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Saved health, saved wealth: an approach to quantifying the benefits of climate change adaptation

Practical application in coastal protection projects in Viet Nam

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CONTENTS

ABBREVIATIONS

AF	Adaptation Fund
AFB	Adaptation Fund Board
CBA	Cost-Benefit Analysis
COP17	Seventeenth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change
DALY	Disability-Adjusted Life Years
FAO	Food and Agriculture Organization of the United Nations
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IFRC	International Federation of Red Cross and Red Crescent Societies
IPCC	Intergovernmental Panel on Climate Change
M&E	Monitoring and evaluation
MISW	Mixed index for Saved Wealth
MNRCZ	Management of Natural Resources in the Coastal Zone of Soc Trang
MONRE	Ministry of Natural Resources and the Environment (Viet Nam)
MRV	Measurement, reporting and verification
NGO	Non-governmental organisation
RBM	Results-based management
RWS	Relative wealth savings
SD	Sustained development
SDC	Swiss Agency for Development and Cooperation
SH	Saved Health
SW	Saved Wealth
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WHO	World Health Organization
WRI	World Resources Institute
YLD	Years lived with disability
YLL	Years of life lost (due to premature mortality)

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1.

EXECUTIVE SUMMARY

Global greenhouse gas emissions are increasing continuously despite two decades of climate policy. By 2012, the average global temperature increase since the late 19th century had already reached 0.7°C. At the same time, the international climate community has realised that effective and efficient adaptation to the adverse effects of climate change is vital.

This report deals with one of the key challenges adaptation project developers are facing: how to consistently estimate, monitor and evaluate the actual outcomes of their adaptation activities. So far many different approaches for various adaptation project types and sectors have been applied, but a standardised set of indicators covering most activities is still missing. It would allow project proposals to be compared before implementation in order to identify the most promising activities in a transparent manner (ex-ante). The standardised criteria would also enable lessons to be drawn from project implementation (ex-post).

We propose a framework consisting of two key indicators that allows the total value of an adaptation project to be assessed. Saved wealth (SW) covers the monetary value of public infrastructure, private property and income loss. Saved health (SH) assesses avoided disease, disability and life loss. Moreover, environmental impacts that are difficult to measure in terms of monetary wealth such as biodiversity can be taken into account qualitatively.

We apply this indicator set to the GIZ project 'Management of Natural Resources in the Coastal Zone of Soc Trang' (MNRCZ) in Viet Nam as a case study.

The main focus of this GIZ project is coastal protection. The first step of this report has been the development of a 'Methodology for estimating the wealth and health benefits of climate change adaptation projects: Adapting coastal zones to rising sea levels', which includes the steps described in figure 1.

The methodology also includes two comprehensive spreadsheets* that perform the calculations and consist of pre-defined formulas, sensitivity analyses and databases.

* The spreadsheets can be downloaded at **www.AdaptationCommunity.net** under *Knowledge > Monitoring and Evaluation > Tools and Training Material*

When applying the methodology in the context of Soc Trang, we have assessed two adaptation options: the 'real' mangrove rehabilitation programme and a hypothetical dyke upgrade. This allows for the evaluation of two different adaptation projects at the same location and a comparison of the expected benefits. The final result shows that the wealth benefits for the local population are almost five times higher for the mangrove option than for the dyke upgrade. Additionally, the mangroves also lead to significant health and ecological benefits whereas the dyke cannot provide such advantages: the dyke upgrade would not even justify its investment.

We conclude that the quantification framework can be successfully applied for measuring project impacts ex-post (monitoring and evaluation (M&E) for the historical mangrove benefits) and predicted impacts ex-ante (for the hypothetical dyke upgrade and the future mangrove benefits) of coastal zone interventions. Furthermore the assessment provided clear guidance for an investment decision as it was able to directly compare the adaptive benefits of two competing projects due to an identical set of applied indicators. The methodology can be replicated for coastal zone interventions in other countries due to large databases providing parameters for developing countries around the globe.

We have identified challenges in the following fields:

- Data gathering at the local level
- Coverage of combined extreme events
- Uncertainty of climate projections

The complexity of the applied tool could be reduced through pre-defined methodologies and simplified versions of calculation tools. External guidance and capacity building help make the tool usable by local project managers. The application of the methodologies and tools by users with different education levels and of different cultural backgrounds, ideally through 'hands-on' workshops, would be crucial to allow for the generalisation of this approach.

The harmonization as well as other internationally available data sources would be helpful and should be supported. Methodologies for other types of adaptation activity would need to be developed and tested. This would allow for cross-sector comparisons of different adaptation project types (e.g. coastal zone interventions vs. drought adaptation activity).

1. Defining the applicability and boundaries of the methodology
2. Deriving a baseline scenario
3. Description of project scenarios
4. Assessment of saved wealth, saved health and environmental benefits/impacts
5. Definition of monitoring parameters

Figure 1: Steps in assessing an adaptation project according to the indicator framework and a related methodology

2. BACKGROUND AND INTRODUCTION

The need for adaptation to mitigate existing and upcoming impacts of climate change is widely recognised in the international climate community. For 2030, the United Nations Framework Convention on Climate Change (UNFCCC) (2007) estimates annual global adaptation costs at USD 49 to 171 billion, with USD 27 to 66 billion accruing in developing countries (see also Parry et al. 2009). Adaptation efforts have evolved significantly in recent years and more experience has been gained. However, the adaptation resources available are many times less than the adaptation needs calculated by Parry et al. (2009). From an economic point of view, it would be desirable to maximise the adaptive benefit achieved with the global investments in adaptation. Against this background there is a strong need for effectiveness criteria to assess ex ante where adaptation measures can bring about the largest benefits for the least cost, and to assess ex post whether or not an adaptation intervention has been successful. Such effectiveness criteria will also be of help for development cooperation and its efforts in monitoring adaptation projects (see also Spearman and McGray 2011, p.5 and GIZ (2012)).

In contrast to mitigation, where the effectiveness of policy action can be measured through the metric 'tonnes of CO_2 equivalent reduced', no universally accepted metric for assessing adaptation effectiveness exists to date. The lack of such a metric is a barrier in planning, monitoring and evaluating of adaptation efforts. The first experiences with allocating adaptation funding show a tendency to use intermediate outcome indicators (e.g. for adaptive capacity and adaptation action taken) but no final impact metrics (e.g. for sustained development despite climate change).

This report introduces indicators for final adaptation impacts that can be used for two purposes. First, the indicators provide information for the ex-post monitoring and evaluation (M&E) of adaptation benefits. Second, the indicators can be used to identify promising and efficient adaptation projects ex-ante. Given the long time horizon of adaptation projects, some overlap between M&E and planning is inevitable. In order to assess future benefits of climate change adaptation, it is necessary to think in alternatives (counterfactuals) even when the adaptation project has already been running for a considerable period of time. This is why our approach for M&E uses a type of cost-benefit analysis (CBA) that is usually applied in project planning and has been suggested for appraising adaptation projects ex-ante (GIZ 2013).

The approach developed by Perspectives Climate Change builds on results-based monitoring systems following the concept of 'results chains' leading from outputs to outcomes and indirect results/impacts (see GTZ 2008, p.5). With each level of the results chain, the level of uncertainty regarding the attribution of a result to the evaluated project increases. In the complex field of climate change, this uncertainty has two main components – uncertainty relating to future climate change impacts and uncertainty regarding non-climatic drivers that influence project impacts. Figure 2 demonstrates how uncertainties influence the assessment of adaptation results in a classic results chain and identifies 'attribution gaps'.

Several studies have shown that estimating adaptation benefits from different project types in different sectors and geographies is challenging. A comprehensive and systematic approach is not available yet, and there are few decision support tools. Moench et al. (2009) were among the first to discuss CBA as a tool for evaluating adaptation projects. The idea evolved to make use of CBA indicators for planning and prioritisation before project implementation as well as for M&E. However, a detailed description of appropriate metrics for such a systematic assessment of adaptation benefits is lacking.

Development agencies like the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) have traditionally applied a broad range of process and outcome indicators for evaluating their adaptation projects. An assessment of natural resource management projects conducted by Michaelowa and Köhler in 2010/2011 revealed that most of these indicators address lower

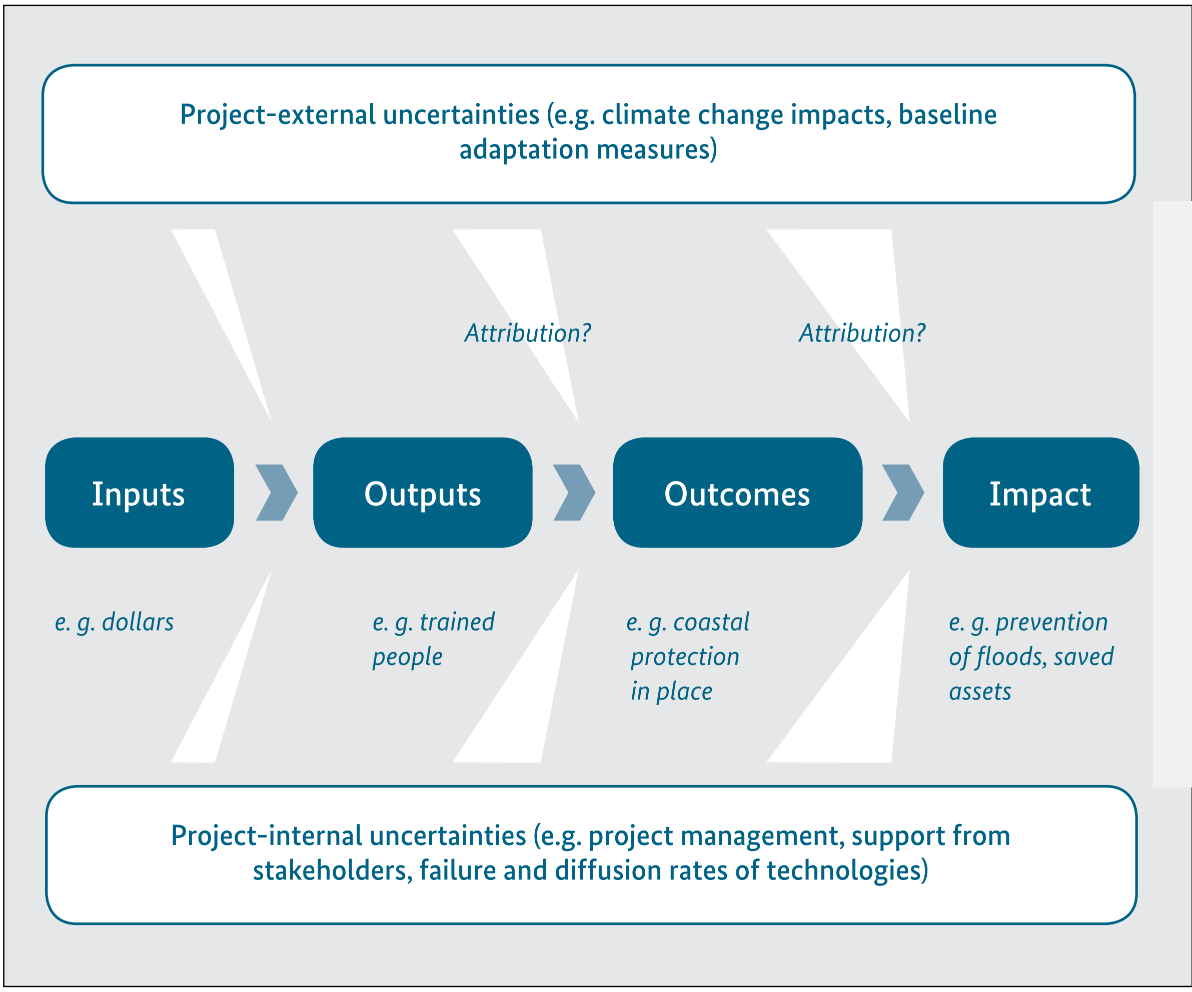


Figure 2:
Uncertainties when predicting and evaluating results of a climate change adaptation project

Source: Modified after Binnendijk 2001, UNFCCC 2010, example of coastal adaptation project in italics levels of the results chain and rarely take into account the indirect long-term impacts (see also Michaelowa and Köhler 2011, p. 15).

Perspectives has elaborated a framework for quantifying the results of adaptation projects and programmes through standardised indicators[1]. The method quantifies long-lasting impacts while taking into account uncertainties. Perspectives has so far tested the practical application of the method in one setting, a project for Kenya's agricultural sector. GIZ's Climate Protection Programme for Developing Countries commissioned further testing of the concept for the GIZ project Management of Natural Resources in the Coastal Zone of Soc Trang (MNRCZ).

The study aims to:

- Communicate the concept of quantifying adaptation benefits to GIZ project developers and related stakeholders and policy-makers. Eventually, the concept could be applied widely for all types of adaptation. The specific aim is to present an innovative indicator approach for ex post M&E of adaptation benefits. At the same time these indicators might also be useable for ex ante planning in the context of CBAs;
- Provide a methodology for quantifying adaptation benefits of coastal adaptation projects, including a spreadsheet and related instructions to operationalise the methodology;
- Apply the methodology and tool to the case study in Viet Nam, illustrating the underlying concept and presenting the benefits of mangrove restoration;
- Document the conclusions drawn from its application as the basis for future applications.

The concept of quantifying adaptation benefits will be introduced in chapter 3. Based on the concept a methodology to assess benefits of coastal adaptation projects is described in chapter 4. Chapter 5 outlines the application of the methodology in the context of the Vietnamese case study. At first, the baseline scenario is described, followed by two potential project scenarios: dyke construction and the rehabilitation of mangroves. The results of both projects are compared to the baseline, which allows for the interpretation of outcomes and identification of lessons learned for similar project types. Identified strengths, challenges and recommendations for improvements are presented in chapter 6. Finally, Annex I documents the full methodology.

[1] This was done on behalf of the Swiss Agency for Development and Cooperation (SDC).

3.

THE CONCEPT OF QUANTIFYING ADAPTATION BENEFITS

Conceptually, estimating adaptation benefits of projects has always been plagued by the challenge to give a monetary value to human life and biodiversity. Attempts to use life insurance data to value human life have been heavily criticised because they value human lives according to their economic potential expressed in monetary terms such as Gross Domestic Product (GDP) per capita which differs greatly between industrialised and developing countries. We avoid this ethical challenge by differentiating between monetary and human life/health-related benefits. In order to cover the existence value* of biodiversity, the concept also includes a procedure to take such environmental benefits into account.

