



## Ecosystem Based Adaptation:

Knowledge Gaps in Making an Economic Case for Investing in Nature Based Solutions for Climate Change



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# Ecosystem Based Adaptation:

## Knowledge Gaps in Making an Economic Case for Investing in Nature Based Solutions for Climate Change

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April 2015

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# Contents

<b>Foreword.....</b>	<b>i</b>
<b>Acknowledgements.....</b>	<b>iii</b>
<b>Executive Summary.....</b>	<b>v</b>
<b>Introduction .....</b>	<b>1</b>
Climate Change and Ecosystems Based Adaptation .....	1
Valuing EbA Projects .....	2
The Study .....	3
<b>Costa Rica .....</b>	<b>5</b>
Country Profile and Existing Climate Trends.....	5
Future Climate Scenarios and Impacts .....	6
Economic Analysis of EbA Measures.....	7
<b>India .....</b>	<b>10</b>
Country Profile and Existing Climate Trends.....	10
Future Climate Scenarios and Impacts .....	11
Economic Analysis of EbA Measures.....	12
<b>Mexico.....</b>	<b>17</b>
Country Profile and Existing Climate Trends.....	17
Future Climate Scenarios and Impacts .....	18
Economic Analysis of EbA Measures.....	20
<b>Peru .....</b>	<b>22</b>
Country Profile and Existing Climate Trends.....	22
Future Climate Scenarios and Impacts .....	23
Economic Analysis of EbA Measures.....	24
<b>Philippines .....</b>	<b>26</b>
Country Profile and Existing Climate Trends.....	26
Future Climate Scenarios and Impacts .....	27
Economic Analysis of EbA Measures.....	29
<b>Tanzania .....</b>	<b>32</b>
Country Profile and Existing Climate Trends.....	32
Future Climate Scenarios and Impacts .....	33
Economic Analysis of EbA Measures.....	35

<b>Gap Analysis and Recommendations.....</b>	<b>37</b>
Lessons from TEEB .....	39
Economic Benefits and Costs of EbA.....	40
 <b>References.....</b>	 <b>43</b>

## Foreword

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Climate change is having increasingly adverse impacts on people and nature. It exacerbates existing environmental threats, poses new risks and impedes our ability to achieve global conservation and development objectives such as the Aichi Biodiversity Targets and the proposed Sustainable Development Goals. Across the globe, initiatives have been established to help communities implement approaches that enable them to adapt to climate change and mitigate its effects. Ecosystem-based Adaptation (EbA) is one such approach.

EbA uses biodiversity and ecosystem services as part of a larger adaptation strategy – an excellent example of a viable nature-based solution. As well as providing climate change adaptation benefits, this approach also contributes to biodiversity conservation and enhances local economies. IUCN has been extensively involved in EbA work, strengthening community resilience and livelihoods in almost 60 countries. This work demonstrates our ongoing commitment to the implementation of nature-based solutions.

The conservation and sustainable development community considers EbA to be a strong method of addressing climate change and its associated challenges. However, there is still a tendency for policy makers to implement traditional engineering solutions for adaptation, rather than investing in EbA. The need for solid data on the cost-effectiveness of this nature-based approach was the driver behind an IUCN study identifying the economic costs and benefits associated with EbA. The lessons learned from this appraisal process will make it easier for policy makers to compare EbA options with engineered solutions.

The study, which was carried out with the financial support of the French Government, reviewed projects and assessed existing data from Costa Rica, India, Mexico, Peru, the Philippines and Tanzania. The results show that there are still extensive knowledge gaps, and that further cost-benefit analysis work and field evidence is required to showcase more clearly the nature-based solutions that EbA offers to climate change. As an example, a cost-benefit analysis was carried out for the Kumbharwadi rain-fed watershed project in Maharashtra state, India, which invested in improved catchment and ecosystem management. One of the largest benefits of implementing such an ecosystem-based approach was improved crop production, which resulted in an increase in net agricultural income for the watershed from US\$ 69,000 per year to almost US\$ 625,000. A better understanding of the benefits of being ‘climate smart’ through the use of EbA will provide additional evidence to assist decision making at the local, national and global levels.

IUCN is very grateful to the French Ministry of Foreign Affairs and International Development (Ministère Français des Affaires Étrangères et du Développement International) for the financial support that made this important study possible. Thanks to additional funding from the French Government, a detailed economic analysis of adaptation projects in the Philippines will be

undertaken to further showcase field evidence on the economic effectiveness of nature-based solutions to climate change. This, IUCN hopes, will act as an incentive for other EbA projects to ensure that they carry out such analyses and further enhance the case for nature-based solutions.

A handwritten signature in black ink, appearing to read 'Inger Andersen', with a stylized, flowing script.

**Inger Andersen**  
IUCN Director General  
April 10, 2015



## Acknowledgements

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This report is a team effort with Ali Raza Rizvi, Saima Baig, and Michel Verdone undertaking the analysis and technical review; Kirstin van Riel assisted in data gathering and preliminary work; Shi Yi helped in data collection; Camille Buyck and Claire Pedrot translated the report into French; Marc Magaud liaised with the French Government; and Edmund Barrow provided overall support. Last but certainly not least; IUCN appreciates the support of the French Government without which this important study would not have been possible.







## Executive Summary

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Changes in global climate are increasingly having adverse impacts on human populations and natural systems. This has resulted in increased efforts to come up with options that can mitigate the impacts, as well as help to adapt to already occurring changes.

Ecosystem based adaptation is used by a number of organisations and in many developed and developing countries as a means for climate adaptation, especially at the community level. It is also applied for disaster risk reduction. Still, there is a propensity of policy makers to implement traditional engineering solutions for adaptation rather than investing in EbA. There is, therefore, a need to raise further awareness on the use of nature based solutions.

An important approach to promote investment in EbA is to identify its economic costs and benefits. This study therefore reviewed a number of projects in Costa Rica, India, Mexico, Peru, Philippines and Tanzania, to assess existing data and knowledge gaps regarding the economic values of EbA projects.

The literature review showed that climate change is likely to change the productivity and benefits from the agriculture, fisheries and forestry sectors. These sectors are important economic contributors to these countries and provide extensively to the national exchequer. Already, impacts are being observed in terms of lower yields and productivity as well as loss of livelihoods and security.

Cost-benefit analyses (CBA) of projects in these countries showed that EbA projects provided many benefits and in general helped to increase resilience and decrease vulnerabilities. However, it was clear that there were extensive knowledge gaps and detailed economic valuation/ CBA studies need to be undertaken to make a stronger case for ecosystems based adaptation. Currently, the studies are context specific, do not include opportunity costs and much of the benefits are in qualitative terms.

Detailed assessments will help to establish the importance of EbA, if they are based on robust methodologies that are developed with appropriate guidance; differentiate between different costs and sectors; incorporate biodiversity and species; are based on gender (and other groups) disaggregated data; and account for co-benefits. This can be undertaken at two scales: undertaking CBA before project initiation, to help stakeholders decide on investment options and actions. More importantly however, there is a need to undertake analyses of ongoing and completed projects in the studied countries, to understand and gather the evidence for the effectiveness of EbA projects as compared to other solutions.



# Introduction

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## Climate Change and Ecosystems Based Adaptation

Climate change associated events, together with unsustainable management of ecosystems, increase the vulnerabilities of people and nature by impacting them adversely. These impacts can be environmental (degradation, conversion, effects of increasingly frequent and severe events such as floods and droughts, and ecological changes), social (loss of adaptive capacities, knowledge and institutions; inability to manage for the scale and scope of changes; and loss of livelihood options and resilience), or economic (globalization, trade, markets). In addition, it is thought that the crisis is likely to impact different groups differently and is expected to affect women disproportionately. Natural disasters also tend to worsen the conditions faced by different groups such as women, children and the elderly.

Adaptation is now increasingly being seen as an important strategy (among others) to cope with a changing climate and its impacts. In response to these effects, countries are likely to invest in traditional options such as infrastructure for coastal defenses and flood control; and new irrigation facilities and reservoirs for water shortages (World Bank 2009). These options are likely to be costly and generally do not take the conservation of ecosystems and biodiversity into account.

Healthy, well-functioning

ecosystems enhance natural resilience to the adverse impacts of climate change and reduce the vulnerability of people. Ecosystem based Adaptation (EbA) offers a valuable yet under-utilized approach for climate change adaptation, complementing traditional actions such as infrastructure development. For example, *"floodplain forests and coastal mangroves provide storm protection, coastal defenses, and water recharge, and act as safety barriers against natural hazards such as floods, hurricanes, and tsunamis, while wetlands filter pollutants and serve as water recharge areas and nurseries for local fisheries"* (World Bank, 2009).

Ecosystem based Adaptation (EbA) uses biodiversity and ecosystem services as part of an overall adaptation strategy

to help people and communities adapt to the negative effects of climate change at local, national, regional and global levels. EbA recognizes the importance of equity, gender, and the role and importance of local and traditional knowledge as well as species diversity. In addition to protection from climate change impacts, it provides other co-benefits such as clean water and food for communities, risk reduction options and benefits and other services crucial for livelihoods and human well-being. Appropriately designed ecosystem adaptation initiatives can also contribute to climate change mitigation by reducing emissions from ecosystem degradation, and enhancing carbon sequestration.

An increasing number of governmental and nongovernmental organisations therefore, are implementing EbA activities. These organisations use diverse techniques for vulnerability

*"Ecosystem based Adaptation is 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...it aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of adverse effects of climate change."*

*Source: CBD 2009*

assessments and subsequent plans of action to enhance resilience. It is important to note that on many occasions, projects aiming at enhancing the climate resilience of communities through sustainable use of natural resources, are not necessarily labelled as EbA. Furthermore, in many cases, ecosystem management interventions are being implemented that would also result in increasing resilience and reducing vulnerabilities. Also, while it is possible in some cases to identify adaptation measures for specific climate impacts, in other cases this can only be done together with sustainable economic development options (Kumar *et al.*, 2011).

EbA provides a strategy that incorporates comprehensive measures that promote development through ecosystem management. While the role of ecosystems and the services they provide is increasingly being accepted, there are still questions regarding costs of implementing EbA projects. This calls for a strong effort to explore nature based adaptation options, how cost effective they are, and how the flow of co-benefits can be optimized in order to ensure that government and non-government organisations invest in them.

## Valuing EbA Projects

***"Ecosystem-based adaptation, which integrates the sustainable use of biodiversity and ecosystem services into an overall adaptation strategy can be cost-effective and generate social, economic and cultural co-benefits and contribute to the conservation of biodiversity."***(CBD, 2009)

From an economic perspective the case for ecosystem-based adaptation has to be made in comparison to other adaptation activities. EbA activities can produce a number of benefits for communities but there might be cases where other adaptation activities, including engineered solutions, may provide communities with more benefits for less cost. Although there are cases where hard engineering solutions for adaptation are necessary, there are many instances where nature based approaches provide cost effective and longer term solutions. In order to understand when EbA is a cost-effective approach, we need to examine the benefits of EbA activities relative to their costs in a number of ecological, institutional, and social settings.

Cost benefit analyses (CBA) of EbA based approaches can be useful in highlighting the cost effectiveness of EbA projects against hard engineering projects, especially when considering development priorities together with conservation and risk reduction aspects. However, while EbA is increasingly becoming popular, it is still a new enough field and as such there is a lack of data regarding the economic benefits provided by EbA projects and whether these benefits exceed the costs of implementation. This lack of information has hindered investment into EbA options, especially from developing countries, where communities are likely to be impacted the most by a changing climate.

In a policy note on the economics of climate change adaptation in India by Kumar *et al.* (2010:5), a proposed key research priority is the economics of EbA, as there is limited evidence regarding actual adaptation costs and benefits. Originally, research on adaptation costs was related to climate change impact studies, where the aim was to understand the expected value of avoided climate associated damages. Kumar *et al.*(2010) highlight studies by Agrawala and Fankhauser (2008), which point out that information on adaptation costs and benefits is limited with the exception of coastal protection.

There are other studies that investigate costs of adaptation, and the benefits thereof, in terms of reduced vulnerability and increased welfare. At the UNFCCC COP 20 in Lima, recommendations were provided by the Standing Committee on Finance on the 2014 biennial assessment of climate financial flows. This report stated that “*Climate finance aims at reducing emissions, and enhancing sinks of greenhouse gases and aims at reducing vulnerability of, and **maintaining and increasing the resilience of, human and ecological systems to negative climate change impacts.***” (UNFCCC 2014)

Recently, a small number of studies have been undertaken to show the benefits of EbA in economic terms against the cost of implementing these projects (Kumar *et al.*, 2010). Some studies have attempted to estimate short-term adaptation costs based on extending protected areas, broader conservation measures and off-reserve measures. Such responses however address current vulnerability and the case can be made that they would result in increased resilience to climate change (Watkiss *et al.*, 2010)

It is also important to understand how the benefits and costs of EbA are distributed, which helps to explain why people might invest in EbA activities and how further investment can be encouraged. People invest in EbA when the benefits outweigh the costs. In some cases the benefits and costs might go to the same person or group of people and if the benefits outweigh the costs they will invest in EbA. In other cases, the benefits and costs might be spread out amongst such a broad group of people that no single individual would have an incentive to invest in EbA because the individual would bear the costs while the benefits would be enjoyed by the broader group. Knowing how the benefits and costs of EbA are distributed can help identify economic policies, like subsidies and taxes, that can align individual incentives to achieve socially beneficial outcomes when they otherwise would not occur.

There is therefore a need to compare costs and benefits of EbA related projects to understand their economic implications in terms of their effects on local communities and ecosystems and to national economies. Such data would help to promote EbA related projects within countries and at global forums.

## The Study

With the above in mind and primarily relying on literature review, this study focuses on climate change impacts and future trends, and the economic benefits of ecosystems based adaptation approaches in Costa Rica, India, Mexico, Peru, Philippines and Tanzania. It contains information on many of the high-level mechanisms countries have put in place to encourage ecosystem-based adaptation to climate change. The profiles of each country and the associated future climate impacts help provide a picture of expected future climate scenarios facing them.

