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ECOSYSTEM-BASED ADAPTATION THROUGH SOUTH-SOUTH COOPERATION

Enhancing Capacity, Knowledge and Technology Support to Build Climate Resilience of Vulnerable Developing Countries

UNEP

International Ecosystem Management Partnership
国际生态系统管理伙伴计划

Research on Ecosystem-based Adaptation (EbA): A reference guide

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Ecosystem-based Adaptation through South-South Cooperation (EbA South)

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ABBREVIATIONS

CBD	Convention on Biological Diversity
CBA	Community-based adaptation
CBNRM	Community-based Natural Resource Management
CCA	Climate change adaptation
CLICS	Climate Change-integrated Conservation Strategies
DRR	Disaster risk reduction
EbA	Ecosystem-based adaptation
ES	Ecosystem services
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
LULC	Land use and land cover
MEA	Millennium Ecosystem Assessment
TEEB	The Economics of Ecosystems and Biodiversity
UNFCCC	United Nations Framework Convention on Climate Change

DEFINITIONS

Adaptive capacity - The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2014).

Climate change - Refers to a change in the state of the climate that can be identified (i.e. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014:4).

Climate change adaptation - Adjustments in natural or human [social and economic] systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2014:4).

Climate vulnerability - A present inability to cope with external pressures or changes, such as changing climate conditions. Contextual vulnerability is a characteristic of social and ecological systems generated by multiple factors and processes. The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).

Ecosystem - A dynamic complex of plant, animal and micro-organism communities and their nonliving environment interacting as a functional unit where humans make an integral part (UN, 1992). Ecosystems can be categorised by a set of biological (e.g. species composition, surface cover), climatic (e.g. climatic zones), social (e.g. land use, resource management) factors.

Ecosystem approach - A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. It recognises that humans, with their cultural diversity, are an integral component of many ecosystems (CBD, 2014).

Ecosystem-based Adaptation (EbA) - An approach that integrates the use of biodiversity and ecosystem services into an overall adaptation strategy. It can be cost-effective and generate social, economic and cultural co-benefits and contribute to the conservation of biodiversity. EbA includes the sustainable management, conservation and restoration of ecosystems to provide services that help people adapt to the adverse effects of climate change (CBD, 2009).

Ecosystem functioning - Ecosystem functions are the ecological (biological, chemical and physical) mechanisms that support the integrity or maintenance of ecosystems. Ecosystem functions, such as primary production or decomposition, result from interactions between ecosystem structures and processes (Ansink et al., 2008).

Ecological processes - Ecological processes are defined as the complex interactions between the biotic and abiotic elements of ecosystems that underpin fluxes of information (e.g. stimuli), energy (e.g. sunlight) and matter (e.g. nutrients, gases, water) (Mace et al., 2012).

Ecosystem services - The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits (MEA, 2015).

Grey infrastructure - Adaptation measures which are in the form of physical interventions, construction measures or the use of engineering services to make buildings and infrastructure essential for the social and economic well-being of society more capable of withstanding extreme events. Grey measures include specific technological and infrastructural changes involving capital goods that consider specific climate change risks in planning and design (Sovacool, B.K., 2011).

Impacts - Effects on natural and human systems. In this report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts (IPCC, 2014).

Resilience - The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (IPCC, 2014).

Sensitivity - The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea level rise) (IPCC, 2014).

1. INTRODUCTION

Why conduct research on Ecosystem-based Adaptation?

It is widely asserted that environmental and climatic changes pose most tangible impacts on communities that are highly dependent on natural ecosystems to support their livelihoods. Climate change adaptation strategies are therefore necessary to be considered as an integral part of the country development planning. Adaptation may take different approaches, and many governments prefer to invest in traditional “hard” engineering solutions, such as coastal defenses, which in the long term may prove to be unsustainable. These solutions are usually costly and do not provide the same range of services as fully-functioning ecosystems do. On the other hand, forests, wetlands, or other ecosystems play an important role in supporting livelihoods through providing essential services like food, water, and building material. Similarly, natural ecosystems can reduce vulnerability to natural hazards and extreme climatic events by providing storm protection, green coastal defenses and regulating water and nutrient recharge. When ecosystems are healthy and well-functioning, they can enhance the resilience of communities to the adverse impacts of climate change. Ecosystem-based Adaptation (EbA) is a promising approach to address climate-related challenges. EbA is part of an overall adaptation strategy that relies on biodiversity and ecosystem services to help people and communities adapt to the harmful effects of climate change.

While the role of ecosystems in adaptation strategies is increasingly being acknowledged, there are still questions regarding the conceptual framework shaping EbA components (e.g. social, ecological, economic, governance) and processes (e.g. planning, implementing, monitoring). To encourage EbA application, it is essential to make the case for the benefits and cost-effectiveness of the approach compared to other types of adaptation measures. It is especially necessary to advance in the scientific evidence for EbA to gain political commitment across different levels, secure funding and private sector engagement, better inform decision-making on EbA, and ultimately facilitate its implementation.

Purpose of the guide

This guide is intended to assist researchers in developing a plan or proposal for a research study on EbA. The objective is to strengthen the understanding of core concepts, provide an analysis of current and prevailing knowledge gaps and research needs for EbA, with an insight into where potential research should be focused for future knowledge generation. It highlights considerations with regards to selecting an appropriate research approach, reviewing the literature to position the proposed study within the existing research. Also, the guide provides an inventory of EbA-relevant tools and lists relevant journals, conferences and funding opportunities.

Audience

The guide is ideal for readers with basic knowledge of the concepts of climate change, adaptation to climate change and ecosystem services, or those readers with intermediate knowledge who need a quick refresher regarding particular aspects of design and methodology relevant for EbA. For advanced readers, this book offers a summary of basic research techniques, useful references and practical recommendations in EbA research.

Structure

The guide is divided into six chapters, outlined below, which may be consulted individually according to user's interests and needs. Definitions and key messages are highlighted throughout the text, and examples are presented.

Chapter 1 describes the foundation of the conceptual approaches to frame this guide. It outlines major concepts of climate change, adaptation and ecosystem services to provide a better understanding of EbA. It further introduces EbA through a detailed analysis of the conceptual framework that shapes the approach and illustrates the synergies with other theoretical frameworks. The section presents an overview of the criteria and principles of EbA measures according to different institutions. This chapter serves as an entry point for researchers to locate themselves and their background with the conceptual framework of EbA.

Chapter 2 provides guidance on the research aspects of EbA and highlights how it relates to different research disciplines. The section then analyses gaps and needs in EbA research. It will help researchers gain a broad understanding of existing methodologies and research approaches applied to EbA.

Chapter 3 provides a step-by-step guidance on how to conduct research projects on EbA. It is divided in four steps: (1) Research scope and design; (2) Research methodology; (3) Data collection and analysis; and (4) Effective communication for EbA research uptake. This section highlights the important aspects to consider in conducting and communicating EbA research to facilitate research uptake and inform policy-making agendas.

Chapter 4 consists of an overview of the main tools relevant to EbA research. The section provides information on the type of tools and their use with regards to the EbA process stages – planning, assessment, design, implementation, monitoring and evaluation. It also highlights a detailed description of the EbA planning tool 'ALivE: Adaptation, Livelihoods and Ecosystems'.

Chapter 5 describes the different formats for the submission of peer-review articles and provides an overview of main international journals of relevance for publishing EbA research. It discusses the importance of presenting research findings in regional and international conferences and provides a list of relevant conferences, where EbA research can be presented. Finally, a list is presented with a description of existing funding sources with relevance to EbA either for research or project implementation, which may integrate action-research elements.

Chapter 6 provides practical recommendations to guide future EbA research.

2. KEY CONCEPTS

2.1 Adaptation to climate change

During the last decades, climate change has been gaining more prominence in scientific, economic and political discussions worldwide. While it used to be a phenomenon discussed mostly by meteorologists in the 1980s, specialists from various academic disciplines are now examining climate change. This has resulted in the mobilisation of resources to address climate change challenges through multiple strategies: economic, technological, institutional, social, political, etc.

Climate change has already resulted in multiple impacts and will increasingly contribute to changes in wind, temperature and rainfall patterns; frequency of extreme weather events; seasonal patterns; and more considerable climate variability (IPCC, 2014). These changes will, in turn, result in significant impacts on ecosystems as well as human activities, for example, the increasing scarcity of freshwater, the expected reduction in crop yields, livestock and forest productivity in many regions of the world.

Vulnerability theory emerged as an effort to better understand the risk of such external shocks, providing a basis to assess impacts and plan adaptation measures. Vulnerability to climate change can be defined in a number of ways. For the purposes of this Guide, it refers to "the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2014). Climate change adaptation (CCA) examines vulnerability through different lenses and CCA research usually focuses on understanding the adaptive capacity and sensitivity of the system at risk.

As scientific understanding of climate change improves, many questions have been answered and many other new ones have also emerged. Uncertainty about the dynamics of climate change persists, although there is greater certainty about the overall phenomenon. At the same time, it has become clear that adaptation is about adjusting development trajectories - not only to deal with climate change, but also to cope with fluctuations in the many other non-climatic factors that influence human well-being.

There are many different ways to categorise the adaptation options. Table 1 presents a summary of adaptation measures under (i) structural/physical; (ii) social; and (iii) institutional categories.

Table 1. Categories and examples of adaptation options (adapted from IPCC, 2014)

Structural/ Physical	Engineered and built environment	Sea walls and coastal protection structures; flood levees and culverts; water storage and pumping system; sewage works; improved drainage; beach nourishment; flood and cyclone shelters; building codes; storm and waste water management system; transport and road infrastructure adaptation; floating houses; adjusted power plants and electricity grids.
	Technological	New crop and animal varieties; genetic techniques; traditional technologies and methods; efficient irrigation; water saving technologies; rainwater harvesting; conservation agriculture; food storage and preservation facilities; hazard mapping and monitoring technology; early warning systems.
	Ecosystem-based	Ecological restoration including wetland and floodplain conservation and restoration; increased biological diversity; afforestation and reforestation; mangrove conservation and replanting; bushfire reduction and prescribed fire; green infrastructure (e.g. shade trees, green roofs); assisted migration or managed translocation; corridors; ex situ conservation and seed banks; community-based natural resource management; adaptive land use management.
	Public services	Food banks and distribution of food surplus; municipal services including water and sanitation; vaccination programmes; essential public health services; improved reproductive health services; enhanced emergency medical services.
Social	Educational	Awareness raising and integrating into education; gender equity in education; extension services; sharing local/ traditional knowledge and integrating into adaptation planning; participatory action research and social learning; community surveys; knowledge-sharing and learning platforms; international conferences and research networks.
	Informational	Hazard and vulnerability mapping; early warning and response systems including health early warning systems; systematic monitoring and remote sensing; climate services including improved forecasts; downscaling climate scenarios; longitudinal datasets; integrating indigenous climate observations; community-based adaptation plans including community-driven slum upgrading and participatory scenario development.
Institutional	Economics	Financial incentives including taxes and subsidies; insurance including index-based weather insurance schemes; catastrophe bonds; revolving funds; payments for ecosystem services; water tariffs; savings groups; microfinance; disaster contingency funds; cash transfers.
	Government policies and programmes	National and regional adaptation plans including mainstreaming climate change; sub-national and local adaptation plans; urban upgrading programmes; municipal water management programmes; disaster planning and preparedness; city-level plans; district-level plans; sector plans; controlling overfishing; fisheries co-management; and community-based adaptation.

Key resources

Global and regional knowledge networks on climate adaptation:

UNFCCC Nairobi Work Programme
Global Adaptation Network (GAN)
Asia Pacific Adaptation Network (APAN)
weADAPT
Adaptation Learning Mechanism (ALM)
Community of Practice on National Adaptation Plans for Latin America and the Caribbean
NAP Global Network

2.2 Ecosystems and their role in climate change adaptation

Climate change and environmental degradation have resulted in irreversible impacts on socio-ecological systems (IPCC, 2014). Socio-ecological system is defined as a linked system of people and nature and often reveals the high dependency of communities on natural ecosystems to support their livelihoods (Adger et al., 2005). Ecosystems provide a range of ecosystem services and goods, which support the basis for livelihoods and human well-being. Ecosystem functions and processes (e.g. soil formation) underpin the provision of ecosystem services (e.g. crop production), which in turn provide goods that people value (e.g. food). However, environmental and human-induced disruption of ecosystem functions (e.g. functioning of hydrological cycle contributing to flood control and drinking water supply) exacerbates the vulnerability of socio-ecological systems (MEA, 2005).

The Millennium Ecosystem Assessment (2005) describes four categories of ecosystem services: (i) provisioning services (e.g. food, fuel, fiber), (ii) regulating services (e.g. pollination, hydrological regulation), (iii) cultural services (e.g. sense of place, tourism), and (iv) supporting services (e.g. soil formation, nutrient cycling). With the growing body of research, ecosystem services have been transformed from a tool of communication to a framework for decision-making about global, regional and local environmental and development challenges (Norgaard, 2010).

Given the important role of ecosystem services in supporting livelihoods and understanding that the provision of ecosystem services depends on the functioning of ecosystems, it is pivotal to consider the climate impacts on ecosystems as an essential step in vulnerability assessments. Healthy ecosystems and their goods and services are critical for reducing vulnerability and enhancing community resilience. The potential impacts of climate change on ecosystems would compromise ecosystem services and thus directly affect human populations; therefore, ecosystem conservation should be an integral part of climate change adaptation. Examples of

such ecosystem services include climate and water regulation, protection from natural hazards such as floods and avalanches, water and air purification, and disease and pest regulation. These services determine the central role of ecosystem management in climate change adaptation and disaster risk reduction. Therefore, the conservation, sustainable management and restoration of ecosystems can help people adapt to climate change.

