Adapting to climate change: risk or benefit for freshwater nature?

An analysis of the Intended Nationally Determined Contributions in the Global North and South

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Alise Versluis • 4029720 • info@aliseversluis.nl
Supervisor: Carel Dieperink
Second reader: Hens Runhaar

Abstract

Safeguarding freshwater nature and adapting to climate change are issues which should be high on the agenda of policy makers. This thesis addresses both by determining the implications on freshwater nature of the envisioned adaptation climate policies of states in the Global North and South. First, the possible adaptation measures are researched within literature as well as those measures' effects on freshwater nature. This information enables the drafting of an assessment framework which tabulates an overview of these measures and effects. This assessment framework is then applied to 20 cases.

The Intended Nationally Determined Contributions (INDCs) are documents that are publicised to communicate which mitigation and adaptation measures will be implemented nationally to adhere to the aims of the Paris Agreement. The INDCs are used to identify which countries aim to implement which adaptation measures. The results of the analysis of these INDCs are compared to identify whether adaptation measures that safeguard freshwater nature are often used. The same can be done for adaptation measures that impact freshwater nature negatively. This way opportunities for win-win situation can be identified. Also, it can become clear which adaptation measures need to be avoided when it comes to freshwater nature. As this is done for countries in the Global North and South, a comparison between the measures found in these regions is made.

From this thesis it can be concluded that the potential effects of the adaptation measures on freshwater nature are diverse. When it comes to the measures most adopted, the measure 'extension or preservation of protected areas' has a clear positive effect, while 'R&D on vector control and vaccines' has a clear negative effect on freshwater nature. Most measures however can be both beneficial or harmful for freshwater nature depending on the way they are implemented. The measures within this category that are currently adopted most by the analysed countries are 'forestry with shorter rotation time, afforestation and reforestation', 'the development of resistant crops' and the 'creation of risk analysis institution and long-term plans'. Many other measures less often adopted that can both be positive or negative for freshwater nature however exist. Thus, when implementing adaptation measures, it is crucial to include freshwater nature within the decision-making process. As more countries in the Global South implement measures in comparison to the Global North, opportunities arise for win-win situations specifically in those areas. However, negative effects may also intensify as a result.

Key Concepts

Freshwater nature, climate adaptation measures, Intended Nationally Determined Contributions

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1. Introduction

1.1. Climate adaptation

The effects of climate change are global and pervasive. These effects are felt in varying ways all over the world in all kinds of sectors. At this point, addressing the source of climate change is not enough. Adaptation is key to dealing with existing and future effects. It is important to recognise and address that our climate is going to change and the effects will become increasingly apparent, even though the extent of the consequences may be uncertainty. Changes such as higher temperatures, higher sea levels, more extreme weather, or drier soils means that humanity must create coping mechanisms to defend human societies and activities (Adger, Huq, Brown, Conway & Hulme, 2003).

Several initiatives have been proposed. One well-known attempt has been initiated by the United Nations. The United Nations is an influential body when it comes to the management of global issues. It has attempted to unify actors on a global level in 2015 with the United Nations Climate Change Conference in Paris, also known as the COP 21. This conference resulted in the Paris Agreement, wherein countries agreed on the global reduction of climate change. The involved parties agreed to keep the global temperature rise of this century 'well below 2 degrees Celsius' with the aim of keeping it at 1.5 degrees. Parties also agreed to strengthen the abilities of countries to deal with the impact of climate change. Thus, the Paris Agreement has been an attempt to deal with the causes and effects of climate change (World Resources Institute, n.d.-b).

The extent to which countries intend to adhere to the Paris Agreements is measured by the Intended Nationally Determined Contributions (INDCs). The INDCs are publicised by countries to communicate their national plans for adhering to the aims of the Paris Agreement. The extent of intensions to adhere to the adaptation goals of the INDCs vary. Some countries may have put in place highly modified systems to reach these goals, while others have only started to implement some measures (World Resources Institute, n.d.-b). Currently, the submitted INDCs cover 192 countries. This means that the INDCs should collectively indicate whether it is possible for the world to meet its target of keeping temperature rise below 1.5 - 2 degrees. The INDCs contains plans for mitigation as well as options for adaptation. One hundred and forty-five countries have covered both mitigation and adaptation, while 49 countries have only focused on mitigation (World Resources Institute, n.d.-a).

1.2. Potential risks for freshwater nature

Water is a vital resource. Unclean water is the cause of millions of deaths due to illnesses, and shortage of shared water supplies can be the source of regional and international conflicts. A growing human population exacerbates these problems. Besides directly impacting humans, a short freshwater supply also causes the destruction of both aquatic environments and ecosystems, which results in the extinction of species (Gleick, 1998). Less than 1% of the earth's surface is occupied by freshwater habitats, but 10% of all species are dependent on this small portion of the planet (WWF, n.d.) The degradation of these freshwater habitats has caused decreases in the range and abundance of species, and the rate of this decrease has exceeded the rate of decrease of species in other land habitats (Dudgeon et all., 2006; Strayer, 2010). Human activities such as overfishing, the introduction of invasive alien species, canalisation, or the regulation of flow and extraction of water have contributed to the degradation and pollution of these habitats. Regarding human activities, it is sometime unclear whether they impact freshwater nature negatively, which makes it difficult to address the causes of freshwater habitat degradation (Gleick, 1998).

Considering the current trends regarding degradation of freshwater habitats on the planet, we must change how we treat these habitats to sustain our freshwater ecosystems and their benefits. In practice, this means that there should be a change in the management of freshwater habitats (Dudgeon et all., 2006).

1.3. Knowledge gap, research objective and main question

Safeguarding freshwater nature and adapting to climate change should be high on the agenda of policymakers at all levels. Countries can consider several options for adaptation to climate change. These options are not without consequences. Besides the intended direct effects, some indirect effects can also occur that may be positive or negative. Freshwater nature is affected by these measures. Though different adaptation strategies can have varying impacts on the conservation of the natural water system, it is often unclear which of these measures are beneficial.

There is a knowledge gap in the literature regarding the implications of the adaptation strategies. No overview exists on the impact on freshwater nature of the strategies for adapting to climate change. Additionally, there is a lack of clarity on the contextual nature of adaptation measures. Some of the measures and their associated risks may be more relevant in countries in the Global South than the Global North. The adaptation measures adopted in certain areas may be less beneficial for freshwater nature, but this information currently cannot be found in the literature.

This is a missed opportunity for identifying win-win situations for adaptation to climate change and the preservation of freshwater resources. Having a clearer overview of the effects of adaptation measures on freshwater nature would enable policymakers to implement more efficient national measures that would be beneficial to freshwater nature as well as adaptation to climate change. Awareness of the context-specific nature of measures will be instructive on whether being situated in the Global North or Global South dictates the choice of certain adaptation strategies and whether these choices are specifically harmful to freshwater nature.

Thus, the objective of this thesis will be to map which measures are used by countries to adhere to the adaptation goals of the Paris Agreement and how these measures may impact local freshwater nature. The thesis therefore seeks to explore the implications of the chosen adaptation strategies in terms of which strategies would be more beneficial or detrimental to freshwater habitats. The goal of this thesis is to inform on the negative and positive effects of some adaptation strategies in the Global North and Global South. This information will enable policymakers to avoid questionable measures and achieve a win-win situation for adapting to global warming and safeguarding freshwater nature. The research question which will be answered within this thesis will be as follows:

What are the implications for freshwater nature of the envisioned adaptation climate policies of states in the Global North and South?

1.4. Research framework and sub-questions

Figure 1 illustrates the steps to answering the research question of this thesis.

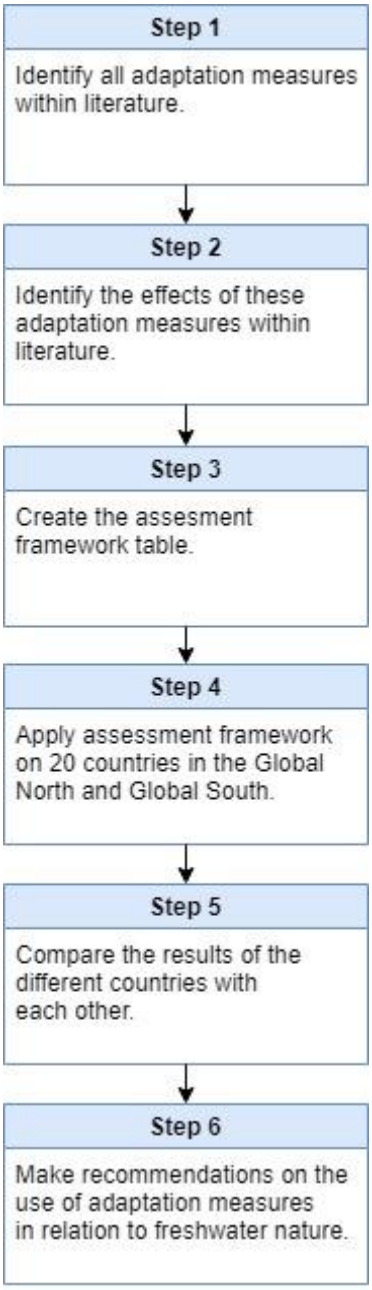

Figure 1: Research framework

Step 1 of the research framework is to identify which adaptation strategies for climate change exist. This will be achieved with a literature study and by scanning some of the INDCs. **Step 2** uses a literature study to identify the implications of these strategies on freshwater nature. **Step 3** visualises the strategies in an assessment framework once they have been identified and their effects are clear. **Step 4** applies the assessment framework to 10 countries in the Global South and 10 countries in the Global North to identify which of the adaptation strategies are used in practice. With the information gathered in the previous steps, it is now possible to complete **step 5** and compare the results of the assessment framework. This step may reveal patterns of countries with comparable or varying adaptation strategies. Identifying these patterns and comparing countries with different characteristics, such as regional location may be instructive on what controls the choice of specific

adaptation measures. **Step 6** makes recommendations that are based on the results to determine which adaptation strategies should be used. The considerations for these recommendations are whether the strategies are detrimental for freshwater nature and whether they can promote the reduction of global warming while also benefiting freshwater nature for both the Global North and South.

The previous steps can be translated to the following sub-questions, which together will be used to answer the main research question:

Sub-question 1: *What adaptation measures are mentioned in the literature?*

Sub-question 2: *What effect do the identified measures have on freshwater nature?*

Sub-question 3: *How can the identified adaptation measures and their effects be visualised in an assessment framework?*

Sub-question 4: *Which of the identified measures are applied by the 20 countries in the Global North and Global South?*

Sub-question 5: *How do the countries compare on the applied adaptation measures?*

Sub-question 6: *Which recommendations can be made to ensure adaptation to climate change while safeguarding freshwater nature?*

1.5. Methods and outline of report

A literature study is used to answer the first sub-question. The concept of adaptation and the individual measures that seek to address it need to be operationalised. Google Scholar will be used to search for literature. Search terms can be variations on 'climate adaptation measures'. The first sub-question will be answered in chapter 2.2.

Additionally, to answer sub-question 2 and execute step 2, a literature study will be necessary to picture the potential effects of the specific measures on freshwater nature and determine the options to decrease the negative effects and enhance the positive effects. Specific literature will be sought for every measure. An overview of the effects of the measures will be provided in chapter 2.3.

The information gathered after answering sub-question 1 and 2 will be used to draft an assessment framework that visualises the identified measures and their effects. This will answer sub-question 3. The assessment framework can be found at the end of chapter 2 in paragraph 2.2.9.

A content analysis of the INDCs will answer sub-question 4. As established earlier, the INDCS are publications of individual countries that signal their plans to adhere to the Paris Agreement. These publications contain a description of the countries' aims to combat climate change and decrease the attendant risks. Thus, the INDCs signpost the adaptation measures that countries aim to implement. This thesis will use the INDCs to identify the adaptation measures used by countries. As the INDCs should contain a clear and complete overview of adaptation measures to be undertaken, this thesis excludes any other sources of information about adaptation initiatives within the 20 countries.

Twenty countries' INDCs will be selected for analysis. This selection is based on multiple factors. First, the country must have an INDC available. For example, countries in the European Union have merged their INDC into one document, meaning that the individual member states do not have INDCs. Some countries have not published an INDC, while other countries' INDCs are not translated to English. These are excluded from the analysis.

Sub-question 5 aims to identify patterns between countries in the Global North as well as the Global South. These patterns indicate whether the socio-economic or political background of countries dictates the choice for certain measures and the associated consequences for freshwater nature. These patterns therefore affect the applicability of recommendations to different countries. Thus, to facilitate the identification of these patterns, half of the countries are situated in the Global North while the other half is situated in the Global South. Within the Global North and South regions, it is attempted to select a diverse set of countries to determine if there is diversity in the approach to drafting an INDC. Sub-question 3 is addressed by the overview of the applied adaptation measures by the 20 countries which can be found in chapter 3 paragraph 2.

The goal of sub-question 5 is to compare the results of the analysis of the 20 countries. The assessment frameworks will be used to compare and find patterns between the countries. Chapter 3.4. contains remarks on the overall character of the INDCs, key findings from performing the analysis, the occurrence of the measures mentioned in the INDCs, and whether a pattern can be found within the countries in the Global North and Global South.

Sub-question 6 will be answered within chapter 4, which contains the discussion and conclusion. The information gathered in the previous steps will be used to make recommendations regarding the use of certain adaptation measures to include the protection of freshwater nature. Chapters 4.2.2. and 4.2.3. will elaborate on the reliability of the report and the limitations of the research.

2. Adaptation measures and their effects on freshwater nature

2.1. Introduction

This chapter will address two sub-questions '*What adaptation measures are mentioned in the literature*?' will be answered in paragraph 4.1, which provides an overview of the climate change adaptation measures found within the literature. '*What effect do the identified measures have on freshwater nature*?' is answered in 4.2. As the results of the both chapters are merged into an assessment framework in chapter 2.3.9., sub-question 3, or '*How can the identified adaptation measures and their effects be visualised in an assessment framework?*', will be answered in that chapter.

The same categorisation of measures in sectors has been used in both chapters. Hallegate (2009) has provided a strong basis for providing a multitude of areas for categorising adaptation measures as well as a comprehensive overview of the adaptation measures that can be implemented to adhere to the Paris Agreement. Hallegate's (2009) article focusses on all decision-making that should consider climate change and its effects. As many decisions and policy planning have consequences for long-term commitment, these choices and the efforts that result are vulnerable to changes in the climate and sea level. Many buildings or other infrastructures last for at least a decade, and some projects such as implementing coastal protection infrastructure have a lead-time of at least 30 years. The author argues that the areas of decision-making that are exposed to the effects of climate change are water infrastructure, land-use planning, coastline and flood defences, building and housing, transportation infrastructure, urbanism, and energy production (Hallegate, 2009). Thus, climate change adaptation should be considered when making decisions within these sectors.