**The main purpose of this literature review was to identify knowledge gaps in EbA implementation in the select countries, in terms of understanding their economic costs and benefits.** The aim of this study is to highlight these gaps and to use this to make the case for detailed cost-benefit analyses of all the EbA projects being undertaken in these countries. Such analyses would help policy makers in poor/ developing countries to make informed decisions regarding implementing EbA approaches, which could subsequently result in mainstreaming EbA in the planning process.



The following sections provide an overview of the six countries. From here on, the study attempts to outline available data on the contribution of three economic sectors: agriculture, fisheries and forests, to the national economy. All of these sectors are extremely dependent on ecosystems services and are likely to be impacted most by climate change. The idea is to highlight their importance to these countries and to show that the adverse effects of climate change on these three (and other) sectors, could result in adverse impacts on their economies. This is followed by a review of the existing climate trends, future climate projections and how these changes are likely to affect these three sectors.

Subsequently, a brief overview of the economic value of natural resources and costs and benefits of some EbA interventions is provided. It needs to be pointed out that this is primarily a literature review relying on available economic and cost-benefit data and undertaking on-ground cost-benefit analysis (CBA) is beyond the scope of this document.

Ideally, the CBA of each project would be laid out by describing climate changes impacts on ecosystem services and how using nature based solutions for adaptation could increase the resilience of communities, with special emphasis on their economic costs and benefits. However, during the course of the research it was noted (and as mentioned above) that there were very few cost-benefit analyses of EbA projects available, especially in the selected countries. There were few well-defined baseline scenarios describing the impacts climate change has on natural capital stocks and ecosystem services and while costs of implementing EbA projects were available in some cases, there was almost no information regarding the economic benefits provided by the projects. This made it difficult to compare and contrast the costs and benefits of adaptation.

Therefore, in order to make the case for the importance of nature based solutions, studies providing general economic valuation data of natural resources in the countries have been reviewed. Wherever possible studies highlighting the cost and benefits of EbA solutions, as well as those indicating the co-benefits they provide have been included.

Based on the review of the countries, the concluding section therefore highlights the knowledge gaps regarding the efficacy and cost of EbA interventions. This section makes the case for the need for future detailed studies looking at all of the aforementioned aspects, especially in order to encourage developing countries to invest in EbA options.



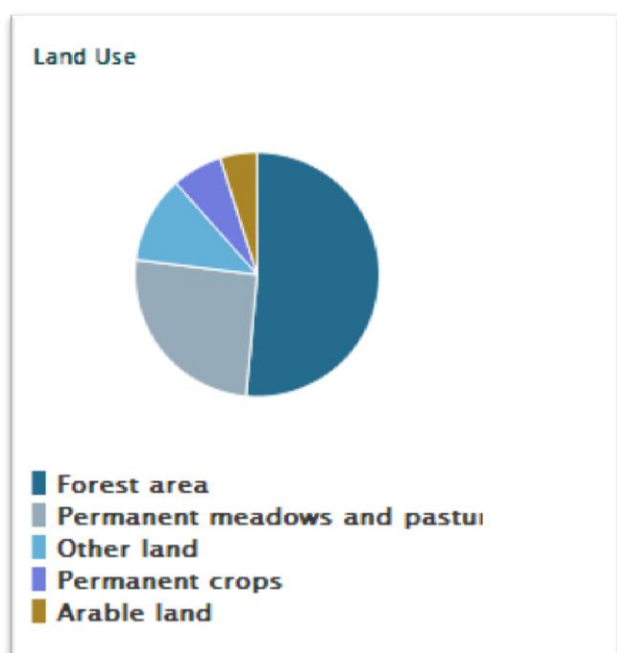
# Costa Rica

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## Country Profile and Existing Climate Trends

Costa Rica is situated in the Central American isthmus and has a continental area of 51,100 square kilometres (km<sup>2</sup>). It lies between the Pacific and the Atlantic oceans and extends from the northwest to the southeast. It is divided by into the Pacific and Caribbean regions by three mountain ranges. The total length of the coastal zone is 1,376 km, with 1,164 km on the Pacific Coast, and 212 km on the Caribbean Sea. It has 34 river basins, all of which are vulnerable to land use planning and five are of major socio-economic importance. These characteristics result in varied and valuable biological and climatic conditions (Villegas Verdú, 2009).

Figure 1 FAO Estimate 2012



By 2006, 11% of the country's territory had been dedicated to agricultural and livestock-related activities, which contributed 14% to economic growth (Villegas Verdú, 2009). Agriculture contributed 14% to the country's employment and 6.2% to the GDP (World Bank, 2011 and FAOSTAT, 2014). Food related exports (excluding fish) accounted for US\$ 2.9 billion in 2011 (FAOSTAT, 2014). Agriculture used 53.36% of the available freshwater in 2002. It provided over US\$3 billion in agriculture production in 2012. According to the Food and Agriculture Organizations, Costa Rica's total agricultural production had an average annual growth rate of 2.03% between 2007 and 2012 (FAOSTAT, 2014).

The country's marine fisheries sector is of socio-economic importance as it generates employment in economically deprived and marginal areas along the Pacific and Caribbean coasts. According to FAO (2004), the fishery and aquaculture sector accounted for 0.32% of the overall GDP in 2002. Over a period of ten years, between 2000 and 2010, its marine fisheries experienced a drop of approximately 38%. In 2010 fishery exports contributed US\$105 million to the national exchequer (FAOSTAT), 2014.

The country's national forest cover increased to 52% by the year 2012, of which 24% (1,206,000 hectares-ha) lies within Protected Areas (Brown and Bird, 2011). In 2013, roundwood production was almost 5 million m<sup>3</sup> (FAOSTAT, 2014).

The Pacific and Caribbean regions have contrasting climate regimes influenced by specific rainfall patterns, the mountain range, the El Niño/La Niña cycles (which can lead to heavy rainfall or

abnormal dry conditions) and oceanic influence. The three main climate regions are i) Humid Tropical Region of the northern zone and Caribbean; ii) Inter-mountainous Central Region, and iii) Tropical Pacific Region, of the north Pacific, central Pacific and south Pacific regions (World Bank, 2011; Villegas Verdú, 2009). The country is highly vulnerable to extreme climate events and natural hazards (i.e. floods, drought, cyclones storm surges and sea level rise). Such events further exacerbate the impacts on populations in areas prone to volcanic eruptions; in unstable, degraded lands; in poorly planned settlements prone to landslides and flooding; and in coastal zones prone to storm-surges and sea level rise (World Bank, 2011).

The highest human and economic impact between 2001 and 2008 was due to flood and storm events. During this period 106,000 people were affected by eight flood events, and the cost of damages reached US\$106 million. The occurrence of landslides, between 2005 and 2009, led to loss of human lives and significant damage to agricultural fields, areas covered with primary forest, and infrastructure (World Bank, 2011). In addition, economic losses of approximately US\$98 million were experienced as a result of Hurricane Mitch. A rise in sea level has also been observed, with up to 2-3 mm per year (*ibid*).

Costa Rica, is considered a primary "hot spot" for climate change in the tropics. It has already experienced changes in climate between 1961-2003, with a rise in temperatures between 0.2°C and 0.3°C per decade, a longer dry season, and an increase in extreme rainfall (World Bank, 2011:4).

## Future Climate Scenarios and Impacts

Using the PRECIS model, projections were made for the period 2071-2100 and presented in the Second National Communication of 2009. These show that temperatures are likely to increase by 2°C-4°C in most parts of the country by the end of the 21<sup>st</sup> century, and that the country's lowlands will experience warmer temperatures than the highlands.

The rainfall regime will vary according to region and is highly uncertain; nevertheless, it is projected to decrease by up to 50% in some areas, while other areas may experience an increase of up to 50%. The frequency of more intense rainfall, however, is expected to increase, as are the number of dry days and extreme events such as storms and floods, with the highest severity expected on the Caribbean Coast by 2080. Sea levels could increase by up to 1 meter (m) by 2100. (Villegas Verdú, 2009).

The country's National Climate Change Strategy identified seven sectors as particularly vulnerable to the projected climate change and prioritizes these for adaptation. These include: i) water; ii) energy; iii) agriculture; iv) fisheries; v) coastal areas; vi) biodiversity; vii) human health, and viii) infrastructure (Keller, Echeverría & Parry, 2011).

- **Agriculture**

To assess the potential impacts of future climate trends on the country's agricultural production, climate vulnerability studies were undertaken on four crops of great socio-economic importance: rice, beans, potatoes and coffee. Based on the outcomes thereof, it is estimated that there will be a potential relative increase in yield of rice in certain areas of the country due to increased

precipitation and CO<sub>2</sub> fertilization. Results for bean and potato cultivation, show that there could be a decrease in yields of both, due to the projected temperature increase and changes in rainfall patterns. Coffee yield could increase with an increase in temperature, especially with a rise of +2°C in maximum temperature. (World Bank, 2011:9).

- **Coastal zone and fisheries**

The projected sea level rise of 1m could shift and broaden coastal areas subject to tidal floods, such as mangrove swamps and salt marshes. As indicated in the *Climate Risk and Adaptation Country Profile of Costa Rica*, by the World Bank (2011), a sea level rise of only 0.3m could lead to in-land flooding of an estimated 150 meters and may affect around 105 ha of tidal flood area.

- **Forests and ecosystems**

The country's ecosystems are highly dependent on temperature and precipitation and therefore particularly vulnerable to even minor changes in climate conditions. The projected changes in intensity and frequency of rainfall, as well as rising temperatures, pose significant threats to the region's biodiversity (World Bank, 2011).

National parks and biological reserves located in the highlands are likely to be most affected by the projected climate trends due to expected shifts and increase in the altitude of cloud formation in the region, which in turn will impact moisture supply to montane forests during the dry season. In particular, the Tapantí-Macizo de la Muerte and Braulio Carrillo National Parks, important as sources of drinking water, will suffer from a decline in annual precipitation (World Bank, 2011; Villegas Verdú, 2009). Biological changes can already be observed in the Monteverde Cloud Forest Reserve and other montane forests that lie above 1000m, as a result of changes in climate (World Bank 2011). Furthermore, increasing temperatures could lead to a shift in species distribution and result in the extinction of certain endemic species that are unable to adapt to the new conditions (*ibid*). Forest ecosystems and their associated biodiversity provide important economic goods and services and any changes will impact local economies.

## **Economic Analysis of EbA Measures**

Costa Rica is one of the first countries in Central America to take concrete steps for the conservation of ecosystems. It is also a leader in curbing forest loss and GHG emissions. It has formulated and implemented a number of policies and programmes that address climate change and has submitted two national communications to the UNFCCC in 2000 and 2009 respectively, which outline government actions and policy frameworks to address climate change. The national communications also highlight vulnerability studies conducted for the coastal zone, water resources, agriculture, ecosystems, and forestry sectors for which adaptation measures were identified (World Bank, 2011).

The country has implemented various conservation and management actions, which made it a leader in addressing environmental issues, regionally and globally. These have now become the starting point of various mitigation and adaptation proposals (UNDP, 2010).

Several adaptation projects have been and are implemented, some of them specifically related to EbA, while others provide economic benefits from nature based solutions, which while not specifically termed EbA, can result in increasing people's resilience. A few examples of such projects are below:

- ***Payments for environmental services***

Costa Rica is also a leader in designing and developing a system of payment for environmental services (PES). It implemented the *Certificates for Environmental Services (Certificados de servicios ambientales - CSA)* to promote the national and international market for environmental services, whereby a company has to pay to conserve one hectare (ha) of forest in a specified area. The CSA is a financial instrument aimed at preserving existing forests and enhancing ecosystems. The certificates are a means of receiving funds (and providing some of them to forest owners) from those companies and institutions that benefit from services provided by ecosystems. A number of PES and CSA related projects are ongoing (Russo *et. al.*,2010).

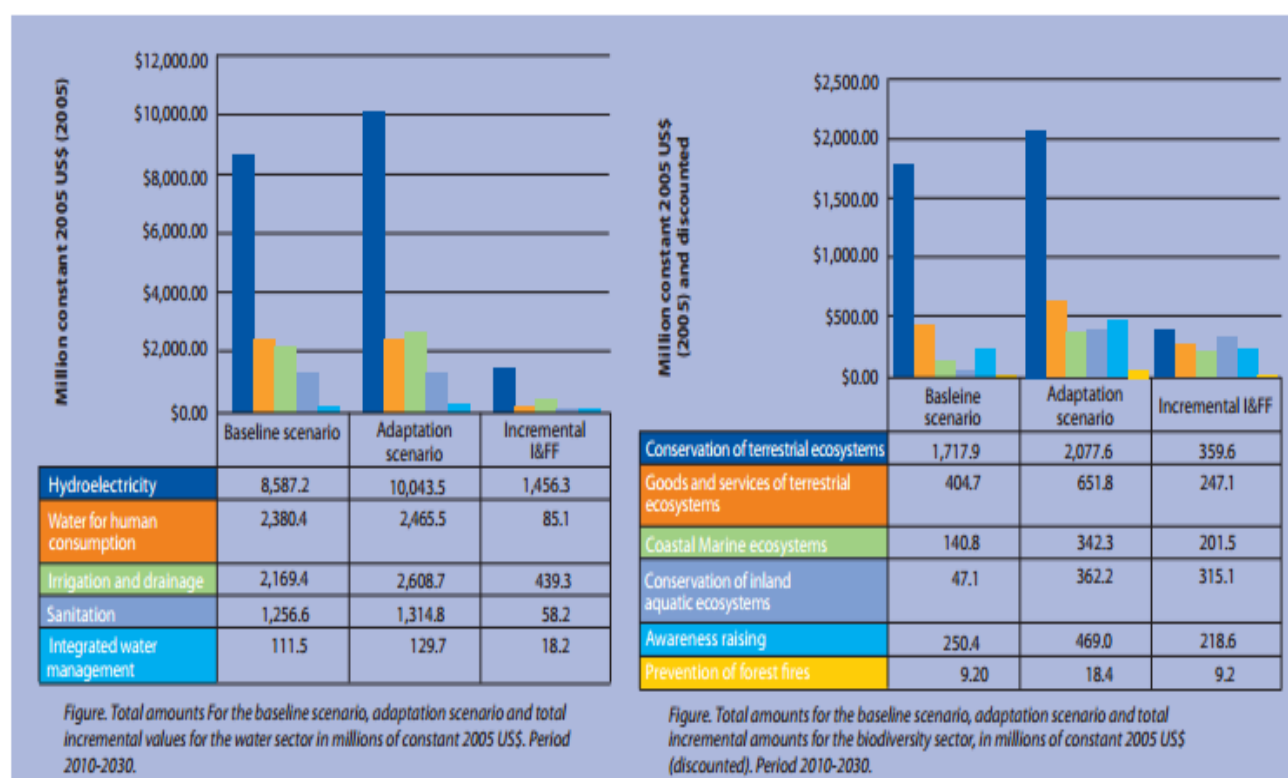
The Del Oro Company, a large producer of citrus juices, collaborated with the government of Costa Rica in conserving tropical Guanacaste National Forests and ensuring provision of essential forest ecosystem services to the plantations. Through an agreement with the Ministry of Environment and Energy signed in August 1998, Del Oro agreed to pay for a number of such services listed below:

- Biological control agents, primarily parasitic wasps and flies of importance to integrated pest control, were valued at US\$1 /ha/yr for the 1685 hectares of adjacent Del Oro orange plantations, for a total of US\$1,685/yr.
- Water from the upper Rio Mena basin services Del Oro farms, and was valued at US\$5 /ha/yr for the 1169 ha totaling \$5,885/yr.
- Biodegradation of the orange peels from Del Oro was valued at US\$11.93/truckload, for a minimum payment of 1000 truckloads per year, for a total of US\$11,930/yr (Janzen, 1999 as seen in The World Bank, 2009).