Based on these general principles, indicators for each of the following three key dimensions related to the adverse effects of climate change are proposed: economic value at risk health of people at risk, and environmental benefits. The aim is to apply a consistent methodology that helps to quantify the benefits for each of the categories and which may help decision-makers to track and compare project impacts as well as allocate available resources systematically. A quantative approach has been developed for economic and health benefits. The downside of purely quantitative approaches is that they provide only a very coarse picture of the reality and that such indicators are difficult to measure. Furthermore, there are uncertainties and value judgments such as the impacts of climate change on extreme events. However, quantitative indicators allow comparing two situations consistently between space and time.

It is proposed to determine the total value of an adaptation project (TV_{Adapt}) as the ***Saved Wealth*** (SW), covering the monetary value of public infrastructure, private property and income loss, plus ***Saved Health*** (SH), covering avoided disease, disability and life loss. Besides this, ***environmental impacts*** that are difficult to measure in terms of monetary wealth such as biodiversity are taken into account qualitatively. In the following, each indicator is explained in detail.

* The existence value reflects the benefits people experience from knowing that a particular environmental resource, such as a forest, endangered species or any other organism or thing exists.

3.1. EXPLANATION: SAVED WEALTH INDICATOR

3

When assessing the wealth benefit of an adaptation project, one can generally use the two different concepts: absolute wealth saved or relative wealth saved. These two types of wealth (described below) can be used to compare the impact of competing investment options (or approaches) within an adaptation project at community level.

1. **Absolute wealth saved:** This approach measures the absolute wealth saved by the project. Taking the fictive example of a community with 1,000 inhabitants and with a moderate level of wealth (USD 1 million), an adaptation activity is, for example, able to save USD 0.2 million. Looking only at the absolute wealth of the community does not necessarily address vulnerability, as absolute wealth may be concentrated among a few community members who are able to cope with the loss of part of their assets.

2. **Relative wealth saved:** Here, the absolute wealth saved by the adaptation project is divided by the total wealth of the community. The number of average personal wealth saved is calculated as a per cent. The relative wealth saved for the community described above would be 20% (USD 0.2 million/1 million). Looking only at the relative wealth of the community may lead to high losses for wealthy community members while spending a lot of resources to protect the limited wealth of poor people.

To combine the advantages of both approaches the authors decided to apply a mixed index for Saved Wealth (**MISW**), which is calculated in two steps: At first the absolute wealth saved, including private and public property, is assessed (e.g. USD 0.2 million for a community as described above). As a second step the relative wealth saved is calculated. Here, the absolute wealth saved is divided by the total wealth of the community and finally multiplied by the population. In the example, this would be e.g. USD 0.2 million absolute savings divided by USD 1 million total wealth = 20% relative wealth savings (RWS) within the community. Finally the approach combines both outcomes by multiplying the two values. In the example, the village would have a total average Saved Wealth of USD 0.2 million * 20% (RWS) = USD 40,000 (RWS). The concept has the advantage that poor, vulnerable communities that lack assets to be protected are not excluded (covered by relative wealth), while concentrations of assets in more developed regions are not neglected (covered by absolute wealth). The formula for the Saved Wealth index is:

$$\boldsymbol{SW = MISW = AWS \cdot RWS}$$

where;

MISW: mixed index for Saved Wealth (MISW)

AWS: absolute wealth saved by a project (in USD)

RWS: relative wealth saved by a project (in relative wealth savings (RWS))

The MISW may be applied to the wealth categories of public infrastructure - which can include natural resources and services - and private property.

In the context of the assessed project activities in chapter 4, the MISW has been balanced equally. However the tool user makes the decision about the weighting of relative and absolute wealth. If both public infrastructure and private property are assessed, then the sum of public and private wealth saved shall be calculated for each sub-indicator (absolute and relative wealth savings) before multiplying the two values to get the MISW. In determining the potential of an adaptation activity to save wealth, one needs to consider the development of wealth in the relevant region over time that would occur in the absence of climate change during the lifetime of the project. Demographic and/or economic developments will lead to changes of property, and therefore wealth in the baseline scenario. Furthermore, the wealth needs to be discounted. Discounting is done to reflect inflation as well as decrease of the economic value of infrastructure and hardware over time that is not related to climate change (depreciation).

3.2. EXPLANATION: SAVED HEALTH INDICATOR

In this section, the concept of Disability Adjusted Life Years (DALYs) saved is introduced to assess avoided negative climate change impacts on humans due to a proposed adaptation activity, also referred to as Saved Health (SH).

The concept of DALYs was developed by the World Bank (1993), and has since then been systematically utilised by – inter alia the World Health Organization (WHO) in the 'Global Burden of Disease (GBD) concept', which provides a comprehensive and comparable assessment of mortality and loss of health due to diseases, injuries and risk factors for all regions of the world (WHO 2010). It is a concept to quantify the burden of disability and death that avoids the monetisation of human life. Instead, adaptation benefits are expressed as the avoided number of life years lost due to disability and early death.

$$DALY = YLL + YLD$$

('YLL' stands for 'years of life lost' (due to premature mortality) and 'YLD' stands for 'years lived with disability'.)

3.3. EXPLANATION: ENVIRONMENTAL BENEFITS

This section explains our method to assess environmental adaptation benefits. Contrary to natural services and resources that are included in Saved Wealth, the concept of natural ecosystems focuses on the intrinsic value of nature. Its major criteria are the quality and quantity of biodiversity. Thus, assessing the saving of endangered species (flora and fauna) in a qualitative manner and the protecting of their natural habitat in a quantitative manner can be main indicators. In the context of the proposed framework, a simplified approach focuses on adequate incentives for project developers to minimise and compensate for potential negative environmental effects of the given adaptation project. Thus, an environmental assessment of the project will be applied, based on evaluation criteria that can be found in chapter 8 (see Annex I). After introducing the general concept of quantifying adaptation benefits, the next chapter describes a specific methodology to apply the indicators in the context of coastal protection projects.

4. METHODOLOGY

The concept developed by Perspectives is used in two ways. First, the health and wealth benefits of two coastal protection approaches are calculated. One approach is integrated coastal zone management focusing on mangrove planting/rehabilitation and the other is a more 'traditional' approach of concrete dyke building. Second, the benefits of the two approaches are compared to the costs. Furthermore, non-health/-wealth related environmental benefits are taken into account in a qualitative manner.

A 'Methodology for estimating wealth and health benefits of climate change adaptation projects: Adapting coastal zones to rising sea levels' has been prepared and can be found in Annex I. The following section describes the main elements and data requirements. The methodology is implemented using a spreadsheet that includes various default values and allows for the calculation of benefits. Five steps are required for desiging and applying an appropriate methodology.

Figure 3: Steps in assessing an adaptation project according to a suitable methodology

1. Defining the applicability and boundaries of the methodology
2. Deriving a baseline scenario
3. Description of project scenarios
4. Assessment of saved wealth, saved health and environmental benefits/impacts
5. Definition of monitoring parameters

The key steps 1, 2, 3 and 4 are explained in detail in the following section. Step 5 depends on the indicator definitions from the preceding steps, is rather simple and can be found in the methodology in Annex I.

4.1. APPLICABILITY AND BOUNDARIES

The methodology has been designed for two main types of intervention: (i) flood prevention and (ii) flood mitigation in coastal zone areas where negative impacts of climate change are already occurring and/or are expected for the next 10-50 years. The methodology mainly covers physical interventions such as coastal infrastructure, natural protection measures, erosion avoidance and soil restoration and avoidance of salinisation. Combinations of physical activities and capacity building/policy planning measures such as early warning systems coupled with emergency shelters are addressed by the methodology. Standalone capacity building/policy planning measures are not suitable for a quantitative approach.

4.2. DERIVING A BASELINE

The baseline is the business-as-usual situation in the project area including impacts of climate change but excluding the proposed project interventions. Both already observed and predicted climate change impacts have to be reflected. Adaptation measures implemented in the past and expected autonomous adaptation form part of the baseline. Such data will be used to calculate predicted wealth and health losses. The full formula can be found in chapter 5 and in the Appendix. The baseline is built from project data on the ground combined with default values. The minimum data requirements that cannot be provided by default values are listed in textbox 1 below.

Textbox 1:
Minimum data requirements*:

- Project lifetime in years
- Population in start year
- Total project area in hectares
- Percentage of wealth and (if applicable) health projected to be lost due to climate change in year t during project lifetime (i.e. percentage of wealth lost per year during project)

*) Other values can be provided through default values. However, the validity of the quantification increases when local data are applied.

4.3. CALCULATION OF WEALTH AND HEALTH BENEFITS DUE TO AN ADAPTATION PROJECT SCENARIO

The intervention to save wealth and health in the project area is the main element of the concept. First, the type of the project has to be specified. The methodology covers the following project types: disaster mitigation, flood protection, avoided erosion and/or avoided salinisation. Specific formulas to calculate adaptation benefits are provided in four individual modules. Next, the required data has to be gathered in order to provide sufficient project-specific input for the calculations. The project specific results are then aggregated (see *'Project* *situation'* tab in the spreadsheet - modules *(3) disaster mitigation, (4) flood protection, (5) avoided erosion and (6) avoided salinisation).*

A damage-frequency function of flood events is the main tool underlying both calculations. The function needs to be elaborated given the area-specific situation. It demonstrates the damage potential of an extreme event on the y-axis and the frequency on the x-axis (see figure 4). The higher the damage potential of an event the lower its frequency. As an example, some river flooding usually happens every year in the rainy season but average damages are low, in part due to the adaptive capacity of local population. However, once per decade, flood levels are much higher leading to significant damages. An extreme flood that on average only happens once per century will lead to catastrophic impacts. This relation is expressed by the damage curve shown in figure 4. A damage curve has been included in the spreadsheet *'Saved Health - Saved Wealth: Excel Tool (for the Dyke Case/ for the Mangrove Case)'* in the *'Damage curve'* tab.

Based on this frequency function curve one can derive the average damage during the project life-time that is prevented by the adaptation project. As discussed above, both absolute and relative wealth are assessed and combined in an index result (see also section 3.1). Both components are weighted equally and thus multiply absolute wealth by relative wealth.

4.4. SENSITIVITY ANALYSIS

The future development of wealth and health conditions in the project area as well as the impacts of climate change are very uncertain. Therefore, a sensitivity analysis of project impacts

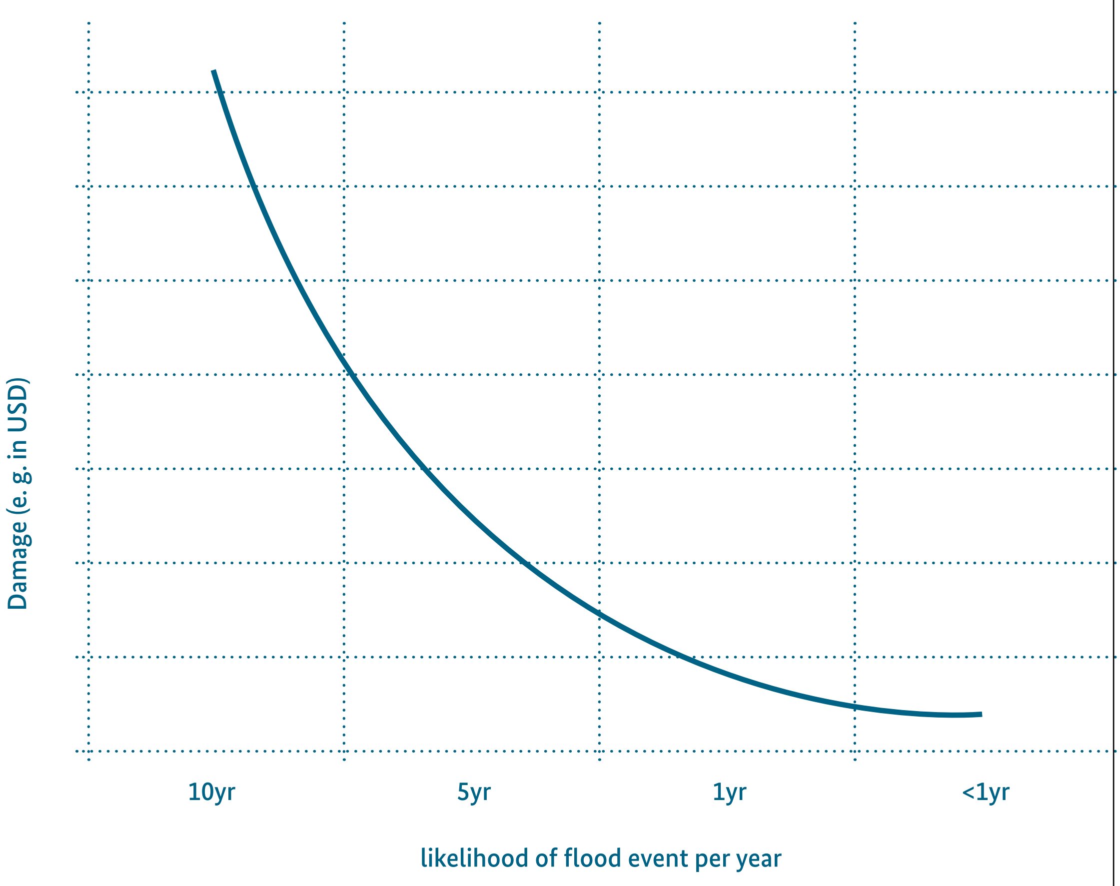


Figure 4: Example of the damage-frequency function of flood events

needs to be conducted. It will explore the implications of changes in major parameters and/or changes from minimum to maximum values. The following key parameters are to be assessed:

- Extreme weather intensity and duration
- Extreme weather frequency
- Value of public and private property
- Number of deaths and incident cases
- Annual maintenance costs during project lifetime

An automatically calculated sensitivity analysis has been included in the spreadsheet *'Saved Health - Saved Wealth: Excel Tool (for the Dyke Case / for the Mangrove Case)'* in the *'Sensitivity analysis'* tab.

4.5. ASSESSMENT OF ENVIRONMENTAL IMPACTS

This method only assesses sustainable development and the environmental impacts of the adaptation project by means of a qualitative checklist focusing mainly on biodiversity. Thus, negative impacts have to be identified and the implementing entity has to describe which measures will be implemented to mitigate such unwanted outcomes. The assessment should include consultations with relevant stakeholders such as national ministries, local governments, local and international non-governmental organisations (NGOs) as well as companies. The full checklist for sustainable development can be found on page 20 and in the spreadsheet *'Saved Health - Saved Wealth: Excel Tool (for the Dyke Case / for the Mangrove Case)'* in the *'Sust. development check list'* tab.

