Mitigation co-benefits of adaptation actions and economic diversification

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1. Introduction

Anthropogenic climate change is a key challenge of the 21st century. For the last 25 years it is a subject for negotiations under the UN Framework Convention on Climate Change (UNFCCC), with the key milestones of the Kyoto Protocol (1997) and the Paris Agreement (PA) (2015). Currently, the work programme for effective implementation of the PA is under negotiation and is scheduled to be finalized at COP 24 in Katowice, Poland, in December 2018.

1.1. The role of adaptation and economic diversification actions in NDCs and the Paris Agreement (Art. 7)

Adaptation means prevention or reduction of impacts from anthropogenic climate change. Such impacts can be generated by meteorological extreme events, or slow changes such as a reduction of precipitation over a long period. Mitigation includes all actions that reduce greenhouse gas emissions or increase sinks for greenhouse gases. Adaptation action can have positive or negative impacts on mitigation, and vice versa.

Historically, adaptation and mitigation have been treated as different strands under UNFCCC negotiations. For example, under the Kyoto Protocol, national commitments of industrialized countries only related to mitigation. The only concrete provision of the Kyoto Protocol regarding adaptation was the share of proceeds levied on issuance of Certified Emission Reductions, which was used to finance the Adaptation Fund.

The PA has fundamentally altered the dynamics. Being one of the three key objectives of the Agreement, adaptation is close to parity with mitigation. Adequately capturing and recognizing adaptation and mitigation co-benefits will facilitate operationalization of the PA. This requires consideration of this issue in the negotiations on the Paris work programme.

Countries are affected differently by climate change. The bottom-up nature of the PA allows each country to focus on its specific vulnerability and capacity to address the impacts of climate change in the context of its Nationally Determined Contribution (NDC). Although this country-driven differentiation addresses the location-specificity of adapting to the impacts of climate change, it creates difficulties in assessing progress towards common goals, and more importantly, requires understanding and recognizing the broad spectrum of actions considered to be adaptation that also contribute to mitigation objectives.

Beyond "classical" adaptation actions supporting economic diversification can also have co-benefits relating to adaptation and mitigation, as defined in Decision 24/CP.18 of COP 18 in Doha 2012.

The central tenets of adaptation are laid out in Article 7 of the PA, with the overarching goal of "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change" (PA Art. 7.1). Article 7.4 recognizes the link between the mitigation ambition level and the adaptation needs but shies away from quantifying adaptation. Art. 7 stresses the country-driven nature of adaptation approaches and specifies (Art. 7.10) that each country prepares an adaptation communication defining its priorities, its implementation and support needs and projects and measures. The detailed specifications of the communication are subject to ongoing negotiations under the Ad-hoc Group on the Paris Agreement (APA). Art. 7.12 states that all adaptation communications are to be made available in a public registry.

1.2. Definition of mitigation co-benefits of adaptation and economic diversification

Mitigation co-benefits of adaptation and economic diversification can be understood as the GHG emission reductions that are the result of implementation of adaptation-related and economic diversification actions[1]. The concept is laid down in PA Article 4.7, which states that "Mitigation co-benefits resulting from Parties' adaptation actions and/or economic diversification can contribute to mitigation outcomes under this Article". However, this wording does not make clear how co-benefits of adaptation are to be integrated and recognized under the PA, as they are not mentioned under accounting (Art. 4.13), market mechanisms (Art. 6) or transparency (Art. 13). Nevertheless, Art. 4.7 provides a good anchor even if its operationalization remains unclear. We also note that there is no formal acknowledgement of adaptation benefits of economic diversification in the PA, other than the passing mention in Art. 7.9e to include "building the resilience of socioeconomic and ecological systems, including through economic diversification…." in adaptation planning processes. We would like to note that para 127 b) of Decision 1/CP.21 asks the technical examination process on adaptation to identify actions "that could significantly enhance the implementation of adaptation actions, including actions that could enhance economic diversification and have mitigation co-benefits". We thus assume that in conjunction with Decision 24/CP.18 the PA covers such benefits and will not discuss this issue in detail in this background paper.

1.3. Key issues in the context of mitigation co-benefits of adaptation and economic diversification

Due to the lack of focus on adaptation in the past, there is no consensus on how adaptation is to be measured and thus a complete absence of modalities and procedures for assessment of adaptation. This asymmetric progress on quantifying

[1] It should be noted that the consideration of mitigation co-benefits of adaptation should not lead to distortions in the selection of adaptation actions.

the benefits of adaptation versus mitigation means there is a risk that the adaptation component of NDCs is completely separated from the mitigation part and synergies are left unacknowledged, potentially setting the stage for governments of certain countries to argue that GHG reductions resulting from adaptation actions are of a lower quality than mitigation actions reported under the mitigation part.

While certain countries are particularly affected by slow-onset changes such as rising sea levels or increased frequency and severity of drought, broader levels of populations are at risk of extreme meteorological events of low frequency but high impact triggered by climate change.

The Convention, the Kyoto Protocol as well as the Paris Agreement recognize that the implementation of mitigation policies and actions, often called response measures, have impacts on Parties, in particular developing country Parties and thus call on all Parties to address these impacts. Changes in prices and quantities for internationally traded goods and services can result from the implementation of mitigation policies. Economies heavily dependent on the commodities which are impacted by response measures are highly vulnerable e.g. economies dependent on production and export of oil, other fossil fuels, tourism, and agricultural commodities. .

Both adaptation measures and economic diversification undertaken as a reaction to response measures are reactions to climate change. The first one directly tries to reduce/prevent negative climate change impacts. The second tends to reduce/prevent negative impacts from the implementation of climate change mitigation policies. It is important that these multiple types of adaptation are recognized on equal terms, including in their ability to generate mitigation co-benefits.

It is important that all mitigation, wherever and however it is generated, reach the “well below” 2°C target of the PA. If quantification of mitigation benefits from adaptation actions and economic diversification is not dealt appropriately under the PA work programme, it risks that mitigation contributions from those Parties that are affected most by response measures are not properly seen and acknowledged adequately. This would harken back to earlier negotiations when mitigation that was achieved by economies in transition during their economic transformation process was considered ‘hot air’ and the rules of the Kyoto Protocol were subsequently changed to prevent use of “hot air” units in the Kyoto Mechanisms from 2013 onwards. It thus needs to be ensured that mitigation co-benefits of adaptation as well as adaptation co-benefits of mitigation are duly reflected, in order to allow countries to report those co-benefits and in order to make sure that their efforts with regard to both mitigation and adaptation are equally honored.

2. Mitigation co-benefits of adaptation in international climate negotiations

This section discusses the emergence of the concept of mitigation co-benefits in the UNFCCC negotiations and its development over time.

2.1. Pre-Paris, including the Doha COP in 2012 and its decision to introduce the concept

In the lead up to the PA, several developments paved the way for the emergence of the concept of mitigation co-benefits. The concept of mitigation co-benefits of adaptation was introduced at COP18 in Doha when Bahrain, Saudi Arabia, Qatar and the United Arab Emirates stated that they would engage in actions and plans that have co-benefits in the form of emissions reduction and would reduce the impacts of response measures by other countries as a way of adapting to the impacts of climate change. This was then reflected in Decision 24/CP.18. Later, the concept of Intended Nationally Determined Contributions (INDCs) of Parties was developed at COP 19 in Warsaw and COP 20 in Lima established that both mitigation and adaptation contributions could be specified within INDCs.

2.2. Post-Paris, including the submissions made in the context of the negotiations of the Paris Agreement work programme

Progress in negotiations since Paris have been relatively slow. For most topics, which are key to anchoring mitigation co-benefits of adaptation and economic diversification, only rough lists of possible subjects to be treated by the modalities and procedures have been defined. The interest in anchoring mitigation co-benefits has however been reiterated at COP 23 where mitigation co-benefits of adaptation featured on the agenda of various subsidiary bodies. These include the APA, where for instance, further guidance to the mitigation sector of decision 1/CP.21 on features of nationally determined contributions allowed room for discussion of adaptation benefits and co-benefits. Document FCCC/APA/2017/L.4/Add.1[2] on APA items 3-8 mentions in Section I.A (Identify and list existing features): "Art 4.7: mitigation co-benefits resulting from Parties adaptation actions and/or economic diversification plans" (p.4). In the informal note on APA item 3[3], Argentina, Australia, Brazil, EU, Korea, New Zealand, Norway and Uruguay are referring to the concept. A further issue is on adaptation communication (APA agenda item 4)[4] where discussions of how to report on adaptation and its co-benefits have taken place. There under "Additional Elements/opt in opt out" information on adaptation actions that result in mitigation co-benefits is listed with two options - Option 1: expected quantified

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[2] https://unfccc.int/sites/default/files/resource/docs/2017/apa/eng/l04a01.pdf

[3] https://unfccc.int/files/meetings/bonn_nov_2017/in-session/application/pdf/apa_3_informal_note_final_version.pdf

[4] https://unfccc.int/sites/default/files/apa_item_4_informal_note_14112017_final_iteration.pdf

emission reductions, Option 2: placeholder on further information on adaptation actions that result in mitigation co-benefits)" (p.5).