- ***Investing in biodiversity***

An assessment of Investments and financial flows undertaken for water and biodiversity sectors amounted to US\$3.4 billion (in constant 2005 US\$). It was estimated that out of this US\$2.1 billion would be required for the water sector and US\$1.4 billion for the biodiversity sector.

**Figure 2 Adapted from UNDP Adaptation to Climate Change in Costa Rica: An Assessment of Necessary Investment and Financial Flows**



The investment required for biodiversity in terms of conservation of ecosystems and their services of US\$1.4 billion may seem large but should be considered with the contribution of agriculture and fisheries to the national exchequer. Both of these biodiversity dependent sectors together contribute more to the economy and as mentioned before are likely to be impacted due to climate related changes. EbA projects therefore can easily be classified as providing adaptation options that are cheaper than other solutions, considering the comparison of the investment required.

# India

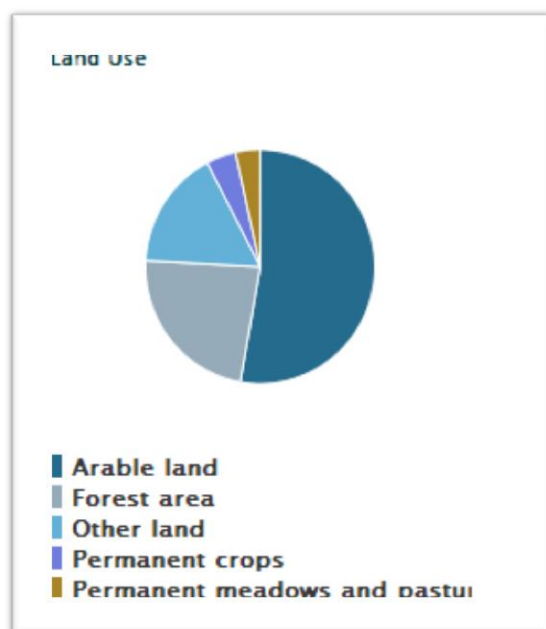
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## Country Profile and Existing Climate Trends

Situated at the foothills of the Himalayas, India, a subtropical country, has a total surface area of 3.28 million km<sup>2</sup>. It is the seventh largest country in the world with approximately 18% of the world's population (MoEF, 2012). The country is divided into the following regions: western Himalayas, northwest, northeast, northern central region, eastern coast, western coast and the interior plateau (MoEF, 2010). It has a diverse topography, climate, environment and biodiversity and this is why it is listed as one of 18 megadiverse countries in the world. It has three global biodiversity hotspots and a high degree of endemism (MoEF, 2012).

The country's forest area spans 696,260 km<sup>2</sup> and comprises of tropical wet evergreen forests in the northeast and the southwest, and tropical dry thorn forests in the central and western regions (MoEF, 2012). It has a large number of rivers with the 12 largest covering approximately 75% of the total surface area (Sterrett, 2011). India's coastal zone is 5,500km along the mainland and 20,000km along its various islands (MoEF, 2010).

Figure 3 FAO Estimate, 2012



More than half of the population lives in rural areas and is highly dependent on climate-sensitive sectors such as agriculture, fisheries and forestry (Porsché *et al.*, 2011; Sterrett, 2011). India's agriculture sector is primarily a mixed crop-livestock farming system. Agricultural lands provide livelihoods for approximately 65% of the people as well as food security for its one billion people. These lands are important contributors to the nation's economy. For example in 2007, agriculture, forestry and fishing accounted for 16.6% of the GDP and employed 60% of the total workforce (Pande & Akermann, 2011:10). In 2011-2012, the country was ranked as the largest producer of milk in the world with an estimated production of 127.9 million tonnes. In 2011 just over 90% of water used was by the agriculture sector

(FAOSTAT, 2014) and during the 2011 - 2012 period, the production of food grains in India was at a record high of about 259.32 million tonnes (DAC, 2013).

India is a large producer of fish and in 2009 the country ranked second in the world contributing an estimate of 5.43% of the global fish production. In 2011, exports of food products, excluding fish, accounting for over US\$ 17 billion, while fishery exports amounted to over US\$2billion in 2010

(FAOSTAT, 2014). Total fisheries production was over 9 million MT in 2010 (FAOSTAT, 2014). During 2012, its annual marine fish landings registered an all-time high at approximately 3.94 million tonnes, compared to 3.82 million tonnes during 2011, thus indicating a growth of 3.4% (FAOSTAT, 2014).

In the year 2013, roundwood production was 357 million m<sup>3</sup> out of which over 10,000 m<sup>3</sup> were exported (FAOSTAT, 2014).

Being susceptible to extreme climate events, India ranks second in the 2011 Climate Change Vulnerability Index (Porsché *et al.*, 2011:24). Climate change exacerbates the pressures on its ecosystems due to rapid urbanisation, industrialisation and economic development. This is further compounded by the occurrence of floods, droughts, and decreased water availability from glacial melt and decreasing rainfall (Porsché *et al.*, 2011).

Extreme rainfall events during the past 50 years show an increasing trend in frequency and intensity, especially in the Western Ghats, and over the central and northeast region. On the other hand, there has been a decreasing trend in moderate (5–100 mm/day) rainfall events (World Bank, 2013:111; MoEF, 2010). Since the 1950's, monsoon rainfall over the country has decreased by approximately 5% to 8%, however the area affected by floods has more than doubled from 1953 - 2003 (Sterrett, 2011). According to the Second National Communication, almost 40 million hectares (Mha) are prone to flooding, which constitute about 12% of the total geographical area (MoEF, 2012:104).

Increase in mean annual temperatures of 0.5°C has been observed from climate data of the last century. After the 1990s it has increased even further (Pande & Akermann, 2011). Also in the last century, six out of the ten most severe drought disasters globally, occurred in India affecting up to 300 million people, and adversely impacting its agricultural sector. Over 50% of the crop area in the country was affected by the droughts of 1987 and 2002/2003 and, in 2002, food grain production declined by 29 million tons in comparison to the previous year. Major droughts occur nearly every five years in the states of Jharkhand, Orissa, and Chhattisgarh (World Bank, 2013:108). Recently, it was observed that ground-level ozone, the main component of smog, damaged 6.7 million tons of Indian crops worth an estimated \$1.3 billion in a single year<sup>4</sup>.

## Future Climate Scenarios and Impacts

PRECIS models used in a study by the Indian Network for Climate Change Assessment (INCCA) show a projected increase in annual mean temperatures of up to 1.5°C and 2.0°C by the 2030s (MoEF, 2010). In addition, projections for 2020, 2050 and 2080 also show an all round warming due to increase in GHG concentrations (MoEF, 2012). The climate model simulations also indicate that while there has been a decrease in frequency of cyclones, there could be an increase in their intensity during the summer monsoon season (MoEF, 2012:103).

Although predicting the impacts of climate change on the Indian monsoon is highly complex with differences in projection between models, it is clear that climate change will affect India's rain-fed

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<sup>4</sup>[http://e360.yale.edu/digest/smog\\_in\\_india\\_damaged\\_enough\\_crops\\_to\\_feed\\_94\\_million\\_study\\_says/4239/](http://e360.yale.edu/digest/smog_in_india_damaged_enough_crops_to_feed_94_million_study_says/4239/)



agriculture, rivers, fisheries, water and power supply (Porsché *et al.*, 2011). This will have consequences in terms of resilience and vulnerability of the population.

- **Agriculture**

Approximately 60% of the cultivated area in India is rain-fed and highly dependent on the onset, duration, spatial extent, and total precipitation of the monsoons (MoEF, 2012). As such climate change is likely to have significant impacts on the sector. Other water resources are also likely to be impacted, in turn affecting livelihoods associated with agriculture (Porsché *et al.*, 2011). For example, a report by Kumar, Shyamsundar and Nambi (2010), estimates a 9% decline in farm-level net revenues in the country under moderate climate change scenarios (i.e. an average increase of about 2.9°C). This could have adverse effects on livelihoods and may lead to food insecurity and poverty (Kumar *et al.*, 2010).

*"South Asian populations in large parts depend on the stability of the monsoon, which provides water resources for most of the agricultural production in the region. Disturbances to the monsoon system and rising peak temperatures put water and food resources at severe risk. Particularly in deltaic areas, populations are exposed to the multiple threats of increasing tropical cyclone intensity, sea-level rise, heat extremes and extreme precipitation. Such multiple impacts can have severe negative implications for poverty eradication in the region."*

*Source: World Bank, 2012 (Turn down the Heat).*

- **Coastal zone and Fisheries**

The end of the 21st century could have a sea level rise of approximately 100–115 cm by 2090 in a 4°C world, and 60–80 cm in a 2°C world (Sumaila & Cheung, 2013). This projection is concerning, as a 1m rise would displace an estimated 7.1 million people (Porsché *et al.*, 2011:181). Studies also suggest that increasing sea surface temperature (SST) could lead to changes in catch rates (Cheung *et al.*, 2010).

- **Forestry**

A report by Porsché *et al.* (2011) concluded that over 50% of India's forests may experience a shift in the distribution of forest type as a result of climate change, with 45% of forested area likely to change by 2035. The most vulnerable forests are in the upper Himalayan stretches, in parts of central India, the Western and Eastern Ghats. The most vulnerable are temperate forests, which occupy over 50% of India's forest area, followed by tropical semi-evergreen forests and dry and moist deciduous forests, respectively (*ibid*:90). The National Action Plan for Climate Change (NAPCC) highlights an increase of pest outbreaks and invasive species, and an increase in wildfires (Gol, 2008).

## Economic Analysis of EbA Measures

The government of India has taken several responses to address climate change issues, and to reduce the vulnerability of its population to the potential adverse impacts of climate change. As part of its National Missions, the government is committed to the UNFCCC and submitted two National Communications in 2004 and 2012 (MoEF, 2012).

In June 2008, the National Action Plan on Climate Change (NAPCC) was published, which formulates the government's climate strategy (current and proposed) and addresses both adaptation and



mitigation issues. The plan identified core 8 National Missions which are: i) National Solar Mission; ii) National Mission for Enhanced Energy Efficiency; iii) National Mission on Sustainable Habitat; iv) National Water Mission; v) National Mission for Sustaining the Himalayan Ecosystem; vi) National Mission for a Green India; vii) National Mission for Sustainable Agriculture, and viii) National Mission on Strategic Knowledge for Climate Change. The missions focus on adaptation (i.e. enhancing the resilience of ecosystems, enabling adaptation of local communities, risk management), mitigation (i.e. enhancing carbon sinks in sustainably managed forests and ecosystems), natural resource conservation, energy efficiency, and enhancing the understanding of climate change (which entails access to information) (MoEF, 2012). In 2011, the Ministry of Environment and Forestry (MoEF) initiated an Economics of Ecosystems and Biodiversity (TEEB) study and began the process of an economic valuation of its natural capital and ecosystem services, focusing on coastal and marine ecosystems, forests and inland wetlands (MoEF, 2011 and TEEB, 2013).

A number of ecosystem enhancement and climate change adaptation projects have and are being conducted. Following are a few examples of implemented ecosystem-based adaptation approaches and the economic outcomes thereof:

- ***Cost-Benefit Analysis of Watershed Development (WSD) in Maharashtra:***

A study by Gray and Srinidhi (2013) provides a cost-benefit analysis (CBA) of WSD for the Kumbharwadi rain-fed watershed in Maharashtra state. The CBA was undertaken in 2012 by World Resources Institute (WRI) in partnership with Water Organisation Trust (WOTR) to evaluate one of their projects. The results indicate that the market-benefits of this particular WSD include the following: Improved crop and livestock sales; avoided travel cost for migratory work and drinking water; avoided cost of government supplied water tankers, and improved fuel wood and fodder supplies. All of these will help to reduce the vulnerabilities of the local populations in the face of climate change.

The non-market benefits include: Carbon sequestration, a co-benefit of the afforestation and reforestation interventions; improved biodiversity, pollination and water filtration; improved nutrition and health; increased enrolment in education due to improved income; female empowerment; community development and improved resilience to drought.