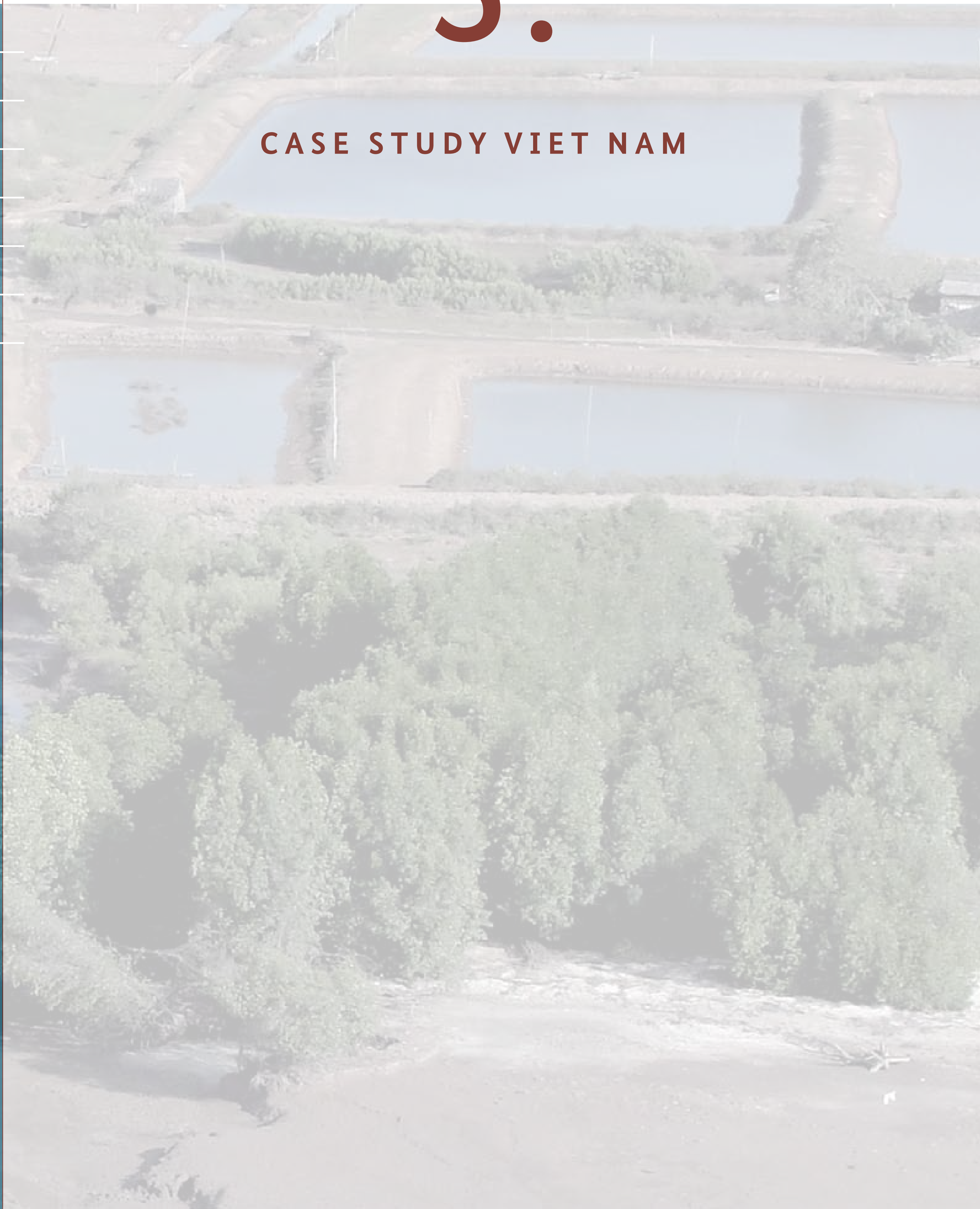
Textbox 2:
Minimum data requirements*:

- Project budget over lifetime (in USD)
- Maximum damage potential of climate change impacts
- Probability of occurrence of climate change impact for every year t (i.e. probability per each year)
- Negative economic impact due to project implementation
- Percentage of wealth and health (if applicable) projected to be lost due to climate change in year t
- Total wealth of the region

*) Other values can be provided through default values. However, the validity of the quantification increases when local data are applied.

5.

CASE STUDY VIET NAM



The methodology for coastal adaptation projects has been applied to the Vietnamese case study on coastal protection in the Au Tho B village in the south-eastern Soc Trang province of Viet Nam. First, the vulnerability of the coastline in the context of a changing climate is described, highlighting historical and expected impacts on the local population. Second, the basic socioeconomic and biophysical parameters of the project region are outlined, providing the background for developing the baseline scenario. The two adaptation options, a concrete dyke and mangrove rehabilitation, are explained and the benefits of each of the activities are quantified. Third, a comparison of both project scenarios that also takes investment and operating costs into account is given.

5.1. VULNERABILITY OF VIET NAM'S COASTLINE

Viet Nam is likely to be one of the most vulnerable nations in the world regarding impacts of climate change. Due to its very long coastline and river deltas with low elevation, its dependence on agriculture (more than 70% of the population lives in rural areas), amount of rural areas with relatively low levels of development and exposure to sea level rise and extreme meteorological events is high, while adaptive capacity is low (McElwee 2010, p.1).

The average surface temperature has risen by 0.7 °C since 1950; the typhoon and flood seasons are longer than they used to be; heavy rainfall and flooding is becoming more frequent and storms are impacting coastal areas that had not been affected so far (McElwee 2010, p.1). The Soc Trang province is particularly exposed to floods and storm surges as well as an increasing frequency of typhoons. It is located in south-east Viet Nam (see red circle in figure 5).

The projected sea level rise in Viet Nam will have significant impacts on coastal areas. As simulated in models by the Ministry of Natural Resources

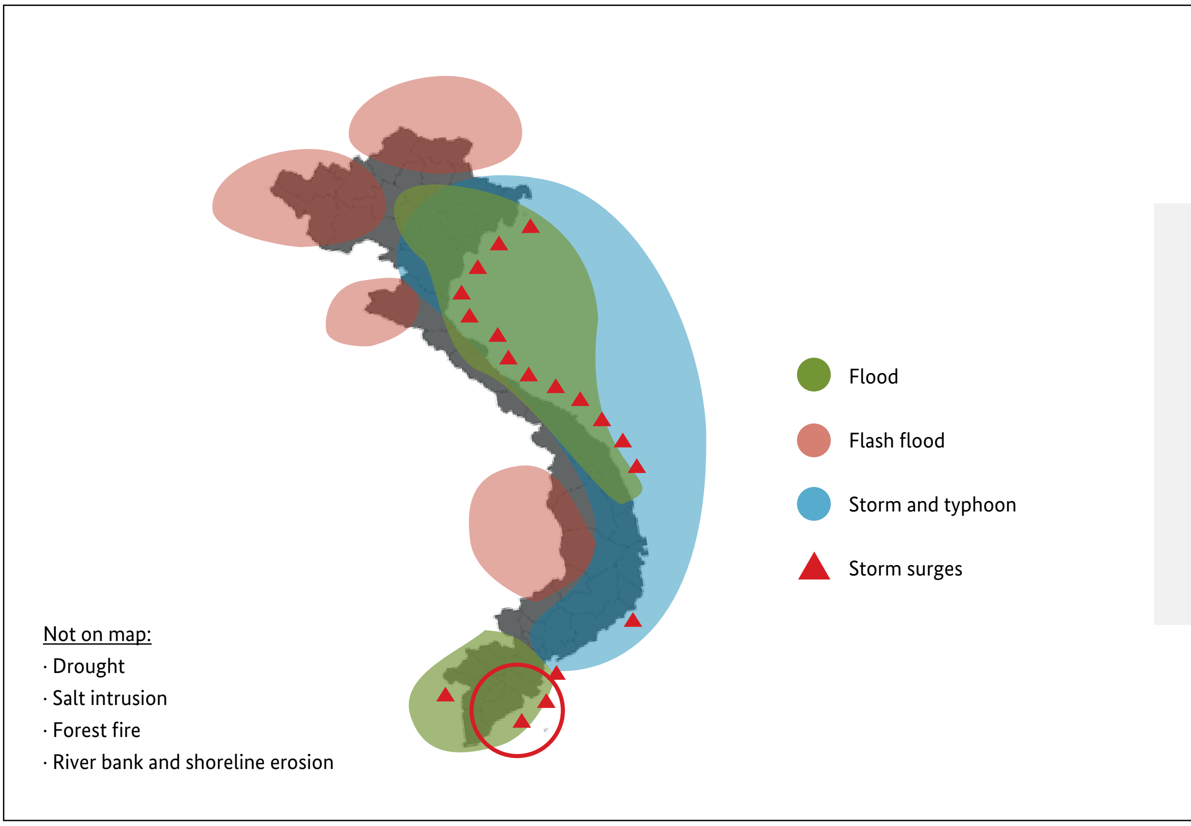


Figure 5: Geographic distribution of primary climate exposure hazards in Viet Nam

Source: McElwee 2010, p.9

and the Environment (MONRE), the average sea level at the coast of Viet Nam will likely increase by 65 to 100 cm until the year 2100 (see table 1)

Such increases in sea level will also lead to higher impacts of extreme events triggering e.g. erosion in coastal areas; estimations of 5-10 metres of eroded area per year have been reported (see McElwee 2010, p.14). Annual erosion rates of up to 30 m have been recorded for the coast of Soc Trang Province (Joffre 2010, Pham 2011). Additionally, increasing salinisation due to salt water intrusion from rising sea levels is a major issue for many farmers. As figure 6 shows, the whole southern coastline of Viet Nam has been affected by salt water intrusion in the year 2000; projections show significantly increased salinity of shallow coastal aquifers with rising sea levels.

Summing up, the southern Vietnamese coastline is increasingly exposed to the following negative climate impacts:

- Storm surges
- Floods
- Erosion
- Salinisation

Successful coastal adaptation projects will have to protect public and private health as well as human life against one or several of the identified impacts. As discussed in chapter 2 and section 4.4, all projections of climate change impacts are challenged by uncertainty. Furthermore there are no local projections for the Soc Trang province; only national data was available for the case study. Thus, discount factors have been included to guarantee conservative estimates for the achieved adaptation benefits and a sensitivity analysis for the main parameters.

5.2. PRESENTATION OF THE BASELINE ADAPTATION OPTIONS AND BENEFITS

The assessed community, Au Tho B village has a coastline length of 2.76 kilometres comprising agricultural areas with adjoining mudflats and sandbanks; the village itself is protected by an earth dyke and a mangrove belt (see Lloyd 2011, p.14). This levee is affected by extreme events and rising sea levels, requiring increased maintenance efforts. A study conducted by the International

Table 1: Projected average sea level rise (in cm) in Viet Nam, relative to average of the 1980-99 period, Source: MONRE (2009)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Low emission scenario (B1)	11	17	23	28	35	42	50	57	65
Medium emission scenario (B2)	11	17	23	30	37	46	54	64	75
High emission scenario (A1F1)	11	17	24	33	44	57	71	86	100

Federation of Red Cross and Red Crescent Societies (IFRC 2010) revealed costs of about USD 97,000 for rehabilitation per kilometre of dyke per extreme event. As such extreme events historically occur in average every ten years and are expected to increase in intensity and frequency; expected maintenance for Au Tho B sums up to more than USD 560,000 over a 20 year period.

About 169 households with about 700 inhabitants are located between the sea and the dyke (see buffer zone in figure 7). As the inhabitants of the buffer zone are dependent on agricultural activities (mainly onion cultivation) erosion and salinisation are major issues jeopardising the economic sustainability of the local population.

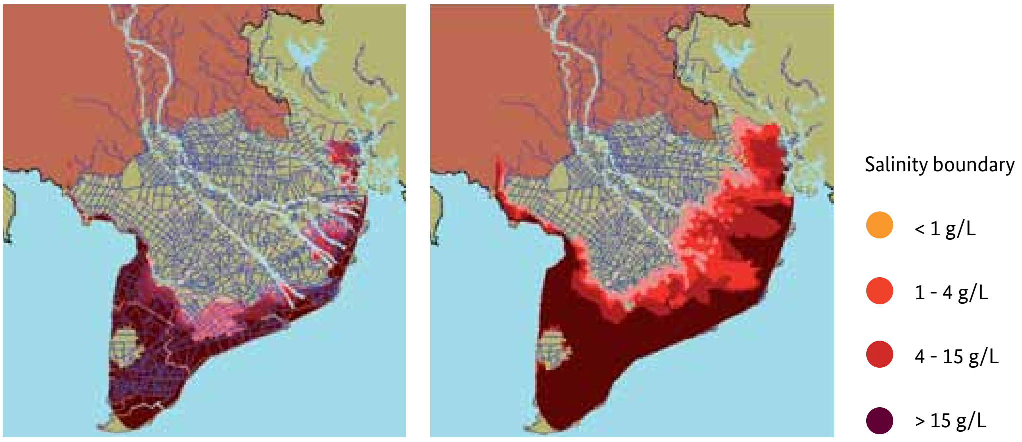


Figure 6:
Salinity boundary in the Mekong river delta in 2000 (left) and projection for a 1 m sea level rise (right);
Source: van Sanh (2009)

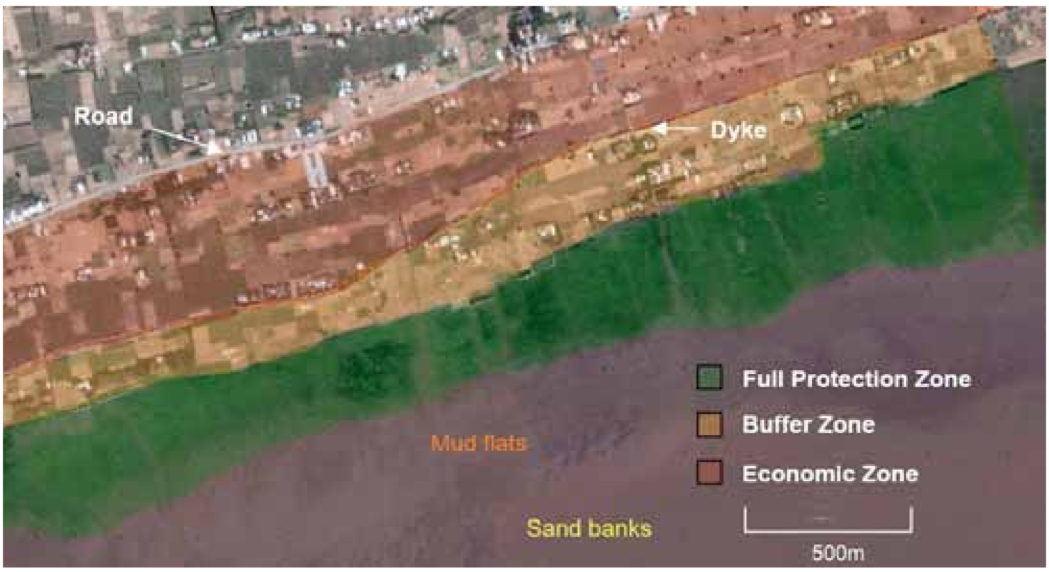


Figure 7:
Satellite image of Au Tho B village with a co-managed zoning plan
Source: Lloyd 2011, p. 20

Based on the observed and expected climate change induced impacts on Au Tho B, two possible adaptation project scenarios have been identified:

- dyke upgrade through replacing the earth dyke with a concrete one, or
- protective mangrove belt in front of the dyke.