Despite the notable progress in exploring ecosystem functioning and their role for human livelihoods, it is in the last two decades that the concept of ecosystem services has firmly stepped on the ground. With the remarkable scientific works of the Millennium Ecosystem Assessment – MEA (2005); the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services – IPBES (2014) and the Economics of Ecosystems and Biodiversity - TEEB (2010) on estimating and valuing the benefits ecosystem services provide for human well-being, a new line of research was established. In the attempts to identify ecosystem services, quantify and estimate their value, researchers paved the road to include this concept into the economic and policy agenda.

Key resources

Millennium Ecosystem Assessment
The Economics of Ecosystems and Biodiversity (TEEB)
Ecosystem Services Partnership

2.3 Ecosystem-based Adaptation

Ecosystem-based Adaptation (EbA) is defined 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" (CBD, 2009). EbA has been receiving increasing attention for it has a great potential to reduce the vulnerability of both people and ecosystems to climate change impacts. Also, the approach provides multiple social and economic benefits such as clean water, food security, risk reduction and other services essential for livelihoods and human well-being (TEEB, 2010). EbA considers that equity, gender, and the importance of local and traditional knowledge are critical constituents in effective adaptation efforts.

The concept of EbA draws on a range of existing practices employed by the conservation and development sectors, such as sustainable natural resource management, community-based natural resources management and community-based adaptation (Figure 1). These practices include existing ecosystem or landscape level approaches, and can involve, for example, integrated watershed management, sustainable land management, or coastal zone management to secure ecosystem functions and services. EbA is based on the approaches: (i) Community-based Natural Resource Management (CBNRM)[1], (ii) Community-based Adaptation (CBA)[2] and (iii) Climate Change-Integrated Conservation Strategies (CLICS)[3], but is unique in the sense that combines achievements of the three approaches (Midgley et al., 2012).

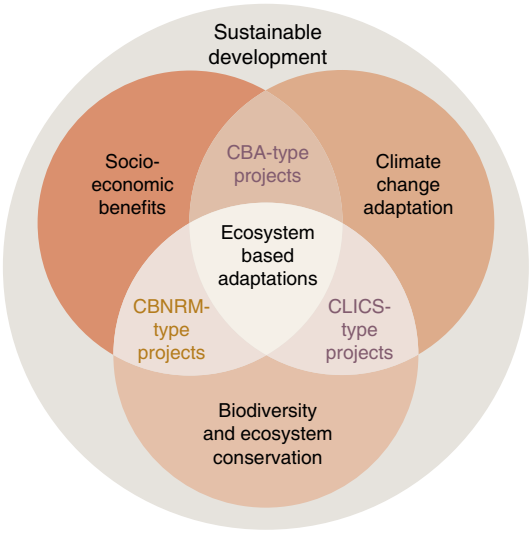


Figure 1. Ecosystem-based Adaptation (EbA) and its relation to other concepts (Midgley et al., 2012)

EbA measures include coastal habitat restoration, agroforestry, integrated water resource management, livelihood diversification, and sustainable forest management interventions that use nature to reduce vulnerability to climate change. Examples of EbA measures include (UNFCCC, 2013):

- Conservation, sustainable management and/or restoration of mangrove forests to reduce the impact of coastal flooding and erosion from storm surges linked to changing frequency and intensity of storms;
- Sustainable management of upland wetlands, forests, and floodplains for the regulation of water flow and control of water quality;

[1] CBNRM: Community-based Natural Resource Management is the management of natural resources by all concerned stakeholders. Communities managing the resources have the legal rights, the local institutions, and the economic incentives to take substantial responsibility for sustained use of these resources (CBNRM Net, 2001).

[2] CBA: Community-based Adaptation projects work to empower people to plan for and cope with climate change impacts by focusing on community led processes grounded in the priorities, needs, knowledge and capacities of communities (Chesterman and Hope, 2011).

[3] CLICS: Climate Change-integrated Conservation Strategies are climate-resilient conservation plans that often result in spatial and related types of planning products. These guide planning for ecosystem service corridors and protected areas that are resilient to climate change (Hannah et al., 2002a, Hannah et al., 2002b).

- Conservation and restoration of forests to stabilise land slopes and regulate water flows;
- Establishment of diverse agroforestry systems to cope with increased risk from changes in climate conditions;
- Management of ecosystems to complement, protect and extend the longevity of investments in hard infrastructure;
- Conservation of agrobiodiversity to provide essential gene pools and facilitate crop and livestock adaptation to climate change;
- Establishment and efficient management of systems to ensure the continued delivery of ecosystem services to support resilience to climate change, for example through protected areas, land use and agricultural systems.

Table 2. Examples of EbA measures by climate change impacts and key beneficiaries (Donatti et al., 2011)

Climate change impacts addressed	EbA measure	Beneficiaries
Extreme rainfall or drought on downstream water users	Wetlands protection and rehabilitation to increase water storage potential, to mitigate floods and to release water gradually during droughts	Water users (communities and businesses); local farmers
Increased coastal erosion as a result of sea level rise and changes in wave dynamics	Coral reef restoration, including enhancing coral populations through coral gardening and larval propagation methods, adding to or enhancing coral reef substrate to promote natural recovery and coastal protection services, and enhancing the environment surrounding and connected to coral reefs	Coastal communities; tourism sector; fishing communities
Increased frequency or intensity of tropical storm surge and flooding	Mangrove protection and restoration to reduce wave energy	Coastal communities; fishing communities; tourism sector
Reduced crop production due to changes in the wet or dry season or extreme weather events	Implementation of sustainable farm management (e.g. agroforestry systems, soil and water conservation practices) that can buffer various climate change impacts on crop production	Smallholder farmers; large-scale farmers; rural communities

A critical aspect of the ecosystem-based approach is that it can be applied to diverse ecosystems and geographical scales – local, national, regional and global (Devisscher, 2010). Thus, due to its multi-sectoral and multi-scale characteristics, it can integrate a variety of disciplines, stakeholders, and institutions, so that they can work at a range of governance levels and can influence decision-making (Vignola et al., 2009).

The principles of what distinguishes an EbA measure from other adaptation measures are being discussed among leading organisations and are presented in detail in Annex II. In summary, the general EbA principles include[4]:

- Resilient ecosystems and maintenance of ecosystem services, including those that reduce disaster risk, in the face of climate change, should be promoted;
- Multi-sectoral approaches should be promoted;
- The functional scale of ecosystems should be considered, recognising that ecosystems have limits and are interconnected;
- Reduction of the risk of maladaptation should be taken into account by considering biodiversity and ecosystem services in adaptation action design, and by developing sustainable monitoring and evaluation systems;
- Participatory approaches and decentralised, flexible management structures should be used to enable adaptive management;
- The best available science and local knowledge should be used, and knowledge generation and diffusion fostered.

There are different available resources defining criteria and principles of EbA measures. According to Friends of EbA – FEBA (2017), there are three elements and five criteria (Table 3) that help answer the question: "*Is this approach EbA or not?*".

Table 3. Elements of EbA according to FEBA (2017)

Elements	Criteria
Element A: EbA helps people adapt to climate change	*Criterion 1: Reduces social and environmental vulnerabilities* *Criterion 2: Generates societal benefits in the context of climate change adaptation*
Element B: EbA makes active use of biodiversity and ecosystem services	*Criterion 3: Restores, maintains or improves ecosystem health*
Element C: EbA is part of an overall adaptation strategy	*Criterion 4: Is supported by policies at multiple levels* *Criterion 5: Supports equitable governance and enhances capabilities*

[4] For more information on principles of EbA see: Travers, A., Elrick, C., Kay, R. Vestergaard, O. (2012) Ecosystem-based adaptation guidance: Moving from principles to practice ('EBA Decision Support Framework'); Andrade, A., Córdoba, R., Dave, R., Girot, P., Herrera, F. B., Munroe, R..Oglethorpe, J., Paaby, P., Pramova, E., Watson, E., Vergar, W. (2011) Draft principles and guidelines for integrating ecosystem-based approaches to adaptation in project and policy design: a discussion document; Girot, P., Ehrhart, C., Oglethorpe, J. (2011) Integrating Community and Ecosystem-Based Approaches in Climate Change Adaptation; Naumann, S., McKenna, D., Munang, R., Andrews, J., Thiaw, I., Alverson, K., Mumba, M., Kavagi, L., Han, Z. (2013) The social dimension of ecosystem-based adaptation. UNEP Policy Series: Ecosystem Management No.12.

Key resources

UNEP-IEMP and IIED (2018): Ecosystem-based adaptation: a handbook for EbA in mountain, dryland and coastal ecosystems
IUCN (2016): Ecosystem – based Adaptation Handbook
Conservation International (2013): Constructing theories of change for ecosystem-based adaptation projects
FEBA (2017): Making Ecosystem-based Adaptation Effective: A Framework for Defining Qualification Criteria and Quality Standards
The World Bank (2009): Convenient Solutions to an Inconvenient Truth: Ecosystem-based Approaches to Climate Change

Global and regional knowledge networks on EbA:

Ecosystem-based Adaptation through South – South Cooperation (EbA South)
Community of Practice on EbA for Latin America and the Caribbean

3. RESEARCH ASPECTS OF ECOSYSTEM-BASED ADAPTATION (EBA)

3.1 Embedding EbA in inter- and transdisciplinary research

What makes EbA an inter- and transdisciplinary research topic?

Research in the natural and social sciences has evolved based on observational, lab-based, and site-specific disciplinary analysis of relationships among systems, which has led to highly connected interdisciplinary and transdisciplinary efforts highlighting linkages among bio-geophysical, human, and social systems. To gain a clear understanding of the different concepts regarding research, Figure 2 demonstrates what is disciplinary, multidisciplinary, participatory, interdisciplinary, and transdisciplinary research.

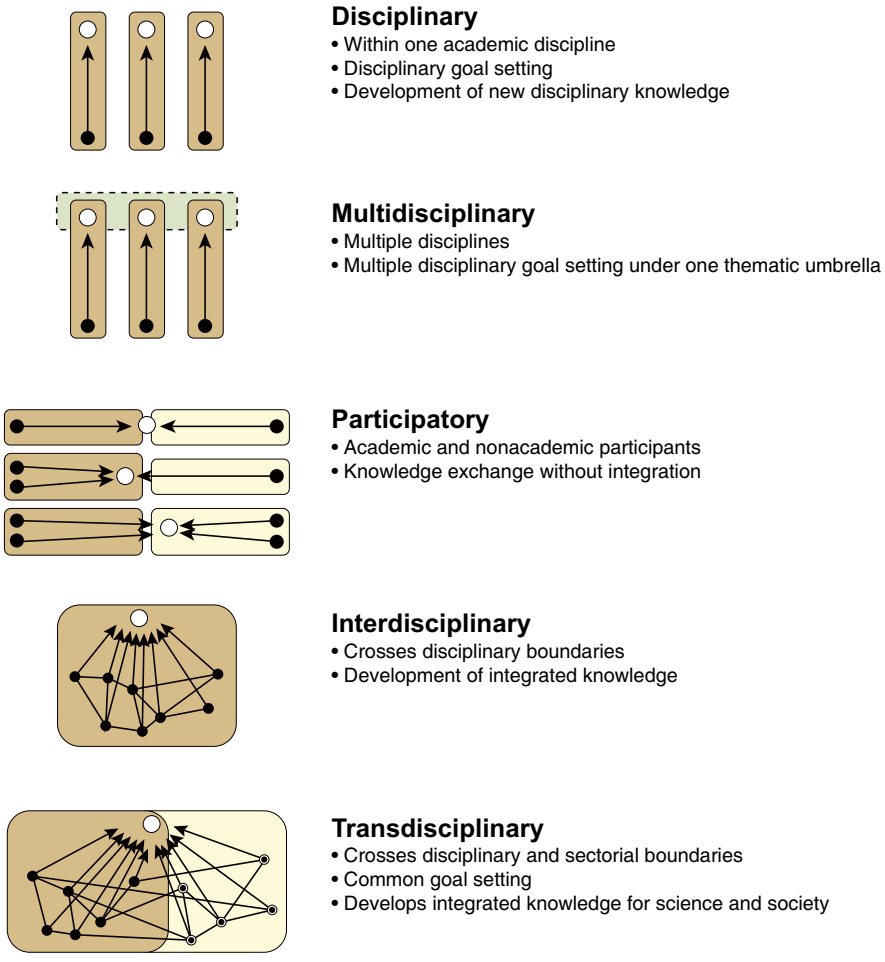


Figure 2. Graphical representation of the concepts of disciplinary, multidisciplinary, participatory, interdisciplinary, and transdisciplinary research (Morton, et al., 2015)

Research on ecosystem services has grown into a major academic field, based on various academic disciplines, perspectives, and research approaches. Within the scope of this interdisciplinary research, a common framework or bridging concept may serve as a link for the diverse approaches, questions and perspectives of the relevant disciplines and sectors to be connected. Thus, the multifaceted concept on ecosystem services can be considered as a boundary concept (Abson et al., 2014; Potschin and Haines-Young, 2016). By boundary concept it is meant that it enables researchers from different disciplines, policy makers and other interested public to develop and use a common language allowing for obtaining knowledge relevant to the different fields (Jordan and Russel, 2014).

