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Ecosystems Adaptation to Global Warming

Surendar Kumar

Assistant Professor, Department of Geography, Maharaja Ganga Singh University, Bikaner, Rajasthan, India

ABSTRACT

Natural ecosystems are one of our most precious resources, critical for sustaining life on the planet. The benefits humans derive from ecosystems are varied, from marketable products such as pharmaceuticals, to recreational opportunities such as camping, to ecosystems services such as erosion control and water purification. For many people, nature plays a powerful spiritual and aesthetic role in their lives, and many place a high value on the existence of wilderness and nature for its own sake. Despite the critical roles ecosystems play, these areas are increasingly threatened by the impacts of a growing human population through habitat destruction and air and water pollution. Added to these stresses comes a new threat — global climate change resulting from increased greenhouse gas concentrations in the atmosphere. "Ecosystems and Global Climate Change" is the fifth in a series of the Pew Center reports examining the potential impacts of climate change on the U.S. environment. It details the very real possibility that warming over this century will jeopardize the integrity of many of the terrestrial ecosystems on which we depend. Among the many key issues raised are:

- With warming, the distribution of terrestrial ecosystems will change as plants and animals follow the shifting climate. The eastern United States will likely lose many of its deciduous forests as the climate zones shift northwards, while more mountainous regions, like portions of the West, will see species and ecosystems migrate up mountain slopes from lower elevations.
- Both the amount and rate of warming predicted represent a threat to our nation's biodiversity. Certain species may face dwindling numbers and even extinction if they are unable to migrate fast enough to keep up with the changing climate. Likewise, as warming shrinks the zone of cold conditions in upper latitudes and on mountains, the future of species that depend on such climates will be in jeopardy.
- Climate change is likely to alter ecosystem composition and function — that is, which species make up an ecosystem and the way in which energy and materials flow through these systems. These modifications are bound to alter the amount and quantity of the various goods and services ecosystems provide.
- Ecosystems are inherently complex and difficult to model, and our ability to predict exactly how species and ecosystems will respond to a changing climate is limited. This uncertainty limits our ability to mitigate, minimize, or ameliorate the effects of climate change on terrestrial ecosystems. In order to maximize nature's own potential to adapt to climate change, we must continue to support existing strategies to conserve biodiversity and protect natural ecosystems.

KEYWORDS: *ecosystems, global, climate, warming, change, atmosphere, biodiversity, conserve*

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INTRODUCTION

Ecosystem-based adaptation (EbA) encompasses a broad set of approaches to adapt to climate change. They all involve the management of ecosystems and their services to reduce the vulnerability of human communities to the impacts of climate change. The Convention on Biological Diversity defines EbA as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change".EbA involves the conservation, sustainable management and restoration of ecosystems, such as forests, grasslands, wetlands, mangroves or coral reefs to reduce the harmful impacts of climate hazards including shifting patterns or levels of rainfall,[1,2] changes in maximum and minimum temperatures, stronger storms, and increasingly variable climatic

conditions. EbA measures can be implemented on their own or in combination with engineered approaches (such as the construction of water reservoirs or dykes), hybrid measures (such as artificial reefs) and approaches that strengthen the capacities of individuals and institutions to address climate risks (such as the introduction of early warning systems). EbA is nested within the broader concept of nature-based solutions and complements and shares common elements with a wide variety of other approaches to building the resilience of social-ecological systems. These approaches include community-based adaptation, ecosystem-based disaster risk reduction, climate-smart agriculture, and green infrastructure, and often place emphasis on using participatory and inclusive processes and community/stakeholder engagement. The concept of EbA has been promoted through international fora, including the processes of the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD). A number of countries make explicit references to EbA[3,4] in their strategies for adaptation to climate change and their Nationally Determined Contributions (NDCs) under the Paris Agreement. While the barriers to widespread uptake of EbA by public and private sector stakeholders and decision makers are substantial, cooperation toward generating a greater understanding of the potential of EbA is well established among researchers, advocates, and practitioners from nature conservation and sustainable development groups. EbA is increasingly viewed as an effective means of addressing the linked challenges of climate change and poverty in developing countries, where many people are dependent on natural resources for their lives and livelihoods.[5,6]