Similarly, discussions on modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the PA provided an opportunity to ensure that adaptation benefits and co-benefits are duly recognized internationally. In the informal note on APA item 5[5], there is frequent reference to mitigation co-benefits of adaptation in Section C: "Information necessary to track progress made in implementing and achieving its nationally determined contribution under Article 4 of the Paris Agreement" and Section D: "Information related to climate change impacts and adaptation under Article 7 of the Paris Agreement, as appropriate", with the following sub-bullets:

C.2 National circumstances and institutional arrangements

- 9. Information on mitigation co-benefits of adaptation actions and/or economic diversification plans

C.3 Description of a Party's NDC under Article 4, including updates

- 8. Specification of components covered by NDCs (mitigation, including mitigation co-benefits resulting from adaptation action…)
- 27. Information on mitigation co-benefits from adaptation actions and/or economic diversification plans

C.4. Progress made in implementing and achieving its NDC under Article 4 to date; a) indicators to track progress made in implementing its NDC under Article 4

- 11. Indicators and source of data use to track progress on mitigation co-benefits from adaptation actions and/or economic diversification plans
- 35. Information on mitigation co-benefits from adaptation actions and/or economic diversification plans and how they contribute to achieving the NDC

C.6 Mitigation policies and measures, actions, and plans, and other actions with mitigation co-benefits resulting from adaptation actions, related to the implementation and achievement of an NDC under Article 4, including effects (historical and expected), barriers and costs

- 11. Information on mitigation co-benefits from adaptation actions and/or economic diversification plans

D. 4 Adaptation policies, strategies, plans and actions and efforts to mainstream adaptation into national policies and strategies

- 7. Economic diversification efforts and associated mitigation co-benefits
- 8. Information on adaptation action that result in mitigation co-benefit

D.12 Reporting formats

- 19. Information on mitigation co-benefits of adaptation actions and economic diversification could be reported together with progress on NDCs

Section G: Technical Expert Review

G.4 Information to be reviewed

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5 https://unfccc.int/files/meetings/bonn_nov_2017/application/pdf/apa_5_informal_note_final_version.pdf

- Information on all aspects of the implementation of the Paris Agreement, including mitigation, mitigation co-benefits resulting from adaptation actions and/or economic diversification, adaptation….
- 8. Information on mitigation co-benefits resulting from Parties' adaptation actions and/or economic diversification

Under APA item 6, the informal note[6] mentions under "other inputs (information needs) of 1/CP21", para 99: "Information on social and economic impacts of response measures and on economic diversification and adaptation co-benefits" (p.7)

Within the SBSTA negotiations, the discussion on the impacts of response measures on the generation of adaptation benefits and co-benefits also featured prominently in Agenda item 9—impact of the implementation of response measures. Nevertheless, the term "mitigation co-benefit" is not mentioned in any documents under this item. Similarly, on matters relating to Article 6 of the PA (Agenda item 11), discussions are ongoing on how GHG reductions generated as co-benefits of adaptation measures can generate Internationally Transferable Mitigation Outcomes (ITMOs) under Art. 6.2. The informal note on Art. 6.2[7] mentions under section 20. Adaptation Ambition, Possible further elements, (i) Mitigation co-benefits of adaptation action, including economic diversification, and 22. MITIGATION CO-BENEFITS RESULTING FROM PARTIES' ADAPTATION ACTIONS AND/OR ECONOMIC DIVERSIFICATION PLANS. For Art. 6.4[8], "mitigation co-benefits of adaptation action, including economic diversification", are mentioned under what could be defined as emission reductions (p.2): "B. Emission Reductions (iv) includes mitigation co-benefits of adaptation action, including economic diversification", as well as section 20. Adaptation Ambition.

2.3. COP 24 and beyond, including processes where the concept plays a role and their timelines

NDC features, accounting, the transparency framework and the design of the Paris Mechanisms are likely to be the key topics of COP 24.

Besides the adaptation article and the nature of the communication under it, a number of negotiation items relate to the concept of mitigation co-benefits of adaptation as discussed in section 2.2 above.

The main challenge is the qualitative and quantitative definition of the global adaptation objective and its consideration in the Facilitative Dialogue in 2018 and in the framework of the first Global Stocktake in 2023. Regarding the overall adaptation objective, it was argued that the IPCC should provide further information, as well as regarding adaptation measures and on how to assess the collective progress in the context of the global stocktake, including the effectiveness of mitigation, adaptation and financing measures. Several Parties would also like the IPCC to provide methodology information related to the adaptation needs of developing countries as well as information on adaptation indicators.

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[6] https://unfccc.int/sites/default/files/informal_note_final_version_14nov2017_1500.pdf
[7] https://unfccc.int/files/meetings/bonn_nov_2017/in-session/application/pdf/sbsta47_11a_third_informal_note_.pdf
[8] https://unfccc.int/files/meetings/bonn_nov_2017/in-session/application/pdf/sbsta47_11b_third_informal_note.pdf

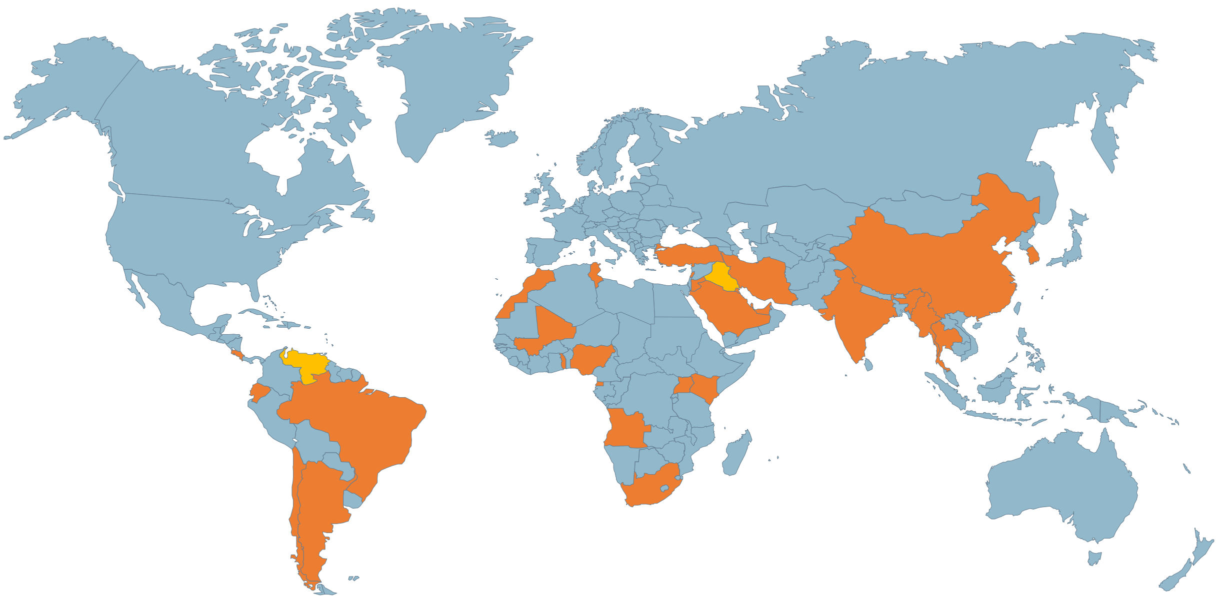
However, although there are currently no agreed metrics for the quantification of adaptation benefits, mitigation co-benefits of adaptation actions and economic diversification can in theory be accounted as mitigation as per Art. 4.7 which states that “mitigation co-benefits resulting from Parties’ adaptation actions and/or economic diversification can contribute to mitigation outcomes under this Article”. This means the current discussion paper, which aims at assisting developing countries to qualitatively and quantitatively assess and report on mitigation co-benefits arising from implementation of adaptation and economic diversification actions can potentially make a meaningful contribution to the debate and eventual negotiations on how mitigation co-benefits of adaptation and economic diversification can be accounted.

