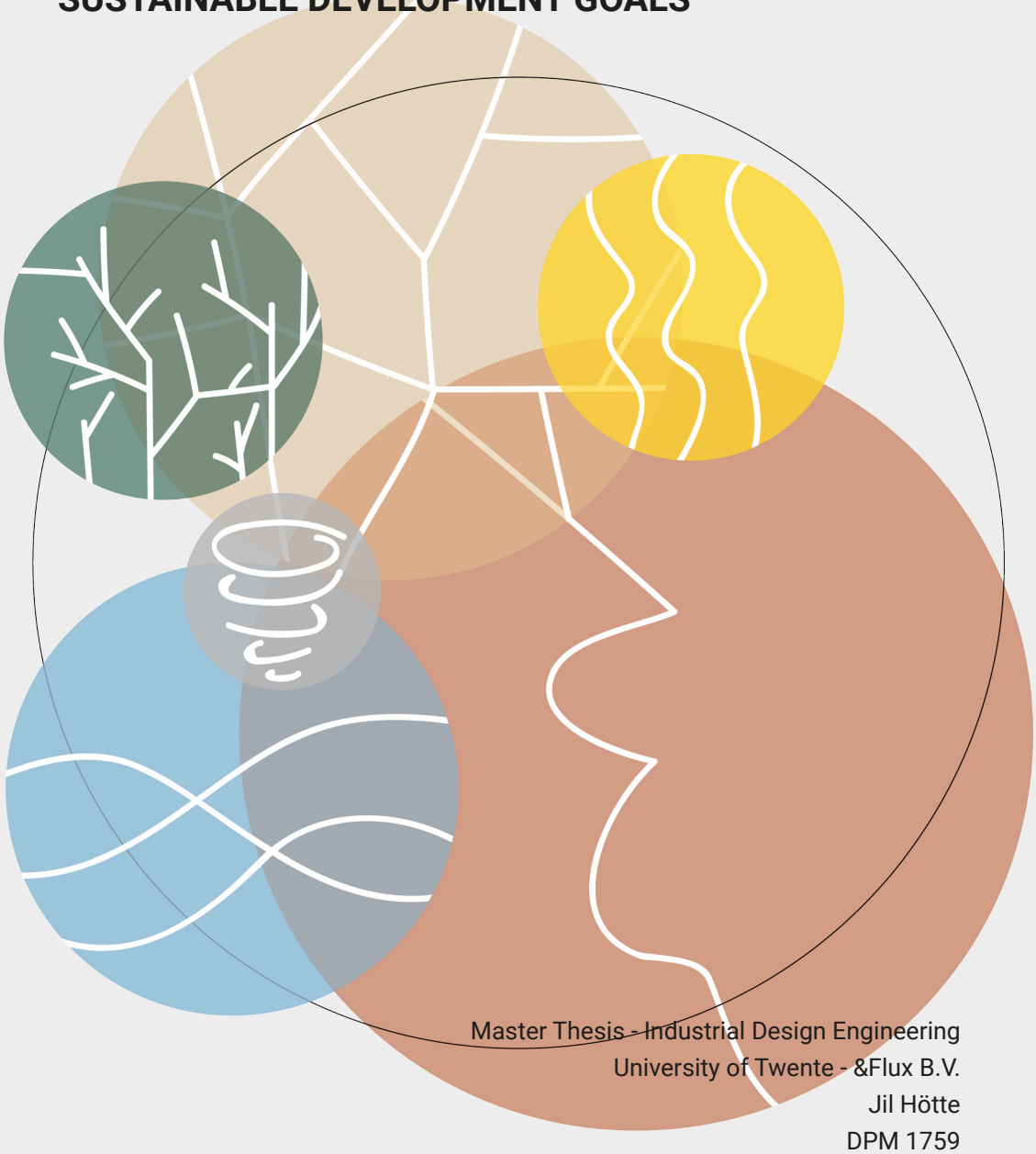
THE DEVELOPMENT OF A FRAMEWORK TO CONNECT SPATIAL CLIMATE ADAPTATION TO THE SUSTAINABLE DEVELOPMENT GOALS



Master Thesis - Industrial Design Engineering
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Jil Hötte
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Supporting vulnerable municipalities in their first efforts towards climate adaptation

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Prologue

This report is the result of my master thesis in Industrial Design Engineering at the University of Twente. It was conducted on behalf of &Flux, a fast-growing start-up committed to creating positive impact.

The thesis is dedicated to exploring the field of adaptation to climate change.
On first notice, this may not seem like a report about sustainability. However, we only just now start to understand the reality of climate change and the necessity to prevent it. At the same time, climate change is already causing harm. Without adaptation, no sustainable future is possible.
This may seem rather pessimistic, but it is in fact the opposite.
During this thesis, I have learned so much about climate change, that I am not surprised anymore when I hear a new story about this flood, that storm, or when I see predictions about what is to come. Adaptation is the chance for optimism facing these challenges.

I have written this report during the year of 2020 and the Covid-19 pandemic. I am very thankful to the company &Flux for nonetheless providing me with the best possible environment for my graduation internship. Never did I feel detached, neither on day one nor while working from home. Most of all, I would like to thank Sander and Michiel for your support and the freedom to explore the aspects of adaptation I felt drawn towards.
I would also like to thank my university supervisor Marten for exploring with me and all your feedback and guidance. Laura, thank you for joining him along the way and providing me with another perspective.
Furthermore, I would like to express my gratitude to all the interview partners providing me with their most valuable insights in the field of adaptation.
Finally, I would like to thank my family and friends for supporting me along the way. Especially, I would like to thank Laura, Floor, Anne, and Julian for our conversations and your genuine feedback on my report.

This thesis is of course just a tiny piece in the field of adaptation but hopefully provides the reader not only with awareness for the necessity of adaptation but also with a perspective. Enjoy the read!

Summary

The consequences of climate change are started to be felt by communities all over the world. These consequences are versatile and widespread; from floods and landslides due to heavy rain events up to dying trees due to extreme droughts. Next to mitigating further climate change, adapting to the already occurring and future changes is gaining attention all over the world. This adaptation to climate change is the process of coping with acute climate hazards and transforming systems fundamentally to climate change.
&Flux, the client company of this assignment aims to develop a future-proof Netherlands through the development of projects in various fields of sustainability. While the Netherlands is considered a frontrunner in adaptation, other regions around the world and especially developing regions are, however, more vulnerable to climate change. Their vulnerability is not only caused by mere exposure to climate change but mainly