Ecosystem-based Adaptation (EbA) describes a variety of approaches for adapting to climate change, all of which involve the management of ecosystems to reduce the vulnerability of human communities to the impacts of climate change such as storm and flood damage to physical assets, coastal erosion, salinisation of freshwater resources, and loss of agricultural productivity. EbA lies at the intersection of climate change adaptation, socio-economic development, and biodiversity conservation .While ecosystem services have always been used by societies, the term Ecosystem-based Adaptation was coined in 2008 by the International Union for Conservation of Nature (IUCN) and its member institutions at the UN Climate Change Convention Conference in 2008.EbA was officially defined in 2009 at the UN Convention on Biological Diversity Conference.

Healthy ecosystems provide important ecosystem services that can contribute to climate change adaptation. For example, healthy mangrove ecosystems provide protection from the impacts of climate change, often for some of the world's most vulnerable people, by absorbing wave energy and storm surges, adapting to rising sea levels, and stabilizing shorelines from erosion. EbA focuses on benefits that humans derive from biodiversity and ecosystem services and how these benefits can be used for managing risk to climate change impacts. Adaptation to climate change is particularly urgent in developing countries and many Small Island Developing States that are already experiencing some of the most severe impacts of climate change, have economies that are highly sensitive to disruptions, and that have lower adaptive capacity.[7,8]

By deploying EbA, proponents cite that many other benefits to people and nature are delivered simultaneously. These correlated benefits include improved human health, socioeconomic development, food security and water security, disaster risk reduction, carbon sequestration, and biodiversity conservation. For example, restoration of ecosystems such as forests and coastal wetlands can contribute to food security and enhance livelihoods through the collection of non-timber forest products, maintain watershed functionality, and sequester carbon to mitigate global warming. Restoration of mangrove ecosystems can help increase food and livelihood security by supporting fisheries, and reduce disaster risk by decreasing wave height and strength during hurricanes and storms.

DISCUSSION

Particular ecosystems can provide a variety specific climate change adaptation benefits (or services). The most suitable EbA measures will depend on local context, the health of the ecosystem and the primary climate change hazard that needs to be addressed. The below table provides an overview of these factors, common EbA measures and intended outcomes.

Table 1 Examples of EbA measures and outcomes the table shows climate hazards and their potential impacts on people, as well as examples of corresponding EbA measures. Many of the same climate hazards affect different ecosystems and have similar impacts on people, as such, the table illustrates the overlap between impacts, EbA measures and adaptation outcomes.

Climate change hazards	Potential impacts on people	EbA measures by ecosystem type	Expected outcomes
Erratic rainfall Floods Shift of seasons Temperature increases Drought Extreme heat	Higher flood risks for people and infrastructure; Decrease in agricultural (and livestock) production; Food insecurities; Economic losses and/or insecurities; Threats to human health and well-being; Higher risk of heat strokes Lack of water	Mountains and forests: Sustainable mountain wetland management Forest and pasture restoration Inland waters: Conservation of wetlands and peat lands River basin restoration Trans-boundary water governance and ecosystem restoration Agriculture and drylands: Ecosystem restoration and agroforestry Using trees to adapt to changing seasons Intercropping of adapted species Sustainable livestock management and pasture restoration Sustainable dryland management Urban areas: Green aeration corridors for cities Storm water management using green spaces River restoration in urban areas Green facades for buildings	Improved water regulation; Erosion prevention; Improved water storage capacity; Flood risk reduction; Improved water provisioning; Improved water storage capacity; Adaptation to higher temperatures; Heat wave buffering
Storm surges Cyclones Sea level rise Salinisation Coastal erosion	Higher flood risks for people and infrastructure; Higher storm and cyclone risk for people and infrastructure; Decrease in agricultural (and livestock) production; Food insecurities; Economic losses and/or insecurities; Threats to human health and well-being; Lack of potable water	Marine and coastal: Mangrove restoration and coastal protection Coastal realignment Sustainable fishing and mangrove rehabilitation Coastal reef restoration	Storm and cyclone reduction; Flood risk reduction; Improved water quality; Adaptation to higher temperatures