EbA research requires integrating approaches, methods and knowledge across disciplines that are often based on different perceptions. EbA considers both ecosystems and socio-economic aspects, but in its core, the concept refers to the mutual dependence on each other. Both natural and social science capacity is needed for conducting EbA research. Natural science is necessary to understand the limits or boundaries of the ecosystem to be managed, to understand basic facts about its functioning, to describe linkages between and within ecosystems, and to understand vulnerability to climate change and potential impacts. Meanwhile, social science allows the researchers to understand the values, attitudes, societal structures, customs, and laws that underlie human behaviours and effects, to place a value on ecosystems and their services, and to understand their importance for adaptation. A combination of natural and social sciences can help better understand ecosystem vulnerabilities, the threats they face, and the extent to which management addresses those threats effectively. Such mutual interdependencies require a specific inter- and transdisciplinary research (Haberl et al., 2015).

Interdisciplinary research is particularly applicable when knowledge is uncertain and the problem at hand affects large parts of society (Hirsch Hadorn et al., 2007). Climate change research has become an umbrella term for a range of physical, social, and social-ecological lines of research. Climate change related research and especially on adaptation is not only based on multifaceted interactions of biophysical variables, but as well on complex interrelationships among social, economic, cultural and ecological factors. This places a requirement on early-career researchers to engage with a broad range of disciplines relevant to adaptation. Deciding on which disciplines are suitable for addressing specific research questions is somewhat of a disciplinary puzzle. This mainly affects early career researchers who may have limited experience in working across the social, natural and human sciences.

If the objective of EbA-related research is to produce results that are scientifically sound and informative for practitioners, policy-makers and other stakeholders, it should be conducted in a problem-oriented, integrative, and target-oriented manner. In this regard, these challenges cannot be fully addressed by applied research approaches, when issues cross boundaries between disciplines (Hirsch Hadorn et al., 2007). Such complex topic can only be tackled with transdisciplinary approaches. Thus, the potentials of a transdisciplinary research should also be reflected in EbA research that aims to understand the dynamic interrelations between climate change, ecosystems and society.

Brink et al. (2016) propose an analytical framework based on theory from ecosystem services, climate change adaptation and sustainability science to place EbA in a transdisciplinary perspective (Figure 2). In this framework, EbA is described through the ecosystem services cascade model, which links the five components: ecological structures, ecological functions, adaptation benefits, valuation, and ecosystem management practices (Haines-Young and Potschin, 2010). Each of these components corresponds to a specific line of research as natural and social sciences, or economy, all grouped under knowledge groups associated with sustainability science: systems, normative and transformative knowledge (Abson et al., 2014).

- **Systems knowledge** relates to the operational understanding of ecological and socio-economic system functioning. It embraces topics such as system functions, system dynamics, risk and uncertainty, and resilience, which come from natural or social sciences and often includes participatory approach. In terms of EbA, systems knowledge provides information on the relations between ecosystem services potential to offer adaptation benefits.
- **Normative knowledge** refers to understanding and quantifying the benefits from EbA. It covers topics like efficiency, well-being, conservation, economic valuation and builds upon ethics and economy research fields.
- **Transformative knowledge** relates to the understanding of the socio-political framework, which shapes EbA governance and develops tangible strategies to manage ecosystems and achieve adaptation goals. It includes topics like education, motivation, empowerment, policy, and governance, which extend across political and social sciences based on participatory research.

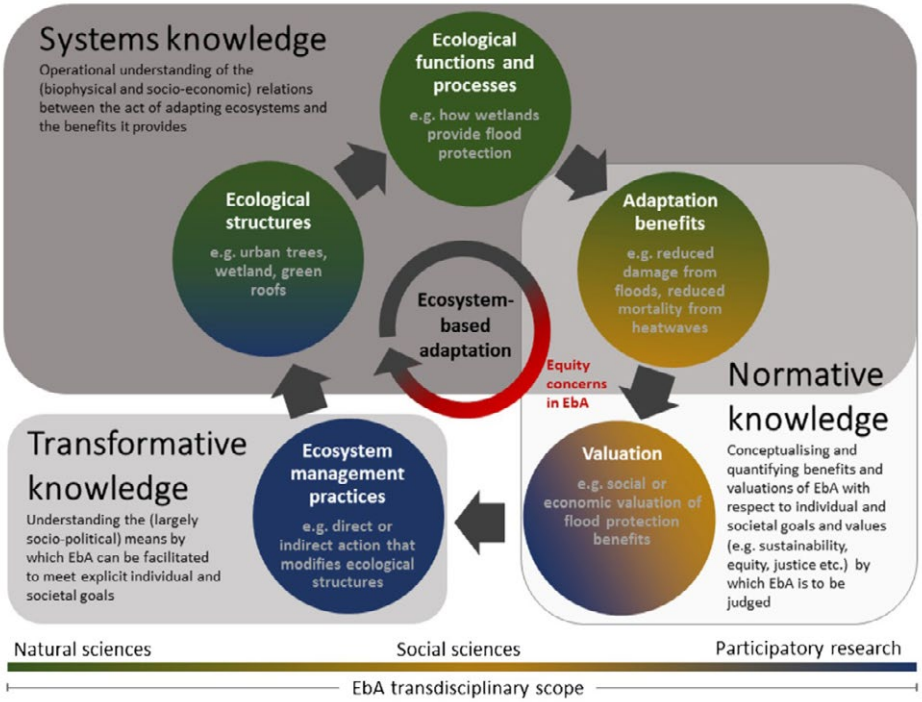


Figure 3. Relations between ecosystem services and knowledge groups relevant to sustainability (Abson et al., 2014)

Overview of advances in integrating EbA in different research disciplines

As discussed, EbA research requires inter- and transdisciplinary research approaches based on a broad set of disciplines from natural to social and cultural sciences to collaborate among and between each. For instance, economics and political science must analyse the processes leading to certain management decisions, while human and cultural sciences explain not only whether and why not such decisions are effectively implemented, but also describe other processes as the role of indigenous knowledge about adaptation and ecosystem management. Natural sciences, on the other hand, have to analyse how beneficial such practices could be from an ecosystem perspective. Therefore, integration of EbA in different disciplines should consider:

- Integrating existing disciplinary knowledge as well as their terminology, methodologies;
- Integrating knowledge from different sources (scientific and non-scientific);
- Reflecting on different purposes for applying the EbA concept (from assessment and awareness raising to policy advice and support for decision-making);
- Embracing different perceptions of EbA by different actors in civil society, policy, and science.

However, considerable challenges in achieving inter- and transdisciplinary research in practice exist. Table 4 lists examples where attempts have been made to integrate EbA research in different disciplines.

Table 4. Examples of existing EbA research integrated in different disciplines

Research field	Research topics on EbA and reference articles
Engineering	Comparison between grey infrastructure and EbA approach (e.g. Daigneault et al., 2016; Jacob et al., 2014; Cheong et al., 2013)
Economics	Comparison of costs and benefits of EbA with other adaptation options (e.g. Daigneault et al., 2016; Turner et al., 2007)
Social sciences	Analysis of the social dimension of climate change, natural resource management and adaptation (e.g. Munang et al., 2014)
Political sciences	Governance, evaluation and formulation of policies, regulations, and instruments relevant to EbA (e.g. Wamsler et al., 2016; Chong, 2014; Vognola et al., 2013; Khan and Amelie, 2015) Analysis of opportunities for mainstreaming EbA in sectoral, national and local levels (e.g. Wamsler and Pauleit, 2016; Walmsler et al., 2014; Pasquini and Cowling, 2015)
Natural sciences	Analysis of the potential of selected ecosystems to contribute to adaptation efforts (e.g. Wamsley et al., 2010; Barbier, et al., 2008; Shepard et al., 2011; Pramova et al., 2012)

3.2 Critical knowledge gaps and research needs for EbA

As EbA has gained recognition in addressing climate change risks, multiple stakeholders such as research centres, government institutions, and non-governmental organisations have contributed to the generation of a considerable body of information and knowledge. This knowledge improves the understanding of topics like climate change impacts, vulnerability, and adaptation options. It is, however, essential to assess what is the current state of knowledge available to identify what are the critical gaps between the increasing awareness on EbA measures and their actual implementation. Drawing on a literature review, some knowledge gaps on EbA require further research and attention. This chapter highlights where some of the most significant challenges in research on EbA are at present. These gaps are both general and sector-specific and touch upon interconnected themes. The identified weaknesses as well as priority areas for further research are presented under three themes as follows: (i) climate change impacts on human and natural systems; (ii) economic aspects and effectiveness of EbA; and (iii) monitoring and evaluation of EbA.

3.2.1 Climate change impacts on human and natural systems

Climate change has implications on the human and natural systems in different geographical areas. Understanding how and to what extent these repercussions affect ecosystems and the services they provide along with human society is imperative for the design of adequate and effective adaptation approaches. Specific knowledge on the short and long-term implications of climate change impacts is still limited. There is a particular need for information and documented knowledge on the following topics (Rizvi and van Riel, 2014):

- **Information on climate change risks and potential impacts on specific sectors:** Among the most vulnerable sectors are agriculture, marine resources, water resources, forest ecosystems, 'hot spots' for biodiversity, as well as human health (Davis and Turner Walker, 2013).
- **Drivers of global environmental change:** The influence of other drivers of global environmental change, such as deforestation and invasive species, influence the ability of ecosystems to sustainably deliver adaptation services. Understanding of these linkages is important in vulnerability and risk assessments (Davis and Turner Walker, 2013; Jones et al., 2012).
- **Gender-differentiated impacts of climate change:** Knowledge of gender-specific climate risks and potential impacts are limited. Although there is recognition of the linkages between gender and climate in research, there is an urgent need to better understand the specific impacts, needs and adaptive capacity of both men and women as well as their dependence on ecosystems.
- **Ecosystem thresholds, boundaries and tipping points:** Understanding the potential thresholds, boundaries and tipping points across a range of EbA approaches is critical, yet little is known. An insufficient number of studies have focused on the potential limitations of EbA approaches about 'thresholds,' 'boundaries' and 'tipping points' that could be exceeded under future climate change scenarios. Such studies are required to inform and guide policy and decision-makers on adaptation options (IPCC, 2014; Munroe et al., 2011).

3.2.2 Economic aspects and effectiveness of EbA

Although EbA is considered as a promising and cost-effective option to address climate change impacts and provide multiple benefits, its implementation still continues to be relatively an underestimated solution especially compared with engineered options. Additional evidence of EbA effectiveness in terms of its benefits and costs as well as compared to 'grey' infrastructure is required to encourage decision-makers for its implementation. Understanding the economic costs, benefits and tradeoffs of different EbA actions can guide policy-makers and development practitioners to choose cost-effective and sustainable strategy for a particular situation. Multiple papers highlight the fact that EbA measures bring numerous social, economic and ecological benefits, yet the lack of experience in evaluating EbA in comparison with engineered options remains one important barrier for its mainstreaming. In this regard, the critical knowledge gaps include:

- **Valuation of costs and benefits:** EbA measures have the advantage to simultaneously generate multiple adaptation benefits and co-benefits, deliver cost-effective long-term solutions in an equitable manner. Thus, failing to count the full range of benefits (direct and indirect, monetary and non-monetary), costs and impacts automatically undermines EbA in adaptation decision-making processes. While there are numerous studies that consider monetary assessments of costs and benefits of EbA, other non-monetary aspects such as livelihood impacts, biophysical effects and social and institutional outcomes of EbA measures are still underestimated (Emerton, L. 2017). In addition, there is lack of clarity on the distribution of the costs and benefits over time and space (Doswald et al. 2014).
- **Comparison of EbA vs. "grey" infrastructure:** Detailed comparisons between EbA and alternative adaptation strategies particularly "grey" infrastructure are essential to contribute to informed decision-making. Of specific interest and need are comparative analyses (e.g. between sites, 'before and after' and types of adaptation measures) to inform when and whether an ecosystem-based intervention, engineered intervention, or a combination of approaches might be appropriate.
- **Communication of existing evidence:** In spite of the existing studies on benefits, costs and impacts of EbA measures, the consideration of the results in policy-making often does not achieve the desired impact. A challenge remains on how to use and communicate (e.g. necessary arguments, communication channels, etc.) the evidence of EbA to effectively inform decision-making processes.

3.2.3 Monitoring and Evaluation (M&E) of EbA

M&E of EbA is important to better understand the progress against objectives and to identify barriers in the short to longer-term. It enables researchers, policy-makers, planners and practitioners to improve EbA initiatives by adjusting processes and targets to ensure that tangible benefits are achieved. The growing interests in monitoring, measuring and evaluating 'successful' adaptation have resulted in setting up M&E frameworks and project-specific indicators for some tangible outputs, yet challenges remain as considering time-horizons, complexity of socio-ecological systems and uncertainties on climate change and development paths. Among the remaining knowledge gaps are:

- **Long-time horizons:** Adaptation is a long-term issue and any success will only be noticeable

after long time horizons. It is, therefore, challenging to monitor success and especially beyond project timelines. This is especially relevant for EbA as ecosystem management and restoration require longer periods to be assessed.

- **Complexity of socio-ecological systems:** Ecosystems are dynamic and do not provide a static baseline against which to measure change and thus the success of EbA measures. Often uncertainty is as well a factor to add to the complexity in monitoring socio-ecological systems.
- **Metrics:** There are no universal metrics for adaptation in general or specifically for EbA. Often it is a challenge to define what exactly needs to be monitored (risk reduction, ecosystem service provision, food security, etc.) and at what level (national, regional and local).

As the identified research gaps are generally too broad to be addressed by one research project, it is recommended to define specific priority areas that will focus on concrete aspects of the research needs. Table 5 presents a list with examples of priority areas under each research need.