3. Typology of the most prominent adaptation activities

Comparisons of adaptation measures across countries are challenging because the measures outlined in contributions including NDCs and NAPs vary greatly in terms of their scope, scale and timing. GIZ (2016) found that of the NDCs with adaptation components, 84% identified water as a priority sector, 77% agriculture, 62% health, 52% ecosystems, 50% infrastructure, 59% forestry, 38% energy, 36% disaster risk reduction, 35% coastal protection and 29% fisheries.

This study reviewed the NDCs of 39 countries (see Figure 1 below) in order to identify the most "prominent" adaptation activities as a basis for selection of the case studies for chapter 4 of this report. Although the majority of countries studied included dedicated sections on adaptation in their NDCs, most countries provided little granular information on specific adaptation activities. We thus define the most commonly recurring clusters of activities, differentiated by a) specific adaptation activities and b) adaptation activities that result from economic diversification plans. The focus is on those activities with potential for mitigation co-benefits.

Figure 1: Countries studied



3.1. Specific adaptation activities

3.1.1. Urban planning to increase urban resilience against heatwaves, storms and floods

Built infrastructure

Sixteen of the 39 countries studied included adaptation of urban infrastructure as one of their priority sectors. Activities include improving the design and construction of buildings and revising building codes to vacate flood-prone areas. Climate change is also to be considered in the engineering and construction of major projects and infrastructures. For already completed infrastructure and human settlements, activities aim at identifying and subsequently correcting vulnerabilities. China proposes establishing functional zones in cities to safeguard city lifeline systems.

Several countries mention the development of land use plans for cities that take into account climate change vulnerabilities (Costa Rica, Fiji, Maldives etc.)

Among the more comprehensive activities planned in this sector are visions to develop next generation cities with sustainable core infrastructure that integrate recycling and reuse of waste, use of renewables and other smart solutions to make them more climate resilient (India). Urban renewal and ensuring widespread basic infrastructure services such as sewerage, storm water drains also appear in the NDCs of selected countries (India, Singapore, Uganda).

In several Gulf states, adaptation activities include the use of district cooling systems to reduce the electric power consumed in cooling houses in residential areas (Kuwait) to reduce vulnerability against heatwaves whilst simultaneously generating mitigation co-benefits.

Closely related to and often elaborated in conjunction with infrastructure and urban planning considerations, adaptation components of NDCs frequently mention increasing resilience against extreme events and disaster risk management. The extreme weather events most frequently mentioned are floods, droughts, storm surges, with specific measures often integrated under relevant sectors listed here.

Transport systems

Actions cited under adaptation of transport systems include increasing public transport efficiency and attractiveness that can contribute to reduction of personal vehicle use and emissions through light rail systems, metro transport links and expanded freight transport on rail (Bahrain, Qatar, Saudi Arabia and the UAE). The underlying philosophy is also found in other country NDCs such as India's, which emphasizes a focus on replacing car use by urban transport systems so that mass rapid transit systems (MRTs) will play an important role

3.1.2. Food security (agriculture, livestock and fisheries)

Agriculture

Agricultural adaptation includes diversifying crops to those that are tolerant to higher levels of salinity or are more resilient to water stress. India, for instance has identified the need to select genotypes of crops with enhanced CO_2 fixation potential which are less water consuming and more climate resilient. Other states identified no till agriculture combined with adequate fertilization and crop rotation to be central to adapting to climate change. Expanding tree cover in an integrated manner with crops and livestock, for instance through the promotion of agroforestry and silvopastoral practices is also mentioned frequently as well as maintaining the balance between grass stock and livestock to prevent grassland degradation.

Better soil management practices including the use of irrigation schemes that use low amounts of water also feature prominently. The use of renewable energy for cooling and heating purposes in post-harvest storage and food processing is suggested by Jordan. Several countries expressed a desire to strengthen existing climate risk insurance mechanisms as well as the expansion of urban and peri-urban agriculture as a potential strategy to increase food security.

Fisheries

Increased access to finance to develop sustainable livelihoods, for instance through mariculture or artisanal fisheries.

3.1.3. Forestry

Several countries mention exploring synergies between adaptation practices in this sector and reduction of emissions through avoided deforestation, through the enhancement of carbon sinks and the management of carbon stocks. Indonesia, for instance, stresses the mitigation co-benefits of community-based forest management that aims at value-addition based utilization of forest resources, in that it not only enhances community income, but also reduces pressure on primary forests.

Some countries emphasized strategies for implementation of adaptation, for instance through the creation of a Forest Code, a robust forest inventory system (Nigeria) and governance reform on the utilization of forest resources for sustainable energy use and biodiversity business (Ghana). Countries surrounding the Mediterranean also emphasized the importance of implementing a forest fire fighting strategy (Lebanon, Morocco, Tunisia) while several countries made an explicit link between reforestation and combating desertification and erosion (Saudi Arabia, Kuwait, Tunisia etc.). For instance, Saudi Arabia proposed actions that would promote the stabilization of sand movements while increasing carbon sinks through using green belts as barriers, with mitigation co-benefits arising from the reduced land degradation and improvement land management practices.

Other activities mentioned in the selected country NDCs include strengthening the construction of forestry infrastructure, enforcing low impact logging practice, raising the productivity of tree nurseries and strengthen conservation programs and expand payments for environmental services to promote ecosystem-based adaptation (Costa Rica) and the use of forest certification programmes as a mechanism to promote sustainable forest resources.

3.1.4. Water savings

Water management is consistently cited as a crucial adaptation sector. Water management activities include desalination and water reclamation through waste water treatment. Often coupled with water management activities is the need to ensure the development of new technologies that enhance the resilience of water infrastructures, for instance by powering desalination plants using renewable energy (UAE) and more generally expanding use of off-grid solar systems to support water supply (Uganda, Mali). Others insist on the promotion of new technologies that may yield higher efficiency systems such as reverse osmosis systems (Kuwait) or increase the artificial recharge of groundwater aquifers (Lebanon, South Africa). Still others plan to increase the water storage capacity through the construction of dams (Morocco, Saudi Arabia). For instance, Morocco proposes the construction of three dams per year on average to reach 25 billion m^3 in stocking capacity which will require investments forecasted at USD 2.7 billion.

Further actions include upgrading water distribution networks to minimize leakages and increase the reuse of water and wastewater (Bahrain, Saudi Arabia, UAE) with increased efficiency resulting in a reduction in water consumption and thus power generation required for desalinization (in turn leading to a reduction of emissions). Actions to enhance security of water supply include:

- Reducing water losses in distribution pipes;
- Introducing water metering;
- Introducing water saving technologies such as low-flow toilets and showers, and efficient appliances;
- Collection of rainwater for gardens, toilets, and other applications;
- Promoting water saving by awareness campaigns.
- Introducing water saving technologies in irrigation schemes such as drip, micro-spray, and night irrigation, etc;
- Introducing new varieties of crops that use less water and are salt-tolerant;
- Increasing the efficiency of irrigation systems;
- Reforming water pricing;
- Using groundwater more efficiently.
- Improving wastewater treatment plants (WWTP);
- Recycling wastewater;
- Developing river protection and sanitation zones;
- Improving chemical and biological monitoring.
  Introducing water cleaning and softening technology

3.1.5. Coastal protection

Ecosystem-based adaptation activities in coastal areas include rehabilitating degraded coastal areas by restoring or replanting mangroves, conserving beaches and sand dunes, protection and restoration of coral reefs, which includes the safe disposal of solid waste that might otherwise present a threat to corals. These measures promote adaptation by protecting against storm surges, salt water intrusion while also increasing the sink capacity and importance of these blue carbon ecosystems

Several activities in this sector focused on studying and identifying vulnerabilities, for instance, impacts of sedimentation and siltation rates on coastal processes. A significant number of states aim to establish integrated coastal management that might for instance impose restrictions on the expansion of industries in certain areas (India, Tunisia), increase protection of infrastructures such as roads, desalination plants and seaports (Saudi Arabia), mapping of coastal hazard lines for emergency response purposes, construction of small scale infrastructure such as cyclone shelters (Myanmar) and protecting coastal livelihoods through sustainable coastal activities. This was often coupled with the establishment of forecasting and data collection to monitor sea level rise and enhance strategic planning.

3.1.6. Public health protection

Though not as frequently cited as water savings or agriculture, states did propose general options for adaptation in the health sector. These include ensuring basic access to health services and health monitoring, formulating contingency plans to improve the capacity of public medical services to adapt to climate change, including dealing with short term surges in health care demand in extreme events (China, Singapore). Further actions include monitoring programmes on pathologies associated with climate change (Costa Rica), adopting climate change informed health information systems including traditional knowledge on health risk management (Ghana) and using epidemiological data and other tools to identify vulnerable populations (India, Jordan) and link environmental and climatic factors to health outcomes.