In terms of economic value, over a 15 year project period, between 1998 and 2012, the net annual income from agriculture and livestock increased significantly. The total income earned from agriculture was equal to US\$6.21 million, whereas the total income from livestock ranged from US\$2.21 to US\$3.03 million. One of the largest benefits was the improved crop production through the WSD, which has resulted in an increase in net agricultural income from US\$69,000 per year to almost US\$625,000 in the Kumbharwadi watershed.

*“The net present value of the WSD project in Kumbharwadi ranged from US\$5.07 to US\$7.43 million, which equates to benefits of US\$5,573 to US\$8,172 per hectare treated, or US\$29,650 to US\$43,479 for each of the 171 households in Kumbharwadi. The benefit-cost ratio (BCR) ranged from 2.28 to 3.7”.*

The study determined the economic value of carbon sequestration based on benefits transfer method. Because this method is highly uncertain these values were not included in the NPV and BCR. However, the estimation suggests that the social benefits of carbon sequestered from 1998 - 2012 were US\$ 1m to US\$1.4m. The study concludes that the results of the CBA show that this WSD was a successful investment. (Gray & Srinidhi, 2013:21).

- ***Restoration of agricultural productivity and biodiversity in India's North***

The state of Uttar Pradesh (most populous and severely poor) is affected by water-induced land degradation, such as salinization, sodification and water-logging, all of which may be exacerbated due to climate change. This degradation has led to declining productivity of food grains, particularly wheat and rice. It has also resulted in millions of hectares of unproductive land due to poorly managed irrigation (Porsché *et al.*, 2011).

In 1993 and 1998, at the cost of approximately US\$248.8 million, the Uttar Pradesh Sodic Lands Reclamation Project I and II reclaimed a total of 253,715 hectares of formerly sodic lands in the state, by implementing sustainable agricultural practices (*ibid*).

Thus far, the benefits generated through this project (I and II) include the following:

Within the reclaimed lands, the quality and productivity of soil have increased; intensity of cropping has tripled; rice yields increased from 0.9 to 3.5 tonnes per hectare, and wheat from 0.4 to 3.0 tonnes per hectare.

The market value of land has also significantly increased, In addition, over 552,000 households ( more than 1 million people) have directly benefited from the project activities. According to a report by the World Bank (2008:61), as a result of the project, the wage rates doubled and additional rural jobs for 86,710 persons/year also materialised. Moreover, the poverty level in the area decreased from 72% to 48%. Additionally, the investment in sustainable land management also improved environmental quality as evidenced by an over “five-fold increase in floral and faunal diversity as well as microbial biomass in sampled areas” (Porsché *et al.*, 2011:129).

- ***Value of the Watershed management Programme in Orissa State.***

A case study report by Sustainet (Pande & Akermann, 2011) highlighted the benefits of a WSD in Orissa state. Agramee, a local NGO active in the tribal region of Kashipur, conducted an integrated watershed development project in the village of Kodikitundas, in 1994. The intended objective was to take an integrative approach to restore, develop and preserve the natural resource base of the local community. At the time, the village comprised of 40 households with a total population of 194. The key activities undertaken through the project included: soil and water conservation; improvement of agriculture land by controlling soil erosion; tree plantations at strategic locations checking erosion and providing additional economic options; the promotion and strengthening of people's institutions (such as water user society and women's' self-help groups), to facilitate infrastructure maintenance and product marketing.

While the authors did not quantify the economic net benefits, they highlight that after nearly 20 years from the start of the project, the benefits are evident and are as follows:

The project led to improved agricultural land, the resource base is used in a more effective way, and new sources of income have been made accessible as the villagers now generate substantial additional income through the sales of fruits, non-timber forest products and timber. The project cultivated fast growing tree species, which grow back within two years, permitting the surrounding villages with important wood sales every year. Subsequently, the majority of the households in Kodikitundas have been able to invest in new housing with a tile roof and brick walls, and many villagers are now also able to send their children to school, as a result of the improved income. (Pande & Akermann, 2011:74-76).

- ***Water Tanks for Irrigation in Godavari River Basin***

The Godavari River basin has a population of 63 million. Nearly all rain falls in the monsoon season (June - October). This means measures for year round water storage must be undertaken. Due to climate change there is uncertainty regarding the frequency and intensity of rainfall. The Government proposed to build a dam costing US\$4 billion on the Godavari River to meet the water storage needs. However, the dam would displace 250,000 and inundate habitats (including 60,000 ha of forests).

Alternatively a WWF project was developed in 2004 to restore ancient village earth dams (1 - 10 ha in size), which traditionally served as water storage tanks but were now deteriorated and out of use. During 2005 - 2006, 12 tanks serving 42,000 people were restored through de-silting. The intervention cost US\$103,000 in total. As a result of this there was less groundwater pumping and water tables rose, reactivating some wells that were worth an average value of US\$2,330. Crop yields were increased and total production value reached US\$69,900/year. Irrigation of additional lands decreased the need for electricity for groundwater pumping, and wages paid for de-silting the tanks supplemented farmers' incomes. Some of the ponds were used for fish production, providing an additional net profit of US\$3,700.

The project estimated that in the Maner River basin there are 6,234 water tanks covering 588 km<sup>2</sup>. These could be de-silted at an estimated cost of US\$635 million. These could store an extra 1,961 mm<sup>3</sup> of water at a cost of US\$0.32/m<sup>3</sup>. On the contrary the government's proposed US\$4 billion Polavaram Dam would store 2,130 m<sup>3</sup> irrigation water but at a cost of US\$1.88/m<sup>3</sup>. (WWF, 2008 as seen in World Bank, 2009).

- ***Karnataka Watershed Management***

The Karnataka Watershed Management project funded by The World Bank aimed towards poverty alleviation in mainly rainfed areas, by improving the productive potential of degraded watersheds. It focused on soil and water conservation and sustainable use, as well as improvement of livelihoods, equity, gender, and community participation, covering 400,000 hectares. Although not an EbA project per se, the benefits provided by it would increase the resilience of people to face future climate impacts.

As a result, agricultural productivity increased by up to 19.8% and average income was increased by 24%. Cropping was diversified, boosting resilience. Employment increased as a result of project

restrictions on using machinery, benefiting the poorest and landless. Consequently outmigration was reduced by 75 percent in the short term (IEG, Undated).

- ***Economic Value of forests and biodiversity***

A meta-study conducted by Markandya (2012) valued ecosystems and biodiversity services in India based on data from existing studies. According to this, direct use values of forests range from US\$3.9 billion to US\$5.9 billion and indirect use values amount to around US\$460 million. Carbon stock values were estimated to be between US\$190 billion to US\$510 billion. Non-use values were between US\$300 - US\$360 million annually. Total value of services from mangroves was estimated at US\$537 million, while those from coral reefs were estimated to be US\$6.3 billion.

The above projects show not only economic values but the co-benefits that nature based projects can provide. The NPV of the first project shows the extent of the economic benefits resulting from the restoration of the watershed. The second project highlights not only the increased resilience of the local biodiversity but also of the communities, who were able to raise the productivity of the land as well as their livelihoods. The third project points to not only decreased vulnerability by providing additional sources of income to the households but also additional co-benefits, such as better soil and water quality. The fourth project highlights the cost effectiveness of EbA based projects compared to traditional methods and also shows the return on investment that such projects can provide. Finally, a total economic valuation of ecosystems and biodiversity services shows their high economic contribution to the Indian economy.

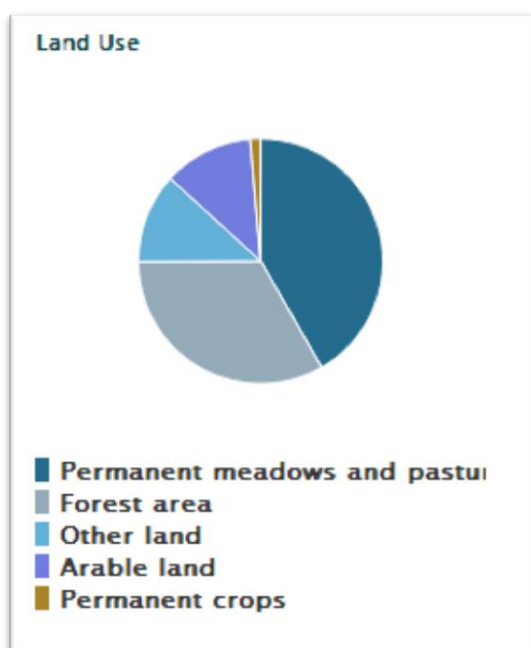
## Mexico

### Country Profile and Existing Climate Trends

Located in North America, Mexico has a total surface area of 1,964,375 km<sup>2</sup>, of which 1,959,248 km<sup>2</sup> mainland and 5,127 km<sup>2</sup> are comprised of 371 islands, reefs and cays. It has 231,813 km<sup>2</sup> of territorial sea, nearly 3,149,920 km<sup>2</sup> of exclusive economic zone, and a coastal zone extending 11,122 km in length. Approximately 15% of the population resides in the coastal zone. The northern and central parts of the country are very arid and semi-arid and occupy 56% of the territory, whereas sub-humid areas, found in the mountains, coastal plains of the Pacific, the Gulf of Mexico, and the north-eastern part of the Yucatan Peninsula, cover 37%. The remaining 7% of the territory are humid areas (MNC, 2007).

Mexico is among the top five countries in the world known as megadiverse, and has between 60-70% of all known biological diversity on earth representing approximately 12% of the world total (MNC, 2007:106).

Figure 4 FAO Estimate, 2012



Agriculture, livestock, forestry, hunting, and fishing are important economic sectors and employed 12.8% of the country's labour force in 2006. In 2005, these sectors contributed an estimated 3.4% to the overall GDP, out of which agriculture contributed 63%, livestock 28.8%, forestry 5.9%, and the fisheries sector contributed 2.3% (MNC, 2007:26). The Third National Communication indicates that a decrease in the country's grains and oil crops (of 10.5%) and bananas (of 5.5%) in 2005, was due to reductions in cultivated area, extreme climate events and an erratic rainy season (MNC, 2007:26-27).

In 2011 over 76% of available water was consumed by agriculture and in 2012 total agricultural production was valued at over US\$38 billion. Exports of food, excluding fish, in 2011 amounted to almost

US\$16 billion, while exports of fisheries in 2010 amounted to US\$773 million. Total fisheries and aquaculture production was over 1.6 million MT in 2010 (FAOSTAT, 2014). The Mexican fisheries sector is an important source of food and employment at the local level, and the country is among the top 15 fishing nations in capture fisheries volume (Aguilar Ibarra *et al.*, 2013). Forestry production in 2013 was over 43 million m<sup>3</sup> of roundwood production out of which over 41,000 m<sup>3</sup> were exported (FAOSTAT, 2014).

Mexico is considered especially vulnerable to the impacts of climate change and variability owing to its geographical location, topography, and socio-economic aspects (MNC, 2007). Climate data

obtained through CRUTEM3<sup>5</sup> shows an increase in seasonal mean temperatures from 1960 to 2010, with a 0.17°C increase per decade for the summer and a 0.26°C for the winter season (Met Office, 2011:13). There also have been higher incidences of extreme climate events and natural disaster between the years 2000-2010 (NCCS, 2013; World Bank, 2009). Its National Climate Change Strategy (NCCS, 2013: 33) reported that the costs of damage as a result of the extreme events have risen from *“a yearly average of about 730 million pesos in the period of 1980 to 1999, to an average of over 21 billion pesos over the period from 2000 to 2012”*.

The country's agricultural sector has been significantly affected due to drought events and in 2009, the north-western and central regions experienced their worst drought in 70 years. This affected approximately 3.5 million farmers, killed over 50,000 cattle, and damaged up to 17 million acres of cropland. Furthermore, water levels were reduced in about 80 of the country's largest reservoirs (Met Office, 2011:25).

## Future Climate Scenarios and Impacts

Climate change modelling scenarios show projected mean temperature increases of between 1.5°C-2.5°C by 2020, and 2°C to 4°C by 2050, especially in the central and northern parts of the country (MNC, 2007). In terms of precipitation however, there is a high degree of uncertainty regarding projected changes (Met Office, 2011). Furthermore, most of the models do not account for tropical depressions, cyclones, and cold fronts (NCCS, 2013). In general, projections show that projected precipitation fluctuations could be in the range of -7 to +12% (December to February) and -8 to +12% (June to August) (Met Office, 2011; MNC, 2007). These projected changes in both temperature and rainfall could lead to an increased frequency and intensity of extreme climate events, such as the number of severe storms and the intensity of severe drought periods.

Sea water temperatures are expected to increase between 1-2°C leading to an increase in the frequency and intensity of tropical cyclones in the Caribbean Sea, the Gulf of Mexico and the Mexican part of the Pacific Ocean (NCCS, 2013; MNC, 2007; World Bank, 2009).

The scale of the aforementioned projections will affect climate-sensitive sectors (i.e. agriculture, fisheries and forestry) and may exacerbate the deterioration of water resources, biodiversity, and ecosystem services, which in turn will have repercussions on social, economic and political aspects of the country.

- **Agriculture**

As a climate-sensitive sector, agriculture is already highly vulnerable to the occurrence of extreme climate events, particularly so in the country's water scarce northern parts and in the south where tropical cyclones (including hurricanes and storms) have caused extensive damage to both crop and livestock production (World Bank, 2009).

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<sup>5</sup>The CRUTEM3 is a global land-based surface-temperature data product, jointly created by the Met Office Hadley Centre and Climatic Research Unit at the University of East Anglia (Met Office, 2011).

A report by the Met Office Hadley Centre on climate observation, projections and impacts for Mexico, highlights that between 40% to 70% of current croplands are projected to undergo declining suitability by 2030. This will rise up to 50-80% by 2100 (Met Office, 2011:71).