2.2. Adaptation measures

2.2.1 Agricultural sector

When adapting to climate change within the agriculture sector, several issues can compel different adaptation measures. Though an increase in temperature and carbon dioxide (CO2) can be beneficial and increase the local crop yield, the same changes in nutrients, soil levels, and water availability can also pose problems. Some areas that are suited for a crop may exceed the crop's optimum temperature level, causing yields to decline and farmers to be forced to switch their type of plantation or move their fields elsewhere.

While some experiments suggest rises in CO2 levels can be beneficial for plant growth, other changes related to climate change may counteract these benefits. Also, some plants experience a decrease in quality due to elevated CO2 levels. Decreases in protein and essential minerals reduce the nutritional value of food crops. Other climate issues that impact agriculture include an increase in extreme weather. Floods and droughts can have a disastrous effect on crops and livestock. Additionally, weeds, pests, and fungi can flourish when the climate becomes warmer, wetter, and higher in CO2 (EPA, n.d.-a).

2.2.1.1. Crop insurance

The literature proposes several measures to counteract these possible effects. One possibility is to develop a form of crop insurance (Hallegate, 2009). Crop insurance gives producers an opportunity to protect against agriculture events that cause considerable losses. One type of event consists of natural disasters that can cause large portions of crops to be lost or crop yield to be low. This includes destructive weather such as hail or frost as well as disease, drought, fire, flooding, or insect

damage. The other type of insurance is crop revenue insurance. This happens when crop prices swing drastically, regardless of the cause. The insurer will base the amount to be paid by comparing the year's revenue to previous years' earnings (Insurance Information Institute, n.d.).

2.2.1.2. Irrigation (possible with water storage and transport)

According to Woznicki, Nejadhashemi, and Parsinejad (2015), irrigation demand is impacted by climate change. The precise impact is sometimes difficult to establish because different trends in temperature changes, CO2 emissions, or other changes such as shifting plantation areas or dates have different outcomes. For example, increasing evapotranspiration can decrease demand for irrigation in some areas, while other drier areas will experience an increase in demand (Woznicki et al., 2015). Overall, however, changes in precipitation and increases in evaporative demands will increase the need for irrigation worldwide (Fischer, Tubiello, Van Velthuizen & Wiberg, 2007). The local nature of these issues may necessitate water storage and transport.

2.2.1.3. Forestry with shorter rotation time, afforestation, and reforestation

Afforestation refers to planting trees in an area where trees did not grow. Reforestation refers to planting trees in areas where the forest has been harvested or damaged by fire, disease, insects or other causes. Both afforestation and deforestation are agricultural measures (Akinnagbe & Irohibe, 2014). Afforestation has the capacity to mitigate and adapt to climate change. Forests can be useful for accumulating some greenhouse gases as well as for adapting to the effects of climate. During droughts, forests can capture larger volumes of wear or nutrients and can decrease runoff. On the other hand, tree-based systems are more able to pump away excess water than other systems with row crops or pastures. Forestry with a shorter rotation time(SRF), the plantation of trees for a shorter period of time after which they are harvested, has similar benefits for adapting to climate change. SRF can, just like afforestation and reforestation, play a role in stabilizing the microclimate and provide protection against the effects of climate change (Verschot et al., 2007).

2.2.1.4. Development of resistant crop

Climate change can pose several challenges for farmers who attempt to grow crops. These challenges have stimulated breeding programs to develop crops that are more resistant to the changing climates. For example, some crops can be developed to be more resistant to drought, such as drought-tolerant maize, or to ensure normal yield under high salinity, such as salt-tolerant rice. As climate change is unpredictable, and flooding or drought cannot always be forecasted, some crops are developed to perform under a wide range of environmental circumstances (Khraiwesh, 2016).

2.2.1.5 Adjustment of planting dates and crop variety

Diversification of crop types is another way to spread farming risk. When a certain crop suffers from too much rainfall, others crops that flourish under those circumstances can serve as insurance for farmers. Mixed cropping, which refers to the planting of two or more crops within the same field, is another form of insurance. Another technique to increase crop variety is the planting of the same crop that contains slight differences. This technique, which is one of the most important adaptation measures adopted in African agriculture, increases the resilience of the overall crop yield to different climate scenarios. Additionally, because climate change has the capacity to alter rainfall patterns long term, planting dates and other crop-related activities may be shifted to different points on the timeline to optimize yield after these changes (Akinnagbe & Irohibe, 2014).

2.2.2. Ecosystems and biodiversity

Climate change can cause a multitude of issues for biodiversity. As local climates shift, species will also shift accordingly. Species that cannot adapt fast enough may suffer. Other species that are isolated or restricted to certain areas may become extinct. Other phenomena include the decoupling

of species that share coevolved interactions with each other, such as plant-pollinator relationships or a changing demographic distribution. This may result in the overrepresentation of certain species. For example, predators who are better suited to cope with the effects of climate change on the local level may threaten the existence of the area's focal species.

Other less-desirable species could flourish with the local climate changes. Some wildlife diseases, parasites, or diseases which can be transmitted to people may increase in certain areas, just like invasive alien plants or animals. Climate change can have a very direct nature. Sea-level rises, floods, increases in forest fires or glacial recessions all have obvious consequences on ecosystems and biodiversity (Mawdsley, O'Malley & Ojima, 2009). Thus, established balances within ecosystems have the potential to be threatened by changes within the climate.

2.2.2.1. Preserve or increase extent of protected areas

One measure to combat these effects is to increase the amount of protected areas on land and water or strengthen existing areas. Though it is possible to make arguments against the long-term effectiveness of this strategy, this technique is nonetheless used on a global level to protect some of the high-priority ecosystems (Mawdsley, 2009).

2.2.2.2. Protect movement corridors, stepping stones, and refugia

Some adaptation measures focus on facilitating connections between different areas of nature. This can be achieved providing corridors or stepping stones, which are small patches of nature between two main habitats, or refugia, which are areas that are likely to be impacted less (Mawdsley, 2009).

2.2.2.3. Translocate species at risk of extinction

Translocating species involves moving animals, plants, or other organisms from one area to another. This technique is necessary because the areas where those beings live are becoming less suitable for survival. The organisms are placed within areas with better conditions for their survival (Mawdsley, 2009).

2.2.3. Coastal zones

Climate change also affects coastal areas, with sea level rise being the most obvious consequence. Additionally, as weather becomes more extreme, this can lead to events such as cyclones and storms. Sea level rise will happen even if emissions are stabilised in the next few decades and will herald a broad range of indirect effects. Some of these effects include the flooding and displacement of wetlands and lowlands, the degradation of shorelines, and the erosion of coral reefs (Klein et al., 2001). Increasing flooding during storms is an issue that countries with coastal zones must be wary of because it can have detrimental effects for both humans and nature. This is especially important because many people in the world live in these low-lying coastal zones (Jonkman, Nicholls, Kanning & Ledden, 2013). Salinisation is also an issue in areas such as estuaries or freshwater aquifers. As sea level rise is a given on a global level, almost all areas with coastal zones must adapt to that rise, and some areas will be more vulnerable than others (European Climate Adaptation Platform, n.d.-a).

2.2.3.1. Coastal defences, sea walls, and dikes

The implementation of coastal defences, sea walls, and dikes is another type of adaptation measure against sea level rise in coastal zones. These constructions have the capacity to defend areas from flooding. There can be significant variance in the specifics of construction, form, and materials of these defences. Sea walls can take the form of concrete barriers, rubble mound structures, brick or block walls, gabions, and boxes filled with rocks or sand. Besides protection from flooding, constructing these measures can have the function of erosion reduction because the blocked wave

action prevents the sliding of soil. These defences can prevent excessive damage, especially in areas where roads and buildings are in danger of falling into the sea (Kamphuis, 2010).

2.2.3.2. Enhanced drainage systems

As weather events become more extreme, drainage systems must be made more resilient. As rainfall increases, current sewer systems may not be able to adapt, resulting in the flooding of buildings and other structures. Several enhanced drainage systems exist to deal with excess water. Single drainage areas in urban areas such as roofs, streets, parking lots, or yards can help with the runoff of excessive rain if the area is sloped, rough textures or vegetation are added, and areas become paved or unpaved. Distinct surface drainage components also exist, such as street gutters which can lead runoff from the surface and underground sewer systems that use inlets. Another strategy is the increase of surface areas on surfaces such as streets, thereby allowing for an increased flow of water in case of flooding. Closed underground sewers can also be installed in urban areas, such as manholes, control structures, and outlets (Schmitt, Thomas & Ettrich, 2004).

2.2.3.3. Relocation and the creation of wetlands as a buffer against sea level rise and flooding

Wetlands can be utilised to guard against sea level rise and flooding. Wetlands such as lakes, swamps, or floodplains have the capacity to delay and store water, resulting in a reduced peak flood flow. These lakes and swamps also can improve the quality of water and detain floodwaters that are polluted. Coastal wetlands such as mangroves and reefs improve the resilience of coastal areas by alluvial plain accumulation. These wetlands also create a freshwater buffer and prevent the intrusion of saline. Wetlands within mountainous areas take the form of mountain lakes or high-altitude peat swamps. These mountainous wetlands can store precipitation and reduce the effects of melting glaciers. When extreme rainfall has passed, these wetlands can then release the water in a steady flow. The same mechanism is useful in dry areas or droughts. Wetlands can absorb water during water-rich periods and slowly release moisture during drought periods. Additionally, coastal wetlands such as mangrove forests and reefs can absorb storm power and create havens for species during those storms. The alternative source of food and building material provided by wetlands is another benefit (Wetlands International, n.d.)

2.2.3.4. Restrictive land use planning

Another adaptation strategy is taking into account climate change and its effects during planning how an area is developed. For example, the risk of flooding can be considered during the urbanisation of an area. While urbanisation may yield short-term benefits, the area may be considered dangerous for the long term if it has a high risk of flooding. Thus, the decision-making process should consider that reversing urbanisation is difficult and that any new projects should include significant preparations for flooding. Planners could therefore disallow certain types of land use (Hallegate, 2009).

2.2.3.5. Insurance, warning and evacuation schemes

Climate change can induce severe economic losses. Insurance can therefore be considered as a strategy. The precise arrangement of the insurance can differ, because insurance can come from both private actors and the government. Both forms of insurance have their own benefits and drawbacks (Botzen & Van Den Bergh, 2008).

Before insurance is necessary, other ‘soft’ measures can be applied to prevent or reduce the losses in the first place. These measures include the implementation of warning systems or evacuation schemes. Warning systems could be implemented in all kinds of circumstances, such as in areas close to flood-prone rivers or in case of heat waves. As technology advances, forecasts can become more

precise, and events further in the future can be predicted (European Climate Adaptation Platform, n.d.-b).

2.2.3.6. Relocation and retreat

Settlements or activities can be relocated or retreat in areas where floods, sea-level rises, or storms become more problematic. This is especially prevalent in coastal areas. Another approach is to compensate the original inhabitants or owners for their risk and the threat to their property. The strategy of relocation and retreat can be combined with the strategy of insurance; the money retrieved from insurance can be used to relocate the settlements (European Climate Adaptation Platform, n.d.-c).

2.2.3.7. Creation of risk analysis institutions and long-term plans

Climate change risk analysis institutions assess the consequences of climate change, the likelihood of certain scenarios, and the potential responses to the local effects of climate change. These institutions assess the likelihood of risk and the significance of the consequences. Based on these assessments, long-term plans can be made to deal with the risks and consequences (Adger, Brown & Surminski, 2018).

2.2.4. Health and housing

Health and housing can be affected by extreme weather such as higher temperatures, flooding, droughts, and storms. The literature has demonstrated mortality increases due to colder and hotter temperatures. People in hotter cities are more vulnerable to colder temperatures and vice versa. Poor housing can contribute to a higher death rate when homes fail to protect against the cold. Temperature changes are more likely to affect health in urban environments than in non-urban areas. Flooding comes with obvious dangers to health. Many settlements and an increasing amount of arable land are at risk of flooding. This flooding will have a multitude of effects on health, including injuries, exposure to toxic pollutants, malnutrition, or mental health disorders. Climate changes such as temperature variations, population migration, and low or high rainfall can increase the spread of infectious diseases (McMichael, Woodruff & Hales, 2006).

2.2.4.1. Air conditioning or insulation

Extreme heat exposure can create adverse health effects that disproportionately affect the elderly, those living alone, and people without access to air conditioning. Thus, installing air conditioning can be an adaptation technique to extreme heat events, especially in assisted-living or retirement communities (Luber & McGeehin, 2008; McMichael, 2006).

The same can be said about insulation. Besides using insulation as a mitigation measure to reduce the use of energy, insulation can improve structure resistance to temperature, wind, and precipitation (Insulation Outlook, 2013).

2.2.4.2. Climate proofing new and old buildings

Constructing new buildings entails an opportunity to make offices and houses that use less water and energy and are resilient against extreme weather. Several options are possible. For example, greenery on facades, roofs, and gardens can absorb excess rainwater during floods, while white-reflecting facades and insulated roofs, windows, and walls can protect against hotter temperatures. Systems of underground polyvinyl chloride (PVC) pipes can blow air and cool houses, and water-saving taps or showers can be installed when water is scarce. Small adjustments include the construction of reservoirs or the heightening of door thresholds, and more drastic changes include the construction of floating villas (Change Magazine, n.d.)

2.2.4.3. Research and development (R&D) on vector control and vaccines

Developing vaccines is a priority for response to a possible increase in epidemics due to climate change. Vaccine development is also key for vector control. Research, development, and implementation of these vaccines and vector control methods are important strategies for the health-related angle to climate change adaptation (World Health Organization, 2016).

2.2.4.4. Improvements on public health systems

It is also essential to develop the entire public health system to deal with the health-related effects of climate change. Prevention is a key component of this strategy. Primary prevention entails trying to prevent the onset of injury or illnesses. Examples include immunisation measures or campaigns to quit smoking or that promote the use of bicycle helmets. Secondary prevention attempts to diagnose diseases early so they can be controlled or cured early, thereby improving health and reducing the burden on the health system. Some examples of a secondary prevention include screening for hypertension or breast cancer. Tertiary prevention is necessary after diseases are diagnosed and aims to reduce morbidity or complications and improve function. Another component of the public health strategy consists of preparedness. Professionals need to be prepared for climate-related events such as the emergence of old or new infectious diseases and the aftermath of events such as earthquakes and hurricanes (Frumkin, Hess, Luber, Malilay & McGeehin, 2008).

2.2.4.5. Urban spatial planning for density and greenery

The density of people living in urban areas influences a city's functioning. The urban heat island (UHI) effect can be felt in urban areas. This effect describes when urban areas are warmer then the surrounding rural areas. Thus, although dense cities can be suitable for mitigation purposes regarding climate change, those cities may not be resilient for adaption to climate change. Measures such as spatial planning can reduce the UHI effect. These measures include planning for moderate density and greenery, which seems to be most effective. Greenery cools down through evapotranspiration, re-radiates less heat than buildings, and provides shades. Thus, it is possible to develop and order urban infrastructure to account for climate change during urban planning (Hamin & Gurran, 2009).

