Cost and Benefits of Ecosystem Based Adaptation

The Case of the Philippines

Saima Pervaiz Baig, Ali Raza Rizvi, Maria Josella Pangilinan, Rosalina Palanca-Tan

Global Ecosystems Management Programme

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Catherine Chico-Almaden, Kresna Navarro, Marichu Obedencio and Caroline Serenas for ***The Total Economic Value (TEV) of the Cagayan de Oro River Basin***. Unpublished Research Report. Xavier University-Ateneo de Cagayan, Department of Economics, 2015.

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About MAEDI: Within the French Ministry of Foreign Affairs and International Development, the Directorate-General of Global Affairs, Development and Partnerships (DGM) develops and follows the French strategies for international cooperation on health, food security, human development, environment and climate. Through its diplomatic network, its operators and partners, it promotes actions in the field of the environment and climate change and participates, in conjunction with the relevant authorities, in international negotiations and processes related to environmental issues. MAEDI is one of the founding partners of the France-IUCN partnership

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IUCN is a membership Union uniquely composed of both government and civil society organisations. It provides public, private and non-governmental organisations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together.

Created in 1948, IUCN is now the world's largest and most diverse environmental network, harnessing the knowledge, resources and reach of 1,300 Member organisations and some 15,000 experts. It is a leading provider of conservation data, assessments and analysis. Its broad membership enables IUCN to fill the role of incubator and trusted repository of best practices, tools and international standards.

IUCN provides a neutral space in which diverse stakeholders including governments, NGOs, scientists, businesses, local communities, indigenous peoples organisations and others can work together to forge and implement solutions to environmental challenges and achieve sustainable development.

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Foreword

As the world moves towards conservation goals, such as the Aichi Biodiversity Targets and the Sustainable Development Goals, it is with the undeniable knowledge that climate change is impacting both people and nature adversely by exacerbating existing threats and posing new risks. In light of this, varied adaptation approaches are being promoted and implemented to enable communities and ecosystems deal with the adverse impacts of climate change. One such approach is Ecosystem based Adaptation (EbA).

This approach is an excellent example of an effective nature-based solution to climate change, as it uses both biodiversity and ecosystems as part of a larger adaptation strategy. It not only provides climate change adaptation benefits, but also contributes to biodiversity conservation and to enhancing 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.

To further promote the implementation of EbA approaches and to gather evidence from the field, IUCN spearheaded a previous study to identify the economic costs and benefits associated with EbA in a number of countries. As a second phase, this study concentrates on showcasing examples of cost benefit analyses specifically from the Philippines. 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 two sites in the Philippines. It highlights that undertaking economic costs and benefits of EbA options is important for decision and policy making purposes. The examples show that in many cases nature based solutions provide more economic benefits than engineering solutions in the long run, especially when co-benefits are considered. For example, in one case mangrove protection provided avoided damages for shoreline protection of USD 206,621, as compared to building a seawall, which provided avoided damages of USD 180,046 with a 10% discount rate. Furthermore, mangrove ecosystems provide additional benefits through fisheries contributing USD 174,000 annually to local community. Such analyses encourage discussion on the viability of EbA approaches in dealing with climate change as well as their contribution to societies and economies.

IUCN is very grateful to the French Ministry of Foreign Affairs and International Development (Ministère des Affaires Etrangères et du Développement International) for the financial support that made this important study possible. 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.

Inger Andersen
IUCN Director General
January, 2016

Executive Summary

The environmental, social and economic impacts of climate change coupled with the unsustainable management of ecosystems, increase the vulnerabilities of people and nature. Furthermore, the crisis is likely to impact different groups differently and is expected to affect the marginalized (women, children and elderly) disproportionately.

Adaptation serves as an important strategy to cope with a changing climate and its impacts; however, in response to global climate change effects, countries are likely to invest in traditional options such as infrastructure for coastal defences and flood control, and new irrigation facilities and reservoirs for water shortages. 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.

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. It recognizes, and in fact highlights, the importance of equity, gender, and the role and importance of local and traditional knowledge, as well as species diversity. Furthermore, it provides 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.

While the role of ecosystems and the services they provide is increasingly being accepted, there are still questions regarding investment in 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 governments and non-government organisations invest in them.

One way to make the case for ecosystem-based adaptation, in comparison to other adaptation activities, is from the economic perspective. EbA activities can produce a number of benefits for communities but there might be cases where other adaptation options, including engineered solutions, may provide more benefits for less cost. Therefore, it is not only critical to assess the environmental and social costs and benefits of adaptation, but also its economic costs and benefits, in order to engage in an informed planning process.

There are a range of approaches that are used to assess economic benefits of goods and services and these same approaches can and are used to assess costs and benefits of adaptation options including EbA. The three most commonly used ones are 1) Cost-Benefit Analysis (CBA); 2) Cost-Effective Analysis; and 3) Multi-criteria Analysis.

In order to contribute to policy through improved decision making at the national level, two case studies are highlighted in this report that look at the costs and benefits of EbA in the Philippines.

An economic analysis of mangrove protection and re-plantation, as compared to building a seawall, was undertaken by a Conservation International team in Calapan City, Mindoro Oriental Province using barangay Silonay as an illustration. Primarily secondary data was analysed using the least-cost and benefit-cost with avoided damage approaches.

Firstly, a Least Cost Analysis was undertaken to show which of the three options was the most cost effective. The results showed that the option with the least cost is the protection of existing mangroves, while the most expensive is the construction of the seawall.

Damage costs avoided were also calculated which highlighted the significant role intact and healthy mangroves play in the face of extreme events. Damage costs were set at 50%, 25%, and 10% of the total calculated damage cost. Protecting and conserving existing mangroves provided the highest avoided damages as compared to replanting them or building the seawall.

The Net Present Value (NPV), the Annualized Net Present Value (ANPV) and the Benefit-Cost Ratio (BCR) were also calculated. A sensitivity analysis was performed to test discount rates (3%, 8%, and 15%) and percent of estimated damages avoided (50%, 25%, and 10%).

Ecosystem-based adaptation options (mangrove protection and mangrove planting) had the highest NPV and ANPV, while the engineering option (seawall) had the lowest values and was negative for certain discount rates and assumed avoided damage. ANPV was highest for the option to protect the mangroves, followed by mangrove planting and building the seawall. In terms of the BCR, over the 20 year period, the ratios remained the same for the option to protect the mangrove, increased for mangrove planting as the discount rate increased, and decreased for the seawall option as the discount rate increased.

The second case study is a Total Economic Value (TEV) of The Cagayan De Oro Basin, undertaken by Xavier University, Department of Economics. Total Economic Valuation is an important approach to assess, in monetary terms, the value of ecosystems. TEV can be useful to make the case for ecosystems based adaptation options, when it is not easy to undertake CBA of options. It can also be used as a supplement to a CBA to highlight the productivity of an ecosystem in economic terms. This can be useful in making a holistic and inclusive case for ecosystem based adaptation options to be selected.

The results showed that the total benefits (stable supply of good quality water, flood control, fishing and recreational value, biodiversity) to households from the rehabilitation and preservation of the CDO River Basin would be PHP 8,911,364-12,851,663 (USD 197,591-284,959) per month or PHP 106,936,365-154,219,960 (USD 2,371,094-3,419,511) per year. The total annual value of fisheries was over PHP 24 million or USD 542,587. Total fishery value from Macajalar Bay was estimated at PHP 62,181,227 (USD 1,378,741).

The total estimated annual tourism values from both direct and induced activities from the white water rafting in the CDO River Basin were approximately PHP 14.37 million, or approximately USD 318,622, while tourism value of the Macajalar Bay was PHP 11,179,460 (USD 190,864).

The reason for such analyses is to encourage discourse on the merits of EbA and other more integrated nature based solutions, in terms of their utility in dealing with climate impacts, as well as their contribution to societies and economies. Crucially, they can be instrumental in convincing countries - especially developing countries - to invest in nature based solutions.

The objective of this report is to increase the knowledge base regarding the effectiveness of EbA by collecting evidence from the field. The understanding of economic costs and benefits of ecosystems based approaches will provide additional important information to assist decision making at the local, national and global levels, and to influence policy. While uncertainties and challenges may still remain, robust and appropriately designed valuation methodologies can help to decrease them. Detailed assessments of cost and benefits (using any of the methodologies described) must be undertaken, of ongoing and completed projects, in order to decrease the existing knowledge gaps and to show policy makers why they should invest in EbA.


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1) Introduction

1.1 Climate Change and Ecosystems Based Adaptation[i]

> *"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."* CBD 2009

The undeniable effects of climate change and the unsustainable management of ecosystems increase the vulnerabilities of people and nature, by impacting them adversely. According to the World Bank, a 40C temperature rise is approaching, due to the current inadequate level of action (World Bank, 2013: Turn Down the Heat). The World Economic Forum's Global Risk Report of 2013, highlights greenhouse gas (GHG) emissions as one of the five major risks that the global economy faces. It points out that global economic and environmental systems are simultaneously under stress and the impacts of climate change on them is more and more evident (WEF, 2013).

Such 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). Furthermore, the crisis is likely to impact different groups differently and is expected to affect the marginalized (women, children and elderly) disproportionately. Natural disasters tend to worsen the conditions faced by different groups such as women, children and the elderly.

The Fourth and Fifth Assessment Reports of the IPCC highlight the fact that mitigation efforts need to continue to control the rate and magnitude of climate change (IPCC, 2007 and 2014). Extensive global efforts have been made to mitigate changes in climate; however, even with current mitigation efforts the climate does and will continue to vary. Therefore adaptation has become a necessary strategy in order to adjust human societies and ecosystems so that they are more resilient and can cope with the adverse impacts of climate change.

Amongst a suite of strategies to cope with a changing climate and its impacts, adaptation serves as a vital approach. In response to global climate change effects, countries are likely to invest in traditional options such as infrastructure for coastal defences 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 and reduce the vulnerability of people to the adverse impacts of climate change (see Box 1). Ecosystem-based Adaptation (EbA) offers a valuable yet under-utilized approach for climate change adaptation, complementing traditional actions such as infrastructure

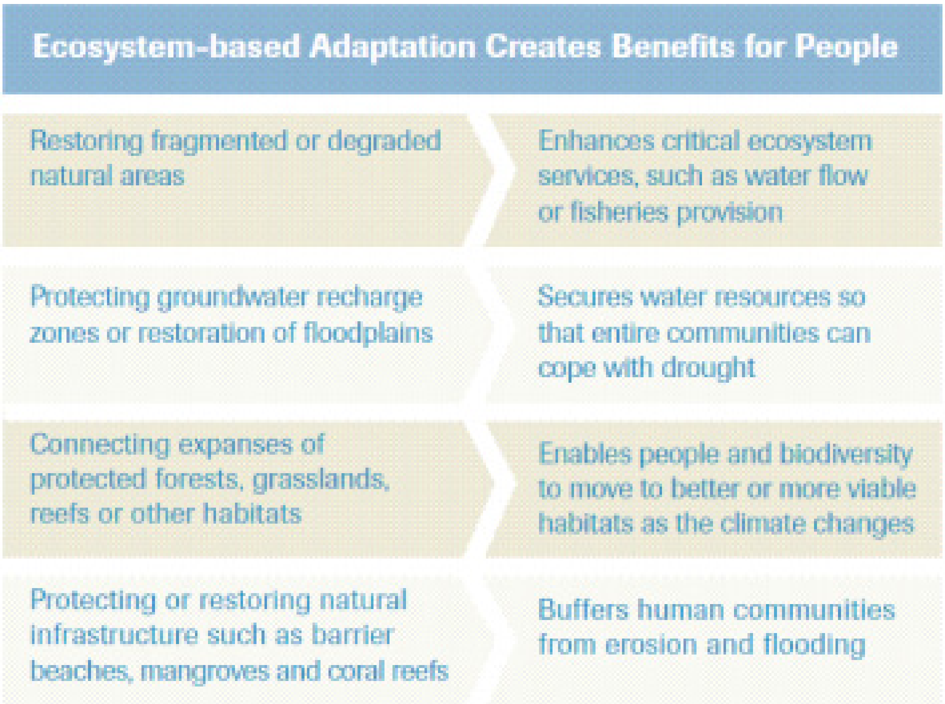
BOX 1

"A study of 286 recent 'best practice' initiatives in 57 developing countries covering 37 million hectares (3% of cultivated area in developing countries) across 12.6 million farms showed how productivity increased along with enhancing supply of ecosystem services (e.g. carbon sequestration and water quality). The average yield increase was 79%, depending on crop type, and all crops showed gains in efficiency of water use. Examples of these 'best practices' included: pest management: using ecosystem resilience and diversity to control pests, diseases and weeds; nutrient management: controlling erosion to help reduce nutrient losses; oil and other resources management: using conservation tillage, agro-forestry practices, aquaculture, and water harvesting techniques, to improve soil and water availability for farmers".