Corn, an important agricultural crop especially for the food security of farming communities, occupies about 50% of total cultivated area (World Bank, 2009). A majority of studies predict that due to its climate sensitive nature (especially to droughts), it is likely to experience decreasing yields by 2050 (Met Office, 2011).

A country profile report by the World Bank highlights that in the northern and central regions, there could be a reduction of pastureland used for livestock, with an estimate of 6% loss by 2020 and 13% by 2050 (relative to 2002 base year), due to increased drought, land deterioration, and an increase in pests and diseases associated with environmental changes (World Bank, 2009:3).

- **Fisheries**

The vulnerability of the national economy to the impacts of climate variability on fisheries by 2050 is believed to be moderate (Met Office, 2011). However, overcapacity, unsustainable practices and weak management strategies will aggravate the situation in this sector.

A recent study undertaken by Aguilar Ibarra *et al.* (2013:17-22) on the economic impacts of climate change on Mexican coastal shrimp and sardine fisheries for the year 2030, found that there could be a decrease in shrimp production. It estimated a reduction of 1.1% in catch for every 1% of temperature increase, and that overall, the monetary impacts are negative for the Mexican shrimp fishery. In contrast, the outcomes for the sardine fishery indicate that the monetary impacts are positive overall, with a potential increase of 4% in production for every 1% increase in temperature.

- **Forestry**

The forest ecosystems in the country cover about 70% of its total surface area. They are diverse and associated with specific climatic conditions, such as rainforests with warm, humid and sub-humid climates, and forests with temperate or semi-cold, humid or sub-humid climates (MNC, 2007:87).

The warmer and humid climate projections for 2020 may provide favourable conditions for the country's rainforests, however, the projections for 2050 show that over 20% of the surface area will be warmer and drier. This will result in increasing occurrences of forest fires as well as in water stress (MNC, 2007). This could mean that the semi-arid vegetation in the central and northern areas could be replaced by arid vegetation. In addition, tropical forest species that are unable to adapt to new climate conditions could become extinct (World Bank, 2009:6). Furthermore, temperate grasslands could be adversely affected by drought events associated with increased temperatures, with repercussions for both agricultural and livestock production (Met Office, 2011).

## Economic Analysis of EbA Measures

Mexico has several national climate change plans and programmes in place. It has submitted five National Communications (most recent in 2012) to the UNFCCC, indicating a strong commitment by the government to address the issue (World Bank, 2009).

The National Climate Change Strategy (NCCS), published in 2013, outlines concrete adaptation and mitigation measures for various sectors, and aims to guide Mexico's climate change policy over a 40 year period. The national climate change policy establishes the country's priorities, defines criteria to identify regional priorities, and sets guidelines (or lines of action) that involve different adaptation and mitigation activities (NCCS, 2013). It became legally binding when the country's General Climate Change Law (GCCL) came into effect in October 2012 (NCCS, 2013:9).

Following are examples of a few implemented measures, their effectiveness, and where applicable lessons learned:

- ***Cost-benefit analysis (CBA) of dryland forest restoration***

Birch *et al.* (2010) assessed the benefits of restoring dryland forests and how they improved the provision and value of selected ecosystem services through a CBA analysis in Central Veracruz and El Tablon in Chiapas, which are global biodiversity hotspots. The results showed that there was a net gain in ecosystem service provision in both areas. An opportunity cost of forest restoration was the decrease in livestock production value. With regards to the net social benefit of the restoration, timber and tourism provided relatively high values in El Tablon with an estimate of over US\$0.8/ha/year. The restored dryland forests in El Tablon also resulted in an increase in the value of US\$0.07/ha/year for non-timber forest products (NTFP) extraction (such as fruits, medicinal plants), using current harvest rates.

The authors do caution however that the results of their study should be viewed as tentative, given the uncertainties associated with mapping and valuing ecosystem services. Nonetheless, they concluded that the results highlight the potential benefits of ecological restoration to enhance biodiversity and improve local livelihoods. They recommend that restoration actions should be undertaken in degraded lands, and that dryland areas need to be considered as high priority areas. (Birch *et al.*, 2010: 21928). This would be especially important when dealing with climate change impacts.

- ***Value of Protected Areas***

According to a report by the Convention on Biological Diversity (CBD) (Mulongoy & Gidda, 2008:11), Mexico's national and state protected areas store 2,446 MtCO<sub>2</sub>, equivalent to 5.6 years of its CO<sub>2</sub> emissions at the 2004 year rate. The value of its protected areas as a carbon sink is estimated at US\$ 12.2 billion.

A co-benefit, highlighted in the same report by the CBD, is that according to a government study 5.5 million tourists visited national protected areas, with direct expenditures close to US\$285.7 million. Another study in 2007 estimated that there were 14 million visits per year, with tourists spending



roughly US\$660 million, or 5.5% of international traveller expenditures to all of Mexico (Mulongoy & Gidda, 2008:16).

- ***Investing in Mangroves***

Studies undertaken in the Gulf of Mexico show that mangrove-related fish and crab species account for 32 percent of the small-scale fisheries landings in the region. They also estimate that mangrove zones can be valued at US\$37,500 per hectare annually (Aburto-Oropeza et al., 2008 as seen in World Bank 2009).

The above case studies point to the fact that because ecosystems provide countless benefits to communities and the national exchequer, EbA related project would tend to be more cost effective than traditional options.

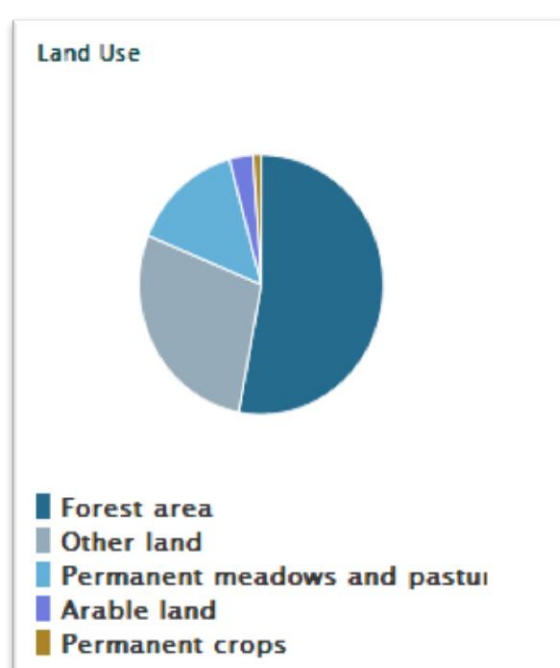
## Peru

### Country Profile and Existing Climate Trends

Peru is the third largest country in South America situated on the Pacific coast. It has a total surface area of 1,285,215 km<sup>2</sup>, and is listed as one of the megadiverse countries in the world (MINAM, 2010). It is divided into three geographical regions: the coastal region, Andean mountains and rainforest. The Andes mountain range, which runs longitudinally from the south to the north, is of great importance. It not only regulates Peru's climate but also consists of glaciers (71% of the tropical glaciers in the world) and rivers that provide the majority of the population with freshwater (IRG, 2011; MINAM, 2010). The *páramo* and the *puna* are unique high-altitude grassland ecosystems that play a very important role in water regulation (IRG, 2011). The country's coast is arid to desert and extends 2,414 km, along which approximately 28 million of Peru's population is settled (MINAM, 2010).

The country has the second largest share of tropical Amazon forests (70 Mha) in the world, which make up about 13% of the total land area and contain great species diversity. It also has the fifth largest contiguous area of rainforest, which makes up about 74% of the total land area (IRG, 2011; MINAM, 2010). According to the Second National Communication (2010), from 2000-2005, while the national deforestation rate was an estimated at -0.136%, (placing Peru among the countries with the least deforestation in the region), a constant annual deforested area has been registered from 1985 to 2005 (MINAM, 2010). The main causes of deforestation are migratory agriculture and conversion of lands for livestock (which also contribute to GHG emissions) as well as mining, urban development, and the expansion of illegal coca crops (*ibid*). The National Protected Areas System (SINANPE) protects approximately 19 million hectares of forests, in addition to regional, local, and private protected areas.

Figure 5 FAO Estimate, 2012



In 2010, the forestry sector contributed only 1% to the nation's GDP (IRG, 2011: 8). In 2013, total roundwood production was almost 9 million m<sup>3</sup>. The country's most productive sectors are agriculture and livestock, manufacturing, construction, and mining. Agriculture and livestock contributed about 7% to the overall GDP and 62.8% of the national supply of food by 2010. The total annual agricultural production increased by 4.98% between 2007-2012 (FAOSTAT, 2014; MINAM, 2010). Agriculture employed 23.3% of the national labour force and 65% of the rural working population by 2010 (IRG, 2011; MINAM, 2010). Total agricultural production value in 2012 was almost US\$10 million. Exports of food items, excluding fish, amounted to almost US\$3million in

2011 and total production amounted to over 4 million MT (FAOSTAT, 2014).

Marine fisheries are another important sector to the culture and to some extent to the national economy, representing 0.5% of the country's GDP (IRG, 2011). Among the marine fisheries, the Peruvian anchovy fisheries is of most economic importance and its catch is used to produce fishmeal and fish oil, which contributed an estimate of over US\$2 billion in exports in 2008 (*ibid*). Export value of fisheries amounted to almost US\$3 billion in 2010 (FAOSTAT, 2014).

The Andes mountains contain valleys and plateaus that create micro climates with varying rainfall and temperature (IRG, 2011). In addition, the El Niño Southern Oscillation (ENSO) is a major force in the country's climate and accounts for the periodic extreme climate events (MINAM, 2010). There has been an increasing trend in the incidence of extreme climate events and natural disasters (MIMAM, 2010). Flood events have increased by more than 60% in the periods of 1970-1980 and from 1990-2000. During the period of 2000-2004, the annual cost of natural disasters was an estimated US\$325 million (World Bank, 2009). Between 2003-2007, three extreme temperatures events impacted 5 million people (approximately 18% of the population) and one flood event impacted 0.5 million people (approximately 2% of the population) (*ibid*).

The retreat of Peru's tropical glaciers due to rising temperatures is of major concern. Studies show that during the last 30-35 years, the country has lost 22% of its glaciers' surface, which represents the loss of approximately 7,000 million m<sup>3</sup> of water (IRG, 2011; MINAM, 2010).

## Future Climate Scenarios and Impacts

Projections show an increase in annual mean temperature of up to 1.6°C by 2030 and by 2°C by 2050 (MINAM, 2010). Peru's National Service for meteorology and hydrology (SENAMHI) data predicts that glaciers can lose up to 37% of their current area by 2030.

Rainfall projections at the national level (for 2030) show increases by 20% in the coast, northern Andes, parts of the central Andes and the southern rainforest. On the other hand decreases of up to 20% are projected in the northern rainforest and parts of the central and southern Andes (MINAM, 2010). Sea level is expected to rise between 0.60 and 0.81 meters over the next 100 years along the northern coast, which will lead to flooding of the low areas, erosion, and saltwater encroachment (IRG, 2011).

- **Agriculture**

Approximately 66% of all agricultural lands in the country are rainfed, thus, the projected changes in rainfall patterns will affect the agricultural sector as well as its population (IRG, 2011).

- **Fisheries**

Projections indicate increase in sea surface temperature (SST) off the Peruvian coast, by around 3-4°C above the current level, which suppresses upwelling of nutrient-rich cold water, threatening Peru's 736 known marine species and artisanal fisheries (IRG, 2011 and World Bank, 2009).

- **Amazon rainforests**

According to a report for the USAID (IRG, 2011:16), the diverse biodiversity of Peru's Amazon rainforests consists of over 3,000 orchid species, 32 species of primates, and 312 species of endemic birds, which could all be affected by fluctuating annual levels of precipitation. Erratic rainfall could also increase the risk of forest dieback; this will alter the provision of forest ecosystem goods and services. Although, productivity could increase with warming temperatures partly due to CO<sub>2</sub> fertilization, as pointed out in a report by FAO (2012:3), this is likely to be temporal and will reduce once CO<sub>2</sub> saturation levels have been reached.

## Economic Analysis of EbA Measures

Peru has submitted two National Communications to the UNFCCC (2001 and 2010). In addition, in 2001, it published its National Strategy for Climate Change (NSCC), which prioritises adaptation and mitigation policies and programmes. It is intended to promote and develop policies, measures and projects to increase the country's adaptive capacity to climate change. This led to the implementation of several adaptation initiatives (Torres & Frías, 2012; World Bank, 2009). The majority of Peru's governmental programmes and plans integrate environmental management and climate change.

Following are a few specific examples of implemented ecosystem-based adaptation actions, and their values:

- **Agroforestry – innovative adaptation measure:**

Between 2006 and 2007, an agroforestry project was implemented in the tropical rainforests of northern Peru (Sisa river basin) by Practical Action - Latin America (*Soluciones Prácticas*). The project aimed to reduce the vulnerability of small-scale coffee and cocoa producers (farmers) and strengthen their capacity to adapt to climate change.

The project integrated environmental conservation into local economic development priorities. It built on local, traditional knowledge, and strengthened social organisation, which opened up access to international markets. Subsequently, the project resulted in increased household income levels (Torres & Frías, 2012).

The main achievements of this project are highlighted in a case study by Torres and Frías (2012) and are as follows:

- **Increased biodiversity:** Through the plantation of various plant, shrub and tree varieties into 135 hectares of coffee and cocoa plantations;
- **Improved technical capacity of farmers:** The farmers were provided with planning tools to improve farm management. They increased yields and diversified production by introducing native forest species, fruit trees and cocoa plantations, and by processing new products (i.e. jams, chocolate and liquors);
- **Improved household income levels:** 278 farms received the fair trade mark and 200 farms were certified as organic, with 25% of all coffee and 45% of all cocoa achieving the quality required for

international markets. This enabled them to access international markets and earn higher prices. The remainder was sold locally and nationally. The presence of Oro Verde Cooperative helped to regulate and maintain prices paid by intermediaries, which has been beneficial for all producers in the region. In addition, improved pruning techniques increased cocoa productivity from 350 to 500 kg/year. Increases in the net value of coffee production led to a 34% increase in income levels, in comparison to incomes prior to the project. Similarly, the net value of cocoa production increased producers' income levels by 7%;

- **Strengthened social organisation:** This was done by establishing sector committees and promoting farmer membership in the Oro Verde Cooperative. This cooperative operates with 19 producers' committees and facilitates access to national and international markets. In addition, through cooperative meetings and by inviting representatives to participate, it strengthened links with the local government. (Torres & Frías, 2012:4).