2.2.5. Water resources

Climate change can put pressure on the world's water resources. Climate change will likely result in an increase in water demand and a decrease in water supply in certain areas. Warmer temperatures may influence the rate of evaporation, leading to drought in some areas while causing excess precipitation in others. Additionally, rising temperatures will mean that people and animals need more water. Water is needed to remain healthy, produce agricultural products, keep cattle alive, or support the production of energy at power plants. It can be a challenge to providing enough water for these activities in a changing climate.

Some events can also influence the quality of water and make it unsuitable for use. Flooding or runoff can introduce pollutants, trash, or animal waste into rivers and lakes, reducing the quality of the water. Also, sea level rises can introduce salt into freshwater. This problem becomes aggravated when humans remove more freshwater because saltwater can move upstream. Reduced water quality means that users must retrieve their freshwater elsewhere or invest in the implementation of desalination mechanisms. Many sectors need freshwater, such as energy production, infrastructure, human health, agriculture, and ecosystems. Thus, it is especially important for freshwater resources to adapt to climate change (EPA, n.d.-c).

2.2.5.1. Institutionalisation of long term perspective

Multiple activities depend on freshwater resources, and multiple sectors have an impact on these resources. The effects of current activities will be felt in the long term, which is why it is important to

manage these sectors with the long-term perspective in mind. Planning for the long-term horizon strengthens the ability to quickly deal with problems because those problems are already anticipated. Institutionalisation of the long-term perspective includes considering different future scenarios and creating strategies to address them (Hallegate, 2009).

2.2.5.2. Loss reduction (leakage control)

To minimise water shortages, water must be used efficiently. Thus, it is important to ensure that water losses occur as infrequently as possible and that no water is wasted through leaks. Leakage can occur at several stages within the water system: the intake process, the water pipelines, the storage reservoirs, and the pumps. Factors that cause water leakage include the pressure in the mains, the instability of soil, corroded water pipelines, poor quality of fittings, and the age of components. Preventive measures should be implemented to address these risks. Preparations can help adapt to climate change and thus minimise water leakage. This includes creating and updating maps and databases of water demand and supply. Useful information for those maps and databases includes the location of water connections, user locations, water mains, valves, and fire hydrants. Once this information is known, tests can be performed to identify losses or defects. Repairs can then be executed. It is necessary to constantly reassess these systems to keep losses to a minimum. This may require the implementation of procedures and standardised activities and building a knowledge and skills base (SSWM, 2018).

2.2.5.3. The expansion of rainwater harvesting

Rainwater harvesting has a dual purpose. Rainwater harvesting has the capacity to store water for dry periods, and the rainwater collection mechanisms can also be used to store water in times of heavy rainfall, thus reducing water stress. Rainwater harvesting can exist in different forms. Individual systems can be used in single houses, and larger systems also exist for buildings such as sport arenas or apartment blocks. These all have a storage component and a catchment component that is usually sited on roofs. Some systems have a treatment component such as filters or disinfection mechanisms. Lower-grade water can be used for irrigation of gardens and landscapes or for toilet flushing and laundry washing (Hofman & Paalman, 2014).

2.2.5.4. Demand control and water reuse

Lifestyle changes can also be a part of the water-focused adaptation to climate change. Demand control focusses on managing consumption by postponing or avoiding the need to develop new water resources. Policies can be implemented to achieve more efficient water use by all members of society. These measures can take varying forms: making temporary or permanent restrictions on the amount of water to be used, creating incentives to implement certain water-saving installations, and the adjustment of pricing mechanisms or regulations pertaining to the use of more water-efficient appliances (Pacific Community, n.d.)

Water reuse is a way to reduce the pressures on water resources by influencing demand. Collected wastewater can be treated and reused for all kinds of purposes. Just like rainwater harvesting, untreated wastewater can be used for toilets, laundry, and gardens (European Climate Adaptation Platform, n.d.-d).

2.2.5.5. Storage capacity increase

Storing water helps to reduce the risk of inadequate water in dry periods. Storage constructions can consist of dams, natural wetlands, water stored in soil, or rainwater harvesting ponds. Depending on the local environment, the relevant needs and possibilities, and the extent of physical water storage, these reservoirs can take a different form or size (International Water Management Institute, 2009).

2.2.5.6. Desalination and water transport

Salination of freshwater is aggravated by climate change. To make salt water useable for a multitude of purposes, desalination is required. This is the process of removing salt from sea or brackish water. Besides the desalination of water, desalination can also address water scarcity problems. Desalination can be electrically driven or thermally driven, and each style has further sub-techniques (European Climate Adaptation Platform, n.d.-a).

Water transportation also falls into the category of measures that address scarcity problems. Water can be transported from water-rich areas to water-scarce areas through canals and pipelines or by containers or tugboats.

2.2.6. Energy

Climate change also affects the energy sector. As temperatures rise, different areas require more cooling and air conditioning, while less energy for heating will be required. In warmer months, electricity demand may peak, which the energy system must supply. Additionally, because the energy production of fossil fuels and nuclear power plants uses water for cooling, a rise in temperature may reduce the efficiency of these plants. This because cooler water leads to more efficient generation. Because climate change makes water scarcer, the energy sector may be affected. Power plants need large amounts of water, and the combination of a decrease in water availability and an increase in the demand for electricity is problematic. Also, as the need for water increases, energy-intensive methods must be developed to provide drinking and irrigation water. Hydroelectric power plants can also be sensitive to fluctuations in water flows (EPA, n.d.-b).

2.2.6.1. Nuclear plant cooling system

As mentioned earlier, power production of some fossil fuels and nuclear power plants require significant amounts of water. This water is used for cooling the system. As temperatures rise, the amount of water will also rise. Planners can increase water use to keep up with the demand or stop or slow down plans for power plants (EPA, n.d.-b).

2.2.6.2. Reduce the dependence on single sources of energy

Diversification of the energy sector is another possible strategy to make the energy sector more resilient. This can be achieved by expanding to other energy systems such as geothermal, solar, or biogas production. This makes the energy production less vulnerable when sources become nonviable (Parry & Terton, n.d.)

2.2.7. Tourism

The tourism sector can also take a hit from climate change. Climate change can have an impact on parts of the natural environment that tourism is dependent on, such as mountain regions, beaches, or coasts. Temperature changes can alter tourist locations, which can be detrimental for those whose livelihoods are dependent on tourism; other areas may experience increases in tourism if those areas are deemed to be more suitable locations for travel. Islands and developing countries with a large tourism sector feel this effect (UNWTO, n.d.)

2.2.7.1. Diversify tourism attractions and revenues

It can be useful to diversify the tourist industry if climate change will have a significant effect on tourism. This can be achieved by shifting to activities that are suitable for the changing climate or towards different sectors that can be expanded. Economic diversification will improve the resilience of an economy and ensure employment in the long run (UNDP, n.d.)

2.2.7.2. Shift ski slopes to higher altitudes and glaciers or make artificial snow

For countries where the tourism sector is dependent on ski vacations, there may be a need to shift ski slopes to higher altitudes and glaciers once snow reliability declines in lower areas. Another option is to create artificial snow to properly cover the slopes so that services can be maintained (Beaudry, 2018).

2.2.8. Transport

Transport is vital for the functioning of societies and economies. Rising temperatures, flooding, sea level rises, or extreme weather events may pose a significant threat to the transport system. Issues such as rail buckling, crackling, or deterioration of pavements can result, but temperature rises can also create discomfort for travellers who must deal with the heat. Some weather events can lead to short- and long-term disturbances due to repairs or detours (European Environment Agency, 2014).

2.2.8.1. Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage

To deal with the above issues, planners can improve standards for transport infrastructure to be more resilient to the influence of climate change. Infrastructure such as roads, rail tracks, bridges, and ports can be designed to resist the elements or be easily repaired (European Environment Agency, 2014).

2.2.9 Synthesis adaptation measures

Chapter 2.2 has identified a multitude of adaptation measures from the literature within different sectors. The following table is an overview of the measures and the sources that those measures are derived from:

Table 1: Adaptation measures per sector: an overview

Sector	Measure	Reference
Agriculture	Developing crop insurance	Hallegate, 2009; Insurance Information Institute, n.d
	Irrigation (possible with water storage and transport)	Woznicki et al., 2015; Fischer et al., 2007
	Forestry with shorter rotation time/afforestation/reforestation	Akinnagbe & Irohibe, 2014; Verschot et al., 2007
	Development of resistant crop	Khraiwesh, 2016
	Adjustment of planting dates and crop variety	Akinnagbe & Irohibe, 2014
Ecosystems and biodiversity	Preserve or increase extent of protected areas	Mawdsley, 2009
	Protect movement corridors, stepping stones, and refugia	Mawdsley, 2009
	Translocate species at risk of extinction	Mawdsley, 2009
Coastal Zones	Coastal defences/sea walls/dikes	Kamphuis, 2010
	Enhanced drainage systems	Schmitt, Thomas & Ettrich, 2004
	Relocation and the creation of wetlands as a buffer against sea level rise and flooding	Wetlands International, n.d.

	Restrictive land use planning	Hallegate, 2009
	Insurance, warning, and evacuation schemes	Botzen & Van Den Bergh, 2008; European Climate Adaptation Platform, n.d.-b
	Relocation and retreat	European Climate Adaptation Platform, n.d.-c
	Creation of risk analysis institution and long-term plans	Adger, Brown & Surminski, 2018
Health and housing	Air conditioning/insulation	Luber & McGeehin, 2008; McMichael, 2006; Insulation Outlook, 2013
	Climate proofing new and old buildings	Change Magazine, n.d.
	R&D on vector control and vaccines	World Health Organization, 2016
	Improvements of public health systems	Frumkin et al., 2008
	Urban spatial planning for density and greenery	Hamin & Gurran, 2009
Water Resources	Institutionalisation of long term prospective	Hallegate, 2009
	Loss reduction (leakage control, etc.)	SSWM, 2018
	The expansion of rainwater harvesting	Hofman & Paalman, 2014
	Demand control and water reuse	Pacific Community, n.d.; European Climate Adaptation Platform, n.d.-d
	Storage capacity increases	International Water Management Institute, 2009
	Desalination and water transport	European Climate Adaptation Platform, n.d.-a
Energy	Nuclear plant cooling system	EPA, n.d.-b
	Reduce dependence on single sources of energy	Parry & Terton, n.d
Tourism	Diversify tourism attractions and revenues	UNDP, n.d.
	Shift ski slopes to higher altitudes and glaciers and make artificial snow	Beaudry, 2018
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage	European Environment Agency, 2014

2.3. Potential effects of adaptation measures

2.3.1. Agriculture

2.3.1.1. Crop insurance

Natural disasters hit hard and may cause heavy losses to farmers and forest owners. Insurance can assist to manage these losses, and crop insurance is especially geared to covering losses from

adverse weather and similar events that are beyond the control of growers. As this measure is financial, it will have no physical effects on water and nature (Roberts, 2005).

2.3.1.2. Irrigation (possible with water storage and transport)

Water must be extracted to conduct irrigation. Extraction can occur from rivers, lakes, groundwater, or surface runoff. However, this means that water is being reduced elsewhere, which influences the way water flows within an area. In some cases, irrigation means more evaporation or a reduction in waterflow in downstream rivers. Extracting water from groundwater can increase or decrease the groundwater level. This is because recharge is spurred on in the area and more water begins to flow.

Bringing up water from lower levels can also cause salination. When an area has been irrigated, more moisture can be released in the atmosphere, changing the circulation and increasing downwind rainfall. Rain may end up in different areas from where the irrigation had taken place. Irrigation may cause the forming of shallow clouds, thereby altering the local climate. Thus, irrigation can have a tremendous effect on how water circulates within an area and on regional water balances. Irrigation can change the character of the local climate and water cycle and affect areas with freshwater nature (Leng, Leung & Huang, 2017; Qjan, Huang, Yang & Berg, 2013).

2.3.1.3. Forestry with shorter rotation time, afforestation, and reforestation

The phenomenon of short rotation forestry (SRF) consists of growing crops to be used in power stations to create energy. Short rotation forestry can pose several threats as well as benefits to freshwater nature. The same goes for afforestation or reforestation, depending on the methods and local context. Short rotation forestry, afforestation, and reforestation can create opportunities for restoring water. For example, planting certain plants can mitigate pollution in the area and form a barrier that prevents matter from agriculture or urban areas from travelling to water streams. It should however be noted that some crops have high-water use, such as conifer or broadleaved crops such as eucalyptus. These crops can have a significant impact on the local water sources and thus impact significantly impact freshwater nature. Conversely, other crops can benefit the same water resources. As different crops have different qualities, this can mean that choosing certain species can cause a trade-off for biomass yield when used for SRF purposes, carbon storage, water quality or water use. Factors such as location and scale also play a role. Thus, the effect of measures such as SRF, afforestation, and reforestation can go both ways (McKay, 2011).

2.3.1.4. Development of resistant crops

The impact of the environment of a crop depends on the crop's traits and characteristics rather than the technology that was used to develop the crop. This applies whether the crop was genetically modified (GM) or whether any of its traits were obtained through GM technology. Thus, it is difficult to be definitive on whether the development of resistant crops influences freshwater nature. Opportunities can arise though the development of GM crops. Some crops are designed to decrease water use. It is possible to select characteristics such as increased rate of photosynthesis, depth of root structure, or decreases in water lost through transpiration. As less water is needed for food production when using these crops, this relieves the pressure on water resources and on local freshwater nature. Other GM crops make it possible to increase the yield per acre. This however can come at the cost of higher inputs such as fertiliser, water, or weed control, which can put higher pressure on water resources and freshwater nature (Zhang, Wohlhueter & Zhang, 2016).

2.3.1.5. Adjustment of planting dates and crop variety

Yang et al. (2015) have argued that rotating different crops on the same land could be beneficial by ensuring food security for farmers and reducing the over-exploitation of groundwater. Crop diversification should reduce the need for external inputs such as pesticides, fertilisers, and water. As

has been discussed above, irrigation has the capacity to change the water cycle for the worse. Hence, reducing the need to irrigate may have a positive effect on freshwater nature (Meynard et al., 2013).

2.3.2. Ecosystems and biodiversity

2.3.2.1. Preserve or increase extent of protected areas

One potential measure to safeguard ecosystems and biodiversity is to preserve or increase the extent of protected areas. As the goal of protected areas is to keep nature safe, this measure is highly beneficial for ensuring the quality of freshwater nature (Mawdsley, 2009).

2.3.2.2. Protect movement corridors, stepping stones, and refugia

Movement corridors, stepping stones, and refugia are made to preserve nature. These constructions allow wildlife to move between habitats, which has a positive effect on ecosystems and biodiversity. Freshwater nature also benefits from this positive effect. In addition, the literature does not discuss any negative effects from the construction of movement corridors, stepping stones, and refugia. Thus, this measure has an overall positive effect on freshwater nature (Mawdsley, 2009).

2.3.2.3. Translocate species at risk of extinction

When some key species go extinct, these species can be translocated to restore the ecological function of an ecosystem. This process can be expensive and complicated but also useful because ecosystems can be dependent on these species. It is important to realise, however, that precautions must be taken because this process can be counterproductive. When native species are introduced in areas where they do not normally live, this can disturb ecosystems and introduce disease organisms (Souty-Grosset & Grandjean, 2009).