The two scenarios do not fully reflect the real situation because mangrove rehabilitation has been initiated already 20 years ago, the dyke upgrade has not been considered as an alternative yet. So the scenarios serve as hypothetical examples, illustrating the situation of Au Tho B before mangrove rehabilitation.

5.2.1. Baseline scenario

We assume in the baseline scenario that Au Tho B is only protected by a simple earth dyke but not a mangrove belt. This used to be the situation before the year 1994, which is when the Province of Soc Trang started mangrove rehabilitation programmes. Hence a substantial mangrove forest had already been in place when GIZ started the co-management project. The aim of this activity was mainly to protect and manage existing mangroves in a sustainable manner.

Table 2: General baseline parameters. Source: 'Baseline situation' tab in the spreadsheet

Parameter	Value	Source
Project country	Viet Nam	*Project document*
Project region/community	Au Tho B village	*Project document*
Project start year	2007	*Project document*
Total project area in ha	439.28	*Project document*
PLT (project lifetime in years)	20	*Assumption*
POP (population in start year) in project area	700 (1277 for erosion)	*Project document*
PGR (POP growth rate per year)	1.06%	*Viet Nam, 2008-2010, World Bank*
LE: life expectancy at birth	74.2	*Default value, Viet Nam*
WPCB: baseline wealth USD per capita/yr	1222	*Viet Nam, 2007, World Bank*
IGR: income (GDP) per capita growth rate (%/yr)	5.9%	*Viet Nam, 2006-2010, World Bank*
AA: autonomous adaptation	10%	*default value*
D: discount rate of existing wealth per capita	0.04	*half of average inflation rate*

The baseline scenario therefore describes a rudimentary dyke that can withhold extreme events but has to be rehabilitated after each storm surge event. The adaptation project scenarios in the subsequent section describe a potential situation for a coastal community in Au Tho B which requires a decision between 'conventional' dyke upgrades and mangrove rehabilitation. The full benefits and costs of a co-management system, as implemented by GIZ in Au Tho B, are reflected in the mangrove rehabilitation scenario. The general baseline parameters that are valid for both scenarios are taken from the spreadsheet *'Saved Health - Saved Wealth: Excel Tool (for the Dyke Case / for the Mangrove Case)'* in the *'Baseline situation'* tab.

Based on the following damage calculation, one is able to derive the expected economic impact of climate change driven impacts within the next 20 years (see *'Damage Curve'* tab in the spreadsheet). Based on the likelihood of impacts, the spreadsheet calculates average wealth losses per year (see table 3). All categories of climate change impacts introduced in section 3.3 are included: infrastructure (dyke damages), loss of private property (population in front of the dyke), erosion and salinisation. Total expected wealth loss is about USD 150,000 annually or USD 2.91 million during the lifetime of the envisaged adaptation activities. The health impacts are taken from the calculation in the *'Damage curve SH'* tab in the spreadsheet

Table 3: Expected annual wealth losses (in USD million/yr). Source: 'Damage Curve' tab in the spreadsheet

Type of wealth	Total value: average over lifetime; deflated)	10 yr floods	6-9 yr floods	1-5 yr floods	2 week spring tide	Total
Public infrastructure	**0.54**	**0.03**	**0.00**	**0.00**	**0.00**	**0.03**
Private property, rich						
Private property, middle class						
Private property, poor	1.53	0.02	0.02	0.01	0.00	0.05
Total private property	*1.53*					*0.00*
Avoided erosion	3.24	0.01	0.01	0.01	0.00	0.03
Avoided salinisation	1.29	0.00	0.00	0.00	0.03	0.03
Total wealth losses per year		0.063	0.027	0.021	0.035	**0.15**

Table 4: Expected annual health losses (in DALYs/yr). Source: 'Damage Curve SH' tab in the spreadsheet

Average health loss	10 yr floods	6-9 yr floods	1-5 yr floods	2 week Spring tide	Total	Average duration (years)	DALYs
Deaths	**0.03**	**0.1**	**-**	**-**	**0.1**	**n. a.**	**4**
Fractures	0.1	0.1	-	-	0.1	0.167	0.024
Diarrhoea	1.6	1.8	2.1	110.9	116	0.115	13.429
...					**Grand total DALYs p. a.**		**17**

and are summarised in table 4. It outlines the DALYs resulting from deaths, fractures and diarrhoea during frequent floods and extreme events that can be expected during the 20-year lifetime of the project. One has to note that estimates regarding the constant diarrhoea of the population living in front of the dyke are mainly responsible for the DALYs that occur. The spring tides that occur every two weeks would flood housings and surrounding areas leading to infection. Death is only expected during extreme events occurring every 6-10 years. These values and estimations are based on historical data sets from the World Bank.

Overall projected climate change driven coastal impacts as described above will lead to estimated absolute wealth losses of about USD 2.9 million and health impacts of about 350 DALYs in Au Tho B during the upcoming 20 years without additional adaptation (see table 5).

5.2.2. Adaptation measure: Dyke upgrade

The first climate change adaptation measure that was assessed was the construction of sufficiently high dykes made out of concrete. Such a structure is able to withstand storm surges or typhoons. Damages are reduced significantly and maintenance is decreased by USD 97,000 was the construction of extreme event compared to the rudimentary dyke that currently exists (see section 5.2 above). As destructive extreme events historically occur every ten years on average and will become more intense and frequent in the future, the upgrade is projected to save public wealth in Au Tho B village totalling USD 588,000 in 20 years. Costs for concrete dykes are USD 200,000 per kilometre of dyke line. Thus, the full upgrade of Au Tho B village's levee structure is estimated to cost about USD 550,000 for a 20 years period.

The following section shows the application of the methodology as described in chapter 3. For the dyke upgrade, only module (3) covering extreme events is applicable, as frequent flooding, erosion and salinisation in the buffer zone are not avoided or mitigated through the improved dyke.

5.2.2.1. Application of the methodology

The 'Methodology for estimating wealth and health benefits of climate change adaptation projects: Adapting coastal zones to rising sea levels' (see Annex I) has been applied to quantify the benefits of the dyke upgrade. As outlined in chapter 4, three key dimensions related to adverse

Table 5: Wealth and health losses in baseline. Source: 'Baseline' tab in the spreadsheet

Name	Description	Result	Unit
WLC_{PLT}	Wealth losses due to climate change during the project lifetime (absolute)	2.9	million USD
HLC_{PLT}	Health losses due to climate change during the project lifetime	348	Disability-Adjusted Life Years (DALYs)

effects of climate change are assessed: economic value at risk, health of people at risk, and environmental benefit. However, the project design only allows for the protection of public wealth as the adaptation impact is decreased rehabilitation effort. As only extreme events are seriously damaging the existing dyke, module (3) (disaster mitigation) could be used for the calculation. This module covers damages from extreme events but not the frequent flooding from e.g. the spring tide. Relevant data has been gathered and fed into the ready-to-use spreadsheet (see spreadsheet *'Saved Health - Saved Wealth: Excel Tool for the Dyke Case'*). Calculations in the spreadsheet are based on both specific project values for Au Tho B, mainly regarding dyke characteristics and national default values for predicted climate change impacts on Viet Nam and regional economic development.

The calculated results in table 6 show that the adaptation activity has a negative benefit/cost ratio. Saved Wealth (SW) in absolute terms is about USD 530,086 or 96% of the project budget (SW_{ABS} indicator). The lower value of absolute SW compared to the maintenance savings outlined above is explained through the default 10% failure rate of the adaptation activity. Taking into account the relative wealth savings of the local population living in Au Tho B (see also section 3.1) which is calculated by dividing the absolute wealth savings by the overall wealth of the region, one can derive the mixed absolute and relative index value (MISW) which, for the dyke scenario, is 56,559 average personal wealth units saved ($MISW_{index\ indicator}$). If this index is divided by the project budget one gets a MISW per million USD of 0.1 (MISWindex per USD indicator). The prevented losses through the dyke compared to overall losses due to climate change impacts are about 20% ($SW_{\%CC}$ indicator). The sensitivity analysis shows that extreme weather intensity or frequency would need to increase by 5% to get a positive benefit/cost ratio in absolute terms. As there are no additional Saved Health or environmental benefits provided through the dyke upgrade, the adaptation measure is estimated to be economically unfavourable.

5.2.3. Adaptation measure: Mangrove plantation

The second project scenario assumes the planting of a mangrove belt in front of the shoreline (as shown as a full protection zone in figure 7). The process of planting and initial growth lasts for three years, during this timeframe no adaptation

Table 6: Main results of the Saved Wealth calculation for the dyke scenario. Source: Saved Wealth as in the 'Project situation' tab in the spreadsheet 'Saved Health - Saved Wealth: Excel Tool for the Dyke Case'

Name	Description	Result	Unit
$MISW_{INDEX\ per\ USD}$	Index/USD million of project budget	0.10	index
$MISW_{index}$	(combined SW REL & ABS)	56,559	index
SW_{ABS}	Absolute Saved Wealth	530,086	USD
$SW_{\%CC:}$	Saved wealth in relation to climate change losses in the project lifetime (%)	0.18	index

5

benefits are assumed. According to Mr Hoang of the Forest Protection Sub-department Soc Trang (personal comment), the costs depend on the soil and mangrove species and range between USD 715 and USD 3,430 per hectare. Applying an average value of USD 1,550 per hectare, planting the full protection zone of 160 hectares results in overall costs of USD 250,000. Additional costs occur through the implementation of the co-management system in Au Tho B and rehabilitation after extreme events (a conservative value of 5% rehabilitation effort additional to the overall costs was assumed). The overall project budget for a 20 year period is estimated to be about USD 580,000. The mangrove belt provides several adaptation benefits:

- The earth dyke structure is granted the same protection against extreme events as from a concrete dyke upgrade.
- The vulnerability of people living in front of the dyke to extreme events is reduced.
- Mangroves deliver protection against frequent flooding (spring tides) that consistently damages the private property of people living in front of the dyke. Health benefits are also created as frequent flooding leads to indirect health impacts through e.g. diseases.
- The mangrove belt provides basic protection against erosion of agricultural land in front of the dyke. The economic benefits of saved area suitable for onion cultivation are considered.
- Mangroves provide protection against salinisation in front of the dyke. Frequent floods would lead to significantly salinised soil which makes agricultural activities impossible. The plantation saves 80 hectares for onion cultivation.
- The mangrove belt itself provides economic co-benefits. The forest provides a habitat for a wide range of aquatic species such as crabs or snails that can be collected by the local population. Furthermore it offers firewood and serves as breeding place for fish. Due to mangrove co-management introduced by the GIZ project Protected Area in the Wetlands of Soc Trang Province on behalf of BMZ, harvesting is conducted in a sustainable way.

Table 7: Main results of the Saved Wealth calculation for the mangrove scenario. Source: Saved Wealth as in the ‘Project situation’ tab in the spreadsheet ‘Saved Health - Saved Wealth: Excel Tool for the Mangrove Case’

Name	Description	Result	Unit
$SW_{INDEX\ per\ USD}$	Index/USD million in project budget	1.88	index
SW_{INDEX}	(combined SW REL & ABS)	1,087,337	index
SW_{ABS}	Absolute Saved Wealth	2,324,225	USD
$SW_{\%CC}$	Saved Health in relation to climate change losses in the project lifetime (%)	0.80	index

5.2.3.1. Application of the methodology

Again, the 'Methodology for estimating wealth and health benefits of climate change adaptation projects: Adapting coastal zones to rising sea levels' (see Annex I) has been applied to quantify the benefits of the mangrove plantation. As outlined above, the mangrove belt not only protects the existing dyke from serious extreme event damages, but also enhances the resilience of the population in front of the dyke against frequent flooding, erosion and salt water intrusion. Thus, module (3) (disaster mitigation), module (4) (flood protection), module (5) (avoided erosion) and module 6 (avoided salinisation) have been used for the calculation. Compared to the dyke upgrade, the mangroves also provide economic co-benefits of more than USD 120,000 through opportunities for fishing and fire wood. Again, relevant data has been gathered and fed into the ready-to-use spreadsheet. Calculations in the spreadsheet are based on both Au Tho B specific project values (mainly regarding dyke characteristics, erosion reports or the influence of salt water intrusion on agriculture) and national default values for predicted climate change impacts in Viet Nam.

Results from planting the mangrove presented in table 7 have a positive benefit/cost ratio. The absolute wealth savings are almost four times higher than the overall project budget ($SW_{\text{ABS indicator}}$). Taking into account the relative wealth savings of the local population living in Au Tho B (see also section 3.1) that are calculated by dividing the absolute wealth savings by the overall wealth of the region one can derive the mixed absolute and relative index value (MISW) – which is for the mangrove scenario 1,087,337 average personal wealth units saved ($MISW_{\text{INDEX}}$ indicator). If this index is divided by the project budget the result is a MISW per million USD of 1.88 ($MISW_{\text{INDEX per USD}}$ indicator). Interestingly almost 80% of the wealth losses can be prevented through mangrove activity ($SW_{\%CC}$ indicator). The difference of 20% of the damage is explained through conservativeness values that estimate particular adaptation failures as well as the time required for the mangroves to grow until full benefits can be provided.