- ***Value of Peru's Protected Areas***

As per the TEEB project, 16 watershed protected areas in the country have an estimated value of US\$81 million/year and supply water to approximately 2.7 million people (TEEB, 2009:17). The rivers in these protected areas also contribute 60% of the country's hydroelectricity generation, with an estimated value of US\$320 million. Additionally, by protecting dams and reservoirs from sedimentation, the protected areas also provided savings of US\$5 million in the decade up to 2008 (Mulongoy and Gidda, 2008:18).

Furthermore, as highlighted in a report by the Convention on Biological Diversity (CBD), and drawing on an analysis in 2007 of Peru's entire protected area system, which covers 14% of the country, it was found that the benefits in 2008 contributed over US\$1 billion per year to the national economy, compared to the US\$1.7 million allocated for park management. Every dollar invested in protected areas returned US\$146 (Mulongoy and Gidda, 2008).

Agroforestry is one of the mechanisms used in EbA projects and the first example here shows how this helped to not only improving household incomes but also in conserving biodiversity. In the long run this would be beneficial in assisting the farmers to cope with climate change through nature based options. The value of watershed protected areas highlights the contribution of ecosystems to the country's exchequer through provision of hydropower and income through tourism; both providing much more value than was invested in them.

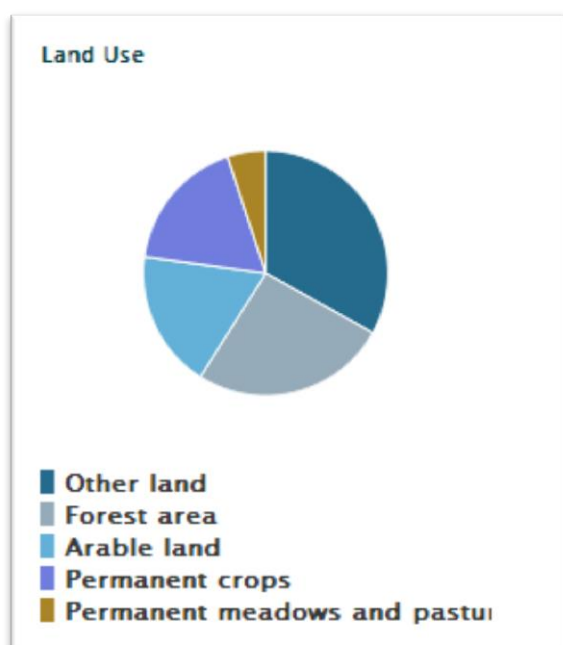
# Philippines

## Country Profile and Existing Climate Trends

The Philippines has a total surface area of 299,404 km<sup>2</sup>, encompassing large mountainous terrain, narrow coastal plains, interior valleys and plains, and 343 independent principal river basins which occupy 66.5% of the area. The country has three major island groups: Luzon, Visayas and Mindanao. Its marine territorial waters cover approximately 2.2 million km<sup>2</sup> (12% coastal waters and 88% oceanic waters within the exclusive economic zone - EEZ) (IACCC, 1999). The coastal ecosystems (including coral reefs) are of significant importance to the country in terms of fisheries for food and nutrition security, employment, coastal protection, tourism, and aesthetic value (*ibid*; White, Ross & Flores, 2000).

The country's total forest area is estimated at 15 Mha and is among the most diverse in the world, yet also among the most endangered.

Figure 6 FAO Estimate, 2012



Alienable and disposable lands (lands not needed for forest use) occupy approximately 14.12 Mha, of which 90% are dedicated to agricultural production, the country's economic mainstay. Of the agricultural lands 33% are situated in the highland, whereas 45% are in the lowlands (IACCC, 1999). In 2010, agriculture contributed approximately 10% to the GDP and in 2011 over 80% of water use was by this sector (FAOSTAT, 2014). Total value of agricultural production in 2012 was over US\$22 million and food exports, excluding fish, amounted to almost US\$4 million in 2011. Total fisheries production was 3 million MT in 2010, with exports amounting to US\$639 million. In 2013, total forestry production was over 15 million m<sup>3</sup> (FAOSTAT, 2014).

Due to the country's location in the typhoon belt, tropical climate, and as an archipelago, the Philippines is stated as the world's third most vulnerable country to extreme climate events and natural hazards (i.e. typhoons, floods, landslides, sea level rise, and droughts). The list of top 50 most vulnerable regions in Southeast Asia also includes 16 of the country's provinces and the cities San Jose, Manila, Roxas, and Cotabato are among the top ten most vulnerable cities to sea level rise and intensified storm surges in the East Asia and Pacific region (World Bank, 2013).

From 1971 to 2000, the country observed an increase in annual mean temperature of 0.57°C, which is an average increase of 0.01°C per year (DOST-PAGASA, 2011). This has affected the country's

agricultural sector and crop yields, such as rice, have shown a decrease whenever rising temperatures exceeded threshold values (DOST-PAGASA, 2011).

Moreover, according to the Philippines Climate Change Commission (CCC), the annual damage to agriculture from extreme events - tropical cyclones, droughts, and floods- was estimated at Php 12 billion (approximately US\$280 million based on 2011 exchange rate), equivalent to 3% of the country's total agricultural production (CCC, 2011). For example, in December 2012, cyclone Bopha, a category five cyclone, caused US\$646 million in damages to the agricultural sector, with an estimate 25% of banana production destroyed. Restoring these damaged banana production farms would cost approximately \$122 million. (World Bank. 2013: Turn Down the Heat). The country's coral reefs have decreased by half after the 1998 to 1999 ENSO-inducing coral bleaching, and fisheries yield diminished by more than Php 7 billion (approximately US\$163 million based on 2011 exchange rate) ( World Bank, 2013: Getting a Grip).

The National Climate Change Action Plan highlights that nearly all of its ecosystems have been significantly transformed or degraded due to the conversion of forests and grasslands into crop lands and settlements, the diversion and storage of freshwater in dams, and the loss of mangroves and coral reefs. Consequently, only 6 to 8 % of the country's primary forests remain, and only 5% of its coral reefs have 75-100% live coral cover. (CCC, 2011:9). Thus, climate change coupled with ongoing unsustainable development practices, environmental deterioration, and additional non-climate factors will place further pressure on already vulnerable ecosystems.

## Future Climate Scenarios and Impacts

The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) carried out climate projections using the PRECIS model for the years 2020 and 2050. These indicated that all parts of the country can expect an increase in annual mean temperatures by 0.9°C to 1.1°C in 2020 and by 1.8°C to 2.2°C in 2050. Extreme temperatures, as indicated by the number of days with maximum temperature exceeding 35°C, will continue to become more frequent (DOST-PAGASA, 2011; CCC, 2011).

The projections also indicate changes in seasonal rainfall, with reduced precipitation in most of the country's provinces during the summer season (March, April and May - MAM) and in most of the provinces in Mindanao by 2050 during the southwest (SW) monsoon season (June-August). Increases in rainfall are likely in the provinces in Luzon (0.9%-63%) and Visayas (2%-22%) during the south-western monsoon. Rainfall is projected to increase during the north-eastern monsoon season (December-February) as well. Thus, an increase in the chances of both flood events and drought in parts of the country is likely (*ibid*).

In addition, other extreme events such as typhoons are expected to increase. It is projected that sea levels will rise by about 50 cm by 2030 and 100 cm by 2060 (World Bank 2013: Turn down the Heat). A global average of 100 cm sea level rise in the region, in addition to an increase in intense typhoons, will intensify the occurrence of storm surges (*ibid*). Additionally, a study by Blankespoor, Dasgupta, and Laplante (2012) assessed the economic implications of a 1m sea level rise on coastal

wetlands in the East Asia Pacific region, and estimated that the Philippines is expected to lose 229 km<sup>2</sup> of great lakes and wetlands by 2100.

These projected climate changes will have significant impacts on the country's population, (particularly on the communities dependent on subsistence livelihoods) and will result in economic losses. Farmers and fishing communities, among the poorest in the country, will be most affected. With storm surges projected to intensify due to rising sea level and intense tropical cyclones, the World Bank (2013) estimates that 14% of the Philippines' total population and 42% of its total coastal population will be affected.

- **Agriculture**

The projected increase in temperatures and rainfall as well as expected increases in the strength or number of tropical cyclones will severely affect the agriculture sector and will lead to further reduced crop yields, especially in the absence of adequate management interventions (World Bank 2013; DOST-PAGASA, 2011). According to the World Bank (2013:24) rice yields could be reduced by up to 75% by 2100 compared with 1990.

Decreases in rainfall during the March-April-May season and an increase in drier periods will also affect the amount of water in watersheds and dams, which provide irrigation services to farmers, particularly those in rainfed areas (DOST-PAGASA, 2011). Consequently, decreased yields and thus reduced livelihoods may lead to climate induced migration, which will place more pressure on already densely populated urban areas (*ibid*:50). In addition, rising temperatures and erratic rainfall could affect the incidence of pests and diseases (DOST-PAGASA, 2011).

- **Fisheries**

The fisheries sector of the country will suffer due to the projected sea level rise, changes in ocean dynamics, such as warmer sea temperatures (SST) and ocean acidification (due to rising atmospheric and ocean CO<sub>2</sub> concentrations). A report by the World Bank (2013:68: Turn Down the Heat) indicated that, in a 4°C warmer world, the projected changes in maximum catch potential of marine fisheries could lead to a 50% decline around the southern part of the Philippines, whereas the northern Philippines could expect a 6 to 16% increase during the 2050's, as fish will migrate toward more favourable conditions. This is likely to create challenges for fishing communities in affected coastal regions resulting in major social, economic, and nutritional impacts (*ibid*).

A number of coastal communities are involved in seaweed production as an adaptation to climate change, however this practice could be impacted adversely by the changing climate as well (DOST-PAGASA,2011:50).

*"South East Asian rural livelihoods are faced with mounting pressures as sea-level rises and important marine ecosystem services are expected to be lost as warming approaches 4°C. Coral systems are threatened with extinction and their loss would increase the vulnerability of coastlines to sea-level rise and storms. The displacement of impacted rural and coastal communities resulting from the loss of livelihood into urban areas could lead to ever higher numbers of people in informal settlements being exposed to multiple climate impacts, including heat waves, flooding, and disease."*

*Source: World Bank, 2013 (Turn down the Heat)*



- **Forestry**

The projected changes in seasonal rainfall coupled with warmer temperatures and drier periods could lead to changes in forests ecosystems, and impacts (such as die backs and forest fires) on forestry and its resources could be expected to increase in the future. This in turn will affect the communities that depend on forest services and they may be forced to alter traditional livelihood practices. This could lead to further degradation of the environment due to the adoption of extensive agricultural production in already degraded areas (DOST-PAGASA, 2011:49).

## Economic Analysis of EbA Measures

In 1991, the Philippine government established the Inter-agency Committee on Climate Change (IACCC), intended to coordinate various climate change related activities, propose climate change policies and prepare its positions to the UNFCCC negotiations (IACCC, 1999). Recognizing the need for coordination among government agencies to effectively deal with the impacts of climate change, the government legislated the Climate Change Act in 2009 and established the Climate Change Commission (CCC) (CCC, 2011). The Commission was mandated to formulate the National Framework Strategy for Climate Change (NFSCC) and the National Climate Change Action Plan (NCCAP) (*ibid*). A number of programmes and projects have been implemented that aim to test integrated natural resource management and adaptation activities (DOST-PAGASA, 2011:52).

An executive report by the World Bank on climate change in the Philippines (2013:41), highlighted that the majority of funding for the country's NCCAP priority on Ecosystem and Environmental Stability, has supported the development and implementation of mitigation and adaptation strategies for key ecosystems. However, the same report also pointed out that there is a need for more research outlining how the projected changes in climate parameters can affect major economic sectors and ecosystems, such as the farming, fishing, water resources, marine resources, local biodiversity, infrastructure, and human health sectors (*ibid*).

A few examples of implemented adaptation initiatives are provided below, which relate to mangrove restoration and fisheries, and highlight a few benefits of natural resource management.

- **Mangrove ecosystem restoration and its effectiveness**

The Philippines has undertaken mangrove restoration activities for over 20 years to deal with the uncertainty associated with climate change, such as the associated sea level rise, and coastal erosion. One activity was the monoculture plantations of *Rhizophora spp.* on 40,000 ha of mudflats. This led to several co-benefits and the following mangrove ecosystem services were enhanced: protection from storms and typhoons, fish habitat, and carbon sequestration. These benefits led to the improvement of fisheries, water resources, livelihoods, increased incomes from improved fisheries, and human well-being. (Alexander & McInnes, 2012).

- **AGCA Marine sanctuary and its effectiveness**

The AGCA Marine sanctuary, is a locally-managed marine protected area (MPA) in Tinambac, Partido, and illustrates an EbA approach in maintaining the integrity of marine ecosystems and sustaining community livelihoods (Demesa *et al.*, 2013). Based on a recent case study undertaken by Demesa *et al.* (2013:5-6), the AGCA Marine sanctuary has provided the following benefits, since its implementation in 2007:

- The AGCA Pride Campaign resulted in the formation of policies, undertaking of environmental education, and regular patrolling and guarding. These processes enhance the communities capacity to adapt to changes associated with climate and ecosystems;
- The sanctuary increases the ability of coral reefs to recover faster from bleaching and improve their resilience to changing SST and sea level rise. Subsequently, there has been a significant increase in fish biomass, from 32.8 MT/km<sup>2</sup> in 2011 to 55.6 MT/km<sup>2</sup> in 2012 within the MPA;
- Local farmers observed an increase of nearly 20% in their seaweed harvest. The income gained was used to make their houses more durable able to withstand strong typhoons. In addition, the income was used as additional capital in diversifying livelihoods (Demesa *et al.*, 2013).