2.3.3. Coastal zones

2.3.3.1. Coastal defences, sea walls, and dikes

The construction of coastal defences, sea walls, or dikes can have a major impact on the surrounding area. These impacts can arise in different ways whether hard and soft engineering techniques are used. During construction, material deposits on the site change the environment in an obvious way. The imported material alters the area and can in some cases contain material that is poisonous to the local species. Material is removed from the seashore during steepening slopes (Jahangirzadeh, Akib, Kamali, Shamsudin, & Kimiaei, 2012). According to Martin et al. (2005), coastal defence structures create changes that are usually negative, particularly on the landward side. Even though small ecosystems are created on the structures and are often inhabited by organisms, natural shores are usually already occupied by different plants and animals and often in higher numbers (University of Exeter, 2010). Thus, when creating coastal defences, sea wall, or dikes, their likely effect on freshwater nature should be considered.

2.3.3.2. Enhanced drainage systems

The effect of drainage systems depends on the types of systems that are used in the local context. When drainage systems allow flooding to occur, this can result in pollution of the environment. Flooding can also lead to the contamination of groundwater sources. Some drainage systems, however, use a system that collects, stores, and cleans water before it is released into the environment. These systems only have a positive effect on the drainage system. Thus, depending on the drainage system used, freshwater nature can be affected in both ways (Nijhuis Industries, n.d.)

2.3.3.3. Relocation and the creation of wetlands as a buffer against sea level rise and flooding

Wetlands have a dual function. On one hand, they create habitats for animals like birds or mammals, which means that the wetlands have a positive effect on freshwater nature. This can be especially beneficial in urban areas where wildlife habitats can be scarce. On the other hand, constructed

wetlands can be used to treat water. This water can originate from surfaces, municipal wastewater, or mine drainage. This means that water in the constructed wetlands can be unclean. Some of the substances, such as suspended solids and nitrogen compounds, can be partially removed by wetlands. Phosphorus removal can be more difficult. Wetlands accumulate pollutions that thrive in solids such as heavy metals, some organic pollutants, and certain types of phosphorus. Thus, constructed wetlands may become waste disposal sites that are detrimental for the environment around them (Heathcote, 2000).

2.3.3.4. Restrictive land use planning

Combing water management regulation and land use planning is a way to protect water resources. Thus, this measure has the capacity to become a win-win situation where planning can be used for adapting to climate change as well as safeguarding freshwater nature. However, this situation is highly dependent on the quality of planning (Angelo, 2000). If land use planning takes freshwater nature into account, there will be a beneficial effect; otherwise, negative effects may result.

2.3.3.5. Insurance, warning, and evacuation schemes

As insurance measures are merely financial, they will have no physical effects on freshwater nature. The same goes for warning and evacuation schemes (Roberts, 2005).

2.3.3.6. Relocation and retreat

Retreat or relocation of settlements, infrastructure, and productive activities due to high exposure to risks such as flood, sea-level rises, and storm surges do not influence freshwater nature. This is dependent on where the settlements are relocated and whether freshwater nature must give way for the relocation (European Climate Adaptation Platform, n.d.-c). Hence, planning that factors in freshwater nature is necessary.

2.3.3.7. Creation of risk analysis institution and long-term plans

Institutionalising and planning for the long term with regard to identifying and anticipating effects of climate change can be beneficial for freshwater nature if it is factored into those risk analyses and long-term plans (Adger, Brown & Surminski, 2018). Thus, this measure can affect freshwater nature both positively and negatively.

2.3.4. Health and housing

2.3.4.1. Air conditioning or insulation

Both air conditioning and insulation influence CO2 levels. While manufacturing and running air-conditioners contribute to greenhouse gases, insulation usually decreases CO2 emissions (Holzer, 2017). Nature is influenced by CO2 levels; some plants flourish with higher CO2 levels, but some others lose quality, and some pests and fungi can also thrive with a rise in CO2 levels. However, it is difficult to make a connection between an increase in air conditioning or insulation and a change in freshwater nature in the local context. Hence, it is difficult to identify a link between this measure and the effect on freshwater nature (EPA., n.d.-a).

2.3.4.1. Climate proofing new and old buildings

Climate proofing new and old buildings does not interact with freshwater nature. Thus, the measure does not have a positive or a negative effect (Change Magazine, n.d.)

2.3.4.2. R&D on vector control and vaccines

Research and development on vector control and vaccines does not harm freshwater nature directly, but the use of insecticides can have a negative impact. Water, air, and soil can contain toxic residues and non-targeted animals can be harmed by the insecticides as well. Biodiversity can be seriously harmed by excessive use of pesticides. Thus, while pesticides may be important for adapting to

climate change within the health sector, it should be noted that freshwater nature may be seriously affected when certain insecticides are used to control vectors (Ansari, Moraiet & Ahmad, 2017; Marcombe et al., 2011).

2.3.4.3. Improvements on public health systems

The health care sector is energy-intensive. Energy is used for all kinds of activities, such as heating and cooling within hospitals, medical and laboratory equipment, and manufacturing pharmaceuticals and medical devices. Additionally, some industrial activities that support the health care sector cause pollution in air, water, and soil. Thus, improvements in the health care system most likely increase these kinds of emissions (Eckelman & Sherman, 2016). However, just like implementing air conditioning, it can be difficult to trace emissions back to the local context of freshwater nature. Thus, it is difficult to establish how freshwater nature is influenced by improvements in the public health system.

2.3.4.4. Urban spatial planning for density and greenery

Greenery within urban areas has the capacity to provide important environmental services. Air and water can be purified, and wind and noise can be filtered. As this measure creates small areas of freshwater nature that sometimes contain water, it has a positive effect on freshwater nature (Chiesura, 2004).

2.3.5. Water resources

2.3.5.1. Institutionalisation of long term perspective

Institutionalising the long-term perspective means that planners must think ahead by several decades and consider freshwater nature into their plans (Hallegate, 2009). If planners fail to do so, freshwater nature will be at risk of long-term neglect. Thus, inclusion in plan-making is crucial for safeguarding natural water. This measure can both be positive and negative for freshwater nature.

2.3.5.2. Loss reduction through measures such as leakage control

Loss reduction and more efficient use of water means that less water will be needed from water resources. If less water is extracted from rivers, lakes, or the ground, the natural water cycle will be less disturbed (Danish EPA, n.d.) Thus, treating water more efficiently keeps natural water intact, making it a win-win measure that adapts to climate change and safeguards freshwater nature.

2.3.5.3. The expansion of rainwater harvesting

The expansion of rainwater harvesting also promotes the efficient use of water and lessens the need to extract from water resources. Additionally, when rainwater is harvested at the surface with a system of rainwater infiltration, this can be beneficial for water quality, biodiversity, and vegetation (Khoury-Nolde, 2016). This causes the measure to have a positive effect on freshwater nature.

2.3.5.4. Demand control and water reuse

Using water efficiently by reducing demand and reusing water relieves pressure on water sources. Most alternative sources of water supply result in more energy use because desalination or water transfers are energy-intensive (European Commission, n.d.) However, it is difficult to establish the overall effect of lower energy consumption on freshwater nature. In general, however, the measure ‘demand control and water reuse’ can be categorised as positive for freshwater nature.

2.3.5.5. Storage capacity increase

Storage constructions can take different forms. Constructions such as dams, natural wetlands, and water stored in soil or rainwater harvesting ponds can impact freshwater nature positively or negatively depending on the specific measure used. Some storage capacity constructions such as dams can change the downstream river flow and water quantities, thereby significantly altering the

character of freshwater nature. Dams can divide water movement and act as a barrier to animals traveling through the river. The transportation of sediment is altered, stopping the creation of some forms of freshwater nature such as river deltas or braided rivers (Kantoush, Sumi, Kubota & Suzuki, 2010). However, although the environmental effect of storage capacity constructions can be detrimental for freshwater nature, some versions of storage construction such as rainwater harvesting ponds do not have these kinds of effects on freshwater nature and can lead to more efficient use of water (Khoury-Nolde, 2016). Planners should consider the varying effects of increasing storage capacity when trying to adapt to climate change because the effect can vary from positive to negative.

2.3.5.6. Desalination and water transport

Desalination processes and water transport cost significant amounts of energy. Thus, processes like these are both reactions and contributors to global warming. It is unclear what that means in the local context of freshwater nature is unclear. Desalination can impact water in oceans because the desalination systems vacuum up ocean water and kill organisms such as plankton, fish eggs, and larvae. However, this effect mainly occurs in marine environments, so freshwater nature is not harmed (Miller, Shemer & Semiat, 2015).

2.3.6. Energy

2.3.6.1. Nuclear plant cooling system

Water is needed to cool nuclear plant systems. This means that a reduction in water resources has effects for the aquatic environment, including fish. Processes related to nuclear plant cooling systems can kill fish, eggs, and larvae that travel though the cooling systems. Additionally, the increased temperature of discharged water disrupts the ecosystem when released back into the water resource. Some solutions can be implemented to mitigate some of these effects, such as the implementation of fish screens. Planners must invest in these solutions and consider the importance of safeguarding freshwater nature (Kotak, 2015).

2.3.6.2. Reduce the dependence on single sources of energy

The effects of this measure depend on the alternative energy source. For example, implementing wind power facilities poses a risk to wildlife, especially birds and bats, and thus impacts freshwater nature when placed close to these areas. Large utility-scale solar facilities or biomass power plants need space, and freshwater nature may have to give way. Additionally, some technologies of solar photovoltaics (PVs) and geothermal power plants need a considerable amount of cooling water that is sometimes retrieved from freshwater sources. As the manufacturing process of solar PVs includes hazardous materials, manufacturers need to dispose of them properly or they will end up in freshwater nature.

Hydroelectric dams take up significant land space and can have major impacts on aquatic ecosystems. Dams can affect organisms, alter landscapes downstream, or lead to excessive algae or aquatic weeds. It is important to make sure that enough water is passed through because downstream ecosystems can dry out, which will have deleterious consequences. Thus, the consequences of diversifying energy sources are highly dependent on the kind of technology implemented and the way that technology is executed (Union of Concerned Scientists, n.d.)

2.3.7. Tourism

2.3.7.1. Diversify tourism attractions and revenues

Some forms of tourism can pressure on freshwater nature. Hotels, swimming pools, golf courses, and other uses of water by tourists all increase the demand for water. This in turn increases the need to extract from freshwater sources and to generate wastewater. Wastewater disposal can pollute lakes

or other water resources. Increasing tourism can cause land clearing and construction to occur in places where freshwater nature exists. Tourism can also degrade ecosystems when they become popular visiting sites. Wetlands, lakes, or rivers can be threatened by activities in the area. Thus, diversifying tourism can benefit freshwater nature if tourist activities are steered away from these areas; otherwise, they may be detrimental if tourism is instead moved to the area (GDRC, n.d.)

2.3.7.2. Shift ski slopes to higher altitudes and glaciers or making artificial snow

Although shifting ski slopes to a higher altitude does have other negative effects, freshwater nature is not harmed or benefited in the process. However, making artificial snow can be detrimental because it requires high volumes of water. Higher demand means that water must be pumped from surrounding lakes, rivers, or ponds (Beaudry, 2018).

2.3.8. Transport

2.3.8.1. Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage

Although establishing infrastructure can have a negative effect on natural freshwater, making infrastructure resilient against the effects of climate change does not have an additional impact (Trocmé et al., 2003).

2.3.9. Synthesis of potential risks and benefits

This chapter retrieves information on the different kinds of adaptation measures that were identified within literature and the effect of those measures on freshwater nature. This information has contributed to an assessment framework that can be found in the following table. The table includes possible adaptation measures, their effect on freshwater nature, and the relevant sources.

Table 2: Potential effects of adaptation measures on freshwater nature: an assessment framework

Measure	Effect	Reference
Agriculture		
Developing crop insurance	Financial measure without effect on freshwater nature	Roberts, 2005
Irrigation (possible with water storage & transport)	Irrigation can have a tremendous effect on water cycles, which may alter freshwater nature	Leng et al., 2017; Qjan et al., 2013
Forestry with shorter rotation time/afforestation/reforestation	The effect of this measure can be positive as well as negative depending on the type of crops and methods used	McKay, 2011
Development of resistant crop	Effects depend on the specific crop. However, opportunities exist for developing water efficient crops, benefiting freshwater nature	Zhang et al., 2016
Adjustment of planting dates and crop variety	Reduces the need to irrigate, which ultimately benefits freshwater nature	Yang et al., 2015; Meynard et al., 2013
Biodiversity and ecosystems		
Preserve or increase extent of protected areas	Directly safeguards areas with freshwater nature	Mawdsley, 2009
Protect movement corridors, stepping stones, and refugia	Benefits ecosystems and biodiversity and is positive for freshwater nature	Mawdsley, 2009

Translocate species at risk of extinction	Depending on the species introduced, this can both benefit or disturb freshwater nature	Souty-Grosset & Grandjean, 2009
Coastal Zones		
Coastal defences/sea walls/dikes	Coastal defences alter the environment around it in a major way, usually negative for freshwater nature	Jahangirzadeh et al., 2012; Martin et al., 2005; University of Exeter, 2010
Enhanced drainage systems	Depending on the type of system used, effects on freshwater nature can go both ways	Nijhuis Industries, n.d.
Relocation and the creation of wetlands as buffer against sea-level rise and flooding	Depending on the way wetlands are utilised, effects can vary from positive to detrimental	Heathcote, 2000
Restrictive land-use planning	Depending on the quality of planning, this can benefit or harm freshwater nature	Angelo, 2000
Insurance, warning, and evacuation schemes	Does not affect freshwater nature	Roberts, 2005
Relocation and retreat	Depending on where is relocated to, this either has no effect or a negative effect	European Climate Adaptation Platform, n.d.-c
Creation of risk analysis institution and long-term plans	Creates opportunity to benefit freshwater nature, but can go both ways	Adger, Brown & Surminski, 2018
Health and housing		
Air conditioning/insulation	Unclear effects of heightened or lowered CO2 levels because of air conditioning and insulation on local freshwater nature areas	Holzer, 2017; EPA., n.d.-a
Climate proofing new and old buildings	Does not interact with freshwater nature and has a neutral effect	Change Magazine, n.d.
R&D on vector control, vaccines	Insecticides may seriously affect freshwater nature	Ansari et al., 2017; Marcombe et al., 2011
Improvements on public health systems	Unclear effect of emissions related to the public health sector on the quality of freshwater nature	Eckelman & Sherman, 2016
Urban spatial planning for density and greenery	Measure creates small patches of freshwater nature and thus has a positive effect	Chiesura, 2004
Water Resources		
Institutionalisation of long term perspective	Effects depend on whether planners include freshwater nature in long-term plans	Hallegate, 2009

Loss reduction (leakage control, etc.)	Treating water efficiently reduces pressure on water sources and benefits freshwater nature	Danish EPA, n.d.
The expansion of rainwater harvesting	Treating water efficiently reduces pressure on water sources and benefits freshwater nature	Khoury-Nolde, 2016
Demand control and water reuse	Treating water efficiently reduces pressure on water sources, benefiting freshwater nature	European Commission, n.d.
Storage capacity increase	Different storage capacity constructions have varying effects on freshwater nature, from the positive to the detrimental	Kantoush et al., 2010; Khoury-Nolde, 2016
Desalination and water transport	Freshwater nature is not harmed by this measure; the effect of heightened CO2 use is unclear	Miller, Shemer & Semiat, 2015
Energy		
Nuclear plant cooling system	There are solutions to the effects of these systems on freshwater nature, but they must be invested in; effects therefore vary from negative to neutral	Kotak, 2015
Reduce the dependence on single sources of energy	Consequences are highly dependent on the kind of technology and the implementation style	Union of Concerned Scientists, n.d.
Tourism		
Diversify tourism attractions and revenues	Depending on where tourism is diversified, effects can be negative or positive	GDRC, n.d.
Shift ski slopes to higher altitudes and glaciers or making artificial snow	Artificial snow requires extraction from water sources, ultimately negatively affecting freshwater nature	Beaudry, 2018
Transport		
Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage	Does not have additional effects compared to 'normal' infrastructure	Trocmé et al., 2003

2.4. Conclusion

This chapter discussed the adaptation measures in the literature and their potential effects on freshwater nature. It has been demonstrated that a multitude of measures theoretically exist within different sectors and that the effects on freshwater nature vary from negative to neutral to positive, depending on the way the method is executed. Now that it is clear which adaptation measures could be implemented, the next chapter will focus on the analysis of the 20 countries and which of the measures identified in chapter 2.2 have been applied by these countries.