Table 5: Summary of research needs and priority areas for EbA research

Theme	Research needs	Examples of specific priority areas
Climate change impacts	*How* and the *extent* to which climate change effect ecosystems, ecosystem services and human society (e.g. human health, water demand, food security and economic development)	• Study the potential implications of projected climate change on specific sectors; • Asses how communities in a certain location are and may be affected by climate change; • Analyse the combined impacts of multiple stressors on specific sectors (e.g. agriculture, natural resources, food security); • Assess the occurring impacts of climate change in relation to water shortage, loss and damage and decreased food security.
	Assess a range of potential future climatic conditions under which particular EbA options are effective	• Assess potential thresholds, boundary conditions and tipping points of EbA approaches; • Assess temporal and spatial aspects of EbA effectiveness.
Economic aspects and effectiveness of EbA	Advance research on lessons learned (successes & challenges) and documenting best and failed practices (e.g. through case studies) for EbA and CCA in general	• Identification of criteria and indicators to define effectiveness; • Systematic review and analysis of EbA experiences at national, regional and local scales and sectors; • Analysis of failed examples of EbA.
	Assess the environmental, social and economic costs and benefits of EbA and CCA approaches	• The economic costs of EbA approaches; • Detailed comparisons between EbA and alternative strategies; • Measure and value the monetary and non-monetary aspects of adaptation approaches.
	Advance research on the role of ecosystems in DRR for different types of natural hazards	• Conduct cost-effectiveness studies of ecosystem services in the context of disasters; • Generate and share knowledge on the linkages between CCA, DRR, biodiversity and climate mitigation.
Monitoring and evaluation	Analysis of the timescale dimension and physical/ ecological/socio-economic conditions shaping EbA actions to measure policy performance	• Identify indicators to correspond to specific needs of monitoring at local, regional and national scales.

4. A STEP-WISE PROCESS TO RESEARCH ON EBA AND COMMUNICATE EFFECTIVELY THE RESULTS

The step-wise process outlines the key principles and steps for conducting EbA research. It is divided in four steps: (1) Research scope and design; (2) Selecting research methodology; (3) Data collection and analysis; and (4) Effective communication for EbA research uptake. It is not a technical procedure but rather intended to guide and assist the researchers on the consideration of principles and aspects relevant for EbA in conducting research. It describes key questions to be answered, outlines the process of how to carry out the steps and refers to other useful materials to support each step.

Guiding principles for research on EbA include:

- **Adopt an adaptive approach.** As EbA is an interdisciplinary approach, researchers should be prepared to modify and adapt the methods and tools they use for different contexts.
- **Understand the context.** Because EbA is rooted in local socio-cultural dynamics and climate variability, becoming familiar with the selected research site will help identifying appropriate methods and tools for research.
- **Account for uncertainty.** Consider uncertainty relevant for your research, but do not let it distract attention from the parts that are known.
- **Consider the interdisciplinary character of EbA research.** Use both natural and social sciences to generate the information needed to support the research.
- **Integrate local and indigenous knowledge.** A key characteristic for EbA is that it is gender-inclusive and promotes equity. Therefore, EbA-related research should ensure active participation of all stakeholders, the integration of local, traditional knowledge, and incorporate gender- and rights-based considerations.

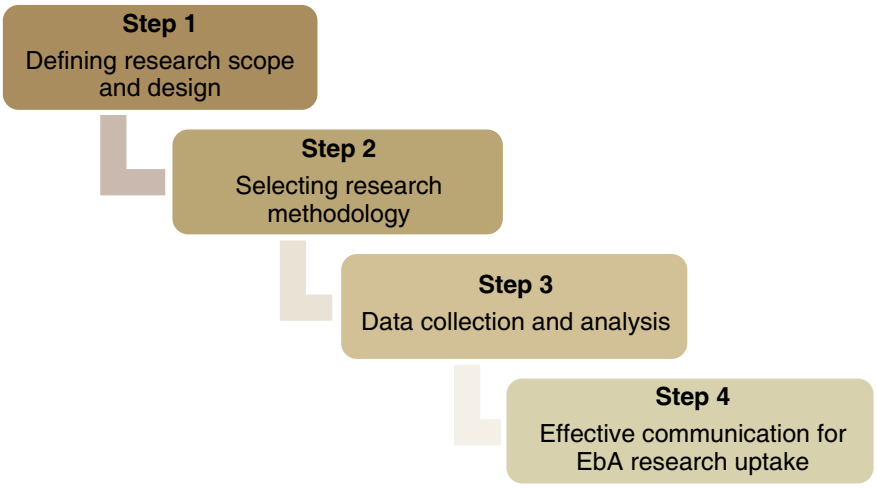


Figure 4. A step-wise process for conducting EbA research

Step 1: Defining research scope and design

What is the purpose of defining the scope and design of the research?

- Determine the **relevance** of the proposed research to current and past research on EbA.
- Formulate a clear and concise **research question**.
- Establish the **scale and focus** of the EbA research.
- Outline the **overall strategy** of the research to integrate the different components in a coherent and logical way to ensure that the research question is addressed effectively.

Guiding questions:

1. Is the research question clearly defined in order to address knowledge gaps on EbA? Does it come from ecological, political, economic or social science background or other research field?
2. Are the scale and focus of the proposed research appropriate to effectively address the research question?
3. How do the research questions and hypotheses address key challenges faced by the local and global community in supporting EbA?

The first step in conducting any research is to define its scope regarding the research question, the scale and focus of the study. Most analyses start with a review of existing literature on concepts and theories. The information collected from those reports can provide an

understanding of the conceptual framework highlighting current advances and gaps in EbA research, which will contribute to better shape the **research question**. It helps to locate own research within the existing literature and its **relevance** for decision-making. Consider reviewing both grey and peer-reviewed literature, as the majority of case studies on EbA can be found in the grey literature. The identified knowledge gaps and examples of priority areas for research on EbA may provide background for defining the research topic and formulating the research question and hypothesis.

Next, the **scale of the research** (geographical limits) should be determined. The scale may be the administrative unit to link to the appropriate management unit for implementing EbA actions (e.g. village, district, region). Alternatively, it may be defined by the natural boundaries of the ecosystem in question, such as a watershed. However, in many cases research scope may need to combine these units or some elements of them. The administrative unit will most likely be the level at which planning for EbA is done. At this unit, policies and institutions are established. Also, there possibly exist available data and statistics describing the socio-ecological system. Ecosystem and administrative boundaries rarely overlap entirely, but they neither are mutually exclusive. For the EbA research, it is essential to attempt to combine the two units to the extent possible, as the socio-ecological system considers both. For instance, if it is watershed scale, consider including all administrative units (e.g. municipalities, villages) in the watershed. Likewise, if delimited to the administrative unit, consider the full extent of the ecosystems essential to livelihoods and well-being within that unit; which may highlight the role of ecosystems and their services at a landscape level. To define the scale of the research to best reflect the principles of EbA, consider the functional scale of ecosystems, recognising that ecosystems have limits and are interconnected.

Also, in the process of defining the scope of the EbA research, the **research focus** needs to be determined. The center may be on vulnerability assessment of particular communities, livelihoods, ecosystems or sectors; climate change impacts; specific EbA measures; policies and governance of EbA, among others. Defining the focus of the research helps to further refine the scale (geographical limits) of the study. For example, there may be a need to assess the spatial links between ecosystems that provide services for the livelihoods considered, such as upstream/downstream relations or relationships between different policies at different governance levels to support EbA implementation.

A common challenge is to define **research design** that will help to apply the analytical framework in practice. This is especially relevant for EbA research given that it often requires a combination of one or more analytical frameworks. It is therefore essential to select a research design, which will assist in translating the conceptual framework to a quantifiable set of indicators or qualitative variables. It is necessary to keep in mind that the research problem determines the type of design to be used, not the other way around. In EbA research, obtaining evidence relevant to the research problem generally entails specifying the kind of proof needed - to test a theory, to evaluate a programme, to propose a policy or to accurately describe a phenomenon. Table 6 presents a list of most common research designs, their relevance to EbA research and examples.

Table 6: Description of most common research designs and their relevance to EbA research

Design type	Description	Relevance for EbA research	Examples of CCA / EbA research
Case study design	This design is for an in-depth study of a distinct research problem rather than a statistical survey. It is frequently used to narrow down a broad field of research into one or a few samples. The case study research design is also useful for testing whether a specific theory or model is feasible in the real world.	**Pros:** Particularly suitable for EbA research as it brings to an understanding of a complex problem through detailed analysis of the context related to a small number of events or conditions and their relationships. Researchers who apply a case study design can use various methodologies and rely on a variety of sources to examine a research problem. **Cons:** A single or a small number of cases offers little basis to generalise the findings. This is considered a limiting factor for EbA, which seeks up-scaling practices. Moreover, the design does not facilitate assessment of causal relationships, which is a crucial aspect of adaptation and EbA research observing climate change impacts, vulnerability and resilience building of communities.	EbA South Oppla Case study Finder Biodiversity and Ecosystem Services Network (BESNet) Panorama EbA Solutions Wamsler et al., 2016
Action research design	The design follows a cycle to develop an understanding of a problem and the relevant intervention strategy. Then the action research is carried out while observations are collected in various forms. The cyclic process repeats, continuing until a sufficient understanding of the problem is achieved.	**Pros:** The research design is collaborative and adaptive thus very suitable for EbA research. As it focuses on pragmatic and solution-driven research rather than testing theories, it provides an opportunity to generate evidence of EbA effectiveness, which will have direct relevance to practice. **Cons:** It should be considered that research is harder to conduct under this design due to the intensive documentation and analysis of the data and information.	International Center for Integrated Mountain Development (ICIMOD)
Exploratory design	An exploratory design is suitable for research problem with only few or no earlier studies are available to refer to. The focus is on obtaining insights and knowledge for later investigation or undertaken when issues are in a preliminary stage of the investigation. The goal of exploratory research can be the generation of new ideas and assumption, development of tentative theories or hypotheses. It also provides insights on the direction for future research and techniques to get developed.	**Pros:** Exploratory design is a useful approach for gaining background information on a particular aspect from EbA, which has not been researched yet. Moreover, it can be used to generate formal hypotheses and develop more precise research problems and research priorities on EbA. **Cons:** It should be considered that the research process underpinning exploratory studies is flexible and often unstructured, leading to only preliminary results and no definite conclusions. Thus, it is a restricting aspect of EbA research, as the results will have limited value in decision-making.	Dorkenoo, K., 2015

Step 2: Selecting research methodology

What is the purpose of defining the research methodology?

- Describe the **methodological approach** to be applied considering EbA principles and criteria.
- Select **methods** that ensure data is collected or generated in a way that is consistent with accepted practice and principles of EbA (e.g. participatory, gender inclusive).

Guiding questions:

1. Does the selected methodological approach consider EbA-specific procedures or techniques used to identify, collect data, process, and analyse information?
2. Are the selected methods for data collection and analysis consistent with the consideration of EbA principles?
3. Are gender aspects considered in the selection and design of data collection methods?

The second step in the process of conducting EbA research is to define the methodological approach to be used. Given the nature of the EbA concept, there is a need for identifying and applying empirical and analytical methods and approaches that foster a more systematic and comprehensive understanding of the interdependencies between nature and society.

The selected research design (in the previous step) will provide insights to consider the most appropriate **methodological approaches.** The three standard methodological approaches are (a) qualitative, (b) quantitative, and (c) mixed methods. A **mixed methods approach** offers particular benefits for research on EbA. The quantitative research method may enable researchers to trace specific climatic and other types of variables (e.g. rainfall trends, socio-economic development, deforestation trends, provision of ecosystem services). On the other hand, the qualitative component of the design helps to achieve an in-depth understanding of specific issues (e.g. vulnerability, perceptions, community dependence on natural resources). Table 7 presents categories of research approaches and examples of relevant methods to be considered applying in the EbA research.

Methods for collection and generation of qualitative and quantitative data vary and depend on the research question, design, as well as the methodological approach. An essential principle of EbA research is to apply participatory approach whenever possible and integrate gender aspect in the design of any of the selected data collection method. Focus group discussions or household questionnaires may be used to elicit information on the importance of ecosystem services to different livelihood groups. Consider other factors in this process, such as the relative wealth or gender of the various groups or households involved in the study, as this may affect how vital specific ecosystem services are to them and how they perceive their supply. Different stakeholders will have different perspectives on the value of particular ecosystem services, and thus an appropriate balance may need to be struck when prioritising the importance of ecosystem services. There is no single perfect method for data collection. Therefore, triangulation is particularly crucial. By using multiple methods and triangulating the results, it is possible to arrive at a more robust conclusion.