Source: Pretty *et al.*, 2006

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 and in fact highlights the importance of equity, gender, and the role and importance of local and traditional knowledge, as well as species diversity. It recognizes that women are natural resource managers and thus uses their expertise in formulating and implementing nature based adaptation strategies. In addition to protection from climate change impacts, EbA provides 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. Figure 1 highlights the benefits that EbA provides.

Figure 1:



Source: TNC 2009[ii]

An important aspect of ecosystem-based approaches is the fact that they can be applied to almost all kinds of ecosystems, as well as from the local to the national, regional and international scales (Devisscher, 2010). Importantly, they can be applied across different social groups, and appropriately designed EbA approaches specifically include knowledge from and participation of women. According to TEEB (2009), EbA can generate multiple environmental and societal benefits while achieving both long and short term priorities. Coinciding with the precautionary principle, by decreasing trade-offs, EbA further lowers risks by reducing mal-adaptation (Devisscher, 2010). In addition, because EbA is multi-sectoral, as well as multi-scale, it has the capacity to integrate a variety of disciplines, stakeholders and institutions, so that they can work at a variety of governance levels and can influence a number of decision making networks (Vignola *et al.*, 2009), as well as provide benefits to disparate groups and communities.

1.2 Purpose and limitations of this Study

This study is a follow-up of a previous study entitled ***Ecosystems Based Adaptation: Knowledge Gaps in Making an Economic Case for Investing in Nature Based Solutions for Climate Change*** (Rizvi *et al.*, 2015) where a number of projects in Costa Rica, India, Mexico, Peru, Philippines and Tanzania were reviewed, to assess existing data and knowledge gaps regarding the implementation and economic values of EbA projects.

The previous study showed that climate change is likely to change the productivity and benefits from nature dependent sectors of agriculture, fisheries and forestry, which are important economic contributors to these countries. A review of economic assessments of projects showed that EbA approaches provided many benefits and in general helped to increase resilience and decrease vulnerabilities. The study also showed that while there was sufficient data to show the costs of EbA projects, there was none that could provide information on the economic benefits, which made it difficult to highlight the competitiveness of EbA as part of a suite of adaptation options, or as replacement for some traditional ones.

This report will build upon the previous scoping study and will assess the importance of nature based solutions to address climate risks and identify knowledge gaps in economic data from the field in the Philippines. The purpose of this study is to "*increase understanding of the economic effectiveness of ecosystems based approaches and provide additional important information that would assist decision making at the local, national and global levels.*"

It must be pointed out that this is primarily a desk study that relied on secondary data analysis. In order to make the case for nature based solutions and their cost effectiveness, two case studies conducted by Conservation International and Xavier University were utilized. These case studies provide recent data on the cost effectiveness and economic benefits of EbA solutions as well as the economic value of natural resources in the Philippines.

1.3 Understanding the economic costs and benefits of EbA Projects[iii]

> "*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*

One way to make the case for ecosystem-based adaptation in comparison to other adaptation activities is from the economic perspective. EbA activities can produce a number of benefits for communities but there might be cases where other adaptation activities, including engineered solutions, may provide 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/or economically beneficial, as well as longer term solutions, with a range of co-benefits in terms of the goods and services provided by ecosystems. Economic assessments of EbA based approaches can be useful in highlighting the effectiveness of EbA projects against hard engineering projects, especially when considering development priorities, together with conservation and risk reduction aspects.

In order to understand when EbA is an economically preferable approach, we need to examine the benefits of EbA activities relative to their costs in a number of ecological, institutional, and social settings. Furthermore, it may also be beneficial to assess the cost-effectiveness of EbA approaches by comparing their costs to other options. However, while EbA is becoming increasingly 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 in developing countries, where communities are likely to be impacted the most by a changing climate.

The UNFCCC in its Nairobi Work Programme (NWP) highlights the importance of assessing economic costs and benefits of adaptation (Box 2).

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. (This study discovered that in the case of the Philippines, this was again the case). There are other studies that investigate costs of adaptation, and the benefits thereof, in terms of reduced vulnerability and increased welfare.

BOX 2

The Nairobi work programme on impacts, vulnerability and adaptation to climate change

The Nairobi work programme on impacts, vulnerability and adaptation to climate change was launched by Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2005. Its objective is to assist all Parties, in particular developing countries, including the least developed countries (LDCs) and small island developing States (SIDS) to:

- Improve their understanding and assessment of impacts, vulnerability and adaptation; and
- Make informed decisions on practical adaptation actions and measures to respond to climate change on a sound scientific, technical and socioeconomic basis, taking into account current and future climate change and variability.

Besides Parties to the UNFCCC, many intergovernmental, governmental, and non-governmental organizations, the private sector and individual experts contribute to the Nairobi work programme, including by carrying out mandated and pledged activities. The Nairobi work programme plays an important role in the UNFCCC process through engaging stakeholders, catalyzing targeted action and facilitating knowledge sharing and learning on adaptation. Relevant activities under the Nairobi work programme on assessing the costs and benefits of adaptation include the preparation of a technical paper reviewing existing literature, submissions by Parties and relevant organizations on efforts undertaken to date, and a workshop on costs and benefits of adaptation options. More information is available at http://unfccc.int/nwp

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 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 among various groups and across genders, which helps to explain why people might invest in EbA activities and how further investment can be encouraged. Governments and 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 terms of finances, time and effort. 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. Furthermore, gender considerations may not be incorporated, such that while the work load of women may increase with project implementation, their benefits may not. 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 (Rizvi *et al.*, 2015)

Therefore, it is not only critical to assess the environmental and social costs and benefits of adaptation but also its economic costs and benefits, in order to engage in an informed planning process (UNFCCC, 2011).

There is also a need to compare costs and benefits of EbA related projects to understand their effects on local communities (especially marginalized groups such as women, children and the elderly) and ecosystems, as well as on national economies. Such data will help to promote EbA related projects within countries and at global forums (Rizvi *et al.*, 2015).

1.4 Assessing Costs and Benefits of EbA

Measuring costs and benefits of EbA options is difficult. There are many uncertainties associated with future climate impacts, as well as the manner in which ecosystem goods and services manifest. Future socio-economic development also constrains the identification and implementation of optimal adaptation options (UNFCCC, 2011). There are few well-defined baseline scenarios describing the impacts climate change has on natural capital stocks and ecosystem services and therefore, while costs of implementing EbA projects are available in some cases, there is usually no information regarding the economic benefits provided by the EbA projects as well as how these benefits are distributed. This makes it difficult to compare and contrast the costs and benefits of ecosystem-based adaptation (Rizvi et al., 2015). Cost-benefit data and measurements also have uncertainties associated with them, due to the lack of baselines (UNFCCC, 2011).

Although there has been an increasing trend of undertaking economic valuation of ecosystems goods and services, there are still data gaps, often resulting in incomplete cost and benefit assessments. Because of the short term nature of projects, economic benefits of ecosystem services also tend to be measured and/or required for the short term. In the case of adaptation, there are similar difficulties in assessing the costs and benefits, specifically when looking at EbA and its related benefits (which come as a host of products and services) (Devisscher, 2010).

As per the IPCC AR4, adaptation costs are *"the costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs," and benefits are "the avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures"* (IPCC, 2007).

In order to reach estimates of the benefits of adaptation (including EbA) against a baseline scenario, it is necessary to examine the projected climate change impacts and the costs of various options. It is also important to understand that EbA (or any other adaptation) measure will not usually result in the complete elimination of the negative impacts of climate change; therefore, the cost of residual damage (i.e. damage left over after implementation of option) must also be included in the overall costs. The options with the highest net benefits are the ones that need to be selected for implementation (UNFCCC, 2011). Finally, it is important to include co-benefits of nature based solutions in the estimation of overall net benefits, in order to get a holistic picture.

There are a range of approaches that are used to assess economic benefits of goods and services and these same approaches can and are used to assess costs and benefits of adaptation options including EbA. The three most commonly used ones are 1) Cost-Benefit Analysis (CBA); 2) Cost-Effective Analysis; and 3) Multi-criteria Analysis (UNFCCC, 2011). In addition, Total Economic Valuation (TEV) is generally used to assess the economic benefits provided by various ecosystems goods and services. These are discussed in some more detail below.

Cost-Benefit Analysis

When efficiency is the only decision making criterion for selecting adaptation (including EbA) projects, Cost-Benefit Analysis (CBA) is used, which involves calculating and comparing all of the costs and benefits, and expressing them in monetary terms. This requires the distribution of costs and benefits to be taken into account, as well as their aggregate values, with the result that a range of impacts can be compared by using a single metric (UNFCCC, 2011). In terms of EbA, it is often difficult to come to monetary conclusions using the CBA, due to the fact that many ecosystems goods and services do not have a market value (although they may provide countless unmeasured economic benefits). In addition, issues of gender, equity and distribution of costs and benefits are not addressed in a CBA (UNFCCC, 2011) and therefore must be considered when selecting projects on the basis of CBA. Finally, more nature based solutions tend to provide benefits (economic and others) after a longer time period, which usually comes after the completion of the project.

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, to understand and gather the evidence that describes why EbA provides more economic benefits than other solutions. This can then be extrapolated for national level EbA approaches, policies and strategies.

A Cost-Benefit Analysis is useful for 4 decision making purposes (Rodgers, 2014):

1. To evaluate a stand-alone EbA intervention ("no project" baseline).
2. To evaluate EbA intervention(s) against alternative approaches ("no project" baseline).
3. To evaluate EbA as one component (climate-proofing measure) of a proposed investment project (baseline: project without EbA intervention).
4. To evaluate EbA as one of alternative approaches to climate-proofing an investment project (baseline: project without EBA intervention).

As per the UNFCCC (2011) important steps in undertaking a CBA are 1) Agree on the adaptation objective and identify potential adaptation options; 2) Establish a baseline; 3) Quantify and aggregate the costs over specific time periods; 4) Quantify and aggregate the benefits over specific time periods; and 5) Compare the aggregated costs and benefits. There are three indicators that can be used to reach the results (see Box 3).