Besides economic benefits, the mangrove forest also reduces the vulnerability of human health (see table 8). Overall, an estimated 243 DALYs are saved over the period of 20 years (SH indicator). Per USD million in invested budget, one could

Table 8: Main results of the Saved Health calculation for the mangrove scenario. Source: Saved Health as in the 'Project situation' tab in the spreadsheet 'Saved Health - Saved Wealth: Excel Tool for the Mangrove Case'

Name	Description	Result	Unit
SH	Absolute Saved Health over project lifetime	243	DALYs
$SH_{per\$}$	Saved Health/USD million in project budget	421.1	DALYs/ USD million
$SH_{\%CC}$	Saved Health in relation to climate change losses in the project lifetime (%)	0.70	index

even achieve 421 DALYs ($SH_{per\$}$ indicator).This equals about 70% of the total expected climate change induced health impacts during the project lifetime ($SH_{\%CC}$).

The sensitivity analysis shows that even significant deviations of up to 20% regarding extreme weather frequency and intensity, flood frequency or a stronger devaluation of public and private property do not lead to a negative benefit/cost ratio (see figure 8). If one e.g. decreases the value of public and private property by 20%, the Saved Wealth index value only falls to 900,000 which would still justify the project costs of about USD 580,000.

5.3. COMPARISON OF PROJECT SCENARIOS

The application of the 'Methodology for estimating wealth and health benefits of climate change adaptation projects: Adapting coastal zones to rising sea levels' shows significantly different results for the two project scenarios.

Whereas the dyke upgrade leads to a negative benefit/cost ratio over the 20 years, the mangrove plantation provides a broader mix of adaptation benefits resulting in an overall positive evaluation.

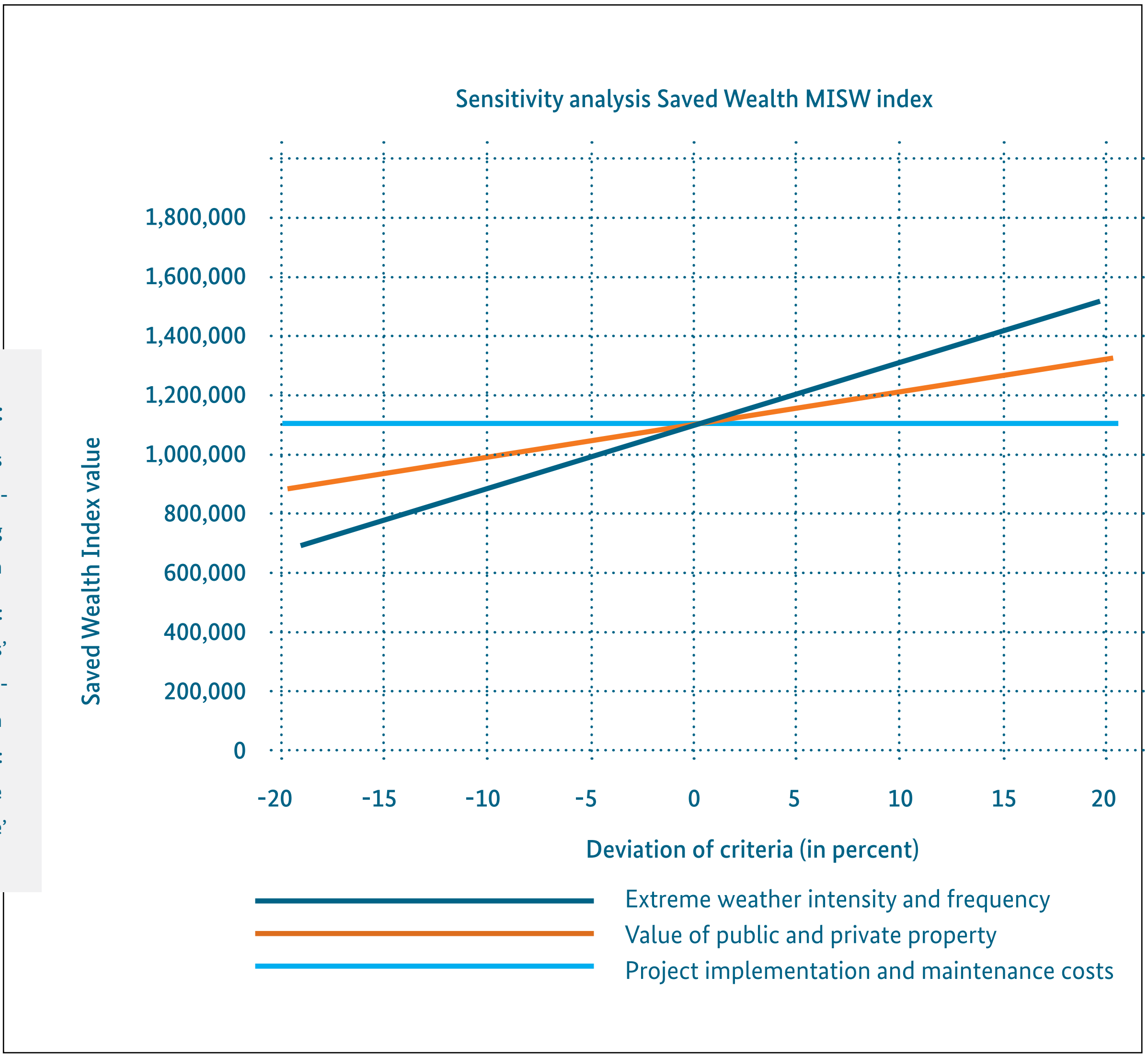


Figure 8: Sensitivity analysis of critical parameters for calculating Saved Wealth

Source: 'Sensitivity analysis' tab in the spreadsheet 'Saved Health - Saved Wealth: Excel Tool for the Mangrove Case'

The SW_{index} per USD invested is about 1.9 for the mangroves compared to 0.1 for the dyke upgrade. Hence the overall economic impact (based on the selected weighting of relative and absolute wealth) is **more favourable** for the mangrove planting. In terms of an absolute assessment of wealth, the mangroves result USD 2.3 million Saved Wealth versus USD 0.5 million for the dyke. Additionally the mangroves are able to provide health benefits of 243 DALYs in 20 years whereas the dyke upgrade does not deliver any positive health impacts.

With regard to the results one has to take into account that the mangrove planting is a realistic scenario whereas the dyke is a hypothetical scenario. In reality the people in front of the dyke might have moved to different places or would have installed breakwaters to reduce frequent flooding leading to erosion and salinisation. Nevertheless the quantification showed clear advantages for mangroves when competing with 'conventional' dyke constructions.

From the perspective of the **ex-post impact evaluation** the indicator concept can provide the framework for monitoring and quantification of benefits. As the mangrove rehabilitation has been implemented already, the exercise of calculating Saved Wealth and Saved Health benefits can be seen as an ex-post assessment with significant overall positive results.

From the perspective of **ex-ante cost benefit analysis,** it can be concluded that the concept provided clear guidance to prioritise the mangrove option. The comparison of benefits with implementation costs showed a positive outcome. The second option, improvement of the dyke, cannot be justified from an economical perspective as repairing the climate change-induced damages would actually be a cheaper option.

6.

CONCLUSIONS REGARDING THE QUANTIFICATION FRAMEWORK AND APPLICATION IN THE CONTEXT OF THE VIETNAMESE CASE STUDY

By applying the methodological framework in the coastal zone protection sector, **plausible and detailed information on the effectiveness** of adaptation options was gained. Both the baseline and two potential interventions have been assessed and estimated benefits have been quantified. The comparison has shown that the mangrove belt has significant advantages compared to the dyke upgrade that would not even justify its implementation according to an economic cost/benefit assessment. The results are useful for ex-post M&E as well as for ex-ante adaptation planning.

The indicators are suitable for 'hardware' interventions. The methodology, which is based on a spreadsheet, allows project benefits to be quantified by applying comparable and transparent assumptions. From a technical point of view, comparisons of projects in the same region are preferable to comparisons of projects in different countries as in the former case, the same datasets regarding social and economic variables can be applied. Projections will have the same level of uncertainty.

We have **identified several challenges**. Adaptation based on pure capacity building projects cannot use the quantification concept. As many coastal adaptation interventions include infrastructure 'hardware' activities this shortcoming is not seen as critical for the general applicability and dissemination of the concept. It was not possible to assess combinations of climate change induced impacts or extreme events, e.g. sea-level rise and typhoons or other storms, therefore they were not included.

Data gathering is challenging at a local level. Whereas national data for natural disasters and extreme events as well as predictions of increased exposure are available, detailed information for local areas such as the Soc Trang province are lacking. This prevents accurate results and challenges comparability within one country. The uncertainty of climate change projections is high for many parameters. It hampers the proper quantification of adaptation benefits. However, this uncertainty also exists in the case of other adaptation planning methods. The tool requires a good understanding of economic methods such as CBA and possible impacts of climate change from its users. Ideally, it is applied by central government planners in host country capitals evaluating all adaptation projects from different donors, for example in the context of the biennial update reports under the UNFCCC. In terms of applying the framework for M&E, it might also be challenging for local project managers to use a standardised set of quantifiable criteria including a detailed development of a baseline instead of other non-standardised indicators as in former projects. Thus it seems useful to develop a simplified version to allow easy access to this new tool.

Recommendations for further improvements that have been identified in the context of this study include support for enhanced publicly available climate change exposure projections. They would make the tool more robust. A source for such improvements would be the international disaster database (http://www.emdat.be/) that will be expanded to include local levels in the future. Identification of local data will be unavoidable if project developers do not want to rely on the national default values included in the spreadsheet.

Methodologies for other adaptation sectors should be developed and tested in the future, also in cross-sector and cross-country comparisons. This will require substantial data collection effort. The methodologies should be tested with users of different education levels in different cultural backgrounds, ideally through 'hands-on' workshops. As a starting point, this methodology can be increasingly used for M&E of adaptation projects in coastal zone activities to identify specific challenges and requirements of local project developers in different locations.

7.

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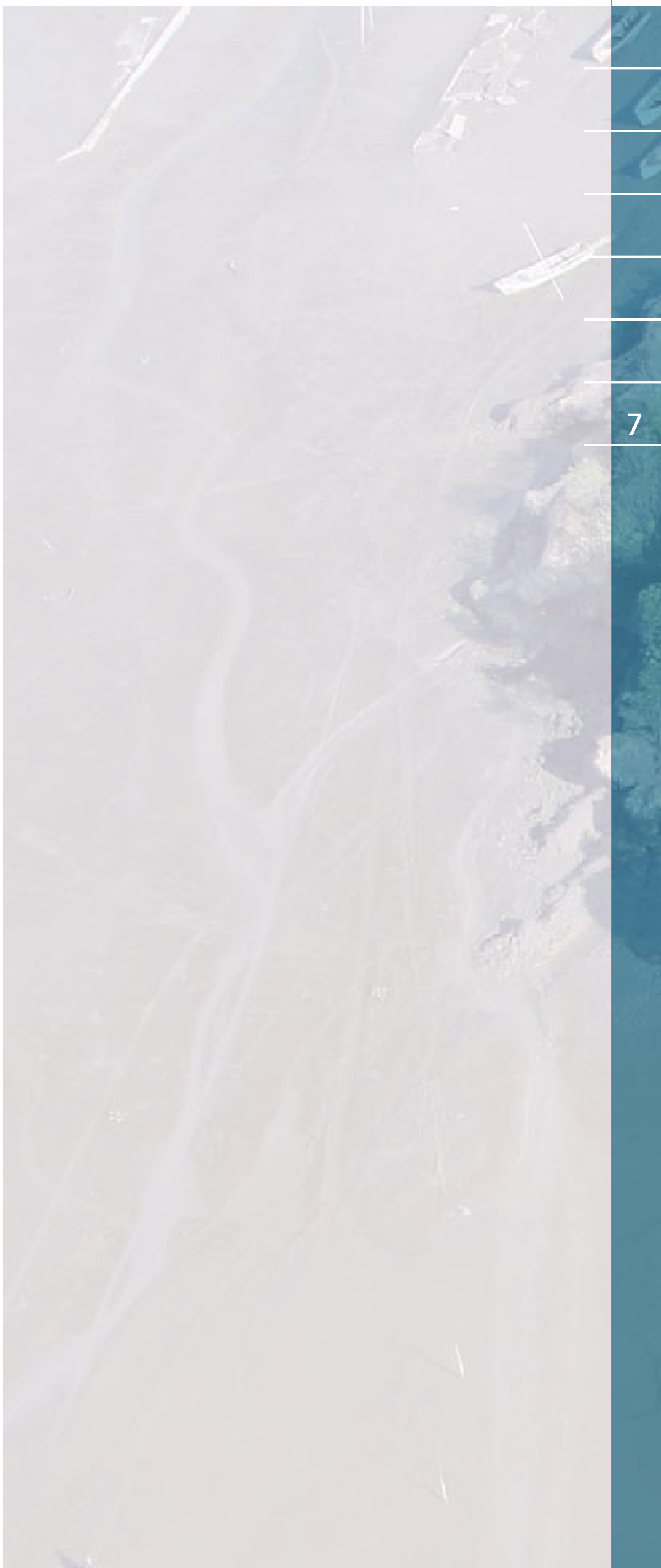

APPENDIX

METHODOLOGY FOR ESTIMATING WEALTH AND HEALTH BENEFITS OF CLIMATE CHANGE ADAPTATION PROJECTS:

ADAPTING COASTAL ZONES TO RISING SEA LEVELS

Content

1. ABBREVIATIONS

°C	degree Celsius
g	grams
ha	hectares
LY	life years
m^2	square metres
mm	millimetres
PPP	purchasing power parity
t	metric tonnes
USD	2009 US dollars (USD have to be transformed to 2009 USD through division using official DAC deflators for the United States, see http://www.oecd.org/dataoecd/43/43/34980655.xls (OECD, 2012)
yr	year

2. PURPOSE AND APPLICATION OF THIS METHODOLOGY

This methodology helps project developers and policy makers to assess the wealth and health benefits as well as environmental impacts of climate change adaptation projects in coastal zones. It is applicable for interventions protecting coastal zones against sea level impacts such as infrastructure improvements (e.g. seawall construction), natural protection measures (e.g. mangrove plantations or sand dune stabilisation through vegetation), erosion avoidance/restoration (e.g. soil conservation, beach replenishment), avoidance of salinisation (e.g. drainage, water table control) and early warning systems. According to the specific intervention, several modules for common climate change-induced impacts are available (e.g. extreme events, frequent flooding or salt water intrusion). These modules can be specifically adjusted and expanded according to the envisaged project type.

The methodology can both help to identify promising interventions and compare proposed projects. It provides effectiveness criteria to assess ex-ante where adaptation measures can bring about the largest benefits for the least cost, and to assess ex-post whether or not an adaptation intervention has been successful.