3.1.7. Energy

Adaptation actions in the energy sector are strongly linked to mitigation actions in this sector and it is often difficult to segment benefits by separate adaptation and mitigation logics. Actions include promoting alternative renewable energies to avoid deforestation, diversification of the energy matrix (Argentina, Nigeria, Saudi Arabia etc.) including decentralizing transmission to reduce vulnerability of the energy infrastructure (Nigeria). Related activities include extending the electricity grid to rural areas and generally increasing access to low emission energy to promote socioeconomic activities. Some favor the development of biofuels to increase the local production of energy (Mali).

The energy sector figures prominently in adaptation actions of fuel-producing states such as Saudi Arabia that have embarked on economic diversification and through such measures ensure the growth of domestic industries that exceeds the losses anticipated by the loss of revenue resulting from response measures by other countries that cause decreases in fossil fuel consumption. One of the main clusters of action is the improvement of energy efficiency in sectors such as industry, building and transportation, which account for a significant percentage of energy demand (90% in Saudi Arabia).

3.2. Actions taken by countries as part of economic diversification

3.2.1. Petrochemical industry

Actions aimed at economic diversification and the mitigation of effects of response measures mainly aim at making petrochemical industrial processes more efficient. These include reducing the volume of gas flaring (Algeria, Gabon, Saudi Arabia) and promoting electric generation through reinjection of the gas to optimise its use (Ecuador, Gabon). This energy can then be used for other actions, for instance, Ecuador intends to transmit the created energy to oil industries and water pumping in remote areas in order to replace the traditional use of diesel. Several countries, mention the development of combined cycle power plants (Iran, Saudi Arabia) while others mention substituting high carbon fuels with natural gas, increasing the share of liquefied petroleum and natural gas in the consumption of fuels (Algeria, Iran).

The UAE and Saudi Arabia also intend to explore the potential applications of captured CO_2 for use in petrochemical plants. For instance, Saudi Arabia will operate a pilot testing of a Carbon Dioxide—Enhanced Oil Recovery (CO_2-EOR) project as part of efforts to assess the viability of CO_2 sequestration in oil reservoirs. The UAE intends to transfer captured CO_2 emissions from other industries to similarly enhance oil recovery and ultimately be stored underground.

3.2.2. Other heavy industry

Actions in this sector are similarly aimed at increasing the efficiency of production processes. Nigeria anticipates that the emissions generated notably by the cement industry will rise but not exponentially through the deployment of efficiency technologies that will reduce future fuel demands and emissions. Saudi Arabia envisages the development of a heavy industrial base built to use domestic oil resources as feedstock or as a source of energy. The UAE intends to develop a commercial scale network for carbon capture, usage and storage, notably by harnessing and compressing emissions generated by a steel manufacturing facility to then be transported to oil fields for enhancing oil recovery.

3.2.3. Knowledge-based industries

Several countries are pursuing programs that promote increasing energy efficiency in various sectors but are unable to implement these measures given existing capacities and technologies. There is thus a strong role for the transfer and diffusion of technologies sought through international cooperation and through investments in education and innovation in universities (Saudi Arabia, Qatar, UAE). It is hoped that these investments in institutions of higher learning will produce graduates specialised in knowledge-based services to increase capacity to implement technologies etc.

3.3. Summary – typical adaptation action

Text box 1: Some adaptation action can increase GHG emissions

It is important to note that some, but not all of the typical adaptation activities listed above result in mitigation co-benefits. In some cases, such as increased use of air-conditioning in buildings to counteract negative impacts of heat waves[9], even leads to an increase of GHG emissions. Hence, mitigation co-benefits of adaptation measures can be positive or negative. The specification of baselines for adaptation is critical to determine whether negative mitigation co-benefits of adaptation occur. For example, if for the air-conditioning case the baseline is chosen to be air-conditioning with two star rated (2*) quality air-conditioners, installation of air-conditioners with more than 2* would lead to positive mitigation co-benefits.

In chapter 6, step-by-step approaches for identifying, assessing, quantifying and reporting mitigation co-benefits of adaptation will be discussed. We will use three case studies to show how the concepts can work in practice. Those case studies are typical adaptation measures applied by various countries, as discussed above:

1. Water supply: Renewable Energy Water Desalination Plant
2. Coastal protection against storm surge and erosion through mangrove and seagrass meadows restoration
3. Replacement of oil export economy by investment in heavy industry

Before engaging in the case studies, we discuss generic methodological approaches for assessment of mitigation co-benefits.

[9] Without respective counter-measures in city planning or in electricity generation (e.g. electricity generated for air conditioning only from renewable energies). The concrete case underlying this example is the installation of air-conditioning in all French hospitals and old-age homes after 2003, when an unprecedented summer heatwave killed several tens of thousands of elderly people.

4. How to account for mitigation co-benefits of adaptation: a generic approach

4.1. General approach & what can be taken over from existing mechanisms

When asking the question how mitigation co-benefits of an adaptation activity can be determined, it is worthwhile to make use of existing approaches under the UNFCCC. The Kyoto Protocol introduced three different market-based mechanisms for countries to reach their targets on limitation or reduction of GHG emissions: the Clean Development Mechanism (CDM), Joint Implementation (JI) and international emissions trading. The large number of baseline and monitoring methodologies for mitigation under the CDM can serve as a solid basis for the assessment of mitigation co-benefits of adaptation actions.

Transferring the rich methodological body of knowledge from the CDM to the assessment of mitigation co-benefits, it needs to be taken into account that the specificities of adaptation action may differ from those of traditional mitigation efforts. Thus, it will not necessarily be possible in all cases to apply existing methodologies. However, the framework offered by the CDM can be used as guidance for the development of new methodologies and of a validation/verification framework of mitigation co-benefits of adaptation and economic diversification action at the international level. Countries could also develop their own methodologies as long as they transparently show that these methodologies are consistent with the principles of environmental integrity and transparency. The latter can then be approved by a UNFCCC body.

4.2. Guiding principles: real, measurable and long-term mitigation co-benefits of adaptation action

As requested by Art. 12 of the Kyoto Protocol and applied for the CDM, mitigation co-benefits of adaptation action should be real, measurable and long term. This means that the emission reductions achieved through adaptation should not result in global increases of GHGs. Paragraph. 37 of the Paris Decision clearly refers to those principles by recommending adoption of rules, modalities and procedures for the mechanism established by Article 6.4 on the basis of principles such as: voluntary participation; real, measurable, and long-term benefits related to the mitigation of climate change; additionality, etc.

4.3. Types of activities and eligibility requirements

In principle, all types of adaptation action that result in the reduction of GHG emissions would be entitled to claim those emission reductions e.g. as part of their NDCs and/or accounting requirements under the UNFCCC (or under Art. 6). Types of adaptation activities could be structures as per the categories defined by the CDM:

- End-use energy efficiency improvements;
- Supply-side energy efficiency improvement;
- Renewable energy;
- Fuel switching;
- Agriculture (reduction of CH_4 and N_2O emissions);
- Industrial processes (CO_2 from Cement etc., HFCs, PFCs, SF_6);

- Solvent and other product use;
- Waste management;
- Sinks projects (only afforestation and reforestation).

Other, non-project-type-specific eligibility requirements could also be inspired by the CDM experience: voluntary participation of countries, establishment of a national entity supervising the whole process and ratification in this case of the Paris Agreement, but also the setup of a national framework for the assessment of mitigation efforts, a national system for the estimation of greenhouse gases, a national registry, an annual inventory, and an accounting system for the sale and purchase of emission reductions.

4.4. Recommendations

4.4.1. Definition of activity boundaries

The experience from the CDM showed that the definition of the activity/project boundary can have important impacts on the level of mitigation impacts induced by the project. The same applies here to mitigation co-benefits of adaptation measures and is relevant to identify the net impact (positive or negative) of the project activity.

Regarding the activity emissions to take into account, various degrees of coverage could be considered:

- only direct emissions (from internal processes, electricity consumption, etc.) are considered as it is the case in most CDM activities, i.e. emissions related to the operation of the project activity.
- indirect emissions of first degree, i.e. emissions related to the implementation of the project activity. In this case we would take into account the emissions the project activity setup, e.g. emissions from lifecycle of inputs (fuels, cement, steel, etc.).
- indirect emissions of whole lifecycle, i.e. all the emissions related to the project activities, including emissions related to the different uses/activities related to the considered adaptation measure.