Principles and standards for implementing EbA

Since the evolution of the concept and practice of EbA, various principles and standards have been developed to guide best practices for implementation. The guidelines adopted by the CBD build on these efforts and include a set of principles to guide planning and implementation. The principles are broadly clustered into four themes:

1. Building resilience and enhancing adaptive capacity through EbA interventions;
2. Ensuring inclusivity and equity in planning and implementation;
3. Consideration of multiple spatial and temporal scales in the design of EbA interventions;

4. Improving the effectiveness and efficiency of EbA, for example, by incorporating adaptive management, identifying limitations and trade-offs, integrating the knowledge of indigenous peoples and local communities.[9,10]

These principles are complemented by safeguards, which are social and environmental measures to avoid unintended consequences of EbA to people, ecosystems and biodiversity.

Standards have also been developed to help practitioners understand what interventions qualify as EbA, including the elements of helping people adapt to climate change, making active use of biodiversity and ecosystem services, and being part of an overall adaptation strategy.

By necessity, Pacific Islands have become hubs of innovation, where climate strategies are piloted and refined to inform adaptation efforts globally. Pacific Island ecosystems are being degraded by pollution, overfishing, and unsustainable development. They also increasingly face severe climate impacts including sea-level rise, changing temperature and rainfall patterns. These impacts result inchanges in food and water security, loss of identity, climate-induced migration and threats to sovereignty. In response, communities in the region are leading climate adaptation strategies, often combining traditional practices and cutting-edge science, to build the resilience of their communities and ecosystems in the face of increasing climate risk. For example, communities are implementing resilient networks of marine protected areas using the best available science and strengthening tribal governance to manage these networks, experimenting with salt and drought tolerant crops, revegetating coastlines with native salt-tolerant plants, revitalizing traditional wells, and implementing climate-smart development plans. Often these efforts contribute to local development priorities and create co-benefits for multiple sustainable development goals (SDGs). These community efforts are being scaled up through provincial and national policies that reinforce the critical role that ecosystems play in climate adaptation and provide a model for the rest of the world. While adaptation efforts are critical to help communities cope with climate impacts, in some cases, they will be insufficient to address the magnitude of climate impacts and local development needs. Thus, there are inherent trade-offs and limitations to climate adaptation with migration being the last resort for some island communities.[11,12]

RESULTS

Climate change could undermine our efforts for the conservation and sustainable use of biodiversity. We need to help biodiversity adapt to changing temperature and water regimes and we have to prevent, minimise and offset any potential damages to biodiversity arising from climate change adaptation and mitigation measures.

The Commission White Paper on Adapting to Climate Change – Towards a European Framework for Action (April 2009) and the EU Strategy on Adaptation to Climate Change both recognised the importance of ecosystems in tackling climate change. The White Paper encouraged the development of "measures which address biodiversity loss and climate change in an integrated manner to fully exploit co-benefits and avoid ecosystem feedbacks that accelerate global warming".

Protecting biodiversity can help us adapt to climate change. Healthy ecosystems will be more resilient to climate change and so more able to maintain the supply of ecosystem services on which our prosperity and wellbeing depend. Ecosystems-based approaches should be an integral part of the overall adaptation and mitigation effort. We can, for instance, ensure the effective management and restoration of Natura 2000 areas, working with- rather than against – nature.

The impacts of climate change on man are largely mediated by natural systems. Climate change will significantly affect economies and societies through its impacts on ecosystems.