Target group

The main target group of the methodology is the one of developers of climate change adaptation projects in coastal zones. By applying the methodology, they can quantify benefits and negative impacts of interventions in the context of monitoring and evaluation after project implementation (ex-post). Furthermore the methodology provides an approach in the context of cost benefit analysis which allows assessing ex-ante where adaptation measures can bring the largest benefits for the least cost.

The secondary target group besides project developers is the one of policy makers who may use the methodology to compare the wealth and health benefits of different climate change adaptation projects. As the calculation requires detailed data from projects, policy makers will have to cooperate with project developers. If policy makers consider wealth and health benefits as major outcomes of climate change adaptation projects, this methodology may also inform decisions on how to allocate adaptation funding.

Application

The simplest way of applying the methodology is to fill out the spreadsheet 'Saved Health - Saved Wealth: Excel Tool for the Dyke Case / the Mangrove Case'. This spreadsheet contains global default values, references tables for national default values and automatically calculates the benefits after some basic project data is entered. The text of the presented methodology is a reference document to better understand the assumptions used to calculate the wealth and health benefits.

Revision of the methodology

This methodology is considered to be work in progress. The methodology simplifies the real world and new scientific evidence will make it necessary to revise assumptions. Therefore, users of this methodology as well as other interested persons are invited to suggest revisions or additions to this methodology.

Limitations of methodology (areas for improvement)

Due to the complexity and the variety of potential adaptation activities the methodology distinguishes between four intervention areas but does not give detailed calculations for each possible adaptation activity. The project developer will have to justify detailed calculations for specifically applied activities[2]. Typical interventions are listed at the end of each module.

[2] In parallel to the methodology, specific calculation models have been developed for dykes, wave-breaking barriers and mangrove planting/rehabilitation.

Several shortcomings have been identified: External terrestrial influences (such as floods coming from rivers) are only covered marginally; non-water related storm impacts (e.g. typhoons), a closer link to climate change impacts and more comprehensive flow charts/systems diagrams are missing.

3. DEFINITIONS

Baseline:

business-as-usual (social, economic and environmental) situation in the project area including impacts of climate change but excluding the proposed project interventions.

Negative impact:

Unwanted effect of a project intervention on parameters where the project mainly has positive impacts (e.g. dyke construction). Not restricted to impacts within the project boundary but also beyond.

Saved Wealth:

Positive economic impact of the proposed project, measured by changes in economic assets during the project period compared to the baseline development. While it primarily focuses on income and wealth endangered by climate change, other economic benefits are also accounted for.

Saved Health:

Positive health impact of the proposed project, primarily by preventing deaths and illness due to climate change impacts.

4. APPLICABILITY AND BOUNDARY OF METHODOLOGY

This section describes the sectors, subsectors and interventions to which this methodology can be applied. Figure 9 shows the boundary (orange line) of the methodology with regard to sectors and type of intervention. Regarding the latter, stand-alone capacity building and policy planning has been distinguished from physical interventions. The orange line represents the boundary describing the kind of intervention that can be assessed with the methodology.

Sectoral boundary:

The methodology is applicable to interventions protecting coastal zones such as

a) Infrastructure improvements (e.g. seawall and dyke construction)

b) Natural protection measures (e.g. mangrove plantations or sand dune stabilisation through vegetation)

c) Erosion avoidance and soil restoration (e.g. soil conservation, beach replenishment)

d) Avoidance of salinisation (e.g. drainage, water table control)

Projects involving non-rising sea level related activities (e.g. typhoons/wind disaster protection, fresh water supply, food security etc.) have to be assessed using different methodologies.

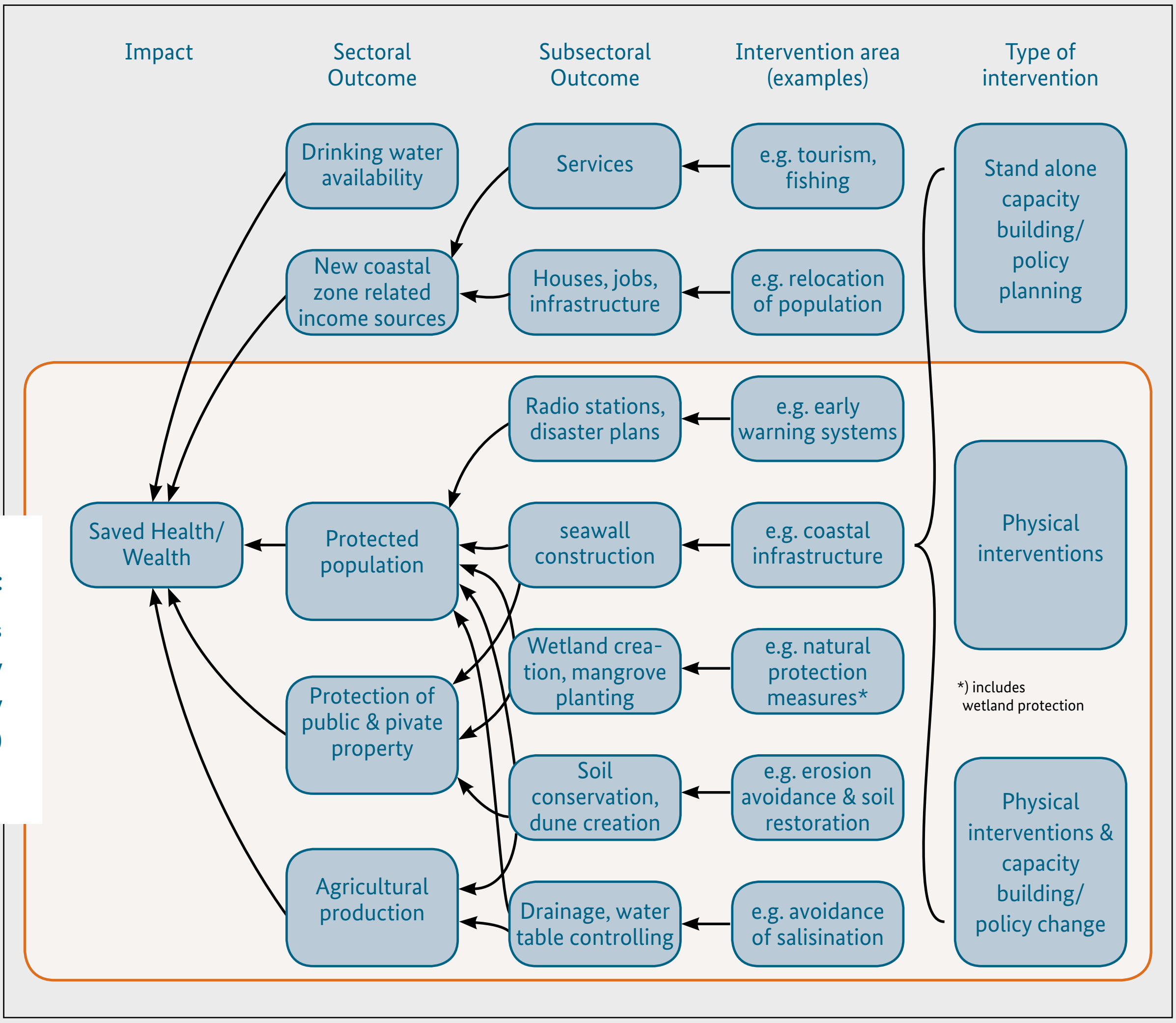

Figure 9: Boundary of this methodology (symbolised by orange line)

Type of intervention:

The project has to include concrete, physical interventions (e.g. infrastructure investments, soil conservation). Policy planning and capacity building can also be part of the project but only benefits connected to the physical interventions are accounted for. Stand-alone capacity building or policy planning projects are to be assessed using different methodologies.

Geographic boundary:

The project covers the area where the project interventions take place, e.g. the area inhabited by beneficiaries of direct food distribution and farmers targeted by other interventions.

Link to climate change impacts:

The project should intervene in coastal zone areas (e.g. avoided erosion, coastal protection measures) where negative impacts of climate change are already occurring and/or are expected for the next 10-50 years (see e.g. reference map of vulnerable coastal delta hotspots in the Appendix). As long as this condition is given, all economic and health benefits of the project are accounted for, including benefits beyond projected climate change damages (award for overcoming the adaptation deficit).

Project period:

Time during which the project interventions have a direct impact on coastal zones (10-50 years, depending on the intervention type)

Sustainable development:

The project should support sustainable development. Therefore, the project developer shall not only quantify economic and health benefits but also assess if the project results in any major harm to the environment, society or the economy. For this purpose, the sustainable development checklist in the Appendix shall be completed.

5. BASELINE SITUATION

The baseline is the business-as-usual situation in the project area including impacts of climate change but excluding the proposed project interventions.

a. Description of changing climate

Have any climate change trends been measured in the last 10-50 years that are in line with expectations from climate models?

Are any climatic changes expected for the next decades in the project area?

Climate parameters to be considered include:

- Sea level increase (in mm/yr)
- Temperature (in °C)
- Extreme events relevant for coastal zones (e.g. storm surges, floods), number of events per year

Sources: official records for past (at least 10 years of data, linear trend to be assessed) and climate models for the future. While current climate models still face major challenges when predicting local temperature and precipitation changes in the next 10 years (van Oldenborgh et al., forthcoming), they are the only source of available information to date. Thus, project developers

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should use such models as sources of information. If no locally downscaled or regional country-level studies are available, the project developers may refer to the regional climate predictions in Christensen et al. (2007)

b. Description of climate change impacts on coastal zones

Are there negative impacts on coastal zones due to climate change observed and/or predicted? Does the project address these negative impacts (see table 9)?

c. Autonomous and already supported adaptation

- Which activities have already been undertaken autonomously by inhabitants within the project area to cope with the impacts of climate change?
- Which activities are already supported by international or national agencies/organisations to cope with the impacts of climate change (by strengthening adaptive capacity and/or improving resilience)?
- Does the project include activities that are already autonomously undertaken or already supported? If yes, please justify why additional funding is needed.
- To guarantee a conservative benefit calculation a default value of 10% autonomous adaptation is applied for Saved Wealth/Saved Health benefits in the baseline scenario. The project developer may justify deviations from the default value.

d. Baseline wealth and health losses due to climate change in the project lifetime

Calculate the impact of climate change on the wealth and health situation in the baseline (without project interventions).

Table 9: Checklist of climate change impacts on coastal zones

	Increase observed?	Increase predicted?	Areas the project addresses
	(Yes/No; if yes, describe extent)	(Yes/No; if yes, describe extent)	(Yes/No; if yes, describe extent)
Direct damages from extreme events			
Flooding due to increased sea levels			
Erosion			
Salinisation of coastal soil			

$$WLC_{PLT} = \sum_{(y=0)}^{PLT} POP_0 \, (1+PGR)^{yr} * WPC_B \, (1+(IGR-D))^{yr} * CC_{(loss,t)} * (1-AA)$$

Where:

WLC_{PLT}	Wealth losses due to climate change during the project lifetime, in 2009 USD
PLT	Project lifetime in years (period of project impact); default is 10-50 years
POP_0	Population in start year (yr=0); source: project data or official data
PGR	Population growth rate (in %) per year; source: project values or national growth rates in last 3 years, data.worldbank.org/indicator/SP.POP.GROW (World Bank, 2012)
WPC_B	Annual baseline wealth per capita (according UN definition), measured in private and public total wealth per capita in the start year of project (in 2009 USD PPP) (only physical and natural capital are reflected: intangible wealth and oil/natural gas value (could be exploited offshore) is not considered); source: local official data; if not available, national data. http://issuu.com/world.bank.publications/docs/9780821384886 (World Bank 2007).
IGR	Wealth per capita growth rate (in %) per year, source: projections or local/national growth rates in the last 3 years. If no wealth growth rates are available, GDP growth can be used: data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG (World Bank, 2012)
D	Discount rate of existing wealth per capita, reflecting the average inflation of the country. Average inflation rate (in %) per year; source: projections or local/national growth rates in last 3 years: http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG/countries (World Bank 2012).
$CC_{loss,t}$	Percentage of wealth projected to be lost due to climate change in year t (excludes savings due to autonomous adaptation). Source: local values. If not available then national or regional values (default: 1.5-3 % of GDP loss due to climate change[3])
AA	Autonomous Adaptation; default value: 10%

[3] This is roughly the worldwide GDP loss due to 3 °C of warming as expected by Stern (2007) and Nordhaus (2006), while GDP per capita losses can be substantially higher for Africa and other developing regions (Yohe et al., 2007).

$$HLC_{PLT} = \sum_{(t=0)}^{PLT} POP_0 \, (1+PGR)^t * (CC_{deaths} + CC_{disab} * DW) * (1-AA)$$

Where:

HLC_{PLT}	Health losses due to climate change during the project lifetime; in DALYs
CC_{deaths}	% of population that dies because of climate change; default is 0.001%[4]
CC_{disab}	% of population disabled because of climate change; default is 0.003%[4]
DW	Average disability weight; the disability weight is a weight factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (equivalent to death); DWs for different diseases can be found in WHO (2004)
AA	Autonomous adaptation; default value: 10%

6. PROJECT SITUATION

In the following, the wealth and health benefits of the project are calculated. The main idea of the calculation model (see Figure 10) is that coastal adaptation activities either improve the (1) wealth situation (through reduced losses or increased valuable soils and enabled economic activities); or the (2) health situation of the population (through protection and avoided diseases directly related to climate change impacts). Protecting the coastal areas is a precondition that leads to the different wealth and health implications. In the model such protection depends on (3) direct disaster mitigation, (4) flood protection, (5) avoided erosion (might have interrelations with flood protection) and (6) avoided salinisation. Negative impacts of interventions on health and wealth are deducted from the positive impacts.

If the project developer is missing project specific values, s/he may opt for conservative default values if available. If a parameter has a positive impact on benefits and if no project or default values are available, the project developer should assume a conservative value of zero. In case a parameter has a negative impact, the project developer needs to assess how likely it will happen and/or which compensation measures have been undertaken to balance the negative impact.

Of the following modules, only (1) and (2) are always used. They aggregate the results of the modules (3) to (6). These modules are only applied if interventions have been undertaken in this area.

[4] Worldwide average of deaths/injuries due to natural disasters excluding earthquakes, 2000-2011, death/injuries numbers from CRED (2012) and population data from World Bank (2012).

Project developers need to select one or several modules according to their activities. The following paragraph explains the calculations for each module in detail.

(1) Saved Wealth

Module (1) describes the aggregated calculation of Saved Wealth. Results of the modules (3) to (6) are combined and negative impacts and failure rates are taken into account. Finally a total absolute and relative SW value in USD is calculated.