4.4.2. Calculation of baselines

The definition of a baseline scenario is key for assessing the anthropogenic emissions by sources of GHGs that would occur in the absence of the project activity. In the case of mitigation co-benefits of adaptation actions, the objective would be to assess emissions of GHG without the implementation of the adaptation action.

If different options can be considered for this baseline scenario, the recommendation would be to select the lowest baseline scenario, as long as it is realistic in the specific project activity circumstances.

4.4.3. Monitoring of "performance"

The monitoring of emissions under project-implementation, i.e. relevant emissions within boundaries after implementation of the adaptation activity is an important step for ensuring transparency of the process. Monitoring should be undertaken under the guidance provided at the international level, but in the absence of internal level guidance countries can voluntarily apply best practice approaches like the CDM methodologies. The monitoring should be based on the measure of concrete and verifiable data related to the project activity and that can be verified by third party entitled for this task.

4.4.4. Ex-post determination of mitigation co-benefits

Based on the data collection undertaken during the monitoring process, emission reductions associated to the implementation of the adaptation measure would be calculated after the implementation period, or in certain intervals during the activity.

After monitoring, data activity and associated GHG reductions should be reported in a transparent way and verified in order to ensure trust in the whole process.

The recommendation here would be to follow the approach of CDM for the development of relevant methodologies to determine GHG emissions and use the existing materials and references that can be useful (e.g. emission factors). For example, the CDM regulators developed standardized baselines for renewable energy, landfill gas and charcoal production in a significant number of countries.

4.4.5. Institutional responsibilities

In order to ensure a good project implementation, institutional responsibilities should be determined for the following tasks:

- Systematic identification of adaptation and economic diversification options in the country
- Structure the national vision/action on mitigation co-benefits of adaptation and economic diversification measures
- Define how to take into account the mitigation co-benefits of adaptation and economic diversification action contribution to the national targets defined in the NDCs.
- Ensure coordination between relevant stakeholders
- Ensure connection with eventually emerging international approaches/frameworks on mitigation co-benefits of adaptation and economic diversification actions.
- Ensure to make the link between mitigation and adaptation stakeholders, both at the institutional and private sector level.
- Support project developers in identifying mitigation co-benefits of adaptation and economic diversification actions
- Structure the process for estimating mitigation co-benefits
- Review and validation of methodologies proposed at the national level;
- Validation and verification of proposed project activities
- Define monitoring guidelines and requirements;
- Facilitate data collection, management and archiving;
- Define rules for verification at national level aligned with the international context /ensure the application of international rules in order to build trust and recognition both at the national and international level.

Text box 2: How to define priorities for adaptation action?

Many governmental leaders and authorities worldwide face the challenge that they understand the likely impacts of climate change on their countries, and also understand what adaptation options could be implemented. However, there will typically be a wealth of possible measures in different sectors – and in many cases financial resources will not be sufficient to implement all those options.

A key question therefore is: how to decide between national adaptation options – i.e. how to set adaptation priorities?

Policy makers would naturally choose the options that are most effective, i.e. that maximize benefits for the invested financial resources. But it should be noted that many countries have clearly stated that they do not want to quantify adaptation. Moreover, 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 assessment of adaptation effectiveness exists.

One option for making educated decisions is to apply the so called “saved wealth, saved health (SW/SH)” approach developed by Perspectives in 2012. The SW/SH approach is an innovative framework for quantifying adaptive effects of adaptation projects and programmes. The conceptual framework establishes three indicators for the adaptive effect: Saved Wealth (SW) is measured by a mixed index of absolute and relative wealth savings, in order to both include economic value and vulnerability. Included categories are public infrastructure, private property, and income loss. Saved Health (SH) is estimated by an established method in the health sector, the Disability Adjusted Life Years (DALYs) that is modified for the purpose of quantifying the adaptive effect of a project/programme. Environmental Benefits (EB) measures those environmental benefits and services that are not economically quantified in the SW indicator.

In this concept, the indicators “Saved Health” and “Saved Wealth” are treated as two separate indicators, because economic quantification of health benefits raises serious ethical challenges. Similarly, environmental benefits are not economically quantified. It would be up to the government to decide what indicators shall be included for the evaluation of environmental benefits. Obviously, it would be straight forward and helpful for the objectives of the UNFCCC and the Paris agreement to add mitigation co-benefits of adaptation action as a key indicator of this category.

The total value of an adaption activity or programme (TV_{Adapt}) would be determined as:

TV_{adapt} = **Saved wealth** (public infrastructure, private property, income loss) + **Saved Health** (avoided disease, avoided disability, avoided deaths) + **Environmental Benefit** (mitigation co-benefits)

Comparing TV_{adapt} of different proposed adaptation actions or programmes allows political decision makers to select those proposals with the highest benefits.

More information on this approach can be found in Annex 1.

5. Where and how to anchor reporting of mitigation co-benefits under the Paris Agreement (Paris rulebook)

5.1. Accounting (Art. 4)

Article 4 currently requires Parties to "account for their nationally determined contributions" and by doing so they should "promote environmental integrity, transparency, accuracy, completeness, comparability and consistency, and ensure the avoidance of double counting".

It is unclear for the moment how those requirements will be translated into the modalities, procedures and guidelines for assessment of mitigation, but countries could for the moment start reporting on this issue through the national documentation submitted to the UNFCCC (National Communications, etc.).

5.2. Paris Mechanisms (Art. 6)

The mitigation co-benefits of adaptation and economic diversification measures should be eligible for generating emission credits if they are aligned with the methodologies applicable under Art. 6.4. and they should also be eligible under Art. 6.2, as long as the corresponding ITMOs generated respect the principles of environmental integrity and transparency. The requirements for eligibility of emission credits need to be defined more clearly but the requirements defined under the Kyoto Protocol for market mechanisms can provide some useful insights.

5.3. Transparency (Art. 13)

Article 13.8 requires Parties to "provide information related to climate change impacts and adaptation under Article 7". Quantified mitigation co-benefits of adaptation actions could be taken into account based on methodologies developed by the UNFCCC or by countries themselves as long as they transparently show that these methodologies are consistent with the principles of conservativeness and transparency. If the rules for transparency are not completely defined for the moment, countries could report the information on quantified co-benefits of adaptation actions in the documents disclosed at the international level (National Communications, etc.), but also start to prepare the national framework (MRV systems, etc.) to take this issue into account.

6. Step-by-step approaches for identifying, assessing, quantifying and reporting mitigation co-benefits of adaptation and economic diversification

This section describes the step-by-step approaches proposed for identifying, assessing, quantifying and reporting mitigation co-benefits of adaptation and economic diversification. The approach is then substantiated through three case studies: i) renewable energy desalination plant, ii) coastal protection and iii) replacement of oil export economy by investments in heavy industry.

6.1. Step A: Identifying mitigation co-benefits of adaptation

Mitigation co-benefits of adaptation actions and economic diversification can be defined as GHG emission reductions that are the result of adaptation-related and economic diversification action and enhance efforts on mitigation. Mitigation co-benefits can be positive when adaptation measures induce net GHG emission reductions (sinks) or negative when adaptation measures are responsible for net GHG emissions.

This paper does not discuss other (sustainable development) co-benefits of adaptation actions and economic diversification. Such co-benefits may be substantial and provide relevant drivers for adaptation actions and economic diversification.

Compared to the CDM experience where emission reductions were easily identified as they represented the main focus of the project, the difficulty here is to identify the mitigation impact induced by adaptation measures. In that sense the definition of the project/measure boundaries is crucial for ensuring a relevant assessment. The recommendation is to begin with a qualitative description and then continue, as applicable, with a quantitative description of the type and volume of mitigation co-benefits for the adaptation measures considered. We define a step by step process for identifying mitigation co-benefits below that is reliable and conservative to the extent that this is possible.

6.1.1. Link to the process of developing/updating NDCs/national adaptation plans

Make the link to the process of developing and updating national climate policies like NDCs and NAPs. On the one hand, the reflection at measure level on mitigation co-benefits can support the better understanding of interlinkages between adaptation and mitigation and enhance its consideration in national policies, i.e. how adaptation and economic diversification measures can support reaching the mitigation goals or on the contrary how they can hamper mitigation efforts. On the other hand, the work undertaken at the national level, which most of the time considers adaptation and mitigation as two separate issues can support the identification of relevant mitigation co-benefits (through the national GHG emissions inventory for example).