Table 7. List of categories of methodological approaches, relevant methods and examples of their use in EbA research

Categories of methodological approaches	Examples of relevant methods	Examples of EbA research
Qualitative	Interviews, focus groups, participant observation, discourse analysis, document analysis, institutional analysis, case studies, comparative analysis	Wamsler et al. (2016) Pasquini and Cowling (2015)
Quantitative	Surveys, economic valuation, cost-benefit analysis, modeling, lab and field experiments	Vognola et al. (2013); Daigneault et al. (2016); Turner et al. (2007)
Participatory	Group facilitation methods (nominal groups, delphi processes), community-based research (traditional calendars, group ranking), participatory-action research	Mercer et al. (2012); Osano et al. (2013)
Evaluative	Monitoring & evaluation, policy analysis, argument analysis	Jacob et al. (2014); Doswald et al. (2014)
Spatial	Geographic information systems (GIS), historical geographic information systems (HGIS), community-based mapping, 3-D mapping, transect walks	Wamsley et al. (2010); Tiburan et al. (2012); Khan and Amelie (2015)
Meta-analytical	Meta-analysis, systematic reviews, qualitative comparative analysis	Munroe et al. (2012); Doswald et al. (2014); Geneletti and Zardo (2016); Shepard et al. (2011)

Considering a wide range of available research methods, it would be useful to define specific criteria for deciding what methods and approaches best suit your EbA research. Below is example of standards to consider in selecting the research methods:

- **Scale.** If you intend to make comparisons on EbA measures at global, regional scale (e.g. governance, global agreements, best practices), surveys may be suitable. Participatory methods may be more suitable for research at a local scale (e.g. decision-making management, livelihoods, technical innovations).
- **Data availability.** Data availability is a deciding factor if you consider using specific tools for the analysis (e.g. modeling).
- **Audience.** Policy-makers can absorb quantitative data and small pieces of information, while development practitioners and academics prefer more detailed discussions.

Other criteria, such as time, budget and available expertise, may also be factors in your choice of methods.

Step 3: Data collection and analysis

What is the purpose of data collection and analysis?

- Identify the **data requirements** relevant to EbA in order to respond to the research question.
- Ensure that the **relevant stakeholders** for the EbA research are identified and involved in data collection and interpretation process.
- Gain an in-depth **understanding of the context**.

Guiding questions

- Is the generated/collected data relevant/sufficient to address the research question?
- Are the stakeholders involved in data collection and interpretation relevant for the EbA research (e.g. stakeholders who have influence on ecosystem management and stakeholders who are vulnerable to climate risk)?
- Are gender aspects considered in the data collection and interpretation process?

The third step in conducting EbA research is related to data collection and analysis. This section provides guidance on the key aspects to consider for selecting the methods recognising EbA principles and defining data needs.

Gaining a good **understanding of the context,** where the study will be conducted, is of paramount importance. This is because EbA research has an interdisciplinary dimension, thus requiring knowledge and information on different socio-ecological, economic and governance aspects.

Depending on the research question, the **data requirements** for the specific research may vary, including climate projections, socio-economic data or ecological assessment. It is essential to define what the particular data needs are to design the data collection methodologies. There is a range of sources of information that may be used as part of EbA research, including primary sources such as questionnaires and field experiments, and secondary sources such as literature reviews and expert knowledge. Collecting primary data can be time-consuming, challenging, and expensive, so it is important to make the most of the existing data available. The categories of data needs for EbA research include:

- **Climate vulnerability profile.** Hazard types, frequency and intensity. Focus primarily on hydro-meteorological disasters, but if other disasters are significant in the area, these would also need to be taken into consideration.
- **Changes in weather patterns and resource availability.** Local weather data and historical trends, and whether these have amplified recently. Pay particular attention to rainfall, heat, cold and dryness.
- **Climate projections.** Downscaled local climate change models, and national and local climate studies.
- **Social assessment data.** These data sources include secondary data (census, historical texts), qualitative interviews, quantitative surveys and participatory rural appraisal on household assets, income streams, expenditures, vulnerable groups, health status, education level and culture.
- **Ecological assessment data.** These data sources include secondary data (e.g. state of the environment report, land cover maps), qualitative and quantitative field assessment of biodiversity and ecological health, and assessment of trends in ecosystem condition.
- **Ecosystem services data.** These data sources include papers on how to associate ecosystem services with specific land cover or specific ecosystem service mapping and decision-support tools (some of these tools are reviewed in literature on ecosystem services indicators).

Table 8 presents a list of possible categories of data needs and how it can be collected.

Table 8: Examples of sources of data relevant for EbA research (Andrew et al., 2015)

Sources of data	Description	Dataset examples	Use examples
LULC (including maps of habitat, vegetation type, biomes)	Categorical spatial data mapping the distribution of vegetation types and other surface features of a study area. Some human activities conducted in an area (land use) may be inferred.	Global: MODIS land cover (Zhan et al., 2000); GLC2000 (Latifovic et al., 2004) National: EOSD land cover (Canada, Wulder et al., 2008)	Used as an indicator of ESs (Metzger et al., 2006), or to spatially map estimates of ESs or ES value (Sutton and Costanza, 2002) or of ecosystem properties to model ESs (Nelson et al., 2009).
Global carbon maps	Derived from field estimates of biomass carbon, spatialized by linking per-area measurements to LULC or biome maps	IPCC global carbon map (Ruesch and Gibbs, 2008)	Directly used as maps of carbon storage (Larsen, Londoño-Murcia, and Turner 2011; Naidoo et al., 2008; Strassburg et al., 2010).
Agricultural production data	Reported crop/livestock yield or revenue. Often aspatial or provided for administrative units.	FAO statistics National/state/county production statistics	Depending on spatial characteristics of data, used to directly map (Anderson et al., 2009), spatially model (Willemen et al., 2008), or extrapolate (Kroll et al., 2012) agricultural value.
Forest inventory	Plots data and aggregates thereof characterising a nation's forest resource base, provides information on species composition and forest structure.	US Forest Inventory Analysis	Information on forest composition and management by county can improve LULC maps of biomass carbon (Polasky et al., 2012).
Climate data	Point or gridded long-term observations of climate variables (temperature, precipitation, and their seasonality, etc.).	WorldClim (Hijmans et al., 2005)	Precipitation to indicate/ model water provisioning (Bagstad et al., 2011; Mendoza et al., 2011) and erosion control services (Dymond et al., 2012; Nelson et al., 2009).
Soil surveys	Categorical spatial data mapping the distribution of soil types, may be linked with data on chemical and physical properties per soil type.	SSURGO database. http://websoilsurvey.nrcs.usda.gov/	Soil maps/properties used to parameterize erosion control and hydrological services (Guo, Xiao, and Li, 2000; Nelson et al., 2009) Soil fertility used to indicate/ model agricultural production (Lautenbach et al., 2011).

For both qualitative and quantitative data collection methods discussed above, it is essential to identify who are the **relevant stakeholders** for the EbA research. This refers to the stakeholders who depend on various ecosystem goods and services, and who have interests and influence in using and managing them. This can be achieved by conducting a stakeholder analysis. At this step, it is particularly important to understand the role of women, indigenous as well as other marginalised groups and consider their perspectives in the data collection methods. Conducting stakeholder workshops is a key option for finding out about sources of existing data and encouraging the input of relevant experts.

Stakeholders involved in EbA research

(I) Stakeholders who have an influence on land use changes and risk factors at different levels, from the community to the national level:

- Which stakeholders –from community to national level- are changing land uses in a way that promotes the delivery of ecosystem services important for adaptation?
- Which stakeholders –from community to national level- are causing ecosystem degradation and, as a result, undermining the delivery of ecosystem services important for adaptation?

(II) Vulnerable stakeholders who are exposed to hazards and only have limited resources and capacities:

- Which vulnerable stakeholders would benefit from EbA, e.g. those exposed to drought, storms, landslides and floods; those with unstable livelihoods, depending on threatened ecosystems for their living?
- How are these vulnerable stakeholders currently coping with climate variability?

Source: Jiménez Hernández, A. (2016). Ecosystem-based Adaptation Handbook.

Techniques and methods for **data analysis** would depend on the research methodology defined in Step 2. Statistics would play an important role to assist both in the qualitative and quantitative data analysis and highly relevant to conduct more rigorous ecosystem services assessments. Statistics also provides the theoretical basis for tracking uncertainty through a vulnerability and ecosystem services assessment, which is an important factor in ensuring that society's valuation of the environment is soundly based. Data analysis on ecosystem services, which may consider statistics, includes (Smith et al., 2011):

- **Statistical data analysis.** This method applied in ecosystem services assessment is to build from a series of statistical analyses, which focus on identifying ecosystem process, function and capital, and provide a quantification of the linkages with their relevant uncertainty measures.
- **Geography and spatial models.** Many ecosystem services studies use spatially referenced data and developments in four areas of spatial analysis: (1) geographic information systems, (2) remote sensing, (3) spatial trends, and (4) hierarchical models.
- **Meta-analysis.** The aim within an EbA research is to provide the consistent overview where different statistical techniques may have been used and link outputs to better inform socio-ecological models.
- **Environmental models.** These models combine the understanding of parts of a selected ecological system and leads to the development of models. There are three main types of environmental model in common use, i.e. empirical, process-based and stochastic models.
- **Societal models.** EbA research includes information gained through stakeholder participation to assess the risk perceptions or ecosystem values. Cognitive or mind maps are useful, where graphical representations are used to identify ideas and the links between them.

Step 4: Effective communication for EbA research uptake

Evidence-based communication is of particular importance for EbA to leverage change and encourage up-scaling and replication of the approach. Effective communication of EbA research results is therefore critical to achieving this change. Over the past decade, there has been growing recognition of the importance of research uptake as an integral part of the research process. Research uptake includes all the activities that promote and contribute to the use of research evidence by policy-makers, practitioners and other development stakeholders. Many different approaches have been used to enhance research communication and engagement with the audience. Research uptake activities aim to (DFID, 2016):

- **Conduct research relevant to stakeholders** - engage with potential users and communicate research effectively for different audiences.
- **Contribute to the demand for evidence** - build capacity and commitment of research users to access, evaluate and use research evidence.

Initially, for effective communication of research results it is key to **engage with the specific audience groups.** There is a wide range of stakeholders who are engaged and benefitted from EbA actions. Key stakeholders (e.g. people that are affected by, or can influence, decisions regarding the research sites) should already have been identified during the preliminary stages of the research, although there may be other groups that need to be engaged when communicating the results. It is worth noting that different groups are likely to have different interests and requirements, such that messages will need to be tailored specifically to their interests. For example, groups will differ regarding their existing level of knowledge, biodiversity and ecosystem services. Tailoring communication on EbA to specific relevant audiences is more likely to result in successful EbA planning and implementation.

Uncertainty is vital information that needs to be conveyed to ensure transparency. In particular, key uncertainties, limitations, assumptions and knowledge/evidence gaps should be communicated clearly alongside any results presented. This information can also help provide an understanding of how robust the results are for use in decision-making. A fundamental shortcoming of many ecosystem and vulnerability assessments, as potential components of EbA research, is that they often fail to provide information concerning the uncertainty and validation of results. It is therefore imperative to assess and communicate the degree of uncertainty in findings transparently and consistently. Uncertainty can be quantified and described in different ways both for qualitative and quantitative findings. In the case of the qualitative conclusions, it can be used as a set of agreed phrases regarding the evidence (e.g. ranging from very confident to not confident).

Finally, it is essential to select the **communication tools and materials** to use. There is a wide range of different tools and materials available. Different formats for presenting and communicating the research results will best inform different audience groups. When using communication materials (e.g. reports, briefings, presentations, videos), it is important to use suitable language with appropriate technical terms, depending on the target audience.

Tips for writing effective research summaries

- Make sure you clearly outline why the research you are presenting is of relevance to policy and what the implications of your findings are.
- Make it attractive; policy-makers, like the rest of us, are more likely to read something visually appealing.
- Summarise the key points and put them on the first page as a clear bulleted list.
- Keep it short – ideally 2-4 pages.
- Spell out any acronyms and don't use jargon.

Source: DFID (2016). Research Uptake: A guide for DFID-funded research programmes.

5. TOOLS FOR EBA RESEARCH

5.1 Overview of tools

Many tools and methods now exist for EbA research, ranging from those that focus on ecosystem valuation and assessment, vulnerability and risk analysis to adaptation planning and decision-support. Multiple tools may be combined to design and carry out an assessment related to EbA and the particular techniques employed can vary from case to case. Many of the existing tools are rather general, therefore they can be applied to different ecosystem types and contexts. Different tools perform different functions and are useful at different steps in the research process. There are two principal groups for tools and methods, either explicitly for (i) EbA research or for (ii) EbA planning and implementation processes. The latter category is also relevant for EbA research as they facilitate context-specific data collection and analysis usually at local level and with a participatory approach. Therefore, these tools provide the opportunity for researchers to strengthen EbA research by identifying knowledge gaps and challenges in the processes for planning and implementation of EbA project.

A number of efforts have been made in order to compile EbA-relevant tools in an inventory to guide future initiatives. Among these initiatives are: Database of Tools for EbA - IIED and EBM ToolsNetwork / NatureServe. Based on this background information, the guide highlights two key characteristics in the inventory of EbA tools: **Function of the tools** (e.g. visualization, modeling, decision-making) and **Project process stages** (e.g. planning, implementation, mainstreaming). Besides these two main characteristics, the tools may be classified by the scale or ecosystems they analyse as well as the level of expertise required to use them.

Function of the tools

The tools relevant to EbA have the objective to describe processes, interrelationships, policies and analytical approaches that inform decision-makers in developing and assessing adaptation solutions. Depending on the data needed and how it is processed, these tools can be separated into three main types. The three types of tools are (Rozum, J.S. and Carr, S.D., 2013):

- **Visualisation tools** use graphics and simulations to provide a picture of the performance of different management decisions. The analyses they offer do not require a lot of user input compared to other analytical tools and commonly do not work with local data. They are easy to use and do not require specialised software or hardware.
- **Modelling tools** model current and likely future conditions of geo-physical, biological, and socioeconomic processes. These are the most technically demanding tools to use and often require GIS software, local expertise, and training. Models also generally need local data on the process being investigated. It is critical to consider data requirements when assessing the appropriateness of these tools.