$SW_{perUSD} = SW_{TOT} / PB$

$SW_{\%CC} = SW_{TOT} / WLC_{PLT}$

$SW_{REL} = SW_{ABS} / W_{PB}$

$SW_{ABS} = SW_{PR} + SW_{PUB} - N\_I_{DIR}$

$SW_{PR} = (ASW_{PR}) * (1-FR_{DIR})$

$SW_{PUB} = (ASW_{PUB} + ASW_{NAT}) * (1-FR_{DIR})$

SW_{perUSD} = Saved Wealth in USD per 2009 USD of budget

SW_{REL} = relative wealth saved (in %)

SW_{ABS} = absolute wealth saved (in USD)

SW_{TOT} = $SW_{PR} + SW_{PUB}$

PB = project budget in 2009 USD[5]

$SW_{\%CC}$ = Saved Wealth in relation to climate change losses in the project lifetime (%)

WLC_{PLT} = wealth losses due to climate change during the project lifetime, in USD

W_{PB} = baseline wealth within the project boundary (in 2009 USD PPP); source: local official data, if not available national data * percentage of population within project boundary

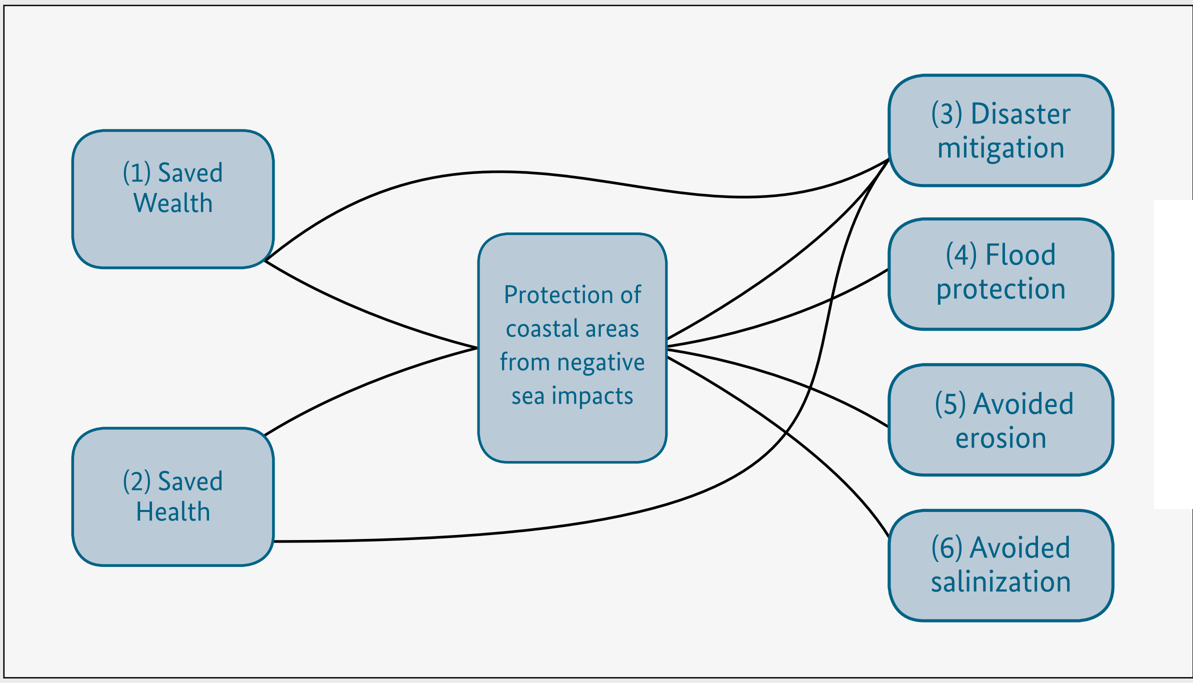


Figure 10: Model to estimate the wealth and health benefits of the project

[5] A detailed description of project expenses including (if applicable) planning, investment, capacity building, maintenance or monitoring costs has to be given in the project document.

APPENDIX

SW_{PR} = Private Saved Wealth in USD saved

SW_{PUB} = Public Saved Wealth in USD saved

N_I_{DIR} = negative impact on income generation due to adaptation activity in USD

ASW_{PR} = absolute Saved Wealth from private property

ASW_{PUB} = absolute Saved Wealth from public property

ASW_{NAT} = absolute Saved Wealth from natural resources and services

FR_{DIR} = failure rate of direct measures; source: project (default is 10%)

(2) Saved Health

Module (2) describes the aggregated calculation of Saved Health. Results of modules (3) to (6) are combined, negative impacts and failure rates are taken into account. Finally a total direct and indirect SH value in DALYs is calculated.

$$SH_{perUSD} = SH_{TOT} / PB$$

$$SH_{\%CC} = SH_{TOT} / HLC_{PLT}$$

$$SH_{TOT} = (SH_{DIR} * FR_{DIR} + SH_{IND} * PIT_{IND})$$

$$SH_{DIR} = (N * (LE - L) + I * DW * LD)_{DIR}$$

$$SH_{IND} = (N * (LE - L) + I * DW * LD)_{IND}$$

$$PIT_{IND} = 1 / FR_{IND}$$

SH_{perUSD} = Saved Health in DALYs per USD of budget

PB = project budget in 2009 USD

$SH_{\%CC}$ = Saved Health in relation to climate change losses in the project lifetime (%)

HLC_{PLT} = health losses due to climate change during the project lifetime, in DALYs

SH_{TOT} = Saved Health in DALYs saved, total

SH_{DIR} = Saved Health in DALYs saved, direct[6]

SH_{IND} = Saved Health in DALYs saved, indirect[7]

N = number of deaths: historic and projections by project or default values by PreventionWeb (2012)

LE = life expectancy at birth, source: current life expectancy (World Bank, 2012) or projections for project period

L = standard life expectancy at age of death: historic and projections by project or default values by PreventionWeb (2012)

I = number of incident cases: historic and projections

DW = disability weight (WHO 2010)

[6] e.g. storm surges
[7] e.g. diseases such as malaria resulting from frequent floods

LD = average duration of disability (years) (WHO 2010)

PIT_{IND} = project impact time of indirect measures, assuming no failure in the first year; in full benefit years. The formula for calculating PIT_{IND} as shown above (= 1 / FR_{IND}) is actually an approximation of the following more complex formula

$$[= \sum_{t=0}^{\infty} (1-FR_{IND})^t]$$

FR_{DIR} failure rate of direct measures per year: default is 20%, minimum is 10%

FR_{IND} failure rate of indirect measures per year: default is 20%, minimum is 10%

Module (3) Disaster mitigation

This module relates to project types that provide disaster mitigation services related to extreme events in combination with increased sea levels. Such extreme events include storms, storm surges, typhoons, cyclones as well as earthquakes and induced tsunamis.

In the absence of the adaptation project, the extreme event would lead directly to wealth and health losses; hence the activity leads directly to wealth and health benefits. The timespan of the extreme event is comparably short, however, its wealth and health impacts can be significant. Figure 11 shows an example of the applicability of the module for extreme events. They are expressed as high-damage-related shares of a typical damage-frequency function. As an example, some river flooding usually happens every year in the rainy season however average damages are low. This is partly due to the adaptive capacity of local

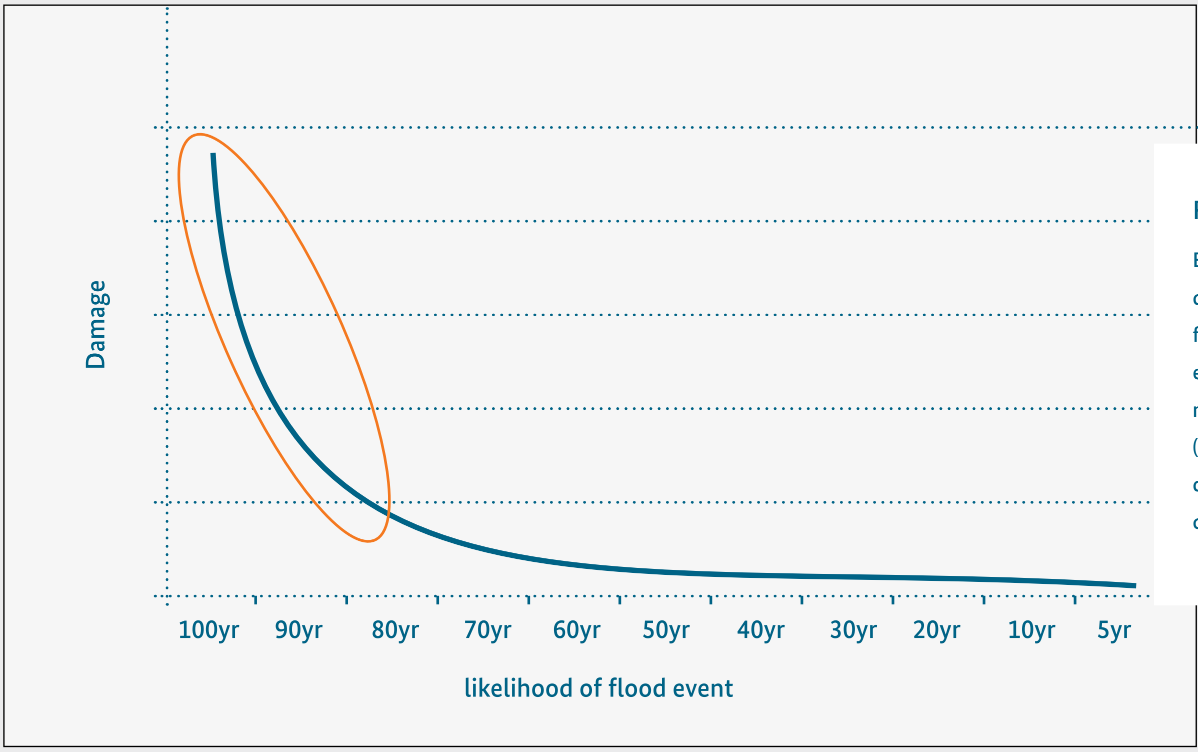


Figure 11: Example of a damage-frequency function for flood events. Disaster mitigation module (3) covers the high damage share of the curve (red oval)

population. This frequent event is not covered in module (3) but in module (4). However, once per decade, flood levels are much higher, leading to significant damages. An extreme flood that on average only happens once per century will lead to catastrophic impacts. These extreme events, as symbolically outlined by the red oval in figure 3, are targeted by module (4).

Essential parameters for taking account of SW in terms of disaster mitigation are the frequency of extreme events with maximum damage potential (has to be conducted for public and private wealth):

$$SW = \sum_{1}^{i} MDP_i * (1\text{-}D)^i * DS_i * p_{occ,n,i}$$

Where:

1...i:	= years of duration of adaptation project
MDP_i	= maximum damage potential from climate change in year i.
DS_i	= Share of discounted MDP damaged by event forecast in year i
$p_{occ,\,n,i}$	= probability of occurrence of a certain damage event n (increase of risk due to climate change) in year i.
D	= discount rate to be applied to the project [8]

Regarding SH only direct health impacts are considered.

SH_{DIR}	= $(N * (LE - L) + I * DW * LD)_{DIR}$

Suitable adaptation activities for this module are, among other things:

early warning systems; infrastructure such as dykes, barrages or wave breaking barriers and plantations such as mangroves.

Module (4)
Frequent flood protection

The main idea of this module is that rising sea levels lead to increasing frequent inundation; extreme events such as storm surges are excluded, as they are accounted for in module (3).

Instead of avoiding significant impacts on health and wealth in rare extreme events, the flood protection module targets constant inundation in an area. Indirect health impacts and damages of wealth over time are the main focus.

The likelihood of inundation and the dimensioning of the protection measure against the damage potential of the flood is key for taking account of the benefits. Of course a combination of extreme event protection (3) and frequent inundation (4) is possible. Figure 12 exemplarly shows the applicability of module (4) for frequent lower-damage-related shares of a typical damage-frequency function.

Essential parameters for taking account of SW in terms of disaster mitigation are the frequency of floods and their average damage potential.

Exemplary calculation of absolute and relative wealth:

[8] The discount rate should be set at the level used for public budgeting. The expected annual inflation rate over the project duration can be used as default.

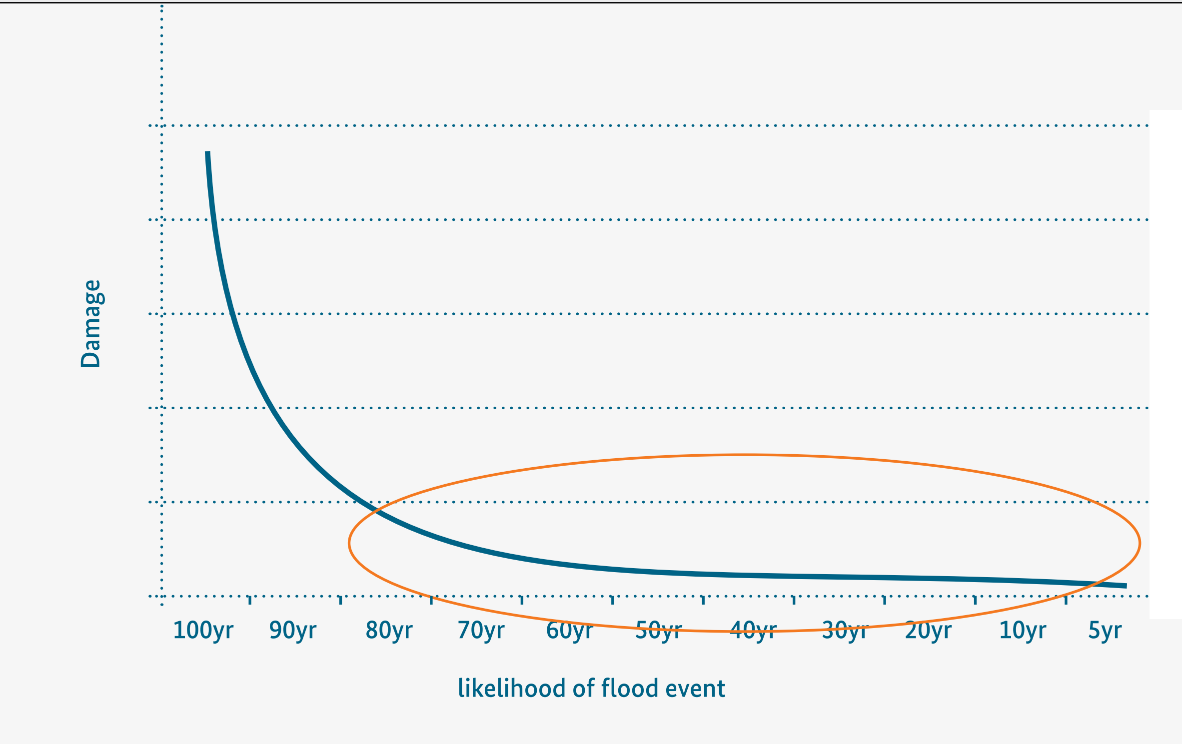


Figure 12: Example of a damage-frequency function of flood events. Flood protection module (4) covers the frequent, lower-damage share of the curve (red oval)

Table 10: Example of wealth loss per flood event

		Wealth loss per flood (% of wealth)				
Type of wealth	Total value (USD million); average over lifetime; already deflated	51-100 yr floods	11-50 yr floods	6-10 yr floods	1-5 yr floods	Wealth per person (USD/person)
Public infrastructure	200	30%	10%	3%	1%	400
Private property, rich	150	3%	1.5%	1%	0.5%	30,000
Private property, middle class	90	30%	10%	3%	1%	600
Private property, poor	40	50%	20%	10%	4%	116
...	...					