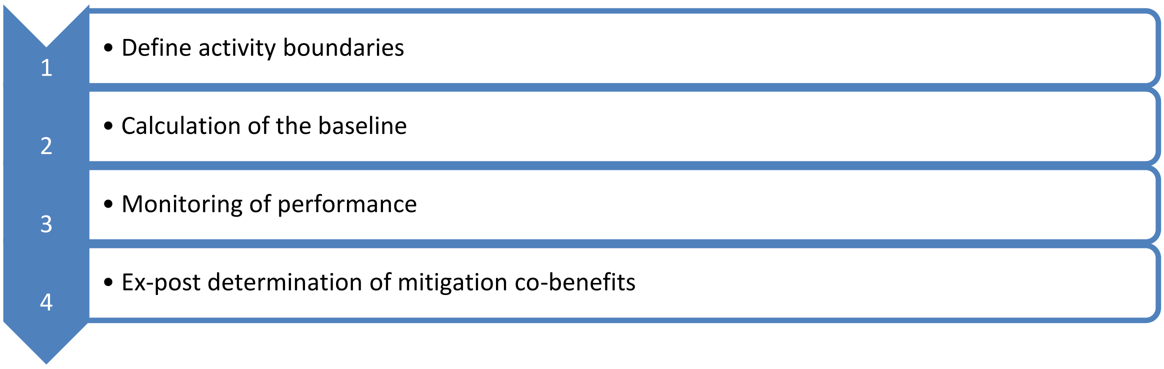
6.1.2. Define responsibilities

Institutional responsibilities regarding adaptation and mitigation actions are very often separated. It thus necessary to clearly allocate responsibilities for the determination and quantification of mitigation co-benefits of adaptation and economic diversification and their eventual verification. Collaboration between different institutions/services responsible for adaptation and mitigation will be necessary. A merging of responsibilities can be another option that can bring high levels of efficiency gains. Moreover, given the high relevance of adaptation and economic diversification for large segments of the population, close engagement with civil society groups is recommended.

6.2. Step B: Assessing/quantifying mitigation co-benefits of adaptation

For the three case studies, we will follow the sequence shown in Figure 2 below.

Figure 2: Steps for assessment of mitigation co-benefits



6.3. Case Study 1: Water supply - Renewable Energy Water Desalination Plant

We will consider here a fictitious case study, using real data from the United Arab Emirates (UAE) given that the country, as many others in the region, mentions water desalination as one of the target sectors of its INDC (UAE, 2015), and is willing to move “towards more efficient forms of desalination, and is investing in research and development of new technologies, including renewable energy to power desalination plants”. Indeed, energy-efficient technology and production of renewable energy could help to limit the majority of emissions from desalination process.

Data used for the calculation are taken from a real case, the pilot project test facility located in Ghantoot, 90 kilometres northwest of Abu Dhabi which provides 1500 cubic meters of potable water per day (547 500 m^3 per annum) and has a consumption of approximately 3.6 kWh/m^3 of produced water through membrane-based seawater desalination (1971 MWh/year). The project is composed of five different plants developed by different leading commercial partners and using different technologies (Masdar, 2017).

6.3.1. Definition of boundaries of the activity

The activity considered for this first case study will be the construction of a desalination plant in an area with limited water resources availability.

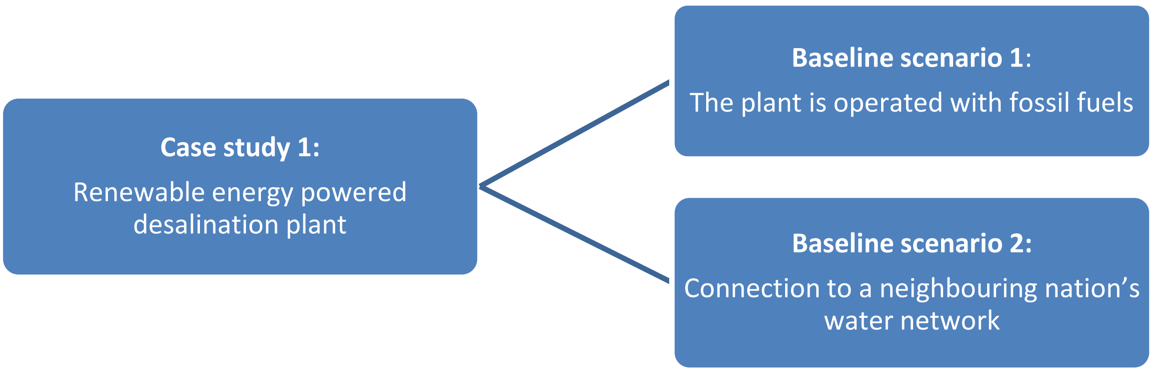
The definition of the boundaries can be narrow or wide, with the transaction costs increasing with the degree of coverage:

- Option 1: Narrow: only direct emissions are considered + electricity consumption: in this case, only emissions from the desalination plant operation will be taken into account.
- Option 2: Intermediate coverage: indirect emissions of first degree: emissions from the construction of the desalination plant will be taken into account
- Option 3: Wide: indirect emissions of whole lifecycle: within this option, emissions related to the different uses of the desalinated water produced by the plant will be taken into account.

6.3.2. Ex-ante baselines

The definition of the baseline consists in identifying the most likely scenario in case the project activity is not implemented. Figure 3 proposes different options for the baseline scenario. In the case of UAE, baseline scenario #1 seems to be the most likely option given the high development of the desalination sector in the country/region and the limited availability of ground water on the whole Arabian peninsula.

Figure 3: Identification of possible baselines for case study 1



The mitigation co-benefits that can be expected from the adaptation activity clearly depend on the baseline scenario that is selected.

6.3.3. Option 1: only direct emissions are considered

The report on desalination presented by Masdar (2018), mentions that 83% of desalination in the UAE is produced at thermal plants, which consume around 3.5 times more energy for each unit of produced water than modern reverse osmosis plants.

In our case, the electricity consumption considered here is an aggregated data for five different plants using different water desalination technologies (reverse osmosis, forward osmosis, dissolved air flotation and gravity dual media filtration, etc.). In order to be conservative for the baseline definition we will not consider the potential energy efficiency effect, but it is important to keep in mind this additional mitigation potential that could be refined in a more in depth analysis.

Information from the Carma database (http://carma.org/dig/show/carbon+plant), identifies emissions of power plants located in different countries. Five power plants located close to Ghantoot have their emissions and energy production quantified on this database. The results are presented in Annex 2.

We choose to take into account an average value of the emission factors estimated for the year 2020: 0.53 t CO_2e/MWh.

Emissions associated to the yearly production of 1971 MWh within the baseline scenario are thus estimated at $Emissions_{baseline\ –\ CS1}$=1044 t CO_2e. This corresponds to the emission associated to the production of 547 500 m^3. The annual emissions for the production of 1 m^3 would thus represent 1.9 kg of CO_2.

Those results are coherent with the results of Jiahong et al. (2015) who estimate emissions related to the operation stage of a desalination plant per m^3 of fresh water produced at 2.72 kg CO_2 with the Multi-Stage Flash (MSF) method, 1.16 kg CO_2 for the Multiple Effect Distillation (MED) method, and 2.24 kg CO_2 for the Reverse Osmosis (RO) method.

The calculation is here provided for one single year but would need to be calculated on a large time range taking into account assumptions on the evolution of freshwater production and renewable energy production.

6.3.4. Option 2: indirect emissions of first degree

In this case, emissions related to the construction of the desalination plant will be considered. This option is similar to option 2 of the project activity and is described below.

6.3.5. Option 3: indirect emissions of whole lifecycle

In this case emissions related to fossil fuel extraction/refining/transport need to be taken into account. Here the values will depend on the fossil fuel used for powering the desalination plant. The impacts on GHG emissions of the different uses of the water produced by the desalination plant are discussed below.

6.3.6. Monitoring, Reporting and Verification (MRV)

Given the project and baseline considered here, recommendations provided by the CDM methodologies could be used for MRV. Indeed methodologies like AMS-1.A Electricity generation by the user for renewable electricity production could be used.

The monitoring and, reporting and verification guidelines would apply to the production of renewable energy. However, the existing methodologies do not take into account parameters specific to the project like:

- Volume of fresh water produced at the plant;
- Energy efficiency for fresh water production;
- Specific parameters of the technology used for desalination
  - Sea water quality;
  - Potable water quality
- Specific data on the different uses of the fresh water produced at the plant
  - Volumes associated to each type of use
  - Associated emissions

There is thus a need to build a MRV system at adaptation-project level that would combine data related to the mitigation co-benefits but also other parameters related to project implementation.