BOX 3

CBA Indicators

Benefit to Cost Ratio (BCR): The BCR indicates the level of benefit that will be accrued for every $1 of cost. A ratio greater than 1 therefore indicates that the project is worth investing in from a financial perspective, whereas anything less than one indicates a negative return.

Net Present Value (NPV): The NPV takes the net benefit (benefit minus costs) each year and discounts these to their present day value. If the result is greater than zero, this indicates that the benefits outweigh the costs. The higher the value, the greater the financial argument for initiating the project.

The Discount Rate is used to discount costs and benefits occurring in the future, as people place a higher value on assets provided in the present and a lower value on benefits that may accrue further into the future. The discount rate is normally equivalent to the average return one might expect if the same money was invested in an alternative project.

Source: Venton, 2010

Example of using Cost-Benefit Analysis

A study by Gray and Srinidhi (2013) provides a cost-benefit analysis (CBA) of Watershed Development (WSD) for the Kumbharwadi rain-fed watershed in Maharashtra state, India. 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 USD 6.21 million, whereas the total income from livestock ranged from USD 2.21 to USD 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 USD 69,000 per year to almost USD 625,000 in the Kumbharwadi watershed.

"The net present value of the WSD project in Kumbharwadi ranged from USD5.07 to USD7.43 million, which equates to benefits of USD5, 573 to USD8, 172 per hectare treated, or USD29, 650 to USD43, 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 USD 1 million to USD 1.4 million. The study concludes that the results of the CBA show that this WSD was a successful investment (Gray and Srinidhi, 2013:21).

Another CBA was undertaken to estimate the cost of rehabilitating abandoned mangrove ecosystems and showed that they can be rehabilitated at a cost of approximately USD 8,240/ hectare (ha) in the first year (replanting mangroves) and subsequently by annual costs of USD 118/ ha for maintenance and protection of seedlings. Benefits from the restoration project were estimated through assessing net income from collecting forest products of USD 101 per ha/year, benefits from habitat fishery linkages (mainly the functioning of mangroves as fish nursery) worth USD 171 per ha/year, and benefits from storm protection worth USD 1,879 per ha/year (Barbier, 2007 as seen in Devisscher, 2010).

Cost-Effective Analysis

In some cases there is a need to find the least costly adaptation option to meet climate targets, in which case a Cost-Effective Analysis (CEA) is used. This however only provides information on the option that has the minimum cost and does not incorporate benefit cost ratios or internal rates of return. This type of measurement is useful to assess options whose benefits are difficult to assess in monetary terms, such as health, freshwater systems, extreme weather events, biodiversity and ecosystems services. The end result does not assess alternatives by looking at benefits but at the most sustainable and cost-effective option (UNFCCC, 2011). Because aspects such as gender, equity, feasibility and co benefits are not considered, there is a need to include them when choosing the option.

As per the UNFCCC (2011), steps to undertake a CEA are 1) Agree on the adaptation objective and identify potential adaptation options; 2) Establish a baseline; 3) Quantify and aggregate the various costs; 4) Determine the effectiveness (that is whether it yields a desired result); and 5) Compare the cost effectiveness of the different options.

Example of using Cost-Effective Analysis (CEA) for project selection

An example of using the Cost-Effective Analysis in the project ***Capacity Building to Enable the Development of Adaptation Measures in Pacific Island Countries project (CBDAMPIC)***.

As part of the project, community consultation and CEAs were undertaken to implement appropriate adaptation measures at nine pilot sites on four islands in the Pacific (Cook Islands, Fiji, Samoa and Vanuatu). Water resources were identified as the biggest concern in terms of quality, quantity and sustainability of supply.

The following options were identified by three communities:

- Installation of desalinisation systems;
- Upgrading of existing mains systems;
- Rainwater harvesting;
- Using brackish or seawater for appropriate systems;
- Watershed protection measures, including contour farming, planting trees on hillsides, planting fruit trees within crop plots to provide shade for the plants or reinforcing salt tolerant vegetation buffers;
- Improving sanitary condition, for example by installing compost or flush toilets (however, the latter would increase water consumption); and
- Awareness-raising on water issues and installation of radio and internet communications.

The three communities selected rainwater harvesting because it was the most cost-effective, practical, easily implementable and sustainable. This option yielded the required quality and quantity at the least cost. The cost at Aitutaki in the Cook Islands was USD 233,155 (for 246 household tanks of 2,000 litres and 12m of gutters for each household). Cost-effectiveness was measured as cost per person/ water harvesting potential per person and was USD 259/547 litres.

The cost of two communal tanks, a new piping system and upgraded dams was USD 63,431 in Tilivalevu, Fiji. In Luli Vanuatu, 24 household tanks of 2,400 litres, each combined with a catchment area of 20m2cost USD 100,480 (USD 334/192 litres) (Kouwenhoven *et al.*, 2006).[iv]

Multi-Criteria Analysis

As is clear from the above two methods, usually a number of criteria are required to estimate effective options, especially in the context of ecosystem-based adaptation. In such cases Multi-criteria analysis (MCA) is an approach that allows assessment of different adaptation options against a number of criteria, each of which is given a weighting. An overall score is obtained using the weighting and the option with the highest score is selected by stakeholders. This method is useful when exact economic data is not available, benefits (such as cultural or ecological) are hard to quantify, or many criteria (in addition to monetary benefit and effectiveness) need to be considered (UNFCCC, 2011). MCA is useful because it can incorporate both quantitative and qualitative considerations and can assess across a suite of criteria. Both of these aspects are extremely important for nature based solutions such as EbA. Assigning weights and scores is however a difficult task, and may have a level of subjectivity.

As per the UNFCCC (2011) the steps for a MCA are 1) Agree on the adaptation objective and identify potential adaptation options; 2) Agree on the decision criteria; 3) Score the performance of each adaptation option against each of the criteria; 4) Assign a weight to criteria to reflect priorities; 5) Rank the options.

Example of using Multi-Criteria Analysis for Project Selection

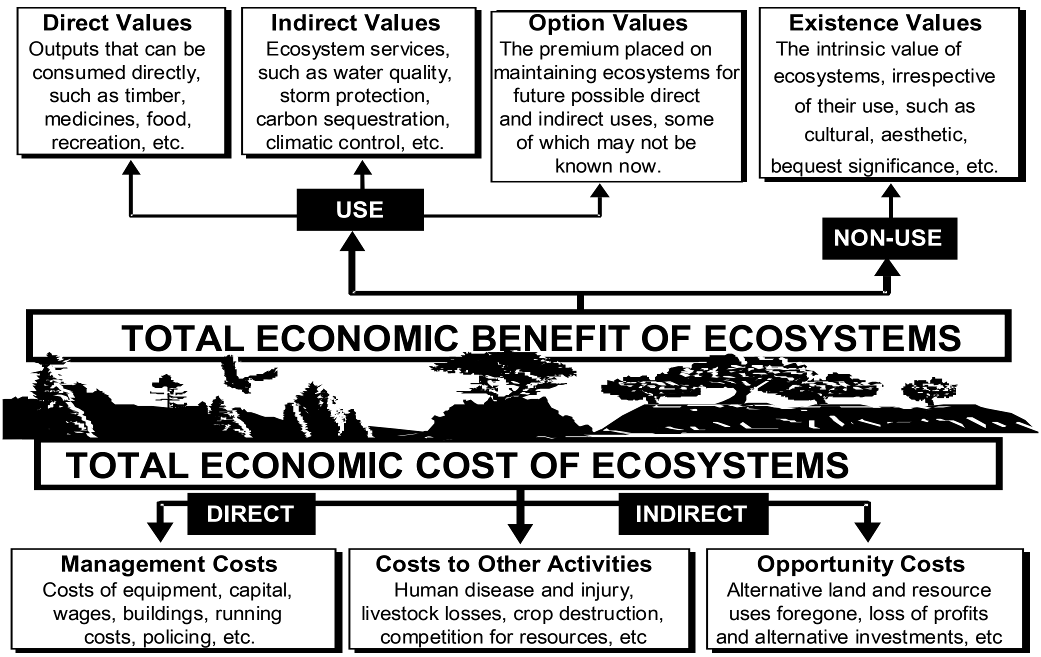
In the Netherlands, a national adaptation agenda was developed through the *Adaptation, Spatial Planning and Climate (ARK)* national programme and adaptation options were selected using MCA. After an extensive literature review, adaptation options were identified for sectors such as agriculture, nature, water, energy and transport, housing and infrastructure, health, and recreation and tourism.

Evaluation criteria were identified and options were scored (1 to 5) for ranking. Experts from a variety of fields were involved to make the scores robust. Integrated nature and water management; integrated coastal zone management; and Water retention and storage scored the highest. The results were used to prepare the Netherlands National Adaptation Strategy and Agenda (van Ierland *et.al.*, 2006).

Economic Valuation of Ecosystem goods and services

It is important to point out that beyond assessing the costs and benefits of EbA, Total Economic Valuations (TEV) of ecosystem goods and services are also undertaken. TEV considers both use and non-use values of ecosystems (see figure 2 for details). These are useful in providing information regarding the overall economic benefits that are generally provided by healthy and functioning ecosystems. TEV has been instrumental in bringing a broader conception of the nature of economic value of ecosystems to the forefront, by demonstrating that their value begins with easy recognizable tangible outputs, called the direct use values (namely food, timber, water, etc.). However TEV also shows that the values provided by ecosystems extend far beyond direct use values and encompass what is referred to as ecosystem services (such as shoreline protection, storm protection, water quality, flood control, ground water recharge, habitat protection, etc.), which include indirect use values and option values (direct, indirect and option values are referred to as use values). Furthermore, TEV also highlights existence values, which are the cultural, aesthetic and bequest values of the ecosystem (referred to as non-use values). Therefore, TEV presents a more complete picture of the economic importance of ecosystems and clearly demonstrates the high and wide-ranging economic costs associated with their degradation (Baig *et al.*, 2007).

Figure 2: Total Economic Valuation



Source: (Baig *et al.,* 2007)

For the purpose of this study we will be concentrating on Cost-Benefit Analysis (CBA) of and EbA option and total economic value (TEV) of ecosystem (mangrove) goods and services to make the case for nature based solutions to climate change.

2) Philippines

2.1 Country Profile and Existing Climate Trends

> *"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)*

The Philippines has a total surface area of 299,404 km^2, 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^2 (12% coastal waters and 88% oceanic waters within the exclusive economic zone - EEZ) (IACCC, 1999), and it has a coastline of 37,000 km (ADB, 2014). The coastal ecosystems (including coral reefs) are of significant importance in terms of fisheries for food and nutrition, security, employment, coastal protection, tourism, and aesthetic value (*ibid*; White *et al.*, 2000).

Total forest area is estimated at 15 million hectares (Mha) and is among the most diverse in the world, yet also among the most endangered. In 2013, total forestry production was over 15 million m^3 (FAOSTAT, 2014).

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 USD22 million and food exports, excluding fish, amounted to almost USD4 million in 2011.

Total fisheries production was 3 million Metric Tonnes (MT) in 2010 with exports amounting to USD 639 million and in 2011 to USD 696 million (FAOSTAT, 2014 and Info Fish, 2012). The share of the fisheries sector in 2011 was approximately USD 4 billion (approximately 2%) (Info Fish, 2011). Fish production is primarily through aquaculture, municipal fisheries and commercial fisheries.