- **Decision-making tools** create scenarios of future conditions as a result of potential climate change effects and management decisions. Commonly, these tools can integrate various tool outputs (e.g. from models) to help develop the so-called “what if” scenarios that allow users to investigate a wide variety of management outcomes (e.g. Adaptation, Livelihoods and Ecosystems (ALivE) EbA Planning Tool). Decision support tools usually require at least a moderate degree of technical capacity such as GIS expertise.

Table 9: Types of tools and their functionality (Rozum, J.S. and Carr, S.D., 2013)

Type/ Function	Data management	Analysis	Mapping/ Graphics	Scenario development	Stakeholder engagement
Visualization tools (V)			√		√
Modeling tools (M)		√	√	√	
Decision-making tools (DM)	√	√	√	√	√

Project process stages

The typical process stages for EbA are:

- **Planning stage** includes reviewing and stocktaking of socio-ecological information as well as information on the institutional and regulatory context;
- **Assessment stage** refers to analysing climate change scenarios and assessing current and future vulnerabilities;
- **Design stage** includes identifying and selecting adaptation options;
- **Implementation stage** refers to carrying out the chosen adaptation options;
- **Monitoring and Evaluation stage** refers to developing and carrying out an M&E system to support adaptive management.

Some of the tools do not fall strictly under only one of the stages but can be applied in multiple stages in the cycle.

5.2 Inventory of tools for EbA research

A number of tools that are widely used have been compiled and presented with a detailed description of their functions, characteristics and aim in Table 10.

Table 10. List of EbA–relevant tools and their characteristics (Process stages: P – Planning; A – Assessment; D – Design; I – Implementation; ME – Monitoring and Evaluation. Types of tools: V – Visualization tool; M – Modeling tool; DM – Decision-making tool)

Process stages					Name	Website	Description	Types of tools		
P	A	D	I	ME				V	M	DM
					Adaptation, Livelihoods and Ecosystems (ALivE) EbA Planning Tool	http://www.iisd.org/project/ALivE	ALivE is a **computer-based planning tool** designed to support practitioners in organising and analysing information to plan effective EbA options within a broader EbA planning process. It is a rapid qualitative assessment technique that can be applied in any ecosystem types and with relatively limited technical knowledge.			
					Community-based Risk Screening Tool - Adaptation and Livelihoods (CRiSTAL)	http://www.iisd.org/cristaltool/	CRiSTAL is a **project-planning tool** to help users identify and prioritise climate risks and identify livelihood resources most important to climate adaptation and uses these as a basis for designing adaptation strategies.			
					InVEST (Integrated Valuation of Environmental Services and Trade-offs)	http://www.naturalcapitalproject.org/invest/	InVEST is a **set of spatially-explicit models** that can be used to quantify, map and value the benefits provided by terrestrial, freshwater and marine ecosystems in either biophysical or economic terms. It can be used to map the relative importance of different areas for ecosystem services.			
					Adaptive risk & vulnerability management at conservation sites (MARISCO)	http://www.marisco.training/	The MARISCO **methodology** is used to facilitate the integration of the risk and vulnerability perspective into the management of conservation projects and sites. It is designed to ensure that the impact of climate change is taken into account in the strategic management of protected areas, but is not limited to climate change.			
					Climate witness: community toolkit. World Wildlife Fund, Suva, Fiji. McFadzien, D., F. Areki, T. Biuvakadua and M. Fiu (2005)		The **toolkit** presents 14 methodologies that are an adaptation of participatory techniques WWF-South Pacific has used over the years in community resource conservation and development projects. It gives facilitators a clear sense of process when trying to elicit information specific to impacts of climate change and developing appropriate community response measures to them.			
					WEAP - Water Evaluation and Planning system	http://www.weap21.org/	WEAP is a user-friendly **software tool** that takes an integrated approach to water resources planning. It comprises a water balance database, a scenario generation tool, and a policy analysis tool.			
					Pacific Climate Futures Version 2.0	http://www.pacificclimatefutures.net/en/	Pacific Climate Futures Version 2.0 is a free **web-based climate impacts decision-support tool** that provides national and some sub-national climate projections for East Timor and 14 Pacific countries. Pacific Climate Futures has three levels of detail: A **basic interface** provides a summary of the projected changes in annual temperature and rainfall and is accessible for everyone; **Intermediate level** provides access to a guided interface to generate climate projections tailored to an impact assessment; **Advanced level** provides more flexibility to the user along with additional options for exporting data for use in risk assessments.			
					PROVIA / MEDIATION Adaptation Pathfinder	http://www.mediation-project.eu/platform/apf_entry/entry_point.html	The PROVIA / MEDIATION Adaptation Pathfinder is a **web-based decision support guide** for monitoring and evaluating adaptation. The guidance provides a framework for considering the full range of approaches to VIA. The structure is based on a five-stage iterative adaptation learning cycle: 1) identifying adaptation needs; 2) identifying adaptation options; 3) appraising adaptation options; 4) planning and implementing adaptation options; and 5) monitoring and evaluation of adaptation.			
					SimCLIM	www.climsystems.com	A **software package** that links data and models in order to simulate the impacts of climatic variations and change, including extreme climatic events on i.e. agriculture, health, coasts or water resources. SimCLIM is an “open-framework” system that can be customised and maintained by users. It contains tools for importing and analysing both spatial (monthly, seasonal) and time-series (hourly, daily or monthly) data.			
					Assessment and Design for Adaptation to climate change – A Prototype Tool (ADAPT)	https://climatescreeningtools.worldbank.org/	ADAPT is a **software-based multi-sectoral tool for screening development projects** for potential sensitive areas to climate change. The tool brings together climate databases and expert assessments on the threats and opportunities arising from climate variability/change and focuses primarily on agriculture, biodiversity, rural infrastructure and coastal zones.			
					Costing Nature (Co$ting Nature)	http://www.policysupport.org/costingnature	Co$ting Nature is a **web-based tool** for the analysis of ecosystem services provided by natural environments, identification of service beneficiaries and assessment of the impacts of human interventions.			
					Ecosystem Valuation Tool	http://www.eartheconomics.org/ecosystem-valuation-toolkit/	A **web-based tool** designed for non-economists to address questions about the benefits of ecosystem conservation, preservation or restoration. It provides a clear, non-technical explanation of ecosystem valuation concepts, methods and applications.			

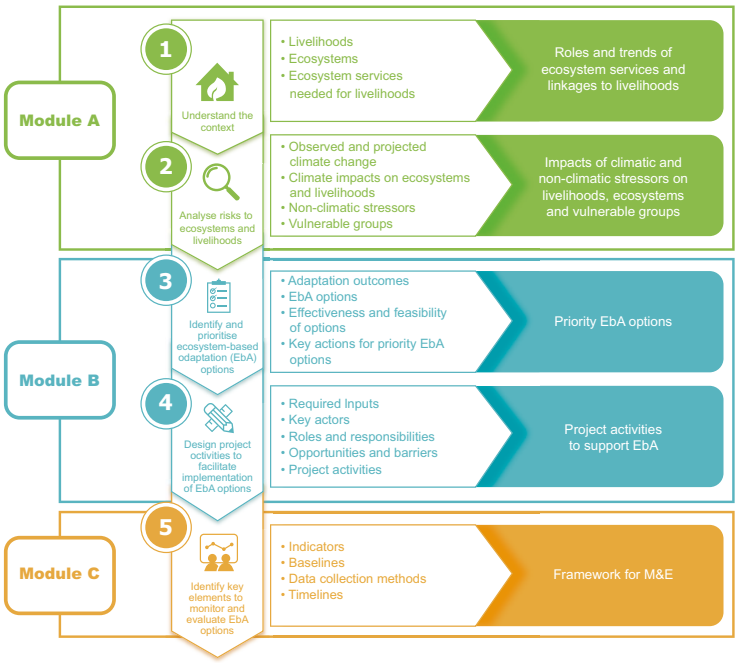
The EbA Planning Tool 'ALivE: Adaptation, Livelihoods and Ecosystems'

'ALivE' aims to provide practitioners with a systematic process to identify and prioritise EbA options based on a context-specific analysis of ecosystems, livelihoods and climate change, in a broader effort to encourage greater uptake of effective EbA approaches. The tool and associated user manual seek to assist with the design, implementation and monitoring of EbA measures to address risks from climate variability to vulnerable people and their livelihoods, by using ecosystems and ecosystem services. Through a structured analysis, users identify and understand the climate vulnerability of livelihoods and people and how critical ecosystems and ecosystem services can reduce these vulnerabilities and improve adaptive capacities. Moreover, the user will understand how climate change and non-climatic stressors will affect the supply of ecosystem services that provide critical support for adaptation. This will facilitate the selection of options for restoring, conserving and managing ecosystems to reduce peoples' vulnerability to climate change and build ecosystem resilience.

ALivE specifically aims to enable users to:

1. Understand and analyse linkages among ecosystems, livelihoods and climate change.
2. Identify and prioritise EbA options for community and ecosystem resilience.
3. Design project activities that facilitate implementation of priority EbA options.
4. Identify key elements and indicators for a monitoring and evaluation framework.

The primary users of the tool are expected to be project managers and practitioners working at the local level designing or implementing an EbA intervention. The users will work closely with a range of stakeholders, including community members, local authorities, non-government organisations and policy-makers. Their engagement through participatory processes provides the necessary information that will be entered into the tool and validation of the results of the analysis.



ALivE is developed under the GEF-funded 'Enhancing Capacity, Knowledge and Technology Support to Build Climate Resilience of Vulnerable Developing Countries (EbA South) Project' in partnership with IISD and IUCN. EbA South is implemented by UN Environment and executed by the National Development and Reform Commission of China (NDRC), through the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences. For more information: http://www.iisd.org/project/ALivE

5.3 Criteria for selecting tools

In the presence of many tools supporting the planning and implementation of EbA, it is essential to select the most appropriate one for the research. Table 11 elaborates general criteria for guiding the selection process. These criteria include the main research purpose (e.g. impact assessment, vulnerability assessment); the objective, scope, and limitations of the tool; and the data that are required and the data that are available.

Table 11. List of criteria for assessing and selecting EbA tool

Is it simple to use or does it require training or other inputs?	Estimate the usability of the tools by looking through the accompanying documentation. In some cases, it will be indicated the time and amount of data collection needed as well as whether training is required.
Is there evidence of application?	It is helpful to examine case studies where the tool has been applied. You may consult the documentation of the tool or contact the developers of the approach to receive this information.
Does it consider relevant social, environmental and economic issues and impact analysis?	This is fundamental – because EbA must be in line with and promote sustainable development.
Does it consider issues related to gender and minority groups?	Because vulnerability is differential, it is likely that women and minority groups will be the most vulnerable to climate change in many cases. Thus, it is important that the selected tool can consider gender aspects wherever possible.
Does it involve stakeholder participation?	Stakeholder participation is vital to ensure ownership; hence effectiveness and success of an adaptation plan.

6. JOURNALS, CONFERENCES AND FUNDING FOR EBA RESEARCH

6.1 Choosing a journal for publishing EbA research

Peer-reviewed publications can be submitted in different formats including:

- Full articles contain significant data, details, developments, and outcomes.
- Letters and rapid or short communications are intended for the quick and early communication of significant advances, without including too much data or detail.
- Review papers summarise recent developments on a specific topic, bringing the audience up to date without introducing new data. These are often commissioned by the publisher and written by a recognised expert.

There are a number of international journals suitable for publishing EbA-relevant research. The thematic areas most relevant to EbA include climate change, environmental management and economics. This is not exclusive of other disciplines. Below are lists of some of the most relevant journals.

Climate Change Science and Policy journals

Table 12. Journals on climate change science and policy relevant to EbA research

Name	Publisher	Link
Climate Change	Springer	http://www.springer.com/earth+sciences+and+geography/atmospheric+sciences/journal/10584
Climate Change Responses	Springer	https://www.springer.com/gp/life-sciences/ecology
Mitigation and Adaptation Strategies of Climate Change	Springer	http://www.springer.com/earth+sciences+and+geography/atmospheric+sciences/journal/11027
Climate Risk Management	Springer	http://www.journals.elsevier.com/climate-risk-management/
Wiley Interdisciplinary Reviews (WIREs): Climate Change	Wiley	http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1757-7799
Climate and Development	Tandfonline	http://www.tandfonline.com/toc/tcld20/current#.VdsYe9NViko Journal of Sustainable Agriculture
Climate Policy	Tandfonline	http://www.tandfonline.com/toc/tcpo20/current#.Vdtr9tNViko
Climate Vulnerability	Elsevier	https://www.elsevier.com/books/climate-vulnerability/pielke-sr/978-0-12-384703-4

Environmental Management journals

Table 13. Journals on environmental management relevant to EbA research

Name	Publisher	Link
Current Opinion in Environmental Sustainability	Elsevier	https://www.journals.elsevier.com/current-opinion-in-environmental-sustainability
Sustainability Science	Springer	https://link.springer.com/journal/11625
Regional Environmental Change	Springer	http://www.springer.com/environment/global+change+-+climate+change/journal/10113
Environmental Development	Elsevier	http://www.journals.elsevier.com/environmental-development/
Global Environmental Change	Elsevier	http://www.journals.elsevier.com/global-environmental-change/
Estuaries and Coasts	Springer	http://link.springer.com/journal/12237
Journal of Mountain Science	Springer	http://link.springer.com/journal/11629
Ambio	Springer	http://link.springer.com/journal/13280
Land Degradation & Development	Wiley	http://eu.wiley.com/WileyCDA/WileyTitle/productCd-LDR.html
Global Ecology and Biogeography	Wiley	http://eu.wiley.com/WileyCDA/WileyTitle/productCd-GEB.html
Earth Surface Processes and Landforms	Wiley	http://eu.wiley.com/WileyCDA/WileyTitle/productCd-ESP.html
Journal of Environmental Planning and Management	Tandfonline	http://www.tandfonline.com/toc/cjep20/current#.VdttBtNViko
Local Environment	Tandfonline	http://www.tandfonline.com/toc/cloe20/current#.VdtsT9NViko
Coastal Management	Tandfonline	http://www.tandfonline.com/toc/ucmg20/current#.VdtsttNViko
Ecological Complexity	Elsevier	https://www.journals.elsevier.com/ecological-complexity
Ecological Modelling	Elsevier	https://www.journals.elsevier.com/ecological-modelling
Ecology and Society	---	https://www.ecologyandsociety.org

Economics journals

Table 14. Journals on economics relevant to EbA research

Name	Publisher	Link
Economics of Disasters and Climate Change	Springer	http://www.springer.com/economics/environmental/journal/41885
Ecological Economics	Elsevier	https://www.journals.elsevier.com/ecological-economics/
Journal of Development Economics	Elsevier	https://www.journals.elsevier.com/journal-of-development-economics
Journal of Environmental Economics and Management	Elsevier	https://www.journals.elsevier.com/journal-of-environmental-economics-and-management

To consult more on relevant journals:

- Elsevier: https://www.elsevier.com
- Springer: http://www.springer.com/gp/
- Taylor and Francis: https://www.tandfonline.com

6.2 Presenting EbA research at conferences

Graduate and post-graduate students, as well as young researchers, are highly encouraged to present research findings at national, regional and international scientific conferences. The value of attending such meetings and presenting research advances and outcomes includes:

- Improving the communication of research outcomes and promoting a more interactive format to encourage research uptake.
- Contributing to and learning about the most recent advances in EbA-relevant fields.
- Communicating and advocating the importance of conducting EbA research.
- Learning how to discuss about EbA specific research with a broader audience, who may or may not be familiar with the topic.
- Meeting other researchers from the field and developing networks.
- Receiving feedback on your EbA research.