3. Adaptation measures in practice: a comparison of 20 countries

3.1. Introduction

The assessment framework from the previous chapter can be applied to the 20 case studies. Paragraph 3.2. contains an overview of the application of the assessment framework to the 20 countries. This will answer the sub-question, '*Which of the identified measures are applied by the 20 countries in the Global North and Global South?*' Chapter 3.2. will provide a country-specific analysis. The assessment tables of the individual countries can be found in Appendix 1. In chapter 3.3., the results of the countries are compared, thereby answering sub-question 5: '*How do the countries compare to each other when it comes to the applied adaptation measures?*'

3.2. Overview of the results

The following table provides an overview of all measures found within the literature and the countries that have decided to include specific measures in their INDC.

Table 3: An overview of the adaptation measures addressed in the INDCs of 20 countries

	Bangladesh	Brazil	Chile	Colombia	India	Malaysia	Mexico	Nepal	Uganda	Ghana	EU	Australia	South Korea	United States	Switzerland	Singapore	Japan	New Zealand	Turkey	Canada
Agriculture																				
Developing crop insurance																				
Irrigation (possible with water storage & transport)						■	■		■											
Forestry with shorter rotation time/afforestation/reforestation	■	■			■		■	■	■		■					■	■	■	■	
Development of resistant crop	■				■	■		■	■	■						■				
Adjustment of planting dates and crop variety	■				■	■			■							■				
Ecosystems and biodiversity																				
Preserve or increase extent of protected areas	■	■		■	■		■		■	■						■			■	
Protect movement corridors, stepping stones, and refugia		■					■		■											

Translocate species at risk of extinction																				
Coastal zones																				
Coastal defences/sea walls/dikes																				
Enhanced drainage systems																				
Relocation and the creation of wetlands as a buffer against sea-level rise and flooding																				
Restrictive land use planning																				
Insurance, warning, and evacuation schemes																				
Relocation and retreat																				
Creation of risk analysis institution and long-term plans																				
Health and housing																				
Air conditioning/insulation																				
Climate proofing new and old buildings																				
R&D on vector control and vaccines																				
Improvements on public health systems																				
Urban spatial planning for density and greenery																				
Water resources																				
Institutionalisation of long term perspective																				
Loss reduction (leakage control, etc.)																				
The expansion of rainwater harvesting																				

Demand control and water reuse																				
Storage capacity increase																				
Desalination and water transport																				
Energy																				
Nuclear plant cooling system																				
Reduce dependence on single sources of energy																				
Tourism																				
Diversify tourism attractions and revenues																				
Shift ski slopes to higher altitudes and glaciers																				
Transport																				
Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage																				

3.3. Country specific analysis

3.3.1. Bangladesh

The INDC of Bangladesh includes paragraphs on mitigation and adaptation that discuss goals and the actions needed to reach these goals. Bangladesh has implemented adaptation measures in most categories of the assessment framework. The INDC goes into the specifics of adaptation measures, such as the implementation of drainage infrastructure or the installation of solar panels to diversify the energy supply of the country. Besides the fact that Bangladesh discusses adaptation measures within the INDC, the Annex contains links to specific adaptation projects and achievements. (Ministry of Environment and Forests, 2015).

3.3.2. Brazil

The INDC of Brazil consists of a section about mitigation goals, some mitigation mechanisms to reach these goals, adaptation undertakings, and a section about south-south initiatives. A section is attached to give additional information to clarify the INDC. The INDC also covers information about fairness, ambition, historical responsibilities, and equity. The document mentioned that 'Brazil considers adaptation to be a fundamental element of the global effort to tackle climate change and its effects' (Federative Republic of Brazil, 2015, p.2). This is reflected within the INDC, as the document spends more time on adaptation measures than some of the other countries, especially those countries in the Global North (Federative Republic of Brazil, 2015).

3.3.3. Chile

Though Chile has published a relatively extensive report on the national plans concerning adaptation and mitigation plans, these plans are difficult to translate to the measures mentioned in the assessment framework. This is because focus of the report is global. Chile wants to create resilience on the national, regional and municipal levels and wants to focus on identifying sources of financing and build synergies to merge mitigation and adaptation plans. Chile also wants to strengthen institutional backgrounds, create measurement and assessment tools and have an updated National Adaptation Plan. Specific measures to reach these goals are not mentioned. Besides the intended nationally determined contribution to mitigation and adaptation, much of the report is dedicated to capacity building and strengthening, technology development and transfer, and financing (Government of Chile, 2015).

3.3.4. Colombia

The report mentions that territorial and sectorial adaptation plans have been formulated in the areas of transport, housing, energy, agriculture, and health. Specifics on the form of these plans are lacking. For example, the report mentions that it prioritises '10 subsectors of the agricultural sector such as rice, coffee, livestock, and silvopastoral, with improved capabilities to adapt appropriately to climate change and variability' (Government of Colombia, 2015, p. 3). This suggests that plans are made to implement measures such as the adjustment of planting dates and crop variety, but because of the global nature of the report, this cannot be confirmed. Colombia's report emphasises more general means of implementation, such as building knowledge with the help of university networks, research groups, and innovation within the private sector. The report uses terms like 'cooperation', 'sharing knowledge', and 'working together'. Note the translation of the INDC to English that was provided on the web**s**ite is unofficial (Government of Colombia, 2015).

3.3.5. Ghana

Ghana's INDC includes an overview of the measures to be implemented regarding mitigation and adaptation. Besides an introduction and an overview of mitigation and adaptation goals, Ghana's INDC includes an overview of investment requirements, the sources of finance, and technology and capacity needs. A section is reserved for the plans regarding monitoring and views about fairness and ambition. The appendix contains a clear overview of adaptation policy actions (Republic of Ghana, 2015).

3.3.6. India

India's INDC elaborates extensively on the measures used to adapt to climate change. India's INDC includes global goals and discusses specific measures to reach these. The report also mentions financing and capacity by training and upgrading skills across sectors and working together with several parties. Notably, the significant portions of the report of India is dedicated to concepts such as fairness and equity. The introduction of the report extensively discusses the history and culture of India which is described as a basis for environmental sustainability. Ancient texts or lessons from Mahatma Gandhi are discussed. The INDC mentions for example that 'Yoga …. is a system that is aimed at balancing contentment and worldly desires, that helps pursue a path of moderation and a sustainable lifestyle.' (Government of India, 2015, p. 1) Thus, the INDC aims to show sustainability is engrained in the culture of India. The INDC of India argues it is far ahead of other countries behind in terms of following a 'cleaner' path and that developed countries should view India as an example. The INDC seems to want to show India is a leader in the field of sustainability. The concept of justice is important within the INDC, (Government of India, 2015).

3.3.7. Malaysia

The INDC of Malaysia is brief and is relatively detailed on the measures described. For example, the INDC of Malaysia mentions 'the control and prevention of dengue transmission using early test kits and community behavioural intervention as well as exploratory research on alternative medicines are among the efforts being undertaken' (Government of Malaysia, 2015, p.6). This shows not only the aim to increase vector control, but also the strategies to reach this goal. Most of the measures are focused on adaptation measures as opposed to mitigation measures. Sectors that are addressed are flood risks, water security, food security, coastlines and health. Besides adaptation, the document also describes barriers for implementation like technology costs, issues with institutional framework and capacity and legacy issues related to land use change and forestry (Government of Malaysia, 2015).

3.3.8. Mexico

Although the INDC leaves room to be more detailed when it comes to certain plans, some specific measurements can be identified. The adaption chapter of the document of Mexico is divided in a paragraph about adaptation to climate change for the social sector, ecosystem- based adaptation and adaptation of strategic infrastructure and productive systems. Capacity building, transfer of technology and finance for adaptation are also discussed. (Mexico Government of the Republic, 2015).

3.3.9. Nepal

The INDC of Nepal mostly discusses its measures on the level of general policies, strategies and frameworks. For example, plans such as the National Adaptation Programme of Action(NAPA) are discussed to address 'the most urgent and immediate needs of adaptation' as well as the National Framework on Local Adaptation Plans for Action(LAPA) to 'ensure integration of adaptation and resilience into local to national planning processes' (Ministry of Population and Environment, 2016, p. 5). However, because of the plan-oriented nature of these programmes, it is mostly not clear which specific measures are used. Thus, although the table suggests that Nepal is doing very little when it comes to adaptation to climate change, this not be truly representative (Ministry of Population and Environment, 2016).

3.3.10. Uganda

The INDC of Uganda has a very specific list of concrete measures to be undertaken for adapting to climate change. This has resulted in a clear overview about which measure within the assessment framework matches with the plans of Uganda. Uganda has proposed adaptation measures in the sectors 'agriculture', 'forestry', 'water', 'infrastructure (including human settlements, social infrastructure and transport)', 'energy', 'health' and 'risk management(particularly in urban areas)'. Thus, the adaptation measures cover a large amount of setors. (Kamuntu, 2015).

3.3.11. European Union and its member states

Countries within the European Union have not published individual INDC's. Instead, a single submission represents all 28 member states. The document is short and only covers the basics of absolute reductions, scope and coverage, a brief planning process and some goals regarding the concepts of fair and ambitions. The list of sectors indicates that some form of afforestation and reforestation will occur. However, there is no mention of adaptation measures or references to documents about adaption (Latvian Presidency of the Council of the European Union, 2015).

3.3.12. Australia

The INDC of Australia is general about its commitments to the Paris Agreement. The document contains a section that discusses its commitments regarding greenhouse gas emission reduction by

certain points in time, such as at 2030 or post-2030. The attachment summarises the targets, gases, and sectors covered. The INDC is short and does not elaborate on the specifics measures to mitigate climate change and to reach the goals mentioned. No measures regarding adaptation to climate change were mentioned in the document. Thus, no measures from the assessment framework can be identified. There was a sentence though about how Australia 'is working to build climate resilience and support adaptation to climate change'(Australia, 2015, p. 2). The document mentions thata National Climate Resilience and Adaptation Strategy is going to be developed in 2015 (Australia, 2015).

3.3.13. South-Korea

South-Korea's INDC contains information about emission reduction goals, specifics about which gasses are targeted and the sectors in which mitigation measures will be implemented. One small paragraph mentions adaptation. Though a few of the measures from the assessment framework are implemented, the INDC's list of actions South-Korea is going to take to adapt to climate change provided describes measures too general to properly fill in the assessment framework. For example, the INDC contains a sentence about the aim to 'develop a climate-resilient ecosystem' (Republic of Korea, 2016, p. 4). Which specific measures to establish this however is unknown (Republic of Korea, 2016).

3.3.14. United States of America

The INDC of the United States of America is also quite brief. Goals regarding mitigation are mentioned, such as a 26-28 % reduction below the level of 2005 by 2025. Some mitigation measures are mentioned, such as the implementation of regulations to cut down carbon pollution for new and old power plants. The INDC of the USA makes no mention of plans regarding adaptation (The United States, 2015).

3.3.15. Switzerland

The INDC of Switzerland includes information about the goals compared to the reference point, time frames, scope and coverage with respect to the types of gases and sectors. The INDC also contains information about the planning process for mitigation of climate change. Some information about methodology is provided, such as that Switzerland's goals are mainly domestic and will be achieved with partial help from carbon credits. However, adaptation is not discussed in the document (Switzerland, 2015).

3.3.16. Singapore

Singapore's INDC begins with some basic information about goals and planning processes. Next, the national circumstances are discussed, as are the advantages and disadvantages of the location and the characteristics of the country. Singapore provides information in its INDC about its adaptation challenges and efforts. This information is provided in several areas: food security, infrastructure, public health, flood risks, water security, coastline protection, biodiversity and climate modelling. The INDC provides a short and clear overview of the adaptation measures to be implemented, which allowed for the assessment framework to be filled in. (Singapore, 2015).

3.3.17. Japan

Although the INDC of Japan is more elaborate then some of the other INDC's within the Global North, the measures are exclusively about mitigation. The goals, planning process, and specific measures to be implemented to achieve those goals are discussed in detail. However, because neither adaptation nor any reference to another document or plans to include adaptation in the future are mentioned, it remains unclear whether Japan is committed to a comprehensive strategy to adapt to future climate change (Japan, 2015).

3.3.18. New Zealand

New Zealand's INDC provides information about commitments, scopes and coverage regarding mitigation. The INDC also has some information about national circumstances and emissions by sector. Fairness and ambition are also discussed in the INDC. Besides some mentions of afforestation, however, adaptation is not discussed. However, chapter 6 of the INDC refers to a document titled 'New Zealand's 6th national communication'. This document does contain information about the adaptation plans of New Zealand. Most plans involve the monitoring or mapping of the current situation and the intention of collecting information, but some specific measures can be derived from the document, such as limiting freshwater to specific users (demand control) or the prevention of rail buckling at high temperatures (resilient infrastructure) (New Zealand, 2015).

3.3.19. Turkey

Turkey briefly mentions some plans and polices to be implemented for the INDC, mostly regarding mitigation measures. The following sectors are mentioned: energy, industry, transport, buildings and urban transformation, agriculture, waste, and forestry. The only adaptation measures can be found within energy and forestry and pertain to diversification of their energy sources and afforestation. Turkey's INDC discusses the topic of fairness and ambition by stating that their country experiences some difficulties regarding finance and technology. Turkey has developed a National Change Action Plan, which the INDC references (Republic Of Turkey, 2015). The INDC mentions the 'National Climate Change Action Plan consists of emission control and adaptation policies and measures which are being implemented in all relevant sectors. (Republic Of Turkey, 2015, p.1.)'.