Due to its location in the typhoon belt, its 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) according to the World Bank. The list of top 50 most vulnerable regions in Southeast Asia also includes 16 of the country's provinces. The cities of San Jose, Manila, Roxas, and Cotaboato 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: Getting a Grip).

According to Mucke (2012:9) the Philippines ranks third as a "global disaster risk hotspot" after Vanuatu and Tonga. In almost a decade from 1993 - 2012, it ranked seventh among countries most affected by natural disasters (Kreft and Eckstein, 2014). In recent years it has been hit by three heavy tropical storms and super typhoons; in 2011 by Tropical Storm Washi, in 2012 by Typhoon Bopha and in 2013 by Typhoon Haiyan. All of these caused coastal flooding and erosion that left thousands of people dead, injured, missing or displaced (IFRC 2012, 2013).

From 1971 to 2000, the country observed an increase in annual mean temperature of 0.570C, which is an average increase of 0.010C per year (DOSTPAGASA, 2011). This has affected its agricultural sector and crop yields, such as rice, have shown a decrease whenever rising temperatures exceeded threshold values (DOSTPAGASA, 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 USD 272 million), equivalent to 3% of the country's total agricultural production (CCC, 2011).For example, in December 2012, cyclone Bopha, a category five cyclone, caused USD646 million in damages to the agricultural sector, with an estimate 25% of banana production destroyed. Restoring these damaged banana production farms would cost approximately USD122 million (World Bank. 2013: Turn Down the Heat). The country's coral reefs have decreased by half after the 1998 to 1999 ENSO-induced coral bleaching and fisheries yield diminished by more than PHP 7 billion (approximately USD159 million) (World Bank, 2013: Getting a Grip).

With a 40C rise in temperature, there is a possibility of a sea level rise in the East Asia and Pacific region of more than 50 cm above present level by 2060 and 100 cm by 2090. Manila is especially vulnerable to sea level rise (World Bank 2013: Getting a Grip). Projections for storm surges show that 14% of the total population and 42% of the coastal population will be impacted, with marginalized groups (women, children and elderly) bearing the largest brunt. Furthermore, informal settlements account for 45% of the urban population and are also vulnerable to floods (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.

2.2 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 350C, will continue to become more frequent (DOSTPAGASA, 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 exacerbate 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^2 of great lakes and wetlands by 2100.

These projected climate changes will have significant impacts on the country's population, (particularly on the communi¬ties dependent on subsistence livelihoods and especially women, children and the elderly) 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 (Getting a Grip, 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: Getting a Grip; DOSTPAGASA, 2011). According to the World Bank (Getting a Grip, 2013:24) rice yields could be reduced by up to 75% by 2100, compared to 1990. As mentioned earlier, the damage to agriculture has reached PHP 12 billion (USD 272 million) due to typhoons, droughts and floods, which is equivalent to 3% of total production. Furthermore, a 30 cm sea level rise will likely reduce rice production in the Mekong River Delta by approximately 2.6 million tons per year (11% of paddy production in 2011) (World Bank, 2013: Getting a Grip).

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 rain fed areas (DOSTPAGASA, 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) and impact marginalized groups (women, children and elderly) disproportionally. In addition, rising temperatures and erratic rainfall could magnify the incidence of pests and diseases (DOSTPAGASA, 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_2 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*).As mentioned before, the 1998-1999 ENSO event resulted in decreasing the coral cover in the country by half, such that fisheries diminished by more than PHP 7 billion (USD 159 million). 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 (DOSTPAGASA,2011:50).

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 may force them 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 (DOSTPAGASA, 2011:49).

The impacts of climate change are exacerbated by other factors such as increasing environmental deterioration, unsustainable development, population growth and extensive migration. For example, it is thought that widespread mining and extensive deforestation in Mindanao were the cause of flash floods, including those produced by tropical storm Sendong in 2011. Manila was swamped by floods in 2012, which are seen as a result of lack of planning and neglect of drainage system (Palanca-Tan *et al.*, 2015).

2.3 Examples of EbA Measures and their Costs and Benefits

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 (DOSTPAGASA, 2011:52).

An executive report by the World Bank on climate change in the Philippines (2013:41: Getting a Grip), highlighted that the majority of funding for the country's NCCAP priority on Ecosys¬tem and Environmental Stability, has support¬ed 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, including through a Cost-Benefit Analysis.

• *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 through 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 enhancement of the following mangrove ecosystem services: protection from storms and typhoons, fish habitat, and carbon seques¬tration. These benefits led to the improvement of fisheries, water resources, livelihoods, increased incomes from improved fisheries and human well-being (Alexander and McInnes, 2012).

However, Primavera and Esteban (2008) note that not all these plantations were successful and there were quite a few negative trade-offs, because many plantations were on mudflats and sea grass beds instead of former (natural) mangrove areas, thereby replacing important marine habitats (Primavera and Esteban, 2008).

• *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^2 in 2011 to 55.6 MT/km^2 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 and 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-Benefits Analysis*

Coral reef valuation studies indicate that reefs in the whole country are contributing an estimated USD 1.35 billion to the national economy, and that *"one km² of healthy reefs with some tourism potential produce annual net revenues ranging from USD29, 400 to USD113,000"* (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 USD1.45 million. The calculated costs for island-wide management of these ecosystems were USD91, 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% (USD 1.4 million) increase in annual net revenues from reef and mangrove fisheries and tourism.[v]

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 USD 870/ ha. On the other hand, a healthy reef, which supported tourism, provided coastal protection and increased fisheries had a total economic value of USD3, 300/ha (World Bank, 2009).

- *Tourism V Logging in Palawan*

A study was conducted in El Nido in Bacuit Bay (which is 120 km² and has 14 islands). Upstream logging was adversely impacting the water quality of the Bay, threatening its fisheries and tourism sectors. The study showed that while logging would provide revenues of USD 9.8 million over ten years, the resultant increase in sedimentation would result in losses of USD 8.1 million from fisheries and USD 19.3 million from tourism(Pagiola *et al.*, 2004). In addition to providing benefits for tourism and fisheries, conserving upstream forests also protects from climate induced flooding.

Having a large coastline and comprising of thousands of islands, the Philippines is extremely vulnerable to climate change impact on coastal areas. Conservation of coastal resources such as mangroves and coral reefs, not only increases livelihoods but also provides additional co-benefits (such as storm protection and carbon sequestration). The studies above clearly highlight that the benefits of nature based solutions far outweigh the costs associated with implementing them.

2.4 Examples of Economic Values of Natural Resources

An estimation of the economic contribution of subsistence fisheries was carried out by ADB (2014), based on the results of a workshop, *Improving Fish Catch Statistics Collection in the Philippines* with Focus on Subsistence Fisheries. The workshop was held in February 2012 and organized jointly with the World Fish Centre. The main objective of the workshop was to "*assess the status of data collection in the subsistence fisheries sector and develop a suitable methodology for local government agencies." Average catch per day was taken from a study by Muallil et al., (2012) of a survey of 25 towns across the country and based on this, fish retained for consumption by households was calculated. The results showed that "an average of 4.8 kg/fisher/day was determined from the study, to which was applied a 10% retention rate for the amount of fish consumed in the household or given away. This translates to 0.5 kg/ day/ fisher or per household in cases where the fisher is also the head of the family. The volume of consumption translates to 195,000 tons of fish or 16% of total production of the municipal marine sector on a yearly basis. The value of fish consumed at home is estimated to be 22% of food thresholds and 16% of minimum wage rate for areas outside metropolitan Manila. At USD 1.80/kg or USD 0.86/ day this amounted to a total of USD 5.50 per day*"(ADB, 2014).This shows that the economic contribution of subsistence fisheries to the local and national economy is extremely important in the Philippines. Climate change will affect it adversely, resulting in an increase in poverty levels (disproportionally impacting marginalized groups).

In addition, the monetary value of forests is also extremely important to the economy, and adverse impacts from climate change will potentially cause decreases in these values. Caradang (2008) conducted a TEV of Philippines forests for the World Bank. Three interventions were considered over a 25 year period. Intervention 1 was to facilitate the closure of all open access areas. This option gave the second highest NPV of PHP 82.4 billion (USD 1.9 billion) at a 12% discount rate. For intervention 2, three million hectares of open, degraded forests and grassland were to be earmarked, one million each for timber production, agro-forestry and carbon market, respectively. This option gave the highest NPV of PHP 108.6 billion (USD 2.5 billion) at a 12% discount rate. Intervention 3 (Adoption and utilization of Payment for Environment Services) gave the lowest NPV at PHP 39 billion (USD 886 million) at a 12% discount rate. The following table (Table 1) provides NPV at all discount rates considered.

Table 1 NPV at Various Discount Rates

Intervention	Potential Area Coverage ("000 ha)	NPV at Various Discount Rates (mil P)			per ha NPV @ 12% Discount Rate (P)
		8%	12%	16%	
1	4,446	130,881	82,427	54,733	18,540
2	3,000	209,017	108,619	55,975	36,206
3	1,000	63,667	39,047	25,117	39,047

Another study conducted by Carandang *et al.*, 2013, estimated the values of the different uses of mangroves in Palawan and Bohol, Philippines. Revenues from major mangrove products were estimated through market surveys. The highest direct use value was estimated at Banacon site in Bohol with PHP 33.37 million/ year (USD 758,409) and for Kamuning site in Palawanat PHP 25.521 million/ year (USD 580,023). The products from which direct use values were calculated were crabs, molluscs, shrimp and fish in addition to Nipa thatch. Contingent valuation was used to determine biodiversity and recreational values. The combined results from both Palawan and Bohol showed a mean willingness to pay (WTP) of PHP 44/ month/ person (USD 1). The different factors affecting the willingness to pay include education, income, and information. In terms of the recreation/ecotourism value of mangroves, the estimated values in Banacon, Bohol, and Kamuning, Palawan, were PHP 83,079 (USD 1,888) and PHP 2,769 (USD 63) respectively.

In Bohol coastal and marine ecosystem (Bohol Marine Triangle) a combined market-based valuation of economic activities, including fisheries, tourism, gleaning, and seaweed farming, and value transfer method for biodiversity conservation, flood protection and fish nursery function, was undertaken. The accumulated total net benefits over a ten year period was USD 11.54 million (10% discount rate). Tourism and municipal fisheries accounted for 44% and 39% of the total net benefits. Coral reefs provided USD 1.3 million in annual revenues and beach and intertidal area provided USD 1.1 million. Lastly, marine waters accounted for USD 646,501, mangroves for USD 239,561, and seagrass for USD 105,990 (Samonte-Tan *et al.*, 2007).

The potential sustainable economic benefits from Philippines coral reefs were estimated in another study to be USD 1.1 billion/ year. The benefits were estimated from the values provided by fisheries, shoreline protection, tourism, and aesthetic values (Burke, *et al.*, 2002).

Ahmed *et al.*, (2007) evaluated recreational benefits of coral reefs along the Lingayen Gulf, Bolinao, Philippines, using the travel cost method. Results showed consumer surplus at USD 223/ person/ year, or potential net revenues to the local economy at USD 4.7 million.

Total economic value of coconut trees was also calculated in another study including both provisioning and regulating services. Regardless of coconut type, toddy production yielded the highest values for provisioning services at PHP 258,000/ ha/ year) (USD 5,864), while the values of the production of young nut were at PHP 57,752/ ha/ year) (USD 1,313) and de-husked coconut at PHP 53,748/ha/ year (USD 1,222). In terms of regulatory services, the values were PHP 80,410/ ha/ year (USD 1,828) for tall coconut type and PHP 77,971/ ha/ year (USD 1,772) for hybrid (Garcia *et al.*, 2009).