Healthy ecosystems must lie at the centre of any adaptation policy and can help mitigate climate change impacts, by absorbing excess flood water or buffering us against coastal erosion or extreme weather events. Forests, peat lands and other habitats are major stores of carbon. Protecting them can also help us limit atmospheric greenhouse gas concentrations.

Consequently 'conventional' pressures that cause the fragmentation, degradation, over-exploitation and pollution of ecosystems must be reduced ('ecosystem climate-proofing'). This is why we have a strategy to reconnect natural areas using green infrastructure to restore the health of ecosystems and allow species to thrive across their entire natural habitat. The underlying principle of green infrastructure is that the same area of land can frequently offer multiple benefits if its ecosystems are healthy.

Biodiversity climate change adaptation tools, such as flyways, buffer zones, corridors and stepping stones, enhance the coherence and interconnectivity in Europe.

An effectively managed, functionally coherent and well-connected Natura 2000 Network can play a vital

role in helping society adapt to, and mitigate, the impacts of climate change.[13]

A guidance document presents the latest scientific information on the risks posed by climate change to species and habitat types of EU conservation concern. It also provides advice, supported by good practice examples, on how to deal with the impact of climate change when managing Natura 2000 sites. It is primarily addressed to site managers and policy makers.

- Guidelines on Climate Change and Natura 2000

A supplement has been developed to assess the vulnerability of Natura 2000 species and habitats. This supplement is based on best available knowledge. Caution is advised in the use and interpretation of the results: for many species, no or little information is available on the impacts of climate change; for habitats, most of the assessment is based on expert knowledge.

- Guidelines supplement: assessment of the vulnerability of species and habitats of Community Interest to climate change

Field-based EbA projects are proliferating. IUCN, for example, has implemented 100 projects that directly and/or indirectly contribute towards climate change mitigation and adaptation across 109 countries. But to decide on how best to approach design and implementation, we need better consolidated, empirical, comparative analysis of their effectiveness.

Increasingly, countries are developing their own policy responses, such as National Adaptation Plans and Intended Nationally Determined Contributions (INDCs), while international policy guidance on adaptation is emerging through the United Nations Framework Convention on Climate Change (UNFCCC) and other multilateral processes.

The international and national architecture for financing adaptation is also being developed. We need learning on EbA effectiveness to inform these responses.

In January 2017, Hannah Reid reviewed the international policy environment and key project activities to that date, arguing that for the policy community to realise EbA's real potential as a viable response for climate vulnerable communities, knowledge gaps on how it works, when and why needed to be plugged.

CONCLUSIONS

Between 2015 and 2022, IIED, the International Union for the Conservation of nature (IUCN) and the UN Environment World Conservation Monitoring Centre (UNEP-WCMC) are jointly implementing a project called 'Ecosystem-based approaches to climate change adaptation: strengthening the evidence and informing policy' in Asia, Africa and Central and South America.[14]

Working with local partners, the project will gather practical evidence, explore opportunities for and obstacles to uptake, and develop policy recommendations on EbA.

Between 2015 and 2019 we worked with partners and developed country-specific policy recommendations in Bangladesh, China, Nepal, Burkina Faso, Kenya, Senegal, South Africa, Uganda, Chile, Costa Rica, El Salvador and Peru. We synthesised findings on EbA effectiveness, the first-ever global scale synthesis based on perceptions and a participatory approach that engaged hundreds of local stakeholders.

We also produced practical guidance in the form of an inventory of tools, the EbA Tools Navigator, available on the Friends of EbA website. The navigator is designed to help practitioners and policymakers incorporate EbA into climate adaptation planning

Between 2020 and 2022, project partners will build on evidence and lessons learnt from the 12 countries to scale up EbA implementation in China, Peru, South Africa, and Uganda. Based on users' demands, we will also develop a web-based EbA Tools Navigator to make it more assessable.[15,16]

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