Table 11: Example of wealth loss per year in % of total wealth

		Expected wealth loss per year (% of wealth)				
Type of wealth	Number of people affected	51-100 yr floods	11-50 yr floods	6-10 yr floods	1-5 yr floods	Total
Public infrastructure	500,000	0.40%	0.33%	0.40%	0.40%	1.53%
Private property, rich	5,000	0.04%	0.05%	0.13%	0.20%	0.42%
Private property, middle class	150,000	0.40%	0.33%	0.40%	0.40%	1.53%
Private property, poor	345,000	0.67%	0.67%	1.33%	1.60%	4.27%
...						

Table 12: Example of average wealth loss per year in USD million

Type of wealth	Total value (USD million); average over lifetime; already deflated	Expected wealth loss per year (Bn USD) 51-100 yr floods	11-50 yr floods	6-10 yr floods	1-5 yr floods	Total
Public infrastructure	200.00	0.80	0.67	0.80	0.80	3.07
Private property, rich	150.00	0.06	0.08	0.20	0.30	0.64
Private property, middle class	90.00	0.36	0.30	0.36	0.36	1.38
Private property, poor	40.00	0.27	0.27	0.53	0.64	1.71
Total private property	*280.00*					*3.72*
Total wealth	480.00					6.79

Assuming a project lifetime of 50 years and 500,000 inhabitants in the project region, the Saved Wealth (either absolute or relative) is now calculated as follows:

SW_{ABS} = USD 6.79 million * 50 years = USD 339 million absolute wealth saved over project lifetime

SW_{REL} = (USD 6.79 million / USD 480 million) * 500,000 inhabitants * 50 years = 353,559 relative wealth savings (RWS) over lifetime of project

regarding SH, only indirect health impacts are considered.

$$SH_{IND} = (N * (LE - L) + I * DW * LD)_{IND}$$

Suitable adaptation activities for this module are, among other things:

infrastructure such as dykes, barrages or wave-breaking barriers; adapted constructions (e.g. bamboo stilts) and plantations such as mangroves.

Module (5) Avoided erosion

The idea of this module is that the wealth of saved land mass from erosion can be quantified by estimating the soil productivity (SPB). Here, project developers are requested to estimate the main parameters and sufficiently justify their estimations.

$$SW_{ER} = SP_B * MP_y * AREA_{ER} * PIT_{IND}$$

Where:

SW_{ER} = SW through erosion protection activity (in USD)

SP_B = soil productivity in baseline (t food/ha/yr); source: project or country default value for cereal yield from http://data.worldbank.org/indicator/AG.YLD.CREL.KG (World Bank, 2012)

MP_y = average market price of yields (in USD); source: project; default values: annual producer prices per country by FAOSTAT (FAO, 2012).

$AREA_{ER}$ = area (in ha) that is protected against erosion; source: project

PIT_{IND} = project impact time of adaptation measures in full benefit years; source: project

To calculate indirect SH benefits due to food security, the methodology 'Methodology for estimating wealth and health benefits of climate change adaptation projects – Food & Agriculture projects' may be used if applicable. Project developers must justify that the local population is dependent on food productivity from the area impacted by erosion.

Suitable adaptation activities for this module are, among other things:

infrastructure such as dykes, fences or wave-breaking barriers and mangrove forests.

Module (6) Avoided salinisation

The idea of this module is that the value of land saved from salinisation can be quantified by estimating the soil productivity (SPB). Project developers are requested to sufficiently justify their estimations, taking into account conservative values as described above (beginning of section 6).

$$SW_S = SP_B * MP_y * AREA_S * PIT_{IND} * SAL_{IRR} * YD_{SAL}$$

Where:

SW_S = SW through activity for avoidance of salinisation (in USD)

SP_B = soil productivity in baseline (t food/ha/yr), source: project or country default value for cereal yield from http://data.worldbank.org/indicator/AG.YLD.CREL.KG (World Bank, 2012)

MP_y = average market price of yields (in USD); source: project

$AREA_S$ = area (in ha) that is protected against salinisation; source: project

PIT_{IND} = project impact time of adaptation measures in full benefit years; source: project

SAL_{IRR} = irrig. area salinised (%); source: project

YD_{SAL} = Salinisation yield decrease (%); source: project or default value for wheat from FAO

To calculate indirect SH benefits due to food security, the methodology 'Methodology for estimating wealth and health benefits of climate change adaptation projects – Food & Agriculture projects' may be used if applicable. Project developers must justify that the local population is dependent on food productivity from the area impacted by salinisation.

Suitable adaptation activities for this module are, among other things:

infrastructure such as dykes, drainage systems and ground water control systems and plantations such as mangroves.

7. SENSITIVITY ANALYSIS

Given the uncertainty regarding project implementation, wealth and health developments in the project area as well as climate change impacts, it is warranted to conduct a sensitivity analysis of project impacts by exploring the implications of changes in major parameters and/or changes from minimum to maximum values. The sensitivity analysis simulates variations of such parameters to demonstrate whether certain outcomes are still valid in case one or several impacts change. In particular, unfavourable conditions are assessed to show that e.g. investment in an adaptation intervention is still justified even if assumed key parameters/impacts develop differently than expected. As an example, one can assume that a dyke would protect a village against increased flooding. It is expected that in 20 years , a flood would occur every two years instead of every five. The sensitivity analysis shows that even if such a flood occurs every four years, the economic benefit would still be higher than the project costs. Hence, the uncertainty regarding the climate change projection has been taken into account.

Assessed parameters have varying uncertainties: therefore different degrees of variation according to confidence in projections are recommended. For example, to support a harmonised approach climate change impact projections are rated according to IPCC criteria (see IPCC 2012, p.8ff).

In the context of the methodology estimating the benefits of coastal zone climate change adaptation project, the parameters in table 5 are recommended to undergo the sensitivity analysis. They have been selected because influence on the quantified outcome is high and confidence according to, for example, the IPCC is weak. Project developers are free to choose further parameters for the sensitivity analysis:

8. MONITORING

Generally the indicators of the framework applied in the context of this methodology are usable for monitoring the project implementation status. This means that overall, the Saved Wealth, Saved Health and environmental benefit indicators can be used for evaluating the outcomes of the adaptation activity ex-post. Several key parameters as described in the following have to be monitored in this work.

Table 13: Parameters to be assessed by sensitivity analysis

Parameter	Recommended deviation (+/- in %)	General confidence in projections
Extreme weather intensity and frequency	20	Weak (by IPCC)
Value of public and private property	10	Depending on individual characteristics of public/private wealth portfolio
Number of deaths and incident cases	20	Weak (by IPCC)
Maintenance costs during project lifetime (per year)	10	Depending on individual characteristics of project intervention

The project should monitor whether the planned activities have been undertaken, how much of the planned resources have been spent and to what extent the planned results of physical interventions have been achieved.

The following list includes the minimum amount of parameters to be monitored. If monitoring a specific parameter is not possible, the project developer should find adequate alternatives or assume a conservative value of zero in case a parameter has a positive impact on benefits.

Parameters/data to be monitored at the end of the project (or more often)

SL = sea level rise (in mm)

D_{fr} = disaster frequency

D_d = disaster duration

D_{int} = disaster intensity

BEN_{DIR} = number of direct beneficiaries of coastal adaptation measures

BEN_{IND} = number of indirect beneficiaries of coastal adaptation measures

SP_B = soil productivity in areas protected against erosion/salinization (t food/ha/yr)

$AREA_{ER}$ = area (in ha) that is protected against erosion; source: project

$AREA_S$ = area (in ha) that is protected against salinisation; source: project

PB_{spent} = project budget in 2009 USD spent (including maintenance)

Optional parameters/data to be monitored at the end of the project

PGR = population growth rate (in %) per year, during project period

WGR = wealth per capita growth rate (in %) per year during project period

$CC_{loss,t}$ = percentage of income projected to be lost due to climate change in year t (excludes savings due to autonomous adaptation)

CC_{deaths} = annual % of population that has died because of climate change in the project period

CC_{disab} = annual % of population disabled because of climate change in the project period

Quality assurance of monitoring

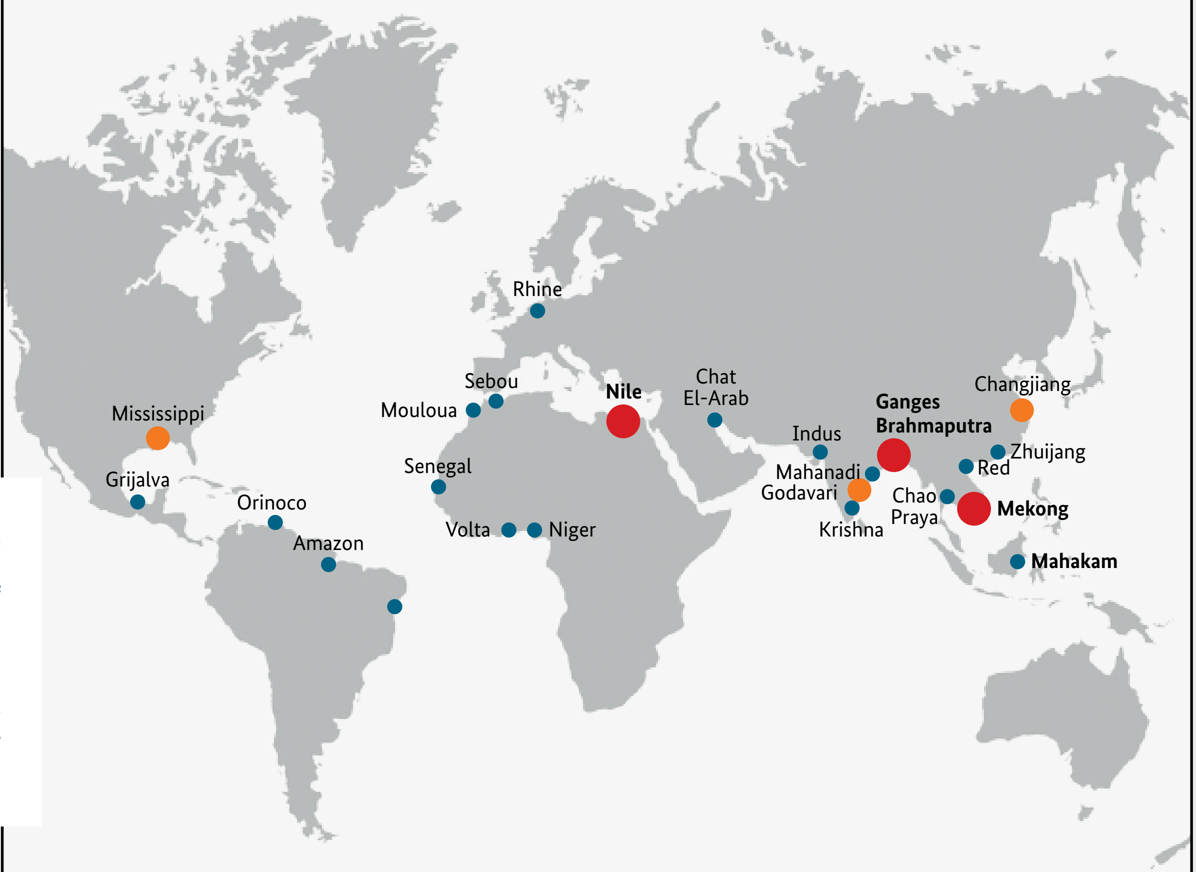
The project document shall include a monitoring plan containing assigned responsibilities for monitoring and reporting, the frequency of monitoring (continuous, annually, biannually), the monitoring methods (measurement, survey, official reports/data) and the procedures for compiling the data in a monitoring and evaluation report.

APPENDIX

9. ANNEX

Checklist for sustainable development

The following checklist should be filled out by the implementing entity after consulting with relevant stakeholders (national ministries, local governments, local and international NGOs, companies). This checklist is a safeguard to avoid typical negative environmental and social impacts of the adaptation activity. If the intervention leads to negative sustainable development, the project developer has to implement mitigation measures which must be outlined in the table 14 below. Usually an independent auditor should verify the statements. If the mitigation of negative impacts cannot be sufficiently guaranteed the project activity should not be implemented.



Relative vulnerability of coastal deltas as shown by the indicative population potentially displaced by current sea-level trends by 2050

extreme = >1 million;
high = 1 million to 50,000;
medium = 50,000 to 5,000;
follwing Ericson et al., 2006).

Figure 13: Reference map of vulnerable coastal delta hotspots; Source: Nicholls et al.(2007), p.327

Table 14: Checklist for environmental impacts and sustainable development. Source: adapted from the CDM Gold Standard Sustainable Development Matrix (Gold Standard, 2009)

Indicator	Score	Justification of score	Measures to mitigate negative impacts
	- if negative, 0 if no and + if positive impact	Explain the score and, if the evaluation is critical, provide sources (e.g. literature, stakeholders, environmental impact assessment) in footnotes	If negative score, show how the negative impact is mitigated, and if it is not mitigated, that no violations of local or national laws/regulations occur
Air quality			
Water quality and quantity (water pollution through livestock?)			
Soil condition			
Other pollutants			
Biodiversity[9]			
Quality of employment			
Livelihood of the poor			
Human and institutional capacity			
Cultural heritage sites			
Quantitative employment and income generation			
Balance of payments and investment			
Technology transfer/ self-reliance			

[9] E.g. evaluation of impacts on species according to the International Union for Conservation of Nature IUCN (2010) rating and habitat of species based on vegetation type.

APPENDIX

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