3) Case Studies from the Philippines

In this section two case studies will be presented. The first one is a study entitled ***Evaluating the Cost-Effectiveness of Ecosystem Based Adaptation Actions for Coastal Protection: Mangrove Restoration and Rehabilitation in the Philippines***, undertaken as part of a project by Conservation International-Philippines, in Barangay Silonay, Calapan City (Pangilinan *et al.*, 2015). The organization implemented a project to rehabilitate, conserve and enrich degraded and/or sparsely covered mangrove areas in Silonay, Oriental Mindoro. Income diversification options were provided to active community members as an incentive for engaging in sustainable mangrove rehabilitation and management activities. To date, the organization has established 7 income diversification activities, which include: 1) selling of mangrove seedlings for planting, 2) mangrove boardwalk tour, 3) kayaking rentals, 4) sales of souvenir items, 5) shingling chips making 6) a newly established souvenir shop and 7) a meat processing activity. Because of the success of the initiative, a number of civil society organizations and the City and Provincial Governments have provided additional support to Silonay to sustain the mangrove management and protection efforts in the area. Apart from the grant that CI has provided to the community, technical and organization capacity building and mentoring activities, such as mangrove management training, financial management training, leadership training and various livelihoods training were also conducted to further develop skills and knowledge of the community.

3.1 Barangay Silonay, Calapan City[vi]

In order to contribute to policy through improved decision making, an economic analysis of implementing mangrove protection and re-plantation activities, as compared to building a seawall, was undertaken by a Conservation International-Philippines team. This was done in Calapan City, Mindoro Oriental Province, using barangay Silonay as an illustration. Secondary data was analysed using the least-cost and benefit-cost with avoided damage approaches.

• *Profile of Barangay Silonay, Calapan City*

Silonay is one of the 21 coastal barangays (village, district or ward) in the north-eastern side of Calapan City in the Philippines. The barangay's territorial marine waters are 2,872.58 ha, which is 17 times more than its land area (166.19 ha; 0.67% of the total area of the City) (Barangay Silonay, 2012). At a distance of 7 km from the city centre, it is surrounded by a river and connected to the mainland by a bridge. Its river area is estimated to be 28.13 ha, the creek is 0.15 ha and the swamp area is 0.15 ha.

There are 1, 407 residents (724 males and 683 females) in 304 households. Out of these, 94 houses are located in plains/flatlands and 210 are in the coastal side of the barangay. The houses are made of concrete materials (41%), semi-concrete (38%), or of light materials (21%) (Barangay Silonay, 2012). Most residents live in rented houses, which are owned by other private owners.

The main economic activity and source of livelihoods is fishing, and in 2013 the Fisheries Management Office placed the number of registered fishers at 127. Other livelihood activities include pig and poultry raising (both for consumption and sale). Mangrove planting and the operation of the Mangrove Eco-Park managed by the Sama-Samang Nagkakaisang Pamayanan Ng Silonay (SNPS) have provided local residents with additional income. A survey in 2012 of 391 residents of the barangay showed that 58% of them earn a monthly income of less than PHP 5,000 (USD 107 as per 2015 conversion rates) (Barangay Silonay, 2012).

Like other areas in the Philippines, barangay Silonay is vulnerable to typhoons, storm surges, coastal flooding and coastal and riverbank erosion. For the period 1948 to 2012, 60 tropical cyclones, 10 tropical depressions, 18 tropical storms and 32 typhoons were experienced in Oriental Mindoro, with more than half (58%) occurring during the last quarter of the year. The highest occurrences were in years 1952, 1971, and 2006 with five typhoons or storms crossing the province (DOSTPAGASA, 2014). It is one of the three barangays (the adjacent barangays of

Navotas and Parangare two others) where storm tides of more than 10 m were recorded in 1967 (Typhoon Karing), 1971 (Typhoon Dadang), and 1986 (Typhoon Weling). It is likely that the area will experience the same in the future and probably higher and stronger storm surges.

Silonay is also vulnerable to tsunami and flooding due to sea level rise. It was estimated that given a 1 m sea level rise, over 100 ha are likely to be inundated, while a 2 m rise can result in over 204 ha inundated and a 3 m rise can inundate over 527 ha, which is one-fourth of the total city area. That is, a 2 to 3 m rise is likely to inundate rice fields and coconut plantations that are about 5 to 10 km further inland.

Coastal and riverbank erosion is also a major problem in the barangay, which is exacerbated by flooding and increased precipitation. Erosion has caused a decline in the land area of the barangay, with remnants of concrete houses underwater indicating that riverbank erosion is a major problem. Coastal erosion in Calapan City is attributed to the improperly placed and designed engineering structures (such as ports), removal of mangrove forests, as well as due to the tsunami associated with the earthquake in 1994 (Boquiren *et al.*, ([eds] 2010).The tsunami was at least six meters high and destroyed houses near the shore and killed at least 41 people in Calapan City and other neighbouring municipalities (PHIVOLCS Quick Response Teams, 1994).

Meanwhile, the 56 ha of currently existing mangrove area in Silonay is considered to be the largest mangrove forest in Calapan City (16% of the total 332 ha mangrove area in Calapan City) (Barangay Silonay 2012). The mangroves species were found to be dominated by *Sonneratia alba*. Trees are pole size, except for old stands of *Avicennia marina* that are of timber size. While the mangrove area was once 85.43 ha, today only 56 ha remain, due to illegal cutting and expansion of residential areas. Another estimate (Conservation International-Philippines 2012) places the current mangrove area at 61.59 ha (natural vegetation and enhancement planting). The existing mangroves along the coastline and riverbank include *Sonneratia alba*, *Avicennia marina*, and *Nypa frutican*, while the dominant species in Puntod Island include *Sonneratia alba*, *Nypa fruticans*, and *Saccharum* sp. The mangroves in the mainland forest include *Acacia farnesiana*, *Dolichandron espathacea*, *Ipomeapes caprae*, *Terminalia catappa*, and *Hibiscus tiliaceus*.

Flooding due to overflow of the river is also a serious threat. The Bucayao River (Pulang Tubig) System, one of the two major river systems in Calapan City, empties into the Verde Island Passage through the Silonay River. The Bucayao River *"has the biggest annual average discharge of 2,629 m³/ second among all the major rivers of Oriental Mindoro"* (Calapan City Ecological Profile 2011 as seen in Pangilinan *et al.*, 2015). It is joined upstream by the Mag-Asawang Tubigthat was found to have shifted its course recently (Boquiren *et al.*, [eds] 2010). For the period 1961-2004, DOSTPAGASA precipitation records from Calapan City show annual rainfall has increased (Boquiren *et al.*, [eds] 2010). For the period 1980-2012, the annual rainfall fluctuates from 1, 200 to 3, 300 mm (mean of 2, 342.7 mm) (DOSTPAGASA, 2014). Heavy rains are recorded in the months of June to December.

With more people than before residing in coastal areas, damage to properties, livelihoods, and threat to lives is increasing. With a barangay population growth rate of 0.01, population is projected to be 1, 375 in 2015 and 1, 432 in 2020. Decisions have to be made regarding coastal protection options, including engineering (seawall) and ecosystem-based (mangrove planting and rehabilitation, and protection) approaches.

- *Adaptation options*

Conservation International used secondary data to undertake the economic analysis of various options. Two EbA options were chosen; 1) Mangrove protection: This is the protection of existing mangrove strands covering 55.5 ha along the coast and which face a constant threat from encroachment and illegal logging; and 2) Mangrove planting: This is protecting existing mangroves and planting mangroves in coastal areas where they are not currently present. Using the data from the Barangay Plan (2012), about 22 hectares (11 ha coastal and 11 ha riverine) were identified for mangrove planting in the barangay. This means that the total area of mangrove plantation would increase to 77.7 ha. This could protect the barangay from coastal flooding brought on by storm surges and sea level rise, and coastal erosion. The mangrove reforestation would consist of propagules from the species already prevailing in the site to ensure a relatively higher survival rate.

Option 3) Engineering option: The construction of a 500 m seawall to be built on the riverbank in Sitio Berberabe, to provide protection from flooding during storm surges and when the river overflows during typhoons. The dimensions of seawalls proposed to be constructed in barangay Catmon, San Juan, Batangas (Perez *et al.*, 2013) were used. That is, it would be 3 m in height and 1 m thick, and will have an underwater base that is 1.5 m high and 3 m thick. The proposed construction materials are a combination of concrete and boulders, stacked to form a wall. The seawall can last up to 20 years without major repairs. The main advantage of a seawall is that it provides a high degree of protection against coastal flooding and erosion (Linham and Nicholls 2010).

Option 4) the final option was business as usual (*status quo*). This means nothing is to be done further to protect the coasts and the people of the barangay.

- ### *Least- Cost Analysis*

As mentioned earlier in this document, the cost-effectiveness analysis is the least-cost analysis, which compares options in order to adopt the one that has the least cost. Following Boardman *et al.*, 2006 to discount over the project's useful life, a 20-year discounting period was used and discount rates of 3%, 8% and 15% employed. While mangroves provide benefits in perpetuity, seawalls are expected to last about 20 years before they require major repairs. The values used came from actual estimates and by using value transfer.

The mangrove re-planting cost estimates were obtained from the mangrove planting activities of the Community Based Mangrove Rehabilitation Project (CBMRP) of the Zoological Society of London (ZSL), implemented from 2008-2012 in selected sites in Panay Island. The re-plantation covered an area of 107.8 hectares and about 100,000 mangroves were planted (Primavera *et al.*, 2012). Out-planting was estimated to cost USD 2,088-2,900.68/ha and their annual maintenance cost was estimated at USD 516/ha. This included payment for the caretaker to secure and clean the planting area (USD 273/ha), supplies (USD 45/ha), and transportation and food of volunteers (USD 198/ha) during months 1, 2, 3, 6,9,12. Following Primavera *et al.*, (2012), maintenance work was for one year and thereafter the community takes over the management of mangroves. In subsequent years, the study assumed annual maintenance cost to cover maintenance supplies at USD 45/ha. Similarly, it was assumed that the protection of the existing mangrove area is community based and annual maintenance cost is payment for maintenance supplies at USD 45/ha). In Silonay, the SNPS (a community based organization) manages the Mangrove Eco-park.

The cost of constructing a seawall was obtained from the Regional Office (MIMAROPA Administrative Region) of the Department of Public Works and Highways (DPWH), which constructed the same structure in Oriental Mindoro in 2012 (PHP3 million for a 103.50 Lm seawall in Poblacion, San Teodoro, 2012 and PHP 3 million for a 129 Lm seawall in Wawa, Calapan City, 2012). As such the cost ranges between USD 528.54-658.77/ Lm. Maintenance costs are a significant and ongoing expense over the life of the seawall. The annual maintenance cost of seawall used in the study is USD 568 based on the study of Perez *et al.*, 2013, which assumed an annual maintenance cost of USD 1,136 for the 1,000 Lm seawall in barangay Catmon, San Juan, Batangas.

The results of the Least Cost Analysis are shown in Table 2. The option with the least cost is the protection of existing mangroves, while the most expensive is the construction of the seawall.