3.3.20. Canada

Canada's INDC also includes information of some characteristics of the country which influence the way climate change is addressed, some emission targets, covered gases, sectors, and implementation timelines. Again, no adaptation is mentioned, and no reference is made to another document that addresses adaptation measures. (Canada, 2015).

3.4 Comparative analysis

Now that the 20 countries have been analysed individually, the results of these countries can be compared to each other.

3.4.1. Overall character of the INDCs

Analysis of the INDCs indicates that there were similarities and differences in the approaches that countries have taken to writing the document. Some countries have written a relatively lengthy document; Chile wrote 30 pages. Others kept it short, such as the 5-page document of Switzerland. Generally, the INDCs were concise.

The measures were described in general terms in most of the analysed INDCs. For example, Chile mentions that it wants to 'implement specific action aimed at increasing resilience in the country (p22)' and is 'strengthening the institutional background of the adaptation in Chile (p23)'. These statements suggest an effort to implement adaptation policies. However, it is difficult to establish from the document which specific measures will be implemented to increase the resilience and strengthen the institutional background. Therefore, it has only been possible to check the boxes in the assessment framework that correspond to measures that are more focused on the planning level, such as 'creation of risk analysis institution and long-term plans' and 'institutionalisation of the long term perspective'. Most of the documents lack an overview of the detailed measures to be undertaken, which made it difficult to fill in the assessment framework.

3.4.2. Occurrence of measures in the INDCs

Of all the measures in the assessment framework, afforestation was mentioned the most; more than half of the countries included it in their INDC. Within the agriculture sector, it is notable that none of the INDCs mentioned the use of the measure 'developing crop insurance'. A considerable amount of INDCs focus on adjusting their use of crops either in terms of the kind of crop or the timing of planting.

The measure that received the most mention within the sector of 'ecosystems and biodiversity' is safeguarding the current state of biodiversity or extending protected areas. To a lesser extent, the INDCs also mentioned construction projects such as movement corridors, stepping stones, and refugia. However, the INDCs did not mention translocating species at risk of extinction.

When the INDCs mentioned coastal zones, the measures 'insurance, warning and evacuation schemes' and 'creation of risk analysis institution and long-term plans' were cited most often. All other measures within this category were mentioned by at least three countries.

Within the category of 'health and housing', the measures 'improvements on public health systems' and 'climate proofing new and old buildings' were mentioned most; six and five times respectively. Research and development on vector control and vaccines as well as urban spatial planning for density and greenery were mentioned less but were still apparent in a few INDCs. There was no mention of using air conditioning and insulation to adapt to climate change.

All measures within the sector 'water resources' were mentioned in the INDCs to some extent. Storage capacity increase was mentioned least, while the expansion of rainwater harvesting was mentioned the most. All the measures were mentioned between two to five times.

In the energy sector, three INDCs mentioned that it was necessary to reduce dependence on single sources of energy and that diversification was needed. The INDCs made no mention of a nuclear plant cooling system.

No INDCs included measures regarding the tourism sector.

Five INDCs reported the aim to design standards and planning to cope with warming and drainage for roads, rail, and other infrastructure.

3.4.3. North-South divide

Some of the documents contain more information about plans to adapt to climate change than others. The INDCs from countries from the Global South contained considerably more adaptation measures than INDCs from countries from the Global North. For example, the countries that mentioned the most adaptation measures included Bangladesh with 12 measures; Mexico with 15 measures; and Uganda mentioned 18 measures, which is the most mentions.

In contrast, the documents of countries from the Global North mostly did not contain information about adaptation measures. Some of these countries' INDCs referred to other documents to determine aims for adaptation to climate change, but many INDCs from the Global North simply do not mention adaptation plans at all. Some exceptions do exist. For example, Chile and Colombia have only written down 2 adaptation measures, while Singapore, a country in the Global North, discusses adaptation measures extensively and aims to implement 16 adaptation measures from the assessment framework.

3.5. Conclusion

This chapter analysed 20 countries in the Global North and South in terms of their application of the measures identified from the literature as well as how the results of the countries compare. While the measures mentioned in the INDCs are pitched generally, some differences can also be found. Countries in the Global North contain significantly less adaptation measures in their INDCs compared to countries in the Global South. The next chapter, titled 'Discussion and Conclusion', discusses the results of the previous chapters so that recommendations can be made for adapting to climate change while safeguarding freshwater nature.

4. Discussion and Conclusion

4.1. Introduction

Within the previous chapter it has been analysed which adaptation measures the 20 countries have included in their INDCs. Through a comparative analysis it has been found which measures are used most, less often or not at all. Also, the differences between INDCs from the Global North and Global South have been identified. This chapter contains the discussion, conclusion and suggestions for further research. The potential risks and benefits of the identified measures found are discussed, as well as the reliability of the reports and the limitations of the research. The conclusion answers the main question of the thesis. The chapter ends with suggestions for further research and suggestions for nature policy.

4.2. Discussion

4.2.1. Potential risks of the identified measures

Through the analysis of the INDCs it has been found which measures from literature are addressed by the 20 countries. An overview of these measures can be found in table 4. These measures have certain risks and benefits. Some measures can be beneficial or harmful depending on the way it is executed, while others have no effect whatsoever. As countries in the Global South have adopted more measures than countries in the Global North, the risks and benefits are overall higher for these countries as well.

Table 4: Adaptation measures addressed in the INDCs of 20 countries

Sector	Measure
Agriculture	Irrigation (possible with water storage & transport)
	Forestry with shorter rotation time/afforestation/reforestation
	Development of resistant crop
	Adjustment of planting dates and crop variety
Ecosystems and biodiversity	Preserve or Increase extent of protected areas
	Protect movement corridors, stepping Stones, and refugia
Coastal Zones	Coastal defences/sea walls/dikes
	Enhanced drainage systems
	Relocation and the creation of wetlands as buffer against sea level rise and flooding
	Restrictive land use planning
	Insurance, warning and evacuation schemes
	Relocation and retreat
	Creation of risk analysis institution and long-term plans
Health and housing	Climate proofing new and old buildings

	R&D on vector control, vaccines
	Improvements on public health systems
	Urban spatial planning for density and greenery
Water Resources	Institutionalization of long term prospective
	loss reduction (leakage control, etc.)
	The expansion of rainwater harvesting
	Demand control and water reuse
	Storage capacity increase
	Desalination and water transport
Energy	Reduce the dependence on single sources of energy
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.

4.2.1.1 Risks

Some risks of the measures found in literature have been identified. This is especially detrimental when risks are relatively high and when they are adopted by a high number of countries.

Within the agricultural sector, analysis has shown afforestation is a measure that is most often implemented. Risks of this measure include the use of certain crops or methods that use a lot of water. This is also true for the development of resistant crops, a measure adopted by quite a few countries as well, as some crops which put pressure on freshwater resources may be developed. Fortunately, the measure of irrigation is not often adopted, as it affects water cycles and alters freshwater nature negatively.

When it comes to the sector 'coastal zones', both the measures of' creation of risk analysis institution and long-term plans' and 'restrictive land use planning' can be detrimental for freshwater nature in the long term when not included in the plans. Though less often used those measures, the same attention needs to be given to the measures 'enhanced drainage system', 'relocation and creation of wetlands as buffer against sea level rise and flooding' and 'relocation and retreat', as all measures can be risky for freshwater nature, depending on the way it is executed. Choices for certain types of systems, methods or locations can all affect freshwater negatively. Most importantly in this category is to keep note that the measure about 'coastal defences, sea walls or dikes' can be detrimental to water nature. Though adopted by only a few countries, usually nature surrounding it is altered in some way. In areas with freshwater nature, planners need to take into account the impact this strategy can have and reflect on its pros and cons.

For some researched measures the effect on freshwater nature can be debated. This has been the case when it comes to improvements on public health systems, the measure mentioned most in the analysis of the countries. It is unclear how the heightened CO2 levels, caused by this measure, will play out in the local context of freshwater nature areas, but there is a possibility there are risks involved with this. It is clear though that, within the category of health and housing, it is crucial that the possible detrimental effect on freshwater nature of insecticides used for vector control is known and accounted for. Especially because this is a measure adopted by quite a few countries.

The measure planners have to be warned for within the sector ‘water resources’, as this could impact freshwater nature negatively when certain systems are chosen, is ‘the increase of storage capacity’. The same goes for ‘the institutionalization of long term prospective’. Failing to include freshwater nature means this nature is threatened for the long term. Both measures are adopted by four countries. Again, the effect of desalination processes and water transport and their accompanied heightened CO2 emissions is unclear, but could be negative.

Within the sector energy, though not used often, the measure of ‘reducing the dependence on single source of energy’ can pose a risk when techniques are used that ultimately are harmful for freshwater nature.

4.2.2.2. Benefits

As information about benefits of adaptation measures for freshwater nature is found and the analysis has shown us whether adaptation measures are adopted, opportunities as well as win-win situations for safeguarding freshwater nature can be identified.

Though the risks of the often-used measures ‘afforestation’ and ‘the development of resistant crops’ have been discussed earlier, these measures can also be beneficial for freshwater nature. As long as the right kinds of crops and methods are used, opportunities arise to address two issues at once. Within the agricultural sector, the measure of adjusting planting dates and crop variety has merely benefits, as it reduces the need for external inputs.

The findings within the sector ‘ecosystems and biodiversity’ seem to be positive for freshwater nature. The measures applied most often, which is ‘the extension or preservation of protected areas’, benefit freshwater nature directly. The measure of ‘protection of movement corridors, stepping stones and refugia’ is only adopted by a few countries, but benefits ecosystems and biodiversity, thus benefiting freshwater nature.

The measure of ‘insurance, warning and evacuation schemes’, used most often within the ‘coastal zones’ sector, has no effect of freshwater nature. It is established that all other measures within the sector ‘coastal zones’, except ‘implementing coastal defences, sea walls or dikes’ can be a risk, but also a benefit to freshwater nature. When freshwater nature is included in the decision-making process for these measures, this can create win-win situations.

As mentioned before, the effects of the measure of ‘improving the public health system’ are unclear. The possibility that this is beneficial for freshwater nature though exists. This measure seems crucial when safeguarding human health, but the unclear effects makes it difficult to give advice regarding freshwater nature. Fortunately, as the measure has been adopted by quite some countries as well, it seems that ‘climate proofing new and old buildings’ does not impact freshwater nature at all. ‘Implementing urban spatial planning for density and greenery’ is a strategy not used by many countries, but is positive for freshwater nature.

Fortunately, a lot of adaptation measures to climate change in the category of water resources do this by treating water more efficiently. The measures ‘loss reduction’, ‘the expansion of rainwater harvesting’ and ‘demand control and water reuse’ all do this. As due to this less water needs to be extracted from water resources, this benefits freshwater nature. These measures are adopted by a few countries, which means opportunities arise to be expanded. Earlier, the measures ‘institutionalization of the long term prospective’ and ‘storage capacity increase’ were characterised as risky, but when executed well these can also be beneficial for freshwater nature. In both cases, it is important to include freshwater nature when the planning-process for adaptation measures. Again, the effect of ‘desalination and water transport’ is unclear, but could be positive.

Lastly, within the energy sector, reducing the dependence on single sources of energy can also be positive for freshwater nature, as long as the right kind of energy sources are chosen. The measure within the transport sector does not have a positive effect on freshwater nature, which may not create win-win situations, but does not have to be avoided when trying to safeguard freshwater nature.

4.2.2. Reliability of the reports

Some comments need to be made about the state of the INDCs analysed. As mentioned within the comparative analysis, some similarities and variations have been observed. The observation that has been made across the border is that INDCs are usually quite general in nature. Adaptation measures are quite general, mentioning global sectors where improvements should be made, but lacking in specifics on how exactly this is going to be done. This has made it difficult to apply the assessment framework to, as the measures within this framework are often more detailed. This can mean two things. Either countries are in general not very advanced yet in the planning for adaptation measures or the INDCs do not contain all information about nation's plans to adapt to climate change. As some INDCs have referenced to external documents or mentioned the intent to implement their National Adaptation Plan, it is hypothesised the latter may be true for at least some of the countries. This however makes it difficult to get a clear view of what countries are actually doing in practice to reach the goals of the Paris Agreement, something the INDCs were originally designed for. Due to the incompleteness of the report, it is hard to make conclusions about the differences in adapting to climate change between the Global North and Global South as well. As a considerable amount of countries in the Global North failed to mention adaptation in the first place, the illusion is created that adaptation is not relevant in these areas whatsoever. Though it can be hypothesised countries in the Global South will feel the effects sooner or more, it is unlikely there is no need to implement measures in the Global North at all. Thus, the INDCs seem to be not only not detailed enough, but also not reliable. It could be argued that the INDCs are, in their current state, not the right tool to measure country's aims and approach regarding the implementation of adaptation measures.

4.2.3. Limitation of the research

As the scope of the thesis needed to be restricted, it was necessary to select the countries for analysis. The amount of analysed countries did not allow for some conclusions to be made about differences or similarities in reporting between countries with different characteristics, such as political background, geographical location, or being situated in a certain continent.

It is most important, however, to recognise the complexity of drafting strategies for adaption to climate change in general. Even when effects on freshwater nature are accounted for, planners should not cease to take external effects into account. Adaptation measures can have effects on other sectors as well. As adaptation measures take varying forms, the effects on these sectors also depend on the specific measure For example, vector control can not only be harmful for freshwater nature due to the insecticides contaminating water, air and soil, but human health can be affected by this measure as well (Ansari et al., 2014). Another example is the effect of desalination processes. As this report focussed on the effects of adaptation measures on freshwater nature, the detrimental consequences that these desalination systems can have on marine life were not included. Nonetheless, the effect on marine ecosystems is serious and should be considered during the implementation of a desalination system (Winters, Isquith & Bakish, 1979).

4.3. Conclusion

This thesis aimed to determine the effects on freshwater nature of the adaptation climate policies that are envisioned by states in the Global North and South.

It can be concluded that the effects are complex. Through the analysis it has been found that currently some measures are more popular than others and that this does not always match with the effect it has on freshwater nature. Some measures have a clear benefit, creating win-win situations for both adapting to climate change and safeguarding freshwater nature. The win-win measure for both addressing climate change and safeguarding freshwater nature that is already often adopted is 'the extension or preservation of current areas of protected areas'. A lot of opportunities exist though to increase the use of measures that both benefit freshwater nature and are useful to adapt to climate change. Measures that impact both issues positively but are not adopted by most countries yet are 'the protection of movement corridors, stepping stones and refugia', 'implementing urban spatial planning for density and greenery' and measures that promote the efficient use of water, which are 'loss reduction', 'the expansion of rainwater harvesting' and 'demand control and water reuse'.

Other measures are clearly negative for freshwater nature. The only measure which has merely risks that is adopted relatively often by the analysed countries, is 'R&D on vector control and vaccines'. The measure of 'implementing coastal defences, sea walls or dikes' can be detrimental to freshwater nature as well, but is adopted considerably less by the analysed countries. When considering these measures, it is essential for planners to weigh the pros and cons for adaptation on the one hand and freshwater nature on the other.