There are two conventional formats for presentations at academic conferences, either with an oral presentation or a poster. Oral presentation usually lasts 15–20 minutes, while poster presentation is 3–5 minute-long. A list of the major international conferences on climate change, ecosystem and biodiversity conservation relevant to EbA is presented below.

Climate change

1) Adaptation Futures

Adaptation Futures is the biennial conference of the Global Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA). The objectives of Adaptation

Futures include to: (i) facilitate dialogue between research and government, civil society, international agencies and business; (ii) continue the shift from problem diagnosis to solutions and innovations; and (iii) link adaptation action to sustainable development, investment and planning.

2) International Conference on Community-based Adaptation

The International Conference on Community-based Adaptation (CBA) is an annual conference focuses on empowering communities to use their own knowledge and decision-making processes to take action on climate change. The conference is designed for practitioners, policy-makers, planners and donors working on CBA at all levels and scales. In the last three CBA conferences it is being recognised the link between CBA and EbA, thus both approaches are presented and discussed at the conference.

3) Actions for a Sustainable World: From Theory to Practice

The International Sustainable Development Research Society (ISDRS) Conferences represent a valuable occasion to discuss opportunities and challenges for a sustainable future bringing together the academic community and other stakeholders from around the world. A special session on biodiversity and ecosystem services takes place at the conference.

4) International Conference on Climate Change: Impacts & Responses

International Conference on Climate Change: Impacts & Responses features research addressing the following annual themes: scientific evidence; the assessment of impacts in divergent ecosystems; human impacts and impacts on humans; technical, political and social responses. Conference partners include: the International Institute for the Inclusive Museum (IIIM); the Vietnam National University (VNU); VNU University of Science; and the Global Sustainability Institute (GSI).

Ecosystem and biodiversity conservation

1) Ecosystem Services Partnership Conferences

The Ecosystem Services Partnership aims to facilitate discussion and cooperation amongst those working in the field of ecosystem services, and its members especially. There is one global conference and several regional ones (e.g. Latin America and the Caribbean, Asia, Eastern Europe, Africa)

2) International Conference on Restoration Ecology and Ecosystem Services

The International Conference on Restoration Ecology and Ecosystem Services aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Restoration Ecology and Ecosystem Services. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Restoration Ecology and Ecosystem Services.

3) International Conference on Biodiversity, Ecology and Conservation of Marine Ecosystems

The International Conference on Biodiversity, Ecology and Conservation of Marine Ecosystems

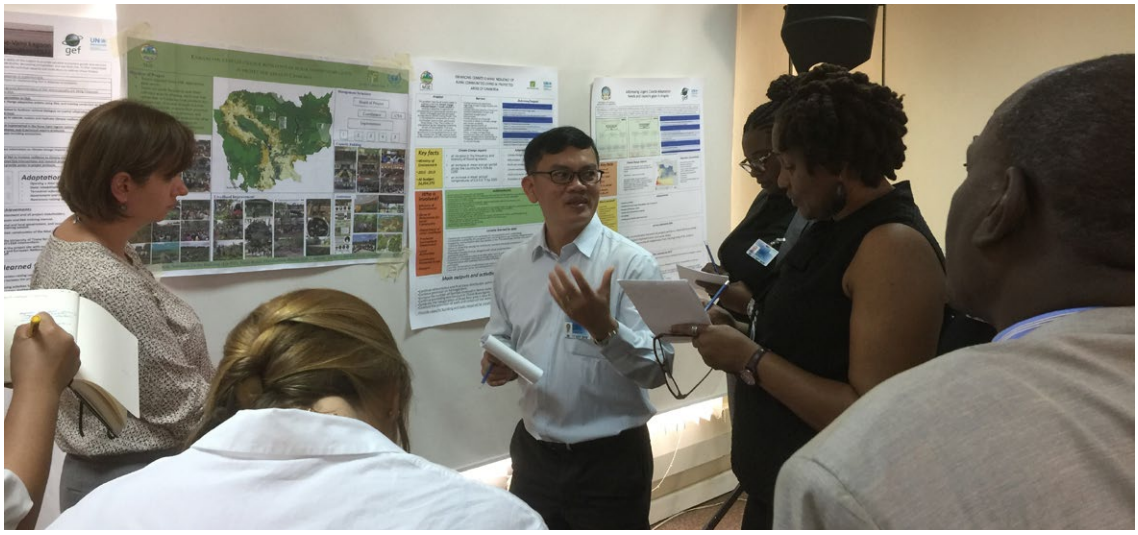
provides a venue for researchers and practitioners to share knowledge and experiences on most recent innovations, trends, and concerns as well as define new research gaps and practical challenges in the field.

4) International Marine Conservation Congress

The Society for Conservation Biology's International Marine Conservation Congress (IMCC) brings together conservation professionals and students to develop new and powerful tools to further marine conservation science and policy.

5) International Conference on Remote Sensing and Geoinformation of Environment

This conference provides a space where leading experts in the field of remote sensing and geo-information can network and further their work. The Technical Program is open to all topics in remote sensing and geo-information of environment and related techniques and applications.



6.3 Funding opportunities for EbA research

To build the capacity of the EbA research community, it is essential to secure funding necessary for implementing research activities. Available funding for research can be divided in three categories depending on the scale and complexity of the research (e.g. research under concrete EbA intervention project, master thesis, doctoral thesis). The three broad categories include:

1. Funds for research fellowships and training – the funding has the objective to support students to complete an academic exchange programme and training in the period between 3 – 12 months.
2. Awards for research – the award is granted to researchers based on outstanding achievements either for completed research or for an innovative proposal for a future research.
3. Funds for research projects – the funding has the objective to support research as part of concrete EbA project usually with duration between 2 – 4 years.

Table 15 below presents an overview of some of the well-known research funding opportunities with relevance to EbA.

Global and regional research networks

Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA)

CARIAA supports collaborative research by four consortia, each addressing a particular climate change hot spot. Each consortium has selected study areas based on geographic and social similarities in the way they experience climate change despite being spread across different countries and continents. This model provides opportunities for institutions with varying expertise and geographic scope to come together to share knowledge and experience across disciplines, sectors, and geographic areas.

Table 15: List of research funds relevant for EbA research

Name of the fund	Website	Relevant topics	Focus geographic area	Descriptions
Funds for research fellowships				
Trees and People: Resilience in a changing climate – John G. Bene Fellowship International Development Research Center (IDRC)	https://www.idrc.ca/en/funding/trees-and-people-resilience-changing-climate-john-g-bene-fellowship-2018	Climate change, forestry, natural resources, agriculture	Canada	This call is open to Canadians and permanent residents of Canada pursuing master's or doctoral studies at a Canadian university. Duration: 3 – 12 months Deadline: mid-June
International Climate Protection Fellowship Humboldt Foundation	https://www.humboldt-foundation.de/web/41145096.html	Climate change, natural resources, governance	Open to all nationalities and the fellowship is located in Germany	With the International Climate Protection Fellowships, the Alexander von Humboldt Foundation enables prospective leaders in academia and industry to implement a research-based proposal in the field of climate protection or climate-related resource conservation during a one-year stay in Germany. Up to 20 International Climate Protection Fellowships are granted annually. A requirement is to have a B.Sc. degree. Duration: 12 months Deadline: annually 1st March

Abe Fellowship Program Social Science Research Council (SSRC) - USA	https://www.ssrc.org/fellowships/view/abe-fellowship/	Threats to personal, societal, and international security; growth and sustainable development; social, scientific, and cultural trends and transformations; governance, empowerment, and participation	United States and Japan as well as nationals of other countries who can demonstrate strong and serious long-term affiliations with research communities in Japan or the United States	The SSRC and the Japan Foundation Center for Global Partnership (CGP) announce the annual Abe Fellowship Program competition. The Abe Fellowship is designed to encourage international multidisciplinary research on topics of pressing global concern. The program seeks to foster the development of a new generation of researchers who are interested in policy-relevant topics of long-range importance and who are willing to become key members of a bilateral and global research network built around such topics. Duration: 3 – 12 months Deadline: annually 1st September
Awards for research				
IDRC Doctoral Research Award	https://www.idrc.ca/en/funding/idrc-doctoral-research-awards-2018	Agriculture and environment, innovation	Canada	This call is open to Canadians and permanent residents of Canada pursuing doctoral studies at a Canadian university. Duration: 3 – 12 months Deadline: end May
Case study competition on adaptation and ecosystem conservation	https://climatechangeresearch.network/nccarf/case-study-competition-3-000-prize-for-projects-supporting-measures-that-address-climate-change-risks-and-impacts-on-australian-biodiversity	Climate change, biodiversity	Open to all participants but the case study presented should come from Australia	The Natural Ecosystems Network invites students, researchers or practitioners to submit original case studies for projects that demonstrate climate change adaptation activities that are supporting adaptation, or resulting in practical action and outcomes. The objective of this competition is to demonstrate how research, planning, or actions focusing on addressing risks and impacts on Australian biodiversity can inform adaptation strategies for conservation programs. The winning organisations will be awarded $3,000 to support their conservation initiatives. Up to four projects will be supported.

Funds for research projects				
International Development Research Center (IDRC)	https://www.idrc.ca/en/initiative/canadian-international-food-security-research-fund	Agriculture and food security, climate change, forestry, environment, health, livestock	Canada and Low- and lower-middle-income countries in Asia, Africa, Latin America, and the Middle East	IDRC offers grants, funding, and awards to researchers and institutions to find solutions for global development challenges. Deadline: depend on each call.
Conservation, Food and Health Foundation	http://cfhfoundation.grants management08.com	Natural resource conservation, production and distribution of food and public health	Low- and lower-middle-income countries in Asia, Africa, Latin America, and the Middle East	The Foundation provides funding for training personnel from developing countries to strengthen local leadership and scientific capacity and initiatives that inspire change. It focuses on regional or cross-boundary issues and opportunities and feature collaborative partnerships embedded in strong networks Deadline: annually 1st January and 1st July.
Economic and Social Research Council (ESRC)	https://esrc.ukri.org/funding/funding-opportunities/	Economy and business, environment, health and wellbeing, politics and governance, public services, society	In general open to all regions but sometimes the call is specific for some countries.	There are useful resources to guide the development of research proposals. Deadline: depend on each call.
British Ecological Society	https://www.britishecologicalsociety.org/funding/research-grants/	Ecology	Open to all regions	These grants support scientific ecological research where there are limited alternative sources of funding. Small projects can be awarded up to £5,000 and early career ecologists can apply for funding up to £20,000. The applicant should be a member of BES. Deadline: annually mid-March and mid-July

National Research Foundation of Singapore	https://www.nrf.gov.sg/funding-grants/international-grant-calls	Ecology, biology, innovation	In general open to all regions but sometimes the call is specific for some countries.	Provides a range of funding opportunities on diverse topics for both individual researchers and research organisations. Deadline: depend on the call.
The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS)	http://www.formas.se/en/Financing/Calls-For-Proposals/	Environment, agricultural sciences and spatial planning, climate change	Open to all regions	FORMAS has annual open call in three sub-calls: - Research and development projects - Research and development projects for future research leaders - Mobility grants The latter two sub-calls are targeted to, and can only apply by, researchers early in their careers. The purpose of the mobility grant is to encourage researchers who have recently been awarded their doctoral degrees to visit new research environments. Deadline: annually 12th April
Newton Fund United Kingdom Government	https://www.britishcouncil.org/education/science/newton	Climate change, ecosystem management	Indonesia, Thailand, Vietnam, Mexico, Kazakhstan, Egypt, India, Malaysia, Colombia, Brazil, Philippines, Chile, South Africa, Turkey, United Kingdom, China, Kenya	Through the Newton Fund, the UK will use its strength in research and innovation to promote the economic development and social welfare of partner countries. By working together on bi-lateral and multi-lateral programmes with a research and innovation focus, the UK will build strong, sustainable, systemic relationships with partner countries. This will support the continued excellence of the UK research base and innovation ecosystem and act as a key to unlock opportunities for wider collaboration and trade.