Table 2 Costs for each option in USD over 20 years (USD 1 = PHP 44)

Adaptations Options	3%	8%	15%
Mangrove protection	14,877	9,818	6,259
Mangrove replanting*			
Minimum	68,565	60,589	53,433
Maximum	86,041	77,256	69,085
Concrete seawall*			
Minimum	262,474	249,747	232,862
Maximum	319,795	304,987	286,421

* shows range of cost

Source: Pangilinan *et al.,* 2015

- *Avoided Damages*

Coastal protection provides benefits in the form of avoided damages or avoided losses that would be incurred without the protection. In barangay Silonay, these losses would be incurred by households, business establishments, by the local government, and more importantly by vulnerable groups (poor, women, children and elderly). When computing the benefits of adaptation options these losses are treated as 'avoided damage'; that is, these are damages that would ***not*** be incurred due to the implementation of the adaptation options. In this case, this would be the value of shoreline protection function of the options.

The economic losses estimated are the losses that the households are likely to incur due to damages to their houses in the event of floods or storm surges. In addition, the losses also include losses to income due to fisheries losses, as well as losses to income from the Mangrove Eco-park. They also include the monetary expenditures in the provision of relief and services by the local government if there is a flood and/or a typhoon (Table 3). Market prices and actual costs were used, calculated on an annual basis based on yearly typhoons in Calapan City.

Table 3 Estimates of potential losses from potential Typhoons and Floods (USD 1 - PHP 44)

Losses with No Adaptation Action (Status Quo)	Estimated loss (US$)/yr
Losses to households (total loss of 304 households)	133,013
Losses of income from fishing (total loss of 127 fishers)	2,337
Loss to income from Mangrove Eco-park (loss in income during closure for a week)	77
Provision of flood relief supplies (local government loss)	3,455
TOTAL	138,882

Source: Pangilinan *et al.,* 2015

Since there was a lack of information regarding the costs of flooding in Silonay, the study used estimates of coastal household damage due to flooding of Peñalba and Elazegui (2011), which estimated damages due to a 2006 flooding, caused by Typhoon Milenyo in San Juan and Tanauan City in the province of Batangas. This was estimated to be USD 339/ hh and after adjusting to 2013 values, was USD 437.54/ hh, or USD 133,013 for all 304 households likely to be affected.

Loss of fishing income was calculated for 127 registered fishers based on the record of Fisheries Management Office in 2013. On-site interviews with fishers revealed that out of their daily catch of 3 kg on average, 1 kg is for consumption and 2 kg is for sale. Price per kilogram would usually be around PHP 120-150 (USD 2.7-3.4), giving them a daily income of about PHP 240-300 (USD 5.5-7). In the eventuality of a typhoon or flooding of about three days (based on the category of areas highly susceptible to flooding by Mines and Geosciences Bureau IV- MIMAROPA, 2012) preventing fishing, each fisher loses an average daily income of USD 5 or USD 2, 338 for all 127 fishers in three days.

In addition, the local government provides relief assistance during floods, which represents a large cost. For this study, an estimate of the cost of assistance during Typhoon Yolanda (November, 2013) was used. The City Social Welfare and Development gave out a package worth about PHP 500 (USD 11). If all 304 households need relief assistance, then this could mean a total amount of USD 3, 455.

The Mangrove Eco-park offers kayaking, guided tours, and sells mangrove propagules to visitors willing to plant mangroves, in addition to souvenir items. Using the Eco-park income generated during the months of January to May 2014 of USD 1,553 as basis, the Eco-park income loss from a week long closure due to typhoon or flooding was estimated at USD 77.

There were other important costs that were not calculated due to lack of data or due to very low expected value. These include damage cost to public structures, education cost (due to loss of school days) and health costs. Income loss due to work (employment) disruption was also not calculated given only few (about 1% of the residents) are employed (Conservation International-Philippines 2013). Also not included in the costs was crops damage due to the fact that only 1% of the residents engage in farming and there is absence of crop cultivation in the barangay.

The study assumed that mangroves provide coastal protection benefits on the fourth year from planting. This is based on information that an abandoned fishpond is restored to its original mangrove state in 3-5 years by Assisted Natural Regeneration or planting, when they start reproduction or produce flowers and viable fruits (Primavera *et al.*, 2012; Primavera and Esteban 2008). Survival rate of mangroves is assumed to be 70-80% in Years 1-2. The already existing mangrove strands can provide benefit on the first year of protection. The seawall is expected to provide protection after its construction is finished within two years (based on the delivery period for seawall construction project in barangay Wawa Calapan City in 2012).

It must be understood that EbA options have different levels of effectiveness when compared to engineering options and consequently different levels of avoided damage. As per Linham and Nicholls (2010), seawalls provide a high degree of protection against coastal flooding and erosion. The study followed Rao *et al.*, (2013) in using varying proportions of the total damages, calculated as the avoided damage (benefits) of coastal protection in Silonay. An appropriately designed seawall is more effective than mangroves in avoiding damages. Under the assumption of absence of design information, Rao *et al.*, (2013) suggest a 10%-25% estimate of avoided damage for EbA option and 25-50% scenario for the engineering option. Thus, the avoided cost damage was estimated at 10%, 25% and 50% of the total calculated damage. The damage estimates were projected over a time period of 20 years, at discount rates of 3%, 8%, and 15% to arrive at the total cost for Silonay.

In order to highlight and assess the benefits of implementing the adaptation options, the projected losses that could occur in a business as usual or status quo scenario were estimated. These estimates are then interpreted as the total monetary value of the shoreline protection function or the 'avoided damages' because storm protection measures are in place.

Table 4 shows the damage costs avoided, which highlight the significant role intact and healthy mangroves play in the face of extreme events. Damage costs were set at 50%, 25%, and 10% of the total calculated damage cost. Protecting and conserving existing mangroves provide the highest avoided damages.

While protecting the existing mangroves provides protection benefits right away, mangrove planting can provide protection benefit only on the fourth year from planting. The seawall provides protection once it is finished in the second year.

Table 4 Damage Costs Avoided (USD1=PHP44)

Adaptation Options and discount rates -	Avoided damage estimateas % of the total calculated damage			
	100%	50%	25%	10%
Mangrove protection				
3	2,066,213	1,033,107	516,553	206,621
8	1,363,564	681,782	340,891	136,356
15	869,308	434,654	217,327	86,931
Mangrove replanting and protection				
3	1,673,370	836,685	418,353	167,337
8	1,005,652	502,826	251,413	100,565
15	552,210	276,105	138,052	55,221
Build Concrete Seawall				
3	1,800,467	900,233	450,117	180,047
8	1,115,901	557,950	278,975	111,590
15	643,527	321,763	160,882	64,353

Source: Pangilinan *et al.,* 2015

- *Benefit cost ratio using Avoided Damages*

The Net Present Value (NPV) was calculated and is outlined in Table 5, while the Annualized Net Present Value (ANPV) is highlighted in Table 6and the Benefit-Cost Ratio (BCR) in Table 7, over a 20 year period. A sensitivity analysis was performed to test discount rates (3%, 8%, and 15%) and percent of estimated damages avoided (50%, 25%, and 10%).

Table 5 NPV Using Avoided Damages (USD1 = PHP 44)

Adaptation Options and discount rates -	Avoided damage estimateas % of the total calculated damage		
	50	25	10
Mangrove protection			
3	1,018,229.26	501,675.89	191,743.87
5	671,963.83	331,072.84	126,538.25
15	428,394.91	211,067.79	80,671.52
Mangrove replanting*			
3	768,119.75; 750,644.02	349,777.18; 332,301.46	98,771.64; 81,295.92
5	442,236.03; 425,569.36	190,823.14; 174,156.47	39,975.40; 23,308.74
15	222,671.56; 207,019.38	84,619.16; 68,966.98	1,787.72; (13,864.46)
Build Concrete seawall*			
3	632,251.87; 576,931.64	183,888.51; 128,568.28	(85,129.50); (140,449.74)
5	306,029.48; 250,789.58	28,141.06; (27,098.84)	(138,592.00); (193,831.90)
15	88,900.52; 34,088.85	(71,981.17); (126,166.15)	(168,510.18); (222,319.15)

*Values are a range where the lowest (first) value is derived when maximum cost is considered; US $1 =P44.

Source: Pangilinan *et al.,* 2015

Table 6 ANPV using Avoided Damages (USD1 = PHP 44)

Adaptation Options and discount rates -	Avoided damage estimateas % of the total calculated damage		
	50	25	10
Mangrove protection			
3	1,018,229	501,676	191,744
8	671,964	331,073	126,538
15	428,395	221,068	80,672
Mangrove replanting*			
3	768,120;750,644	349,777;332,302	98,772;81,296
8	442,236;425,569	190,823;174,157	39,975;23,309
15	222,672;207,019	84,619;68,967	1,788;(13,865)
Build Concrete Wall			
3	632,252;576,932	183,889;128,568	(85,130);(140,450)
8	306,030;250,790	28,141;(27,099)	(138,592);(193,832)
15	88,901;34,089	(71,981);(126,166)	(168,510);(222,319)

Source: Pangilinan *et al.,* 2015

Table 7 BCR Using Avoided Damages

Adaptation Options and discount rates -	Assumed % damage avoided		
	50	25	10
Mangrove protection			
3	69.44	34.72	13.89
8	69.44	34.72	13.89
15	69.44	34.72	13.89
Mangrove replanting*			
3	12.20; 9,72	6.10; 4.86	2.44; 1.94
8	8.30; 6.51	4.15; 3.25	1.66; 1.30
15	5.17; 4.00	2.58; 2.00	1.03; 0.80
Build seawall*			
3	3.39; 2.80	1.70; 1.40	0.68; 0.56
8	2.23; 1.82	1.11; 0.91	0.45; 0.36
15	1.38; 1.12	0.69; 0.56	0.28; 0.22

Source: Pangilinan *et al.,* 2015

Ecosystem-based adaptation options (mangrove protection and mangrove planting) have the highest NPV and ANPV, while the engineering option (seawall) has the lowest values and is negative for certain discount rates and assumed avoided damage. ANPV also is highest for the option to protect the mangroves, followed by mangrove planting and building the seawall. In terms of the BCR, over the 20 year period, the ratios remain the same for the option to protect the mangrove, increase for mangrove planting as the discount rate increases, and decrease for the seawall option as the discount rate increases.

From the above assessment, the option to protect existing mangrove areas was the most desirable option followed by planting mangroves in sparse areas. If the seawall is well-designed and can effectively avoid damage (at 50%), then it would also be desirable to implement.

A very crucial and important fact to consider is that mangroves are extremely productive ecosystems that not only provide shoreline protection functions, but also various other ecological and economic benefits. These include increasing biodiversity, improving fisheries, providing fuel wood, medicine and honey and can also be a source of ecotourism. Based on this, a total economic valuation (TEV) of mangroves was also assessed to highlight co-benefits.

The TEV was calculated by using data from the study as well as from other available studies. Thus, the use values were calculated from fishing and eco-tourism, *on the assumption that both incomes are attributed to mangroves protection and management* and carbon sequestration.

Non-use values, particularly willingness to pay for biodiversity conservation, were also estimated in order to calculate the total economic value of mangrove co-benefits.

Table 8 below shows the TEV in adopting option 1 (protection of existing mangroves). The annual value of fishing is based on the average daily income of PHP135 (USD 3) and the 54,441 kg annual production of fisheries from well maintained and protected mangroves. The ecotourism value was estimated based on the monthly income of individuals benefiting from the existing ecotourism activities in Silonay. The rest of the values were estimated using data from similar studies and global data for price per metric tonne of carbon. In terms of adopting option 2 for mangrove replanting, the co-benefits can be enjoyed only when it has reached its full maturity, an approximate of 3 to 5 years depending on the species.