The definition of guidelines at the national level for those parameters not necessarily covered by existing methodologies will be crucial for ensuring a strong and coordinated approach by the different project developers.

6.3.7. Ex-post determination of mitigation co-benefits according to the principles proposed in section 5.

Option 1: only direct emissions related to the plant operation Given that emissions from desalination come from energy use, the project emissions to be compared to the baseline scenario will thus be related to the emissions of the renewable energy selected for desalination. In our case we consider desalination powered by PV solar power. The CDM methodologies like AMS-1.A mentioned above do not consider any emission for the operation of PV solar plants, thus $\text{Emission}_{\text{project – CS1}} = 0\ t\ CO_2e$

For option 1, the mitigation co-benefits would thus be:

$$\text{Mitigation Co-benefits}_{\text{Option 1 – CS1}} = \text{Emissions}_{\text{baseline – CS1}} - \text{Emission}_{\text{project – CS1}}$$

$$= 1044\ t\ CO_2e/\text{year}.$$

Option 2 additionally takes into account emissions from the construction of the RE production facility. Jiahong et al. (2015) estimate the emissions related to the construction phase of the desalination plant in UAE (based on data of a power plant located in China), at about 10% the emissions of the operation of the desalination plant; approx. 100 t CO_2e/year. Mitigation co-benefits would thus be reduced to around 900 t CO_2e/year.

Option 3 additionally takes into account emissions related to water consumption. In this case the objective would be to consider the different water uses of desalinated water and assess their impact on GHG emissions. For example, emissions from pumping of water would have to be calculated.

6.4. Case Study 2: Coastal protection through mangroves

Coastal wetlands can be more cost effective than traditional infrastructural solutions such as seawalls and levees and co-benefits include securing spawning grounds for commercial fish. In addition, these ecosystems can contribute to reducing vulnerability caused by the salinization of soils and associated impacts on agriculture. We will consider here the protection of a coastline of 3 km through mangrove restoration in the Jizan province of Saudi Arabia.

6.4.1. Definition of boundaries of the activity

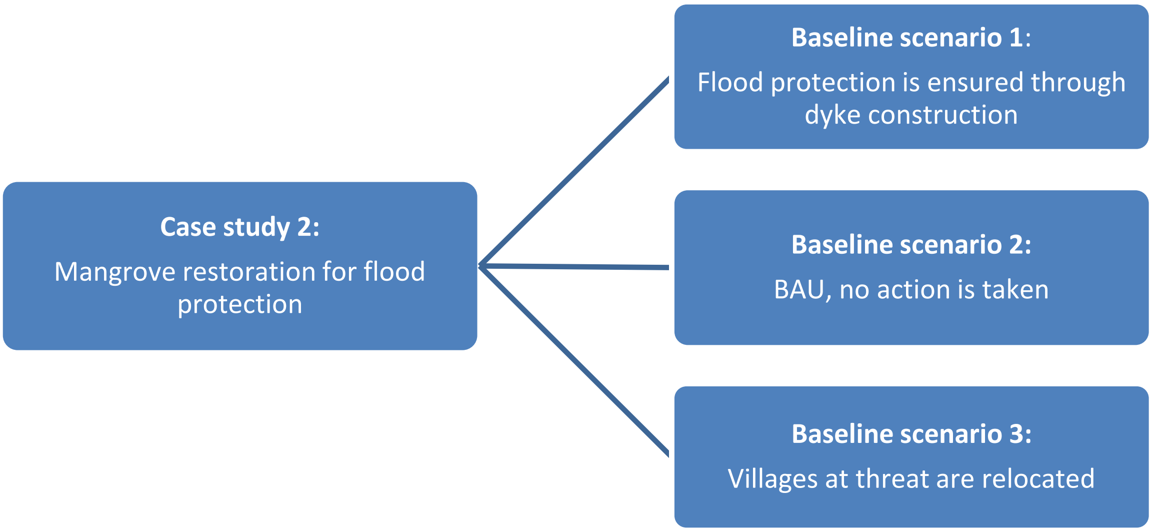
- Option 1: Narrow (only direct emissions are considered): emission reduction / sequestration through vegetation /soil (“blue carbon”)
- Option 2: Intermediate coverage: indirect emissions of first degree: emissions related to the project implementation (mangrove seedlings production and plantation).

- Option 3: Wide: indirect emissions of whole lifecycle: emission related to the developed activities that rely on mangrove restoration (fisheries, etc.).

6.4.2. Ex-ante baselines

The definition of the baseline consists in identifying the most likely scenario in case the project activity is not implemented. Figure 4**Figure 3** proposes different options for the baseline scenario.

Figure 4: Identification of possible baselines for case study 2



In the case of the Arabian Gulf coast in Saudi Arabia, baseline scenario #1 seems to be the most realistic option. We will consider here the construction of a dyke of 3 km.

The baseline is as follows:

Option 1: Direct emissions are considered: no significant emission once the dyke is in place. Emissions $_{\text{baseline – CS2}}$ = 0 t CO_2e

Option 2: indirect emissions of first degree: Dyke construction In this case, the different modalities of construction will be taken into account, for example the fossil fuel used for the dyke construction. Thus the number of hours of machines' operation and the characteristics of machinery (fossil fuel used, type of motors) will be an important input for calculated GHG emissions.

Option 3: indirect emissions of whole lifecycle: emissions related to concrete production.

Here the emissions associated to the production of the different materials used and their transport to the construction site should be taken into account. Emissions will depend on the material considered, for example the concrete production is associated to average emissions of about: 100 to 300 kg CO_2 per m^3 of concrete (NRMCA, 2008).

6.4.3. MRV

MRV can be done according to the CDM methodology AR-AM0014: Afforestation and reforestation of degraded mangrove habitats, covering the following indicators stratified according to the major baseline vegetation types and soil types:

- Area of each tree biomass stratum
- Area of each soil organic carbon stratum
- Area of each shrub crown cover stratum
- Area of sample plot for each stratum and related crown cover percentage
- Tree diameter and height

6.4.4. Ex-post determination of mitigation co-benefits according to the principles proposed in section 4.

In our case we consider that the protection of a 3 km shoreline would require the plantation of about 400 ha of mangroves.

6.4.5. Option 1: only direct emissions and sequestration related to mangrove plantation

Table 1 shows the carbon sequestration capacity of Red Sea mangroves (Almahasheer et al. 2017) which is relatively low compared to other regions of the world.

Table 1: Red Sea Mangroves and Seagrasses as Carbon Sinks

	Seagrass	Mangroves
Sequestration rates (tCO_2/ha per year)	0.2	0.5

The annual carbon sink potential of the project considered for this case study would thus be of 400*0.5=200 t CO_2e.

Mitigation Co-benefits $_{\text{Option 1 – CS2}}$ = Emissions $_{\text{baseline – CS2}}$ - Emission $_{\text{project – CS2}}$

= 200 tCO_2e/year.

6.4.6. Option 2: indirect emissions of first degree

In addition to emissions considered in option 1, emission related to the project implementation (mangrove seedlings production and plantation) will also be taken into account. Those emissions are expected to be slightly positive, reducing the total mitigation co-benefit.

6.4.7. Option 3: indirect emissions of whole lifecycle

Here the indirect impacts of mangrove plantation like increase of fisheries, etc. will be taken account. Those impacts are expected to generate emissions.

6.5. Case Study 3: Replacement of oil export economy by investment in heavy industry

The decrease in oil prices and associated oil revenues since 2015 puts pressure on Saudi Arabia to initiate a transformation of its economy. A report by McKinsey Global Institute - MGI (2015) identifies petrochemicals as one of the eight sectors that will generate growth and jobs in the country and that could contribute to doubling the national GDP by 2030 if appropriate investments are made. We assess the economic diversification measure where export of crude oil produced in the country is replaced by domestic use of the oil in petrochemical plants operating nationally. We will base the analysis on data available for the Saudi Arabian Basic Industries Corporation (SABIC) and assume that half of Saudi oil export in the future will be processed in the petrochemical industry.

6.5.1. Definition of boundaries of the activity

- Option 1: Narrow (only direct emissions are considered + electricity consumption): emissions related to the operation of the production sites.
- Option 2: Intermediate coverage: indirect emissions of first degree: emissions related to construction of the production sites.
- Option 3: Wide: indirect emissions of whole lifecycle: emissions related to the use of materials produced by SABIC.

6.5.2. Ex-ante baselines

Figure 5**Figure 3** shows the single baseline scenario based on export of oil production which was the observed scenario before the transition to a more diversified economy.