- **Coral reef and wetland management: Cost and benefits**

Coral reef valuation studies indicate that reefs in the whole country are contributing an estimated US\$1.35 billion to the national economy, and that “one km<sup>2</sup> of healthy reefs with some tourism potential produce annual net revenues ranging from US\$29,400 to US\$113,000” (White *et al.*, 2000:2).

A cost benefit analysis(CBA) carried out by White *et al.* (2000), on the potential value of sustainably managed coastal resources on Olango Island, illustrated that sustainably managed coral reefs and wetlands yielded annual incremental benefits from fisheries and tourism of up to US\$1.45 million. The calculated costs for island-wide management of these ecosystems were US\$91,000. The study thus concluded that there is a very strong justification to invest in the management of coral reefs, as improved reef quality and wetland stewardship on Olango Island could mean a 60%(US\$1.4 million) increase in annual net revenues from reef and mangrove fisheries and tourism.<sup>6</sup>

Balmford *et al.* (2002) synthesized economic studies that examined the exploitation of Philippine reefs and showed that although there were high initial benefits, fishing techniques that resulted in the destruction of reefs reduced social benefits and the degraded reefs had a total economic value of US\$870/ha. On the other hand, a healthy reef which supported tourism, provided coastal protection and increased fisheries had a total economic value of US\$3,300/ha (World Bank, 2009).

Having a large coastline and comprising of thousands of islands makes the Philippines extremely vulnerable to climate change impact on coastal areas. Conservation of coastal resources such as mangroves and coral reefs, not only increase livelihoods but provide additional co-benefits (such as storm protection and carbon sequestration) to the fishing communities. The studies above clearly

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<sup>6</sup> A detailed summary of the annual net revenues (benefits) derived from the resources of primary concern with and without management interventions on Olango Island are summarized in a Table on p. 12 in the report by White *et al.* (2000), available at: [www.oneocean.org](http://www.oneocean.org)

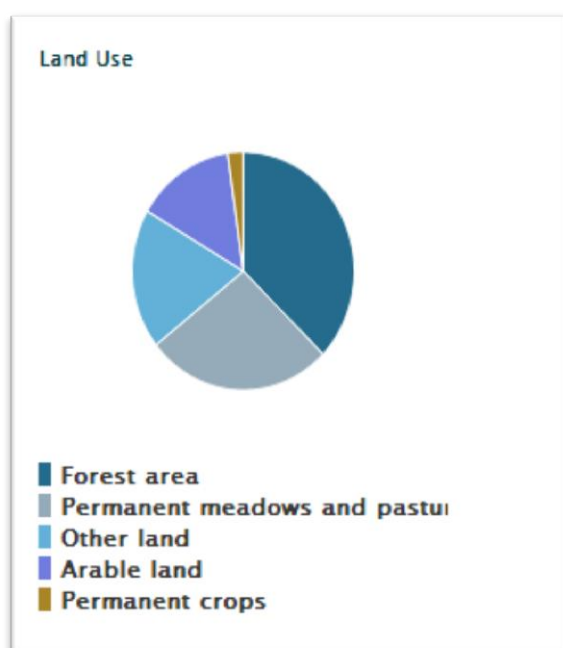
highlight that the benefits of ecosystems based adaptation activities far outweigh the costs associated with implementing them.

# Tanzania

## Country Profile and Existing Climate Trends

The United Republic of Tanzania is situated in the southern hemisphere and includes Tanzania mainland and Zanzibar. It has a total continental area of 945,087 km<sup>2</sup>, comprised of 883,749 km<sup>2</sup> land area (881,289 km<sup>2</sup> mainland and 2,460 km<sup>2</sup> Zanzibar), 59,050 km<sup>2</sup> of inland water bodies, and part of the Indian Ocean (URT, 2012).

Figure 7 FAO Estimate, 2012



The country has the highest forest cover within Eastern and Southern Africa. Out of a total area of 35.3 Mha of forests, 16 Mha are reserve forests, 2 Mha are in national parks and 17.3 Mha (49% of all forestland), are unprotected forests. Forests are estimated to contribute approximately between 2.3% and 10% to overall GDP, though this estimate does not include the contribution from, wood fuels, bee products, catchment and environmental values (URT, 2012: 13). In 2013, roundwood production was over 25 million m<sup>3</sup> (FAOSTAT, 2014).

In 2010, agriculture, forestry and fisheries formed 26% of the GDP (Promar Consulting, 2010). The mainstay of the country's national economy is agriculture, comprising of crops and livestock sub-sectors. It contributed 23.7% to the overall GDP,

provided 30.9% of export earnings, and employed approximately 75% of the total labour force in 2011 (URT, 2012). The country's agricultural sector has grown over the years at an average rate of 4.4%, which is higher than the average annual population growth rate of 2.9%, implying an increase in household incomes (*ibid*). In 2012, total agricultural production value amounted to almost US\$9 billion and total food exports, excluding fish, amounted to US\$474 million (FAOSTAT, 2014).

Wetlands cover 10% of the total land area and 5.5% encompass the four Ramsar sites: Malagarasi-Moyovosi (32,500 km<sup>2</sup>), Lake Natron Basin (2250 km<sup>2</sup>), Kilombero valley floodplain (7,950 km<sup>2</sup>) and Rufiji-Mafia-Kilwa (5,969.7 km<sup>2</sup>). Wetlands are important for fishing and related livelihood activities, supporting millions of people (URT, 2012).

In 2010, an estimated 85% of the total fish production (approximately 350,000 MT) in the country came from freshwater fisheries and about 15% came from marine fisheries. In 2010, Lake Victoria had a domestic catch of 70%, followed by Lake Tanganyika with 9% and Lake Nyasa with 3% (Promar Consulting, 2010). Combined fresh water and marine fisheries contributed 1.7% in 1998 to 1.4% in 2009 to the overall GDP (URT 2012: 18). Fishery exports were valued US\$268 million in 2010 (FAOSTAT, 2014).

Tanzania's climate is complex with variations across the country and strong seasonality, due to its topography, altitude, and a wide variety of physical features such as inland lakes, the Great Rift Valley System, diverse vegetation, and mountain ranges (URT, 2012). Two main rainfall regimes can be identified: the long (mid March to end of May) and the short rain (mid October to early December) (URT, 2012). Extreme climate events also occur, such as floods during the rainy season and El Nino years, as well as drought in the dry season (Watkiss *et al.*, 2011; Devisscher, 2010).

An analysis of recent (2009) climate data from the country's meteorological stations and observational evidence from local communities, indicates that temperatures have shown an increasing trend in most parts of the country, particularly over the highland areas. A decrease in precipitation, as well as a seasonal shift in rainfall patterns are becoming more common (URT, 2012). Tanzania's National Adaptation Programme of Action (NAPA) also reported that while rainfall trends are more difficult to interpret, in recent periods, rainfall patterns have become more unpredictable with some parts of the country receiving extreme minimum and maximum rainfall (Watkiss *et al.*, 2011:6).

The country is highly vulnerable to changes in climate because of its high economic dependence on climate-sensitive sectors (agriculture, forestry and fisheries) and the goods and services these provide. Additionally, the majority of its population have a limited livelihood base and poor access to markets and services, making them particularly vulnerable to the adverse impacts of climate variability and change (Devisscher, 2010). In the last 40 years the country has experienced several severe and recurring droughts (especially in 2003, 2005, and 2009) that have led to major economic losses. The impact of the 2005/2006 drought event affected millions of people and had damage costs of at least 1% of the overall GDP (URT, 2012; Watkiss *et al.*, 2011). During 2012-2013, Tanzania experienced severe flooding due to an intense monsoon season (World Bank, 2013: Turn down the Heat).

## Future Climate Scenarios and Impacts

The study 'Economics of Climate Change in the United Republic of Tanzania' by Watkiss *et al.* in 2011, produced statistically downscaled climate projections, which indicate that the average annual minimum and maximum temperatures are expected to increase in the range of 1-3°C for the period 2046-2065. By 2100, average temperatures are expected to increase in the range of 1.5°C to 5°C, with the greatest increases expected to be inland and in the north-eastern areas. These results are predominantly consistent with projections from other studies using global models (i.e. URT, 2012; Devisscher, 2010).

More uncertainty is however prevalent in projected changes in precipitation, as the degree and direction of change differ across the models. According to Watkiss *et al.* (2011) and Devisscher (2010), there are also variations between seasons, regions and rainfall regimes. The projections from many Global Circulation Models (GCM) indicate that due to doubling of CO<sub>2</sub> concentration in the atmosphere by 2100, there will be an increase in rainfall in some parts (mainly the northern areas) while other parts will experience decreases (URT, 2012; Watkiss *et al.*, 2011; Devisscher, 2010).

With regard to extreme events, GCMs indicate that both the frequency and intensity of rainfall could increase, thus leading to greater flood risks in some parts of Tanzania. However, the affect from climate change on the frequency and magnitude of El Niño are unclear (Watkiss *et al.*, 2011; Devisscher, 2010). Similarly, there is uncertainty about whether droughts will become more intense and/or frequent (Watkiss *et al.*, 2011).

These projections could lead to large economic costs. The study by Watkiss *et al.* (2011), based on top-down aggregate models (though with a level of uncertainty), indicate that net economic costs could be equivalent to an additional 1-2% of overall GDP annually by 2030. The study also reports that the impacts of existing climate variability and projected climate change together may place challenges towards achieving key economic growth, development and poverty reduction targets (Watkiss *et al.*, 2011).

- **Agriculture**

Over the years, a number of studies have assessed the possible impacts of climate change on Tanzania's agricultural sector, using different projections and models, considering different regions, and thus, showing different results. As identified by Watkiss *et al.* (2011:7-8), some projections predict adverse impacts, with significant declines in yields (for certain products) in some regions, while others imply lower impacts, and some even estimate an increase in agricultural yield (in some products) for some regions.

An additional threat to agriculture is the decrease in water resources, leading to increased vulnerability of irrigation systems and livestock mortality (URT,2012).

*"Sub-Saharan Africa's food production systems are increasingly at risk from the impacts of climate change. Significant yield reductions already evident under 2°C warming are expected to have strong repercussions on food security and may negatively influence economic growth and poverty reduction in the region. Significant shifts in species composition and existing ecosystem boundaries could negatively impact pastoral livelihoods and the productivity of cropping systems and food security."*

*Source: World Bank, 2013 (Turn down the Heat)*

- **Coastal zones, marine area and fisheries**

As an island, Zanzibar will be vulnerable to future sea level rise from climate change. Potential sea level rise may cause flooding and loss of low-lying areas, coastal erosion, saltwater intrusion and increased salinity in aquifers and water supplies. These impacts are likely to affect human settlements, agricultural lands, infrastructure, transport, and water resources within the coastal zone, as well as tourism and provisioning services such as fishing, aquaculture and agriculture (Devisscher, 2010).

In addition, possible drought events could lead to a decline in fish yields and rising sea surface temperatures (SST) could alter coral reefs, causing bleaching and mortality, which will have impacts on the reef fisheries sector (Kangalawe, 2013).

- **Forests**

According to Watkiss *et al.* (2011:9), the potential effects of climate change on forests are highly complex. There could be some potential benefits as well as several threats, either through direct climate change impacts (i.e. changes in temperature, precipitation and variability, including extremes) and indirectly (i.e. effects on soil, moisture, pests and diseases and fire risk). Such impacts

could affect the growth rate, health of forests, biodiversity, and ecosystem stability, which could lead to die backs. Consequently, this will reduce the services and economic value that the forests provide (i.e. timber, building material, soil and flood protection, carbon storage).

## Economic Analysis of EbA Measures

Over the years Tanzania has undertaken a number of initiatives and programmes that address climate change (URT, 2012). Some examples of these initiatives include: the Environmental Management Act; the National Communication to the UNFCCC in 2003; the National Adaptation Programme of Action (NAPA) in 2007; the implementation of REDD+ initiatives; and the National Climate Change Strategy in 2012 (*ibid*).

The National Climate Change Strategy outlines initiatives to address both adaptation and mitigation, with a focus on preserving the countries forests and on sustainable development (URT, 2012).

The EbA approach has been integrated in the following national strategies: The Development Vision 2025; the National Strategy for Growth and Reduction of Poverty (2010–2015); the National Strategy for Urgent Actions on Land Degradation and Water Catchments (2006); the National Biodiversity Strategy and Action Plan, and the National Climate Change Strategy (2012) (Kangalawe, 2013).

Following are a few case studies that highlight the value of a few of the implemented EbA initiatives within the country:

- **Forests and natural resources**

A government initiative entitled Hifadhi Ardhi Shinyanga (HASHI), meaning ‘soil conservation’ in Swahili, was initiated in 1986 in the Shinyanga Region, Western Tanzania. Based on indigenous knowledge, this project used a natural resource management system called *Ngitili*, a Sukuma word meaning ‘enclosure’ or ‘fodder reserve’, to create and restore forests in the region. Over the years this project has proven crucial in revitalizing the local communities traditional practice of conservation, and by 2002, between 300,000 and 500,000 ha of *Ngitili* were restored in the 833 villages of the region. Thus, it helped protect the environment and improve the livelihoods of the communities (Barrow & Shah, 2011).