Table 8 Total Economic Valuation

TEV Components	Types of Outputs	Annual Value	
		PhP	USD
Direct Use Value	Fishing	7,349,535.00	167,034.89
	Eco Tourism	60,000.00	1,363.64
Non-direct Use Values	Carbon Sequestration	56,300.31	1,279.55
Non Use Value	Biodiversity Conservation	206,448.00	4,692.00
Total Economic Value		**7,672,283.31**	**174,370.08**

Source: Pangilinan *et al.,* 2015

3.2 The Economic Value of the Cagayan De Oro River Basin [vii]

The second case study is a Total Economic Value (TEV) of The Cagayan De Oro Basin (CDORB), undertaken by Xavier University, Department of Economics. Total Economic Valuation is an important approach to assess, in monetary terms, the value of ecosystems. TEV can be useful to make the case for ecosystems based adaptation options, when it is not easy to undertake CBA of options. It can also be used as supplement to a CBA to highlight the productivity of an ecosystem in economic terms. This can be useful in making a holistic and inclusive case for ecosystem based adaptation options.

The project undertaken by Xavier University aimed to measure the total economic value (TEV) of the flow of ecosystem services from the Cagayan de Oro River Basin (CDORB) in Mindanao, Philippines. The objective was to utilise the results to provide the rationale for the adoption of a river basin-wide payment for environmental services (PES) scheme and to use the results in making decisions on various land uses in the basin. Xavier University - McKleough Marine Center (XU-MMC) is currently undertaking this scheme in collaboration with the Cagayan de Oro River Basin Management Council (CDORBMC). The idea is to use payments for environmental services to generate resources, as well as to reward local initiatives that restore and preserve the ecosystem. This approach has been identified as one strategic way to safeguard and enhance the continuing flow of environmental services from the CDORB. The continuation of ecosystem services will also increase the resilience of the local communities in the face of climate change.

Estimating the economic values of the various components of the CDO River Basin ecosystem can help to establish the underlying basis and justification for the potential contribution that might be collected from different beneficiaries. A sustainably managed and protected watershed can provide security of water supply, fish supply, recreation, biodiversity, flood control and increased resilience to extreme weather events. Therefore, the general public, especially those in the downstream communities, stand to benefit substantially.

A list of potential buyers of the services of the river ecosystem was identified as part of the on-going CDORBMC/XU-MMC PES programme. These are: (1) Mindanao Authority (MinDA), a semi quasi government entity mandated to promote, coordinate and facilitate the active and extensive participation of all sectors, to effect socio-economic development in Mindanao. Its programme 'Mindanao Nurture Our Waters (MindaNOW)' supports the rehabilitation, protection and proper management of river basins and watersheds in Mindanao; (2) Cooperatives such as MASS-SPEC Cooperative Development Center, the biggest regional federation of cooperatives in Mindanao, with more than 300 primary cooperatives holding at least PHP 11 billion (USD 250 million) assets and with more than 1.5 million individual members; and (3) agribusinesses such as Del Monte and Agrinanas, whose operations are heavily dependent on the quality of the ecosystem.

The current TEV research goes further and focuses on the following more massive, long term and sustainable buyers or sources of rewards for protectors of the CDORB: (1) Households in the downstream communities: In particular, the poblacion and 40 village settlements (17 urban and 23 rural barangays) in Cagayan de Oro city. These glean benefits from a well-functioning CDO River Basin in terms of a stable supply of good quality water, flood control, food supply (fish and other seafood), recreation (white water rafting and other water sports activities in CDO River and Macajalar Bay), power supply, climate change mitigation and biodiversity; (2) Industries and institutional establishments: The industrial/commercial and other institutions represent a significant portion of water consumption in the area. Many of the industrial, commercial and institutional (schools, churches and government offices) water users have their own wells and are not served by water districts. Operations of these establishments are usually heavily dependent on a stable supply of water. They are also severely affected by extreme weather conditions and flooding; (3) fishing: Heavy siltation caused by upstream deforestation affects the productivity (catch) of the fisher folks around the CDO River and Macajalar Bay. This group also stands to gain from a well-maintained watershed; and (4) Tourism: A major income generating and fast growing sector in the area, is likewise heavily affected by siltation.

The aim of the economic valuation is to address the following environmental policy questions: (1) what is the value of the total flow of benefits from the CDO River Basin? (2) How are these benefits distributed among the various stakeholders? And (3) who can be the potential financing sources for ecosystem conservation efforts? Furthermore, an important aspect (together with other activities of the project) would be to affect PES / EbA related laws in the local government units and the development and integration of PES in the Cagayan de Oro River Basin Master Plan.

- *The Study Site: Cagayan de Oro River Basin, Mindanao*

With an area of approximately 137,000 ha, the Cagayan de Oro River Basin (CDORB) is spread over the three provinces of Bukidnon, Misamis Oriental and Lanao del Norte. It has three municipalities (Baungon, Libona, and Talakag in Bukidnon), and covers two cities (Cagayan de Oro City in Misamis Oriental and a small portion of Iligan City in Lanao del Norte). It is bounded by Northern Cotabato in the south, by Lanao del Sur in the south west and by Bohol Sea in the north. The highest elevations are the peaks of Mt. Kalatungan and Mt. Kitanglad at 2,824 masl and 2,899 masl, respectively. The steep slopes are predominant in the upland area in the south and south-eastern portion of the basin, where the majority of the river's headwaters are located. They can also be found in the ridges of sub-basins where they serve as topographic divide between sub-catchments. Gentler slopes can be found along the coast and on the flat portions of several elevated terraces around the basin (CDO River Basin Management and Development).

The River Basin encompasses1, 521 km^2 of protected mountain ranges and the River itself traverses the plains of the watershed, with its six major rivers, six creeks, four streams, and eight watershed divides (Roa - Quiaoit, 2011). The residue of the various upland activities falls into the seas of Macajalar Bay in Misamis Oriental, heavily loaded with sediments, domestic sewerage and mining by-products. During heavy rains and flooding, this creates a sedimentation plume at the mouth of Cagayan de Oro River. Impacts experienced due to climate change include the major flooding catastrophe after Typhoon Washi in 2011.

Cultivated areas mixed with brush land or grassland have the largest coverage, occupying 53.56% of the total basin area. Closed and open canopy of mature trees with a combined area of 346 km^2 accounts for 25% of the total basin area. The built-up areas, covering less than 1% of the basin, are found in the northern tip of the basin (CDO River Basin Management and Development).

It should be noted here that EbA approaches have been mainstreamed in the River Basin's Master Management Plan.

- *Methodology*

The TEV undertaken for CDORB consists of both use and non-use values. The use values include those from a stable water supply, flood control, fishing and tourism. Non-use values (those resource values that are separate from people's present use of the resource), include existence values, bequest values and option values. Existence values are the value of simply knowing that the good exists, a sense of stewardship or responsibility for preserving certain features of the natural resource. Existence values may accrue to both users and those who are not actually using the resource but who nevertheless have an interest in it. Bequest value is the value of being able to preserve the resource for future generations. Option value is the desire to preserve the resource for use in the future.

In the context of CDORB, use values were water supply, flood control, food supply and recreation, while non-use values included biodiversity of the CDORB ecosystem to downstream households (mainly CDO City). Contingent valuation method (CVM) was used to value non-market public goods and CDO households were asked in a contingent valuation survey of their willingness to pay (WTP) or contribute to watershed rehabilitation and preservation efforts, to ensure the steady flow of ecosystem services from the CDORB. Their WTP serves as an estimate of the benefits they perceive to derive from the ecosystem's services. Both use and non-use values are integrated in a single estimate using the CVM. The majority of the household members questioned were female (70%), due to the fact that women tend to be responsible for budget allocation in the area, even if they are not the major income earners.

In terms of water supply for commercial, industrial and institutional establishments, results of groundwater depletion studies conducted in CDO in 2003 and 2012 by Palanca-Tan et. al., were used. These estimated the safe yield of the CDO aquifer, produced a survey of deep wells, and estimated the rate of groundwater withdrawal. The survey of deep well owners in the 2011 study included a willingness to pay question for raw groundwater.

Tourism values were estimated by collecting revenues and costs data from tourism business operators, comprising of white-water rafting companies for CDO river and resort/cottage owners for Macajalar Bay.

Primary data collection was used to arrive at net fishing value from the CDO River and Macajalar Bay. A sample of fishers from different zones along the CDO River (upstream, midstream and downstream) and Macajalar Bay was surveyed for fishing effort, gear and catch, to arrive at the net annual fishing values from CDO River and Macajalar Bay.

Benefits from flood control were calculated using the damage costs function method. Existing estimates of damages from previous flooding, together with scientific projections of the frequency of these events with and without adequate watershed protection and management are cited. An estimate of the Value of Statistical Life (VSL) of Palanca-Tan (2014) was utilized to measure the lifesaving benefit of flood control.

- *Summary of Results*

The following table outlines the results estimated from the TEV.

Table 9 Results Estimated from TEV

Ecosystem Services Payer/Benefiting Sector	Unit Value	Total Annual Value
Use & non-use values (water supply, flood control, fishing, recreation, biodiversity) to CDO households	12.19-17.58% of water bill PhP64.83-93.49 (US$1.44-2.07) per household per month	PhP106,936-154,219.290 (US$2,371,094-3,419,511)
Water supply for CDO businesses/institutions	PhP1.00 per m^3 of groundwater extracted	PhP11,738,508 (US$260,277)
CDO River tourism (white water rafting) income	PhP1,197,488 per month (US$26,552)	PhP14,369857 (US$318,622)
CDO River fishing income	PhP4,482 (US$99.38) per fisherman per month	PhP24,470,665 (US$542,587)
Macajalar Bay tourism (resort/cottage) income	PhP31,288 per month (US$15,905)	PhP11,175,460 (US$190,864)
Macaljar Bay fishing income	PhP8,481 (US$188) per fisherman per month	PhP2,181,227 (US$1,378,741)

Source: Xavier University, 2015

The results indicate that with the total household population of 137,465 as per the 2010 Census, the mean Willingness To Pay (WTP) per household ranged from 12.19% to 17.58%, and with a mean monthly water bill per household of PHP 531.8, the total value of the benefits (stable supply of good quality water, flood control, fishing and recreational value, biodiversity) that can be derived from the rehabilitation and preservation of the CDO River Basin would be PHP 8,911,364-12,851,663 (USD 197,591-284,959) per month or PHP 106,936,365-154,219,960 (USD 2,371,094-3,419,511) per year (based on PHP 64.83-93.49 or USD 1.44-2.07/ hh/ month).

For the industrial and commercial sectors, assuming a raw groundwater fee of PHP 1.00/ m^3 of water withdrawn and a monthly groundwater extraction of 978,209 m^3 by businesses and institutions, the total amount funds that can be potentially generated for watershed rehabilitation and preservation from this sector will be PHP 11,738,508 (USD 260,277).