Within this thesis, it has been found that most measures have both risks and benefits. Freshwater nature can be affected negatively or positively depending on the way it is executed, making it crucial for planners to keep freshwater nature in mind while implementing these measures. Currently, the measures within this category that the 20 analysed countries adopt most are 'forestry with shorter rotation time/afforestation/reforestation', 'the development of resistant crops' and the 'creation of risk analysis institution and long-term plans'.

A comparative analysis of the policies of the Global North versus the Global South indicated that the INDCs of the countries in the Global South pledged to adhere to more adaptation measures. This means that the negative effects on freshwater nature can possibly be larger by default, but the opportunities for win-win situations would also increase.

4.4. Suggestions for further research

As discussed earlier, the INDCs do not always contain the information that is needed to analyse whether and to what extent a country has adaptation plans for climate change. Thus, it can be useful to turn to other sources to identify the specifics of country's adaptation measures. This way, a more reliable analysis can be made. Additionally, it would be useful to enlarge the scope of the analysis, by increasing the number of countries investigated.

As adaptation measures affect multiple sector besides freshwater nature, the main recommendation to be made is to explore other unintended effects of adaptation measures as well. To make properly thought-out decisions, all the direct and indirect pros and cons of each measure needs to be known. Measures may be particularly effective when it comes to climate change or be specifically beneficial to freshwater nature, but can affect another sector negatively. Planners need to know this information, to make the most appropriate decision in the local context.

4.5. Suggestions for nature policy

Within this thesis, it has been found that only one adaptation measure that is adopted by a relative large amount of analysed countries should be avoided at all costs when aiming to safeguard freshwater nature. One the other hand, only one measure that is included often within the analysed INDCs can be implemented without worrying freshwater nature is harmed. Most measures have the capacity to be both positive or negative for freshwater nature. Thus, awareness about the importance of freshwater nature and need to regard this when making decisions that can affect it is crucial. The drawbacks of the fact that measures do not have a straightforward positive or negative effect but are depended on the way they are executed is that the inclusion of freshwater nature into the adaptation plans has to be constantly negotiated. Opportunities however arise too, as nearly all adaptation strategies have the potential to benefit freshwater nature and every implementation moment provides an opening to take action in favour of freshwater nature. The presence of actors knowing the importance of freshwater nature and having the ability to be influential in the decision-making process of implementing adaptation strategies is crucial. Whether originated from governments, NGOs, civil society, businesses, or scientists, actors have to vouch for freshwater nature at these moments.

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Appendix 1: Analysis INDCs

Analysis 'Bangladesh's Intended Nationally Determined Contributions'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	p. 10: ''Ecosystem based adaptation (including forestry co-management)'' p. 11: ''..afforestation.''
	Development of resistant crop	p. 11: ''introduction and dissemination of stress tolerant crop varieties and seeds''
	Adjustment of planting dates and crop variety	p. 11: ''introduction and dissemination of stress tolerant crop varieties and seeds''
Ecosystems and biodiversity	Preserve or increase extent of protected areas	p. 11: ''biodiversity and ecosystem conservation''
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	p. 11: ''construction of embankments and river bank protective works'' p. 11: ''Inland monsoon flood-proofing and protection''
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	p. 11: ''drainage infrastructure'' ''improvement of drainage system to address urban flooding''
	Restrictive land use planning	p. 10: ''Community based conservation of wetlands and coastal areas''
	Insurance, warning and evacuation schemes	p. 11: ''Improved early warning system for tropical cyclone, flood, flash flood and drought''

	Relocation and retreat	p. 11: ''improved Early warning system for tropical cyclone, flood, flash flood and drought'' ''climate resilient … communication''
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	p. 11: ''building cyclone resilient houses'' p.11: '' Climate resilient housing'' P. 11: ''Improvement of Urban resilience''
	R&D on vector control, vaccines	''enhanced urban resilience''?
	Improvements on public health systems	p. 11: ''adaptation to climate change impacts on health''
	Urban spatial planning for density and greenery	
Water Resources	institutionalization of long term prospective	p. 10: ''policy and Institutional Capacity Building''
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	p. 11: Installation of solar panels
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis Brazil's 'Intended Nationally Determined Contribution Towards Achieving the Objective of the United Nations Framework Convention on Climate Change'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	p. 4: ''the implementation of REDD+ activities'' ,'' forest monitoring systems'', '' restoration and reforestation activities''
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	p.4: ''conservation and sustainable use of biodiversity''
	Protect movement corridors, stepping Stones, and refugia	p. 4: '' management of protected areas''
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	p. 3: ''has in place an early warning system and action plans to respond to natural disasters''
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	p. 3: ''housing, basic infrastructure…constitute key areas for adaptation policies'', '' The Government of Brazil gives particular attention to the poorest populations, in terms of improving their housing and living conditions, bolstering their

		capacity to withstand the effects of severe climate events.''
	R&D on vector control, vaccines	
	Improvements on public health systems	
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	P3.: Basic infrastructure… in the areas of … transportation constitute key areas for adaptation policies''. P4.: ''and improve infrastructure for transport and public transportation in urban areas''

Analysis 'Intended Nationally Determined Contribution of Chile towards the Climate Agreement of Paris 2015'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	P 21: ''Chile's Climate Change strategy'', '' National Climate Change Adaptation Plan'' P22: ''The creation of forecast models that Chile can share and distribute nationally and internationally''
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	

	improved climate-sensitive disease surveillance and control	
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	P21: ‘’Pursuant to this national plan, two sectorial adaptation plans have been developed and approved (forestry and agriculture, and biodiversity plans), while other seven plans are scheduled: water resources…’’
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'INDC Colombia'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	P6: ''Delimitation and protection Colombia's 36 "paramo" areas (high mountain Andean ecosystems) (approximately 3 million hectares).'' '' Increase of more than 2.5 million hectares in coverage of newly protected areas in the National System of Protected Areas -SINAP-''
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	P 6: ''Incorporation of adaptation and resilience considerations in sectorial, spatial and development planning''
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	

	Improvements on public health systems	
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	Loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'Ghana's intended nationally determined contribution (INDC) and accompanying explanatory note'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	
	Development of resistant crop	P15:'' Promote innovations in post-harvest storage and food processing and forest products in 43 administrative districts.''
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	P15:''Manage 413,000ha fragile, ecologically sensitive and culturally significant sites in 22 administrative district in the forest and savannah areas.''
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	P15:''Expand and modernize the current 22 synoptic stations based on needs assessment, and increase the number to 50 stations for efficient weather information management''
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	P15:'' Building standards for strategic infrastructure in housing, transport, coastal, waste management,

		telecommunication and energy) adopted in 10 urban administrative regions.''
	R&D on vector control, vaccines	
	Improvements on public health systems	P15:'' Strengthen climate related disease surveillance in vulnerable communities in 3 Districts.''', '' Adopt climate change informed health information systems including traditional knowledge on health risk management.''
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	P15;'' Strengthen equitable distribution and access to water for 20% of the population living in climate change risk communities''
	Storage capacity increase	
	Desalination and water transport	
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	P15:'' Building standards for strategic infrastructure in Fhousing, transport, coastal, waste management, telecommunication and energy) adopted in 10 urban administrative regions.''

Analysis 'India's Intended Nationally Determined Contribution: Working Towards Climate Justice'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	P 21: '' National Agroforestry Policy (NAP) of India aims at encouraging and expanding tree plantation in complementarity and integrated manner with crops and livestock.'', '' It will also complement achieving the target of increasing forest/ tree cover.''
	Development of resistant crop	P 20: ''The mission focuses on new technologies and practices in cultivation, genotypes of crops that have enhanced CO2 fixation potential, which are less water consuming and more climate Page 21 of 38 resilient.''
	Adjustment of planting dates and crop variety	P 20: '' The mission focuses on new technologies and practices in cultivation, genotypes of crops that have enhanced CO2 fixation potential, which are less water consuming and more climate Page 21 of 38 resilient.''
Ecosystems and biodiversity	Preserve or increase extent of protected areas	P 22: '' … conservation and protection of critical habitats'' P 25: '' The National Mission for Sustaining the Himalayan Ecosystem (NMSHE) addresses important issues concerning Himalayan Glaciers and the associated hydrological consequences, biodiversity and wildlife conservation and protection''
	Protect movement corridors, stepping stones, and refugia	

	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	P 22: '' Mapping and demarcation of coastal hazard lines for development of emergency response plans is being carried out in all the coastal states and union territories''' P 23: '' The IPZ focuses on disaster risk reduction through bioshields with local vegetation (mangroves) and other soft protection measures, and the conservation of beaches and sand dunes.''
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	P 22: '') Government of India has also set up the National River Conservation Directorate for conservation of rivers, lakes and wetlands in the country''
	Insurance, warning and evacuation schemes	P 22: '' India has demarcated vulnerable areas on the coasts and declared them as Coastal Regulation Zone (CRZ) with restrictions imposed on setting up and expansion of industries, operations and processes in these areas''
	Relocation and retreat	P 21: ''India has developed 580 district level (covering many states) contingency plans based on early warning systems and other weather forecasting systems.'' P 24: '' Strategies include early warnings and communications''

	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	P 21/22: '' Several municipal authorities, including Page 22 of 38 Delhi have amended their existing building bye-laws, making it compulsory for every large house or hotel (200 yards or more in area) to undertake rainwater harvesting.''
	R&D on vector control, vaccines	P 22: ''The mission aims at analysing epidemiological data, identify vulnerable population and regions, build knowledge base and expertise, increase awareness and community participation.''
	Improvements on public health systems	P 22: ''Apart from the overall public heath infrastructure at the national and sub national levels…'' P 22: '' Government of India has launched programmes like Integrated Disease Surveillance Programme (IDSP), National Vector Borne Disease Control Programme (NVBDCP) to deal with vector borne diseases like malaria, dengue etc.''
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	P 21: ''The main objective of India's National Water Mission (NWM) is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". One of the key goals of the mission is to enhance water use efficiency by 20%.''

	The expansion of rainwater harvesting	P 21: '' Rainwater harvesting, which offers a promising solution to replenish and recharge the groundwater is a significant component of Watershed Development Programme''
	Demand control and water reuse	P21: ''The main objective of India's National Water Mission (NWM) is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". One of the key goals of the mission is to enhance water use efficiency by 20%.''
	Storage capacity increase	
	Desalination and water transport	P 222: '' Another important initiative relating to rivers is the National Mission for Clean Ganga which seeks to rejuvenate the river along its length of more than 2,500 km through multifarious activities such as pollution inventorization, assessment and surveillance and laying of sewage networks, treatment plants etc.''
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'Intended Nationally Determined Contribution Of The Government Of Malaysia'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	P 5: '' New granary areas and adequate and efficient irrigation and drainage infrastructure will be developed to increase the production of rice.''
	Forestry with shorter rotation time/afforestation/reforestation	
	Development of resistant crop	P 5: '' The Eleventh Malaysia Plan would further expand implementation of good agricultural practices and intensifying research and development for improving agriculture production.''
	Adjustment of planting dates and crop variety	P 5: '' The Eleventh Malaysia Plan would further expand implementation of good agricultural practices and intensifying research and development for improving agriculture production.''
Ecosystems and biodiversity	Preserve or increase extent of protected areas	
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	P 5: '' New granary areas and adequate and efficient irrigation and drainage infrastructure will be developed to increase the production of rice.''
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	

	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	P 5 : '' Detailed sea level rise studies had also been conducted at some of the vulnerable coastal areas to project future vulnerabilities in a 20-year sequence from 2020 to 2100.''
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	P 6: '' The control and prevention of dengue transmission using early test kits and community behavioural intervention as well as exploratory research on alternative medicines are among the efforts being undertaken''
	Improvements on public health systems	
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	Loss reduction (leakage control, etc.)	P 5: '' the Eleventh Malaysia Plan among others aims to strengthen the regulatory framework of the water services industry, expand the water supply network and treatment capacity infrastructure and increase the efficiency of water supply services.''
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	P 5: '' the Eleventh Malaysia Plan among others aims to strengthen the regulatory framework of the water services industry, expand the water supply network and treatment capacity infrastructure and increase the efficiency of water supply services.''

	Desalination and water transport	P 5: '' To ensure adequate and safe water supplies, inter-basin water transfer projects are being implemented to supply water to areas that are experiencing water-stress''
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	P 5: ''resilience of infrastructure''

Analysis 'Mexico Intended Nationally Determined Contribution'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	P 8: '' Water technologies for savings, recycling, capture, irrigation and sustainable management for agriculture purposes.''
	Forestry with shorter rotation time/afforestation/reforestation	P 7: '' Reach a rate of 0% deforestation by the year 2030.'', ''Reforest high, medium and low watersheds with special attention to riparian zones and taking into account native species in the area''
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	P 7: '' Guarantee food security and water access in light of growing climate threats through integral watershed management, biodiversity and land conservation.'' P 7: '' Conserve and restore ecosystems in order to increase ecological connectivity of all Natural Protected Areas and other conservation schemes, through biological corridors and sustainable productive activities'' '' Substantially increase the Programs of Action and Conservation of Species in order to strengthen the protection of priority species from the negative impacts of climate change. ''
	Protect movement corridors, stepping stones, and refugia	P 7: '' Conserve and restore ecosystems in order to increase ecological connectivity of all Natural Protected Areas and other conservation schemes, through biological corridors and

		sustainable productive activities'' '' Substantially increase the Programs of Action and Conservation of Species in order to strengthen the protection of priority species from the negative impacts of climate change. ''
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	P 7: '' Increase carbon capture and strengthen coastal protection with the implementation of a scheme of conservation and recovery of coastal and marine ecosystems such as coral reefs, mangroves, sea grass and dunes.'' P 8: '' Guarantee the security of dams and strategic hydraulic infrastructure, as well as communications and transportation strategic infrastructure.''
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	P 7: '' Relocate irregular human settlements in zones prone to disasters through land use regulations.''
	Insurance, warning and evacuation schemes	P 7: '' Reduce the population´s vulnerability and increase its adaptive capacity through early warning systems, risk management, as well as hydrometeorological monitoring, at every level of government.'' P 8: '' Access to information systems in order to monitor hydrometeorological events in real time and thus consolidate

		and enhance early warning system''
	Relocation and retreat	P 7: '' Execute infrastructure relocation programs currently located in high-risk zones in priority tourism destinations and implement restoration actions of vacated locations.''
	Creation of risk analysis institution and long-term plans	P 7: '' Reduce the population´s vulnerability and increase its adaptive capacity through early warning systems, risk management, as well as hydrometeorological monitoring, at every level of government.''
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	P 7: '' Prevent illnesses that are exacerbated by climate change through an early warning system with epidemiologic information.''
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	Loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	P 8: '' Water technologies for savings, recycling, capture, irrigation and sustainable management for agriculture purposes.''
	Demand control and water reuse	P 8: '' Water technologies for savings, recycling, capture, irrigation and sustainable management for agriculture purposes.''
	Storage capacity increase	P 8: '' Water technologies for savings, recycling, capture, irrigation and sustainable

		management for agriculture purposes.''
	Desalination and water transport	P 8: '' Water technologies for savings, recycling, capture, irrigation and sustainable management for agriculture purposes.''
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	P 7: '' Execute infrastructure relocation programs currently located in high-risk zones in priority tourism destinations and implement restoration actions of vacated locations.'', '' Incorporate adaptation criteria for public investment projects that include infrastructure construction and maintenance'', P 8: '' Guarantee the security of dams and strategic hydraulic infrastructure, as well as communications and transportation strategic infrastructure.'' P8: '' Transportation technologies that are resilient to the adverse effects of climate change in particular for roads and massive transportation''