7. RECOMMENDATIONS

Drawing on the previous sections, the following recommendations for research activities on EbA can be made. These recommendations are mostly targeted at junior researchers involved in advancing EbA research.

Address uncertainties. Uncertainties will remain an inherent factor to research on adaptation and EbA in particular. Therefore, it should be acknowledged and taken into account in research design and process to support decision-making effectively. Researchers should communicate uncertainties with practitioners, policy- and decision-makers and provide guidance on how they can deal with it.

Develop and test tools and methods. There will be a constant need for the development and provision of new research tools and methods on EbA. It is also necessary to update existing ones as understanding improves and the environment and socio-economic circumstances change. The new and existing tools and methods need to be pilot-tested in the field to assess their value and efficiency as well as to identify those best suited to specific needs and contexts.

Ensure active participation, integration of local, traditional knowledge, and incorporate gender- and rights-based considerations. Research on EbA requires a multi-stakeholder, participatory process that includes a gender- and rights-based approach; and all those elements are essential for long-term success of an adaptation process. The reason is that it allows for the recognition of diverse interests and needs as well as the exchange of different knowledge relevant to the issue at hand. Researchers need to ensure the integration of local, traditional knowledge of communities, promote gender equity, and support a higher representation of women in both the decision-making and implementation processes for adaptation initiatives.

Interdisciplinary dialogue and collaboration are ones of the crucial means for introducing EbA in different research lines. A high level of collaboration and cooperation between researchers in different disciplines is required. This will allow for the identification of robust, no-regret EbA options through iterative processes of action learning and transdisciplinary thought.

Strengthen action learning and knowledge management. Managing knowledge and undertaking action learning are vital in supporting EbA research throughout the entire process. These actions need to be strengthened to: (i) efficiently guide projects; (ii) influence policy; (iii) enhance collaboration and coordination between organisations, the public, private sectors and countries; (iv) improve understanding of EbA; and (v) increase awareness. These processes also involve the joint development of research needs and consensus building among researchers, practitioners and policy-makers.

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ANNEX I: ADDITIONAL READINGS

This annex provides a list of materials that may be useful to users of this guide. The list is structured based on the sections and steps of the guide. Descriptions are provided to give the reader an overview of the material and to make reference to the specific step within the guide.

2. Key concepts

2.1 Climate change

1) Fifth Assessment Report of the Intergovernmental Panel on Climate Change (AR5): https://www.ipcc.ch/report/ar5/

2) Managing the Risks of Extreme Events and Disasters to Advance Climate Adaptation (SREX): http://www.ipcc.ch/report/srex/

2.3 Ecosystem-based Adaptation (EbA)

1) EbA Handbook (IUCN, 2016): https://www.iucn.nl/files/klimaat_water_voedsel/eba_handbook.pdf

2) Ecosystem-based adaptation: a handbook for EbA in mountain, dryland and coastal ecosystems (UNEP-IEMP and IIED, 2018): http://pubs.iied.org/pdfs/17460IIED.pdf

3) Constructing theories of change for ecosystem-based adaptation projects (Conservation International, 2013):

https://www.conservation.org/publications/Documents/CI_IKI-ToC-Guidance-Document.pdf

4) Making Ecosystem-based Adaptation Effective: A Framework for Defining Qualification Criteria and Quality Standards (FEBA, 2017):

https://www.iucn.org/sites/dev/files/feba_eba_qualification_and_quality_criteria_final_en.pdf

5) Convenient Solutions to an Inconvenient Truth: Ecosystem-based Approaches to Climate Change (World Bank, 2009): https://openknowledge.worldbank.org/handle/10986/2686

6) Ecosystem-based Adaptation Flagship Programme: http://www.adaptation-undp.org/projects/mountain-eba

7) Ecosystem Based Adaptation Guidance – Moving from Principles to Practice (Travers et al., 2012): https://www.researchgate.net/profile/Carmen_Elrick-Barr/publication/287319167_Ecosystem-based_Adaptation_Moving_from_Policy_to_Practice/links/5675492008aebcdda0e446c3/Ecosystem-based-Adaptation-Moving-from-Policy-to-Practice.pdf?origin=publication_detail

8) Ecosystem-based Adaptation: a natural response to climate change (Colls et al., 2009): https://www.iucn.org/content/ecosystem-based-adaptation-natural-response-climate-change

9) Draft Principles and Guidelines for Integrating Ecosystem-based Approaches to Adaptation in Project and Policy Design: a discussion document (Andrade et al., 2011): https://portals.iucn.org/library/sites/library/files/documents/2011-063.pdf

10) Framework for assessing the evidence for the effectiveness of Ecosystem- based approaches to adaptation (Munroe et al., 2011): http://www.cambridgeconservation.org/collaboration/effectiveness-ecosystem%E2%80%90based-approaches-adaptation-critical-review-current-evidence

11) Operational Guidelines on Ecosystem-based Approaches to Adaptation (GEF, 2012): https://www.thegef.org/sites/default/files/council-meeting-documents/Operational_Guidelines_on_Ecosystem-Based_Approaches_to_Adaptation_4.pdf

12) Building Resilience to Climate Change. Ecosystem- based adaptation and lessons from the field (Pérez et al., 2010): https://portals.iucn.org/library/sites/library/files/documents/CEM-009.pdf

13) Ecosystem-based Adaptation: a Guiding Framework for decision-making criteria (ICLEI): http://durbanadaptationcharter.org/wp-content/uploads/2015/06/Urban-EBA-Guiding-Decision-Making-Framework-2013.pdf

14) Harnessing nature to help people adapt to climate change (Jones et al., 2012): https://people.ucsc.edu/~zavaleta/pubs/Jones_NatureClimate_2012.pdf

15) Guidance on Integrating Ecosystem Considerations into Climate Change Vulnerability and Impact Assessments to Inform Ecosystem-based Adaptation, UNEP-WCMC, Cambridge, UK. (Monroe et al., 2015): http://adaptation-undp.org/sites/default/files/downloads/viag_guidance.pdf

3. Research aspects of Ecosystem-based Adaptation (EbA)

3.1 Embedding EbA in interdisciplinary and transdisciplinary research

1) Ecosystem Services as a Boundary Concept: Arguments from Social Ecology

Schleyer, C., Lux, A., Mehring, M., and Görg, C. (2017): http://www.mdpi.com/2071-1050/9/7/1107/htm#B49-sustainability-09-01107

4. A step-wise process to conduct EbA research

Step 2. Research methodology

The knowledge platform Oppla (www.oppla.eu) aims at providing access to a wide range of resources on natural capital, ecosystem services and nature-based solutions. It promotes tools

that provide assistance in finding methods and approaches fit for purpose in a broad range of management and policy-making contexts, in different social-ecological systems and institutional contexts. The tools include (http://www.guidetoes.eu):

- Decision Trees (DTs) for structuring the process of selecting ecosystem services assessment methods - A set of linked decision trees has been developed which aims to provide guidance to researchers and practitioners in choosing bio-physical, socio-cultural and monetary ecosystem service assessment methods that are suitable for their context.
- Bayesian Belief Network (BBN) tool – for filtering different bio-physical, socio-cultural and monetary assessment methods according to a user's needs. Oppla has been developed jointly by the OpenNESS (www.open-ness-project.eu) and OPERAs (www.operas-project.eu) projects.
- German, L. a., Tiani, A. M., Daoudi, A., Maravanyika, T. M., Chuma, E., Jum, C., and Yitamben, G. (2012). The Application of Participatory Action Research to Climate Change Adaptation in Africa: a reference guide: http://r4d.dfid.gov.uk/Output/189934/Default.aspx

Step 3. Data collection and analysis

Slocum, N. (2003). Participatory Methods Toolkit. A Practitioner's Manual, UNU-CRIS, King Baudouin Foundation, Flemish Institute for Science and Technology Assessment, Brussels.

Community Tool Box – bringing solutions to light: https://ctb.ku.edu/en

Peh et al. (2013). Toolkit for Ecosystem Service Site-based Assessment (TESSA). Cambridge, UK: http://tessa.tools/

Step 4. Effective communication for EbA research uptake

Communication and reporting

The Communication, Education, and Public Awareness (CEPA) programme of the Convention on Biological Diversity (CBD) has produced a toolkit that is freely available here: http://www.cbd.int/cepa/toolkit/2008/cepa/guide.htm

Peh et al. (2013). Toolkit for Ecosystem Service Site-based Assessment (TESSA). Cambridge, UK. http://tessa.tools/

A framework template for presenting the results of Natura 2000 site-based ecosystem service assessments is provided in Ch. 7 of Kettunen et al. (2011). Assessment of the Natura 2000 co-financing arrangements of the EU financing instrument. A project for the European Commission – final report. Institute for European Environmental Policy (IEEP), Brussels, Belgium.

http://ec.europa.eu/research /science-society/science-communication/ index_en.htm

Ecological Society of America: Communicating Ecosystem Services http://www.esa.org/ecoservices/

https://ecosystemsknowledge.net/resources/guidance-tools

Uncertainty

The Intergovernmental Panel on Climate Change (IPCC) have produced a set of guidance notes for lead authors that outlines both qualitative and quantitative approaches to describe uncertainties. The standard terms used to define levels of confidence and the likelihoods of specific results are given in the IPCC Uncertainty Guidance Note. For more information, see: https://wg1.ipcc.ch/publications/supportingmaterial/uncertainty-guidance-note.pdf

For similar approaches, see the UKNEA (2011) in which key findings are presented alongside qualitative uncertainty terms derived from a 4-box model and complemented, where possible, with a likelihood scale. Estimates of certainty are derived from the collective judgement of authors, observational evidence, modelling results and/or theory examined as part of the assessment.

Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy. Research overview and overarching questions Nathalie Seddon, Hannah Reid, Edmund Barrow, Charlotte Hicks, Xiaoting Hou-Jones, Val Kapos, Ali Raza Rizvi, Dilys Roe (2016), IIED Report

Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy (2015), IIED, IUCN and UNEP-WCMC Project flyer (en français | en Español)

ANNEX II: EBA CRITERIA AND PRINCIPLES

IUCN, WWF, CARE and others (Andrade et al. 2011)	General principles of EbA: 1. Promotes the resilience of both ecosystems and societies. 2. Promotes multi-sectoral approaches. 3. Works at multiple geographic scales. 4. Integrates flexible management structures that allow adaptive management. 5. Minimises offsets and maximises benefits with development and conservation goals to avoid unintended negative social and environmental impacts. 6. Is based on the best scientific and local knowledge available, and promotes the generation and dissemination of knowledge. 7. Refers to resilient ecosystems, and the use of nature-based solutions to benefit people, especially the most vulnerable.
UN Environment (2013)	Criteria for EbA (and microfinance - MEBA): 1. Reduces the pressure on ecosystems and the services they provide. 2. Increases the social or economic resilience of human populations vulnerable to climate change. 3. Reduces risks associated with climatic events in productive activities. 4. Protects, restores or uses biodiversity and ecosystems in a sustainable manner. 5. Has a positive impact on the economy of people in the short term.
IUCN (Rizvi 2014)	Criteria to evaluate if a given project pertains to the EbA approach: 1. Assessments of climate vulnerability and risk have been (or will be) undertaken. 2. Builds the adaptive capacities for EbA of the population and local institutions. 3. Integrates local knowledge and institutions with respect to the management and adaptation of risks, the use of biodiversity and ecosystem services. 4. Improves the governance of land / water / natural resources and biodiversity with respect to adaptation to climate change. 5. Includes practices that use appropriate species and technologies better adapted to climate change. 6. Supports the restoration of ecosystems with species better adapted to climate change and thus improves connectivity in the landscape, as well as the resilience of ecosystems and the maintenance of their services. 7. Supports the maintenance of ecosystem services, e.g. watershed management, in a manner that actively takes into account climate risk. 8. Preserves biodiversity and manages the threats associated with it in the context of climate change. 9. Diversifies land use and livelihood options (including crop diversification) to reduce risk and improve resilience to climate change. 10. Improves the management of seasonal movements of people and livestock between winter and summer to better protect ecosystem services and the biodiversity against climate impacts. 11. Actively protects and restores the natural infrastructure to reduce the risk of climate impacts.

UN Environment, UNDP and IUCN (Rossing 2015)	For a measure to be qualified as EbA it should: 1. Manage, conserve and restore climate-resilient ecosystems. 2. Help people adapt to the adverse effects of climate change. 3. Reduce climate risks and hazards. 4. Work at multiple geographic scales. 5. Improve knowledge and develop capabilities. 6. Promote governance.
FEBA, 2017 Three elements and five criteria that help answer the question: Is the approach EbA or not?	The EbA principles represent the key elements of the CBD (2009) definition. Each principle contains at least one criterion: **Element A:** EbA helps people adapt to climate change Criterion 1: Reduces social and environmental vulnerabilities Criterion 2: Generates societal benefits in the context of climate change adaptation **Element B:** EbA makes active use of biodiversity and ecosystem services Criterion 3: Restores, maintains or improves ecosystem health **Element C:** EbA is part of an overall adaptation strategy Criterion 4: Is supported by policies at multiple levels Criterion 5: Supports equitable governance and enhances capabilities

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