Each artisanal fisherman in the CDO River Basin earns an average of PHP 4,482 (USD 99) monthly and PHP 53,782 or USD 1,195 annually (total annual value of fisheries is over PHP 24 million or USD 542,587). Urban areas provide alternative income opportunities and as such fishermen there are part-time, who earn between PHP 4, 000-PHP 48, 000 or approximately USD 89-1,067 annually. On the other hand, a fisherman engaged full-time in artisanal fishing can earn between PHP 60, 000-106,000 or approximately USD 1,300-2,350 annually. Fishery value from Macajalar Bay was estimated at PHP 62,181,227 (USD 1,378,741) based on PHP 8,481 (USD 188)/ fisherman/ month.

The total estimated annual tourism values from both direct and induced activities from the white water rafting in the CDO River Basin are approximately PHP 14.37 million or approximately USD 318,622 while tourism value of the Macajalar Bay is PHP 11,179,460 (USD 190,864).

4) Discussion and Conclusion

> *"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". (Watkiss et al., 2010)*

Ecosystems provide extensive and important goods and services on which human communities rely. The resilience of ecosystems, in turn, increases the resilience and adaptive capacities of people and decreases their vulnerability to external pressures (Devisscher, 2010), and helps them adapt to climate change. They form the basis of every aspect of life and people depend on them for food security, shelter, health, carbon sequestration, climate regulation, livelihoods and ethnic, cultural and spiritual aspects (World Bank, 2009). Healthy ecosystems provide essential goods and services that underpin global and national economies, in particular for developing countries.

Ecosystems based adaptation (EbA) approaches can thus be extremely beneficial in order to deal with the consequences of climate change. It is essential to understand that EbA approaches cannot just be looked at in isolation or just as providing one particular benefit. Implementing EbA ensures that multiple goods and services that underpin human activities continue to be provided in both quantity and quality. They reduce vulnerabilities that occur due to other factors in addition to providing adaptation options. Therefore, the stresses that are manifested due to climate change can be countered but also, productive economic sectors can continue to function and livelihoods can be better secured. This means that because ecosystems provide not only environmental, but also social and economic benefits, EbA can integrate climate adaptation priorities with the development requirements of countries (Colls *et al.*, 2009). As such it is crucial to promote investment in EbA, so that people and nations can increase their resilience and achieve effective economic and development priorities, such that they do not only deal with the adverse impacts of climate change but also achieve development progress (and contribute to Sustainable Development Goals). In this sense EbA is a win more-lose less approach to adaptation, which can help develop strategies that achieve multiple objectives that not only minimize human induced stresses, but also simultaneously support human development (Devisscher, 2010). Importantly, EbA approaches can provide mitigation benefits and therefore, they can be designed to create synergies between mitigation and adaptation, thus achieving climate change objectives, in addition to conservation and development priorities (Rizvi, Baig, Barrow and Kumar, 2015)

The case studies discussed in this document provide clear examples of how economic analyses can be used to make the case for EbA. It is clear how economic valuation of ecosystems can provide a more inclusive and holistic justification for the relevance of EbA. The studies show that EbA approaches can be cost effective and economically beneficial to societies and can serve as optimal means of adapting to climate change. Increasing the resilience of ecosystems by conserving and sustainably managing them provides natural protection against extreme events, as was depicted in the first case study on mangrove conservation and restoration. While a seawall was also an acceptable solution, well conserved mangroves were not only more cost effective, their overall co-benefits far exceeded those of the seawall. They not only can increase resilience by providing storm protection, but more importantly, by positively impacting peoples livelihoods and providing other social and economic benefits. Therefore, in many cases and wherever appropriate, EbA measures can act as substitutes or complements to other protective methods (World Bank, 2009).

This report makes the case that economic valuation of natural systems and cost benefit analyses (CBA) of EbA approaches can be extremely useful in highlighting the potential benefits of conservation, restoration and sustainable management, especially when multiple goods and services are considered in the assessment (Piran *et al.*, 2009). Therefore, any economic assessment should also account for the multiple benefits in addition to the replacement cost (Devisscher, 2010).

When undertaking CBA of ecosystem based options it is crucial to undertake vulnerability and impact assessments (UNFCCC, 2011). This is because such assessments can help to highlight the potential impacts of climate change and how these will affect human populations, allowing for appropriate EbA options to be identified.[viii]

It is also necessary to consider both long and short term adaptation options and integrate them into the larger development planning context, as well as in national and sectoral policies (UNFCCC, 2011).

Since a central feature of EbA, as compared to other approaches, is the pursuit of social benefits for the local community, including such vulnerable groups as women, youth, elderly and the otherwise disenfranchised, an extremely important aspect to consider is how all the benefits will be distributed, which means looking at all the groups involved. Costs can be borne by groups who may not necessarily receive the resultant benefits. Therefore, who bears the costs and who reaps the benefits should be an important consideration when conducting CBA and economic assessments and these must be consciously incorporated. It must be ensured that vulnerable groups, especially women, children and elderly are included in all assessments of benefits and their distribution. Involvement of all stakeholders will also lead to successful implementation of options.

BOX 4

Regardless of which assessment approach the adaptation planner chooses, each should be:

(a) ***Practical***, i.e. approaches have to be appropriate for a given cultural and socio-economic setting and take into account data constraints. For example if the benefits cannot be quantified monetarily it is not advisable to undertake a CBA;

(b) ***Relevant***, i.e. results should be presented in a timely manner and in a format that is compatible with existing decision making. For example, if public policy options are usually assessed using CBA, assessing adaptation options using CEA may be less acceptable;

(c) ***Robust***, i.e. approaches should be transparent and consistent within and across sectors regarding the underlying climatic and socio-economic assumptions, expert judgments and uncertainties such as discount rates and be explicit about inherent uncertainties;

(d) ***Comprehensive***, i.e. approaches should assess a wide range of options, including inaction, action outside sectoral boundaries and co-benefits; and

(e) ***Proportional***, i.e. the depth of the selected approach should be driven by the decisions to be made and not by the aim for the perfect decision.

Elsewhere in this document it has been highlighted that not just CBA but also cost-effectiveness analysis, as well as multi-criteria analysis are also options that can be used when assessing different EbA actions. This is important because often there are complexities in choosing options and their objectives that may not be captured by using just one type of assessment method. In this case, multiple methods can be adopted to cater for distribution, equity and other aspects (UNFCCC, 2011).

A sophisticated, robust and appropriately designed assessment methodology must be developed that would help to understand the benefits provided by EbA projects.The first case study reviewed in this report undertook a sensitivity analysis of the variation of the discount rate. This is an essential step in order to have a robust analysis. The assessments should consider the long term sustainability of the projects to ensure that their benefits continue well into the future.

Importantly, a Total Economic Valuation (TEV) is beneficial in providing a holistic picture of benefits over time. The first case study not only undertook a CBA of nature based options but also conducted a TEV of mangrove ecosystems to highlight the multitude of goods and services they provide in addition to just coastline protection. The second case study undertook a TEV of the CDO River Basin which highlighted the importance of the basin (including the river and the bay) to the local economy and community livelihoods. Such valuations can provide important information to decision makers and assist them in selecting appropriate adaptation options, as this helps them to look beyond just the current need and focus on a holistic and sustainable approach.

An important issue to consider - according to a review undertaken by Independent Evaluation Group (IEG) of World Bank projects - is maladaptation[5], 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. 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 also to give optimal attention to natural systems, biodiversity and species; a rather more difficult undertaking. However, such evidence collected (as was done in the two case studies) at the local level will inform strategic thinking nationally as well as globally.

Two approaches can thus be useful: undertaking economic assessments, specifically 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, to understand and gather the evidence that shows why EbA was more cost-effective and/or provided greater economic benefits than other solutions. This can then be extrapolated to national level EbA approaches, policies and strategies. Overall TEV of natural resources, in addition to CBA or cost-effective analyses of EbA options, can also be undertaken to provide a more holistic picture of benefits.

The reason for such analyses is to encourage discourse on the merits of EbA and other more integrated nature based solutions, in terms of their utility in dealing with climate impacts, as well as their contribution to societies and economies. Crucially, they can be instrumental in convincing countries - especially developing countries - to invest in nature based solutions.

The objective of this report is to collect such data and increase the knowledge base regarding the effectiveness of EbA, by collecting evidence from the field. The understanding of economic costs and benefits of ecosystems based approaches will provide additional important information to assist decision making at the local, national and global levels, and to influence policy. While uncertainties and challenges may still remain, robust and appropriately designed valuation methodologies can help to decrease them and must be a part of all EbA implementation plans. Detailed assessments of cost and benefits (using any of the methodologies described) therefore must be undertaken, as an important part of ongoing and completed projects, in order to decrease the existing knowledge gaps and to show policy makers why they should invest in EbA. Finally, Box 5 briefly lists some key conclusions.

The main point of this report is to make the case that undertaking analyses of economic costs and benefits of EbA options is important and must be undertaken to assist in decisions and policy making, as well as demonstrating the real benefits (co-benefits) to human livelihoods and to natural resource management. This, however, should be done while considering their strengths and weaknesses and ensuring that aspects that often get neglected are included.

BOX 5

Based on the review presented in this report, the following are some key conclusions:

- Develop a holistic adaptation portfolio that can be applied across sectors, groups and over time. Consider hybrid adaptation solutions that include EbA as well as other solutions, wherever required.
- Undertake vulnerability assessments as a means to understand closely tied socio-political factors such as political will, local capacity, access, distribution and rights.
- Make CBA/ cost-effective/ MCA of projects and TEV of ecosystems goods and services part of the implementation plan.
- Undertake economic valuations of ecosystem services as part of initial assessments during the planning phase of EbA projects. This will increase understanding of the role of ecosystems in human well-being. Both use and non-use values form important aspects in this case, as well as their access, distribution, scales and timelines.
- Undertake assessments after implementation as required, to compare the benefits received over time, so that they can be used to assist in the decision making processes.
- Increase understanding of and incorporate synergies between options as well as tradeoffs and co-benefits, to provide an inclusive and holistic picture for decision making.
- Ensure that distribution and equity issues form an integral part of the process as these tend to get neglected.

5 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).

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Endnotes

i Adapted from Rizvi *et al.*, 2015 unless indicated otherwise.

ii Reproduced from Naumann, Sandra, Gerardo Anzaldua, Pam Berry, Sarah Burch, McKenna Davis, Ana Frelih-Larsen, Holger Gerdes and Michele Sanders (2011). ***Assessment of the potential of ecosystem-based approaches to climate change adaptation and mitigation in Europe***. Final report to the European Commission, DG Environment, Contract no. 070307/2010/580412/SER/B2, Ecologic institute and Environmental Change Institute, Oxford University Centre for the Environment.

iii Adapted from Rizvi *et al.*, 2015 unless indicated otherwise.

iv For additional information please visit the Pacific Regional Environmental Programme (SPREP) at http://sprep.org/climate_change/pacc/index.asp

v 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

vi Information in this section is taken directly from Pangilinan M.J.M, Nunez E. Jr., Ferrer A. and Hole D. (2015). ***Evaluating the Cost Effectiveness of Ecosystem based Adaptation Actions for Coastal Protection: Mangrove Restoration and Rehabilitation in the Philippines***. Conservation International, Philippines, with permission from Conservation International.

vii Information in this section is taken directly from Palanca-Tan R., Almaden C.C., Navarro K., Obedencio M. and Serenas C. (2015). ***The Total Economic Value (TEV) of the Cagayan de Oro River Basin***. Unpublished Research Report. Xavier University-Ateneo de Cagayan, Department of Economics, 2015, with permission from the authors.

viii Conservation International website:http://www.conservation.org/projects/Pages/adapting-to-climate-change-ecosystem-based-adaptation.aspx.

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