g. timber, non-timber forest products (NTFPs) for local livelihoods), to regulating (e.g. storm flow regulation for the benefit of downstream communities), and cultural (e.g. opportunities to develop ecotourism from which the entire region could benefit).

When indigenous species are used, biodiversity benefits as well. More birds and insects are found in agroforestry systems than in monocultures. Forested watersheds provide a habitat for a vast number of plants and animals while mangroves support fish populations and corals, many of which are of significant economic importance. EBA contributes to mitigation as well, as agroforests, forested watersheds and mangroves for example, sequester and store vast amounts of carbon. EBA strategies could thus benefit from carbon finance as well, such as clean development mechanism (CDM) financing.

EBA measures are no-regret measures. Multiple benefits will be provided even in the absence of a climate threat. Furthermore, ecosystems can adapt themselves to changing
conditions and are thus more ‘flexible’ than hard technology (e.g. a dam). Changing the course of an EBA measure to suit new conditions is easier than altering an infrastructure which is built on heavy investments.

And lastly, EBA measures can be more cost-effective than infrastructural measures, especially if the multiple benefits are taken into account. As reported in The Economics of Ecosystems and Biodiversity, maintaining nature’s capacity to buffer the impacts of climate change on people is often less costly than having to replace lost ecosystem functions through the use of heavy infrastructure or technology. For example, economic valuations in Vietnam have shown that the planting of mangroves on the seaward side of the sea dike systems provides a benefit of cost avoided in maintenance of these defenses with technical measures, as mangroves dissipate destructive wave energy, stabilize the sea floor and its slope, and trap sediment. A mature stand will avert 25–30% of the costs of dike maintenance, with annual benefits ranging from 0.75 to 1.40 million Vietnamese Dongs per hectare, depending on the discount rate.
Co-benefits, or correlations between services, can materialize at different levels. A forested watershed that is conserved for water regulation at the meso-level can contribute to adaptation at the local level by providing forest goods for livelihoods and services for agriculture (e.g. shade crops such as coffee can be grown under the canopy). The same example can be given with mangroves that protect coastal settlements, reefs and fisheries, at the meso-level, and offer goods for communities at the local level. But forested watersheds and mangroves also contribute to the mitigation of climate change by sequestering and storing carbon. This is a global effect and benefit.
The feasibility, effectiveness and cost-efficiency of EBA strategies depend on a variety of biophysical, socioeconomic and governance factors.

Site and landscape characteristics such as topography, geology, and soil type and condition influence the effectiveness of EBA in reducing vulnerability to climate hazards, especially in restoration interventions. In reforestation interventions for example, careful selection of species is needed, with considerations based on site characteristics and type of ecosystem service prioritized for addressing climate risks (e.g. different species will be prioritized for water regulation services, and different ones for the provision of timber). In general, indigenous species are preferred to avoid maladaptation and adverse consequences for biodiversity, even when exotic species seem to be more cost-efficient in the short-term. Indigenous species are also valued more by local communities, and are thus more likely to be protected.

The extent of the area restored or conserved in an EBA strategy, and the age and composition of species, can influence the effectiveness of ecosystem services to minimize risks, and on the overall cost-efficiency of given adaptation plans.

For example, the extent of mangrove forest required for the protection of a coastal
settlement will depend on the area's geomorphology and the degree of extreme event risks. Several studies and reports have indicated the importance of mangrove width for the protection of different areas, with recommendations ranging from 100 m to 1,500 m. However, the optimal mangrove width for a particular area will also depend on species composition, stem density and other biophysical characteristics.

The spatial nature inherent in most ecosystem services should be taken into account. However, it can be difficult to define the exact ecosystem extent and stocks needed for the reduction of vulnerability, and predict the intervention's effects on other ecosystem services (as well as on adjacent systems), adaptive management and learning-by-doing should be planned for and used.

But ecosystem-based adaptation initiatives should not only concentrate on the biophysical performance of the measures but also on the socioeconomic costs and benefits.

Diverse socioeconomic factors can influence the success and sustainability of EBA initiatives, especially in situations where ecosystem benefits take a longer time to manifest or the adaptation intervention targets the use of ecosystem goods (e.g. non-timber forest products (NTFPs) from mangroves or forests). Vulnerable communities often have immediate livelihood needs and if land valuable for agriculture is put aside for ecosystem restoration, trade-offs will need to be balanced effectively until the EBA effects materialize. For interventions based on ecosystem goods, the role which human and other assets (e.g. knowledge) play in the creation of well-being or welfare bearing goods should also be acknowledged (e.g. trees are an insufficient input to generate timber which also requires human skills and technology).

Insurance, compensation, and payment for ecosystem services (PES) schemes are mechanisms that can facilitate economic benefits or balance opportunity costs, and contribute to the overall sustainability of EBA initiatives.

Participatory governance systems and secure property, access and use rights are important as well. Community participation and recognition of tenure is essential to make the transition from short-term extractive strategies for coping to sustainable ecosystem management for adaptation.
The diagram related to a potential EBA strategy with a coastal vegetation barrier for storm protection illustrates both the opportunities and challenges mentioned in the previous slides.

If the barrier is established through mangrove reforestation, multiple co-benefits will occur, as mangroves provide a habitat for fish nurseries, regulate the inflow of saline water, reduce coastal erosion, sequester and store carbon and provide a lot of products that are important for coastal communities (e.g. fuelwood, honey etc.).

However, the level of protection from extreme storms will depend on the species, density, position, age and size of the coastal barrier, the intensity of the storm surge and the hydrological conditions at the site (which also influence the success of the restoration process).

There is also a risk to biodiversity if exotic or invasive species are used (e.g. cauarina plantations established in certain areas where they are exotic) and a risk to people if they overly rely on the vegetation barrier for protection and do not consider establishing further measures such as early warning systems and evacuation routes. The absence of a protective vegetation barrier increases the risk of damage to settlements when storms...
hit the coast.
References


References


References


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