Figure 5: Identification of possible baselines for case study 3

The definition of the baseline scenario needs to consider the potential evolution of oil exports considering that the economic diversification is not taking place. This exercise requires assumptions on global fuel demand and oil extraction.

This analysis could be compared to the reflection on suppressed demand under the CDM, Indeed, the concept of suppressed demand recognizes that in some cases, future emissions could increase because of the income effect (demand for a service/product will increase over time because of increasing incomes) and rebound effect (the demand for a service/product will increase because of decreasing unitary costs). The baseline nevertheless assumes that the suppressed demand would be covered through an alternative source.

The estimation of the potential evolution of oil exports without economic diversification can be compared to the definition a baseline based on suppressed demand.

6.5.3. Option 1: only direct emissions are considered

Direct emissions of oil exports are the emissions from burning this oil in the countries it is exported to. According to OPEC (2016), crude oil exports of Saudi Arabia reached 7.5 million barrels/day, i.e. around 380 million t crude (one barrel representing 0.14 t of crude oil). Half of this oil would mean 190 million t. Burning this oil would generate 870 million t CO_2.

$Emissions_{baseline-CS3}$ = 870 million t CO_2

6.5.4. Option 2: indirect emissions of first degree

Option 2 would additionally consider emissions related to oil exploration and production. According to Gavenas et al. (2015) there reach 0.13 t CO_2 per t crude, i.e. 25 million t CO_2 for our case.

6.5.5. Option 3: indirect emissions of whole lifecycle

Within option 3, emissions related to the different uses associated to oil consumption, i.e. transport emissions for oil tankers and associated electricity use for industrial combustion of oil would be added. According to ETSAP (2011) large oil tankers emit 4 t CO_2/million tkm. Assuming an average distance for Saudi oil exports of 9000 km, transport emissions reach 7 million t CO_2.

6.5.6. MRV

The MRV system developed here could build on the existing references for calculating emissions from industry (2006 IPCC Guidelines for inventories). The monitoring reporting and verification of those activities could follow the guidelines established at national level for the national GHG inventory.

We considered here a case study at national level, but the analysis could also be conducted for specific companies of specific petrochemical subsectors (depending on the products that need to be considered).

The different parameters to consider for the MRV system would be:

- Volume of oil exports;
- Destination of oil exports (distance between production/refinery/consumption site);
- Uses of oil exported;
- Volume of production for each petrochemical product
- GHG emissions per tonne of petrochemical products produced (separating the different processes).

6.5.7. Ex-post determination of mitigation co-benefits according to the principles proposed in section 4.

We now assume that the not exported crude oil will be fully used in the Saudi petrochemical industry.

6.5.8. Option 1: only direct emissions are considered

In the petrochemical industry, energy is used as raw material (or feedstock) and also consumed within the own chemical processes in form of thermal energy (see discussion in Park and Patel 2017). GHG emissions occur when fuels are used for energy purposes. For example, 75% of naphtha used on petrochemical processes is assumed to be stored in the petrochemical end products according to the IPCC 2006 inventory guidelines and thus not emitted. A full assessment of this storage according to all petrochemical intermediate and end products requires complicated modelling (Park and Patel 2017). In order to keep our case study simple, we just assume 75% of the crude oil input into the petrochemical industry is used as feedstock. Activity emissions thus reach 25% of 870 million t CO_2

Emission $_{project – CS3}$ = 217.5 Mt CO_2e.

Mitigation Co-benefits $_{Option\ 1 – CS3}$ = Emissions $_{baseline – CS3}$ - Emission $_{project – CS3}$

= 652.5 Mt CO_2e.

6.5.9. Option 2: indirect emissions of first degree

Option 2 would additionally consider emissions related to the first use of the end product. This would include transport emissions of the products to the end user. These emissions would probably be in the same order of magnitude as transport-related emissions in the case of crude oil exports, probably higher due to less dense storage in the ships.

6.5.10. Option 3: indirect emissions of whole lifecycle

Within option 3, emissions of all end products at the end of their use would have to be taken into account. This would mean that all end products incinerated at the end of their technical life would be accounted as emissions. Of course this leads to temporal inconsistencies, given that these emissions will occur over decades. Landfilled material will not generate emissions.

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Annex 1: The Saved Wealth / Saved Health Approach

The Saved Wealth / Saved Health Approach was originally developed for quantifying economic and health benefits of adaptation to climate change projects. Conceptually, evaluating 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 criticized because they value human lives according to their economic potential, expressed in monetary terms such as GDP per capita, that is significantly different in industrialized and developing countries. The SW/SH approach avoids 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, the SW/SH approach introduces indicators for each of three key dimensions related to adverse effects of climate change: economic value at risk, health of people at risk, and environmental benefits. The aim is to apply a consistent methodology that allows evaluating the benefit for each of the categories, and which may help decision makers to track and compare project impacts as well as allocate available resources systematically. For economic and health benefits, a quantitative approach has been developed. The downsides of pure quantitative approaches are that they provide only a very coarse picture of the reality and that such indicators are difficult to measure. Uncertainties and value judgments such as the impacts of climate change on extreme events need to be considered. However, quantitative indicators are the best way to compare two situations consistently between space and time.

The SW/SH approach determines the total economic value of a project as ***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 may be taken into account qualitatively. In the following, each indicator is explained in detail.

The Saved Wealth indicator

When assessing the wealth benefit of a project one can generally use two different concepts: absolute wealth or relative wealth saved. The two types of wealth can be used to compare the impact of a project at the community level.

1. **Absolute wealth saved:** This approach measures the absolute wealth saved by the project. Taking the fictitious example of a community with 1,000 inhabitants and with a moderate level of wealth (1 million USD), an activity is e.g. able to save 0.2 million USD. Looking only at the absolute wealth of the community does not necessarily address vulnerability, as absolute wealth may be concentrated in 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. As a result, the number of average personal wealth saved in percent is calculated. Regarding the example above, the described community would get a result of 0.2 million USD / 1 million USD = 20 %. Looking only at 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. 0.2 million USD 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. 0.2 million absolute savings divided by 1 million total wealth = 20 % personal wealth savings (PWS) 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 0.2 million USD * 20 % (PWS) = 40,000 USD (PWS). The concept has the advantage that poor, vulnerable communities, lacking of assets that can 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 indicator is:

$$SW = MISW = AWS \cdot RWS$$

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 personal wealth savings, PWS)

The MISW may be applied to specific wealth categories, such as “private property”. Overall, it is the tool user’s decision about 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 activity to save wealth, one needs to consider 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).

The Saved Health indicator

For quantifying saved health, the concept of Disability Adjusted Life Years Saved (DALYs) is introduced to assess avoided negative climate change impacts on humans due to a proposed adaptation activity, shortly described as Saved Health (SH).

The concept of DALYs was developed by the World Bank (1993), and has since then been systematically utilized – inter alia by the World Health Organization (WHO) in the “Global Burden of Disease Concept” (GBD), 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 monetization of human life. Instead, adaptation benefits are expressed as the avoided number of life years lost due to disability and early death. The formula for the Saved Health indicator is:

DALY = YLL + YLD

where:

YLL - Years of life lost due to premature mortality.

YLD - Years lived with disability

Considering Environmental Benefits

It would be up to the government to decide what indicators shall be included for the evaluation of environmental benefits. Obviously, it would be straight forward and helpful for the objectives of the UNFCCC and the Paris agreement to add mitigation co-benefits of adaptation action as a key indicator of this category. But, it could also be other indicators such as the value of preserving natural ecosystems (intrinsic value of nature), etc.

Annex 2: Emissions of electricity generation for case study 1

The Carbon Monitoring for Action (Carma: carma.org), provides detailed data for various energy production plants on CO_2 emissions and power generation for the years 2009 and a prediction for 2020. The information for five power plants located close to Ghantoot are presented in the table below.

	2009			2020		
Power Plant	Power generation [MWh]	$C0_2$ Emissions [t]	**Emission Factor [$tC0_2$/MWh]**	Power generation [MWh]	$C0_2$ Emissions [t]	**Emission Factor [$tC0_2$/MWh]**
TAWEELAH-A1	3.926.600	2.002.800	**0,51**	6.934.500	3.807.900	**0,55**
TAWEELAH-A2	2.379.300	1.213.600	**0,51**	2.379.300	1.213.600	**0,51**
TAWEELAH-B	6.863.600	3.768.400	**0,55**	6.863.600	3.768.400	**0,55**
TAWEELAH-C	0.0000	0.0000	**/**	11.042.000	5.591.100	**0,51**