A case study carried out by Barrow and Shah (2011:2) on the cost and benefits as well as lessons learned of this restoration project revealed the following:<sup>7</sup>

- The economic value of a restored *Ngitili* is US\$14/person/month, while national average rural consumption is US\$8.50/person/month. It has reduced the time required to collect fuel wood, pole, thatch, water and fodder by several hours;
- Sukuma agro-pastoralists pointed out that the conservation of the trees and catchment area improved water quality in the region, the restored woodlands provide fodder for oxen at the

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<sup>7</sup> For a full overview of some of the outcomes of the *Ngitili* study, please refer to the original report by Barrow and Shah, 2011, Table 1, page 2: Barrow, E. & A. Shah (2011). “*TEEBcase: Traditional forest restoration in Tanzania*”. Available at: [www.TEEBweb.org](http://www.TEEBweb.org)

end of the dry season and that revenues from the sale of tree products (i.e. honey and poles) paid for their children's education;

- Restoring the forest had an indirect effect as well (which was not part of the original objectives), that *Ngitilis* made a large contribution to carbon sequestration. The analysis estimates that about 23.2 million MT of carbon were sequestered with a value of approximately US\$213 million. The authors highlight that the region could thus be used as a REDD pilot site (Barrow & Shah, 2011).

- ***Coastal protection***

Results of a cost-benefit analysis (CBA) on coastal protection and beach nourishment (to counter erosion) show that the number of people at risk from flooding reduced from 0.3 to 1.6 million per year in 2030 in the absence of adaptation, to 0.04 to 0.1 million per year with adaptation. The costs of climate change are reduced from up to US\$55 million per year in 2030 (2005 values, undiscounted) to under US\$20 million per year with adaptation. The benefits can be even higher with greater reductions in costs in subsequent years, highlighting the cost-effectiveness of such adaptation measures (Watkiss *et al.*, 2011:11).

- ***Value of Biodiversity***

Direct use values of wild foods either as contributions to household consumption or income from sale were estimated in select African countries. In Tanzania these amounted to 58% of cash income from sale of NTFPs and wild foods, providing US\$378 per household per year. These included US\$265 as plant medicine, US\$27 as wild fruits, US\$15 as wild vegetables, US\$20 as wild animals, US\$10 as insects, US\$18-126 as wild honey and US\$21 as leaves and stems (Kesthala *et al.* 2008 as seen in Bharucha *et al.* (2010).

The example of forest conservation not only reduced community vulnerabilities by increasing their livelihoods but also provided the additional co-benefit of carbon sequestration. The second study shows that the costs of climate change can be significantly reduced if adaptation measures are implemented in coastal areas.



## Gap Analysis and Recommendations

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***"Climate change is a complex problem, which, although environmental in nature, has consequences for all spheres of existence on our planet. It either impacts on-- or is impacted by-- global issues, including poverty, economic development, population growth, sustainable development and resource management. It is not surprising, then, that solutions come from all disciplines and fields of research and development."*** UNFCCC <sup>8</sup>

UNEP (2014) undertook a preliminary assessment report on the adaptation gap. According to this report ***"Estimating the adaptation gap is far more challenging than calculating the emissions gap, as there is no globally agreed goal or metrics for adaptation, and adaptation is a response to specific climate risks and impacts."***

The review of EbA (or EbA related and other nature based) projects in this study shows that adaptation has become a necessary strategy to *"adjust human and natural systems so that communities are more resilient and can cope with the harmful effects of climate variability"* (CGIAR, 2013). To this end, adaptation interventions have taken place to ensure that human and natural systems both adapt to already occurring climate variability, by reducing their vulnerability and increasing resilience. It is now clear that no matter how strong mitigation efforts are, there would still be impacts from climate change and adaptation to these impacts is crucial.

Ecosystems based adaptation (EbA) is increasingly being considered as a strong and cost-effective means of dealing with the impacts of a changing climate. To this end, a rapid assessment was undertaken of the six countries to increase the understanding of EbA implementation and especially to gather information regarding their economic costs and benefits, in order to make the case for investing in nature based solutions for climate change.

These countries are dependent on natural systems for their economic growth. All of them rely on agriculture, fisheries or forestry as main economic sectors, which contribute extensively, not only at the local levels but also to the national exchequer. Another sector not reviewed in the study is the water sector, which is extremely important for all of the countries and also directly affected by climate change. This makes a strong case for implementing EbA projects in order to increase the resilience of people and nature.

While there are EbA projects per se, as well as sustainable development and conservation projects being implemented in the six countries, there is a lack of a conclusive evidence base to highlight the effectiveness of ecosystems based approaches to deal with climate change. Furthermore, inadequate technical knowledge regarding the designing and implementation of projects, as well as issues related to capacity also serve as obstacles to effective implementation (Naumann *et al*, 2010). An important challenge is regarding the distribution of institutional, financial and technical resources.

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<sup>88</sup> [http://unfccc.int/essential\\_background/items/6031.php](http://unfccc.int/essential_background/items/6031.php)

To overcome this, there is a need to increase knowledge regarding the implementation of EbA approaches. This can be done by gathering an effective evidence base of successful projects, those which not only made communities resilient and less vulnerable, but were also maintained over longer periods of time. The important economic sectors of agriculture, fisheries and forestry, as well as water need to be individually assessed to understand the risks they face from changes in climate and how these risks can be minimized. It is also important to assess the species variability and importance in EbA projects in terms of agriculture, fisheries and forests.

*"Knowledge gaps can be framed in the context of bridging either the generic adaptation gap or a specific adaptation gap. While they are difficult to quantify, it is possible to set specific and measurable targets for addressing them."*

*Source: UNEP 2014*

A sophisticated, robust and appropriately designed assessment methodology is required that would help to understand the benefits provided by EbA projects in the countries. The assessment should consider the long term sustainability of the projects, to ensure that their benefits continue well into the future. An important aspect to consider - according to a review undertaken by Independent Evaluation Group (IEG) of World Bank projects - is maladaptation<sup>9</sup>, which could mean undertaking adaptation projects that may provide benefits in the short term but result in issues in the longer run. Lack of consideration for specific species in adaptation projects can also lead to maladaptation.

Technological requirements, that meet human and ecological needs in addition to providing climate benefits must also be assessed. (UNEP 2014). As per UNEP (2014)" ***technology transfer as such is not the key obstacle for closing the adaptation technology gap—rather dissemination and uptake pose more important obstacles.***" This can be facilitated by increasing incentives, improving regulation and strengthening institutions (UNEP 2014).

Climate change also has implications at the social level and different groups can be impacted by it differently. Assessments of projects also need to consider disaggregated data in terms of age, gender, indigenous and other social groups and income levels. This is important because decision making is impacted by the social status of communities and of groups within communities. In particular, gender is an important aspect to consider, as both men and women play important roles in natural resource management. A study of community water projects by the International Water and Sanitation Centre (IRC) found that project that had the full participation of women tended to be more effective than those that did not (GGCA, 2013). Having data on EbA projects that provided benefits to all groups, including women and children would be extremely useful in designing future projects.

Another aspect that needs to be underscored, is to delineate projects in terms of increasing resilience and decreasing vulnerability. A mix of projects that encompass those that are working to raise resilience by strengthening livelihood activities and those that are working primarily to decrease vulnerability to disasters is required.

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<sup>9</sup>Any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability, but increases it instead. (McCarthy, Canziani and others 2001 as seen in IEG World Bank).

Important information can also be garnered from EbA projects that can provide mitigation co-benefits and such projects can be useful in promoting ecosystem based adaptation nationally and globally.

Finally, an effective way to show the success of EbA projects is to undertake economic valuation/cost-benefit analyses to show their contributions in economic terms.

## Lessons from TEEB

The Millennium Ecosystem Assessment (MA, 2005) established the services provided by ecosystems. As a result of this report, it became clear that human societies are extensively dependent on natural systems and their supporting, provisioning, regulating and cultural services.

Despite this understanding there were still complications in applying nature based solutions, due to the fact that the contribution of these systems in economic terms were not clearly understood. The task of increasing this understanding was taken by the TEEB project, which provided and (is still providing) more and better data and understanding of the economic significance of biodiversity loss and the contribution of nature to the economies of the world (TEEB 2010).

This huge undertaking was based on the realisation that *"Human decisions lead to actions that have impacts on ecosystems, causing changes in ecosystem structure and function. These changes in turn lead to changes in the provision of ecosystem services. Changes in ecosystem services have impacts on human welfare. A clear understanding of these links can provide information that can lead to the reform of institutions and better decisions that ultimately improve the state of ecosystems and the services they provide to society"*(TEEB 2010).

As a result of this and other studies, economic valuation of nature has become an important requirement for decision making in natural systems. A large number of valuation studies around the world now make the case again and again that nature provides us with services that contribute to human well-being economically and the loss of which would result in major economic losses.

In 2009, TEEB Climate Issues Update was published, which highlighted challenges related to losses of coral reefs, forest carbon and investment in ecological infrastructure in the context of climate change. This document cited a study by Martinez *et al.* (2007), which estimated the value of global coral reefs at US\$172 billion annually. It also cited the Eliasch (2008) review, which estimated the cost of halving deforestation between US\$17 billion to US\$33 billion per year to 2030, which in turn would generate economic benefits of US\$3.7 trillion in the long term (including only the avoided damage costs of climate change).

Importantly, the TEEB update recommended investment in ecosystems for climate adaptation. It highlighted three important areas for adaptation, namely: agricultural productivity, freshwater supply and natural hazard management, all of which are directly affected by climate change (TEEB, 2009).

## Economic Benefits and Costs of EbA

Just as economic valuation studies have informed decision making for investing in sustainable development projects, there is a need to do the same for climate change related EbA interventions. UNEP (2014) highlighted that the possibility of there being a major adaptation funding gap after 2020 if new finance is not available. Because LDCs and Small Island States have higher adaptation needs and therefore there is a need to make the case to invest more in adaptation in these countries.

The countries in this study use nature based systems for the well-being of their populations. However the extent of the contributions of these ecosystems, especially in economic terms, is unclear. As noted previously, there is a crucial need to evaluate the benefits that they provide and the losses that would be incurred due to their degradation, especially in the face of a changing climate. This will provide knowledge for informed decision making in the future.

This highlighted the need for a rapid cost benefit analysis of ongoing and completed projects in the assessed countries. The projects reviewed for each country are not specific to EbA; some of them are general ecosystem conservation projects, due to lack of economic information regarding EbA options. However, the reason for their inclusion was that they tend to increase resilience of people and biodiversity.

The literature review showed that while information on the costs invested was easily available, there was lack of quantitative data that would help to assess the economic benefits provided by EbA projects especially because benefits were generally highlighted in qualitative terms. The available national data was insufficient to give a clear understanding of the contribution of ecosystems on which agriculture, fisheries and forestry rely, to the economy. The results were context specific and from different time periods, therefore difficult to apply to other scales and more importantly because benefits accrued were not easy to quantify. A study undertaken by Naumann *et. al*, (2011) of EbA projects in Europe showed variations in the amount and quality of evidence across projects. There were also data gaps regarding opportunity costs borne by communities in most cases. The assessment in this study also conforms to this. This is because no clear cost benefit analyses were undertaken and most of the information is the result of anecdotes and the estimations of project managers. The reason for this is often a lack of guidelines and little understanding of economic benefits in the context of uncertainty due to climate change.

The case studies indicate that many of the projects that applied ecosystems based approaches, did result in benefits that could be translated into economic terms to some extent. It can be presumed that the EbA projects are likely to be more cost effective than traditional engineering solutions, but in some cases the impacts of climate change may be so large that only engineered solutions will work. However, it is clear that further evidence is needed to make the case for EbA stronger. To promote ecosystem based adaptation to deal with climate impacts, especially in the context of developing countries, requires extensive data for policy makers to make informed decisions. As mentioned before, this information is lacking for EbA options in the selected countries. There is, therefore, a need to make the case for EbA solutions and this requires analysis of the economic costs and benefits of EbA options being implemented. Such studies would make the economic case for investing in EbA and to mainstream the approach into planning. Detailed and robustly designed

studies will also provide information to scale up EbA from local levels to more national and global arenas and also be an awareness raising tool to show damage avoided and benefits accrued.

The challenge is not only to value the benefits provided by EbA projects to show that they are not only more cost-effective in the long run, but to give optimal attention to natural systems, biodiversity and species; a rather more difficult undertaking. However, such evidence collected at the local level will inform strategic thinking nationally as well as globally. Non-market economic valuation methods can estimate values of EbA benefits that do not have market prices. Using non-market valuation helps account for all of the benefits of EbA and allows it to be compared on a more level playing field with engineered adaptation.

Two approaches can be applied: undertaking CBA before initiating the project to help stakeholders understand the costs and benefits of different EbA activities. More importantly however, there is a need to undertake detailed economic analyses of ongoing and completed projects in the six countries, to understand and gather the evidence that describes why EbA was more cost-effective than other solutions. This can then be extrapolated for national level EbA approaches, policies and strategies.

Extensive assessments will need methodologies that would differentiate between EbA and other development costs. This is important because it is difficult to differentiate between them and the two approaches are often integrated. Defining one-time and recurrent costs is also a necessary component in addition to having a uniform costing methodology.

This study highlighted the importance of agriculture, fisheries and forestry to the national economy. Detailed studies must differentiate between these sectors, as well as the water sector. Reviews of ecosystems contribution to agriculture; fisheries (especially in terms of coral reefs and mangroves); contribution of forests (and forest biodiversity and species) will make a strong economic case for ecosystem based adaptation.

*"Estimating the costs of adaptation involves a large number of methodological challenges, but perhaps the most important is the need to recognize uncertainty. There is a need to plan robust strategies to prepare for an uncertain future and not to use uncertainty as a reason for inaction".*

*Source: Watkiss, et .al, 2010*

In terms of quantifying the benefits accrued, appropriate assessment criteria must be established. As such there is a need for uniform and shared guidelines and methodologies that would provide crucial results to make the economic case for ecosystem based adaptation. It is also important to include monetary values of co-benefits, especially with regard to increased mitigation potential, among others.

The bottom line is this: the understanding of economic costs and benefits of ecosystems based approaches will provide additional important information, that would assist decision making at the local, national and global levels. While uncertainties and challenges may still remain, robust and appropriately designed valuation methodologies can help to decrease them. Detailed cost benefit studies therefore must be undertaken, of ongoing and completed projects in these countries, to decrease the existing knowledge gaps and to show policy makers why they should invest in EbA.







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