Analysis Nepal's 'Intended Nationally Determined Contributions (INDC)'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	P 6: '' Plant trees in at least 10% of the current open/barren land''
	Development of resistant crop	P 9: '' Similarly, efforts are underway to develop flood and drought-resistant crop varieties to cope with climate change impacts.''
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	P 5: ''Nepal has adopted a National Framework on Local Adaptation Plans for Action (LAPA) to ensure integration of adaptation and resilience into local to national planning processes''
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	

	Urban spatial planning for density and greenery	P 6: '' Increase greenery through tree plantation and management of gardens and parks''
Water Resources	Institutionalization of long term prospective	
	Loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	P 6:: '' Promote rainwater harvesting and ponds construction''
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'Uganda's Intended Nationally Determined Contribution (INDC)'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	P 5: '' Extend electricity to the rural areas or expanding the use of off-grid solar system to support value addition and irrigation.''
	Forestry with shorter rotation time/afforestation/reforestation	P 6: '' Promoting intensified and sustained forest restoration efforts (afforestation and reforestation programmes, including in urban areas)''
	Development of resistant crop	P 5: '' Expanding research on climate resilient crops and animal breeds''
	Adjustment of planting dates and crop variety	P 5: '' Expanding diversification of crops and livestock''
Ecosystems and biodiversity	Preserve or increase extent of protected areas	P 5: '' Promoting biodiversity & watershed conservation (including reestablishment of wildlife corridors)''
	Protect movement corridors, stepping stones, and refugia	P 5: '' Promoting biodiversity & watershed conservation (including reestablishment of wildlife corridors)''
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	P 7: '' Identifying better drainage plans''
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	P6: Managing water resource systems, including wetlands, particularly in cities, in such a way that floods are prevented and existing resources conserved (through the establishment of an Integrated Water Resources Management system)''
	Restrictive land use planning	

	Insurance, warning and evacuation schemes	P.5: ‘’Expanding climate information and early warning systems’’ P 6: ‘’Improving early warning systems for disease outbreaks’’ P 7: ‘’ Building more effective early warning systems’’
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	P6: ‘’ Updating of risk assessment guidelines’’
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	P 6: ‘’ Investing in making existing and new buildings more resilient’’ P 6: ‘’ Ensuring that land use plans and building codes reflect the need to make public and private buildings more climate-resilient’’
	R&D on vector control, vaccines	
	Improvements on public health systems	P 7: ‘’Making provision for a safe water chain and sanitation facilities to limit outbreaks of water-borne diseases and implement strong public awareness programmes to promote better hygiene’’ P 6: ‘’ Conducting vulnerability assessments of the health sector to climate change impacts’’ P 7: ‘’ Putting in place contingency plans to develop climate change resilient health systems’’, ‘’ Strengthening public health systems by building hospitals (including regional referral hospitals) and supplying them with medicine, equipment and well-trained personnel’’
	Urban spatial planning for density and greenery	

Water Resources	Institutionalization of long term prospective	P 7: '' Mainstreaming climate resilience in all sectors''
	Loss reduction (leakage control, etc.)	P 6: '' Improving water efficiency''
	The expansion of rainwater harvesting	P 6: '' Ensuring water supply to key economic sectors, especially agriculture, and domestic use, including water harvesting and storage''
	Demand control and water reuse	
	Storage capacity increase	P 6: '' Ensuring water supply to key economic sectors, especially agriculture, and domestic use, including water harvesting and storage''
	Desalination and water transport	
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	P 6: '' Promoting renewable energy and other energy sources''
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	P 6: '' Updating transport codes and regulations and implementing measures to ensure compliance with them''

Analysis 'Submission By Latvia And The European Commission On Behalf Of The European Union And Its Member States'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	P4: ''Afforestation, reforestation''
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	

Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'Australia's Intended Nationally Determined Contribution to a new Climate Change Agreement'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	

Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'Submission by the Republic of Korea Intended Nationally Determined Contribution.'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	P4: ''Strengthening infrastructure for climate change monitoring, forecasting and analysis''
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	P4: ''Enhancing the system for the management of negative impacts of climate change on health''
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	P4: ''Developing a management system for disaster prevention and stable water supply;''
	loss reduction (leakage control, etc.)	

	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'U.S. Cover Note INDC and Accompanying Information'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	

Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'Switzerland's Intended Nationally Determined Contribution (INDC) and Clarifying Information'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	

Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'Singapore's Intended Nationally Determined Contribution (INDC) And Accompanying Information'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	P7:'' The array of natural ecosystems (including evergreen rain forest, mangroves, freshwater streams, freshwater swamp forest, coral reefs and mudflats) will continue to be conserved, with targeted programs for habitat enhancement and species recovery where required.''
	Development of resistant crop	P5: '' The Singapore Government encourages food security research and development, and incentivises the adoption of technology to increase productivity and resilience of local farms.''
	Adjustment of planting dates and crop variety	P5: ''Singapore's main strategy is to diversify sources for food supply resilience.''
Ecosystems and biodiversity	Preserve or increase extent of protected areas	P7:'' The array of natural ecosystems (including evergreen rain forest, mangroves, freshwater streams, freshwater swamp forest, coral reefs and mudflats) will continue to be conserved, with targeted programs for habitat enhancement and species recovery where required.''
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	P5:'' To protect critical transport infrastructure from flood risks, flood barriers have been installed at subway stations that may be affected, with ongoing work to do so for the remaining ones.'' P6:'' : 70–80% of Singapore's coastline is protected against

		coastal erosion by hard structures such as sea walls and stone embankments. The rest are soft coasts, such as sandy beaches and mangrove swamps.''
	Enhanced drainage systems	P6:'' Drainage improvement works are continuous, with 190 enhancements completed in the last cycle and another 154 locations being upgraded under present plans.''
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	P6:'' : 70–80% of Singapore's coastline is protected against coastal erosion by hard structures such as sea walls and stone embankments. The rest are soft coasts, such as sandy beaches and mangrove swamps.''
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	P7:'' CCRS focuses on tropical climate and weather research, including work to improve prediction of convective thunderstorms (responsible for some extremes of weather in the tropics), understand the behaviour of the monsoons in Southeast Asia, and to better describe the drivers behind other complex climate system processes.''
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	P5: ''Singapore's Building Control Act requires buildings to undergo periodic structural inspections to ensure structural resiliency. All road and rail structures also undergo regular inspections by registered professional engineers''
	R&D on vector control, vaccines	P6: ''Singapore has an integrated regime of environmental management and intensive source reduction to suppress the

		mosquito vector population.''
	Improvements on public health systems	P6:'' A surveillance programme – anchored in human case, virus, mosquito and weather monitoring – has been established for the early warning of increased risks'' P6:'' Contingency plans are also in place to deal with the anticipated impacts of climate change (including during haze episodes and heat waves), which result in short-term surges in healthcare demand.''
	Urban spatial planning for density and greenery	P6:'' : Enriching Singapore's urban biodiversity and extensive greenery is part of the national vision for a "City in a Garden".''
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	P6:'' Singapore has developed a robust, diversified water supply system through "The Four National Taps": namely, local catchment water, imported water, NEWater7 and desalinated water.''
	Demand control and water reuse	
	Storage capacity increase	P6:'' Not being dependent on rainfall, NEWater and desalinated water can be used to supplement water from local reservoirs in extended dry spells.''
	Desalination and water transport	P6:'' Singapore has developed a robust, diversified water supply system through "The Four National Taps": namely, local catchment water, imported water, NEWater7 and desalinated water.''
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	

Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	P6:'' A range of technologies are also being deployed to enhance coastal infrastructure at specific locations for the long term, while continued efforts are made to protect Singapore's critical logistics supply infrastructure (located in coastal regions) against the risk of increased flooding.'

Analysis 'Submission of Japan's Intended Nationally Determined Contribution (INDC)'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	P17: ''Promotion of revegetation''
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	

Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'New Zealand's Intended Nationally Determined Contribution'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	P147(national communication): ''In 2011 the Government allocated funding of NZ$35 million over five years to support the development of irrigation infrastructure proposals to reach the investment-ready stage.''
	Forestry with shorter rotation time/afforestation/reforestation	P4 (INDC): '' Our planted forests have enabled the phase out of timber from our natural, indigenous forests, protecting these original forests and providing a sustainable supply of timber and wood products for both export and domestic use.''
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	P153(national communication): ''The Harvest Strategy Standard provides for targets and limits to be set for fisheries and fish stocks in New Zealand waters and to take into account changes in environmental conditions.''
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	P150(national communication): ''for example, by establishing 'no build' zones seaward of 50-year lines, with existing buildings restricted to the current footprint and floor area, and 'relocatable' buildings between 50- and 100-year lines.''
	Insurance, warning and evacuation schemes	P150(national communication): '' The Civil Defence and

		Emergency Management Act 2002 provides for the comprehensive management of hazards and risks, and emergency response and recovery, through coordinated and integrated policy, planning and decision-making processes at the national and local level.''
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	P148(national communication): ''The assessment of coastal hazard risks must take account of climate change.'' P148(national communication): '' Assessments of areas potentially affected by coastal hazards should use a 100-year risk assessment timeframe and include an assessment of sea-level rise and other climate change effects.''
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	P151(national communication):'' It aims to provide central, regional and local authorities with information to help them formulate and plan the implementation of responses and adaptive strategies for increasing human health resilience to the infectious disease consequences of climate variation and change.'' P152(national communication): ''a disease-attributable intelligence system – a dynamic risk assessment tool for monitoring emerging disease risk.''
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	P147(national communication): ''Irrigation development,

		particularly water harvesting and storage, also has a climate change adaptation function.''
	Demand control and water reuse	151(national communication): '' efficiently allocate fresh water to users within those limits'' P151:'' avoid over-allocation and address existing over-allocation''
	Storage capacity increase	P147(national communication): ''Irrigation development, particularly water harvesting and storage, also has a climate change adaptation function.''
	Desalination and water transport	
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	P152(national communication):'' Within the energy sector, a key issue identified in the Plan is that New Zealand's energy mix will need to change over the next 20 to 40 years, in part because of resilience issues'' P152(national communication):''The Plan notes that New Zealand's electricity market is currently highly reliant on rainfall, and that, increasingly, wind and other less weather dependent renewable sources are being developed.''
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	P152(national communication):''Specifically, within the transport sector, and considering the movement of freight, a need is identified for a more strategic approach to land-use, aligned with the need to examine the resilience of New Zealand's supply chains across the country.'' P154(national communication):"' manage increased hazards from climate change impacts on state highway infrastructure'' P154(national communication): '' strengthening and monitoring

		programmes that work to prevent rail buckling in high temperatures'', '' work programmes to maintain and strengthen the rail network, to reduce vulnerability to floods or tidal surges''

Analysis Turkey's 'Intended Nationally Determined Contribution'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	P157(national action plan): ''UT3.1.4. Developing irrigation and water management systems specific to the local conditions''
	Forestry with shorter rotation time/afforestation/reforestation	P5(INDC): '' Implementing Action Plan on Forestry Rehabilitation and National Afforestation Campaign''
	Development of resistant crop	
	Adjustment of planting dates and crop variety	P157(national action plan): UT3.1.2. ''Promoting crop types suitable for climate and water availability in agricultural basins''
Ecosystems and biodiversity	Preserve or increase extent of protected areas	P4(INDC): ''Rehabilitation of grazing lands'' P160(national action plan): '' UO1.1.3. Integrating and spreading adaptation to climate change into the existing planning for selected/priority protected areas''
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	P159(national action plan): '' UT5.2.4. Increasing the accessibility of early warning and climate information'' P165(national action plan): ''UA1.1.4. Establishing, spreading and developing monitoring, forecast and early warning systems for natural disasters caused by climate change''

	Relocation and retreat	P158(national action plan): ''UT4.3.1. Prioritizing land consolidation practices in regions with flood risk''
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	P167(national action plan): ''UİS1.1.2. Installing and spreading early warning systems and giving emergency warnings to reduce the effects of extreme weather events on public health'' P167(national action plan): '' UİS1.2.3. Establishing Tropical Diseases Diagnosis Laboratories at the regional level, or strengthening the infrastructures of some of the public health laboratories to this end in some provinces''
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	P149(national action plan): '' US1.1.1. Incorporating measures to tackle the impact of climate change on water resources in the Development Plans and Programmes''
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	P149(national action plan): ''US1.1.6. Identifying economic instruments, in accordance with water utilization purposes, in consideration of socioeconomic conditions and the principles of user pays- polluter pays so as to ensure effective and efficient utilization of water''

		P152(national action plan): '' US4.2.4. Reuse of water collected and treated in settlements''
	Storage capacity increase	
	Desalination and water transport	
Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	P3: ''Increasing capacity of production of electricity from solar power to 10 GW until 2030'', ''Increasing capacity of production of electricity from wind power to 16 GW until 2030'', '' Tapping the full hydroelectric potential''
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	

Analysis 'Canada's INDC Submission to the UNFCCC'

Sector	Measure	Reference
Agriculture	Developing crop insurance	
	Irrigation (possible with water storage & transport)	
	Forestry with shorter rotation time/afforestation/reforestation	
	Development of resistant crop	
	Adjustment of planting dates and crop variety	
Ecosystems and biodiversity	Preserve or increase extent of protected areas	
	Protect movement corridors, stepping stones, and refugia	
	Translocate species at risk of extinction	
Coastal Zones	Coastal defences/sea walls/dikes	
	Enhanced drainage systems	
	Relocation and the creation of wetlands as buffer against sea level rise and flooding	
	Restrictive land use planning	
	Insurance, warning and evacuation schemes	
	Relocation and retreat	
	Creation of risk analysis institution and long-term plans	
Health and housing	Air conditioning/insulation	
	Climate proofing new and old buildings	
	R&D on vector control, vaccines	
	Improvements on public health systems	
	Urban spatial planning for density and greenery	
Water Resources	Institutionalization of long term prospective	
	loss reduction (leakage control, etc.)	
	The expansion of rainwater harvesting	
	Demand control and water reuse	
	Storage capacity increase	
	Desalination and water transport	

Energy	Nuclear plant cooling system	
	Reduce the dependence on single sources of energy	
Tourism	Diversify tourism attractions and revenues	
	Shift ski slopes to higher altitudes and glaciers	
Transport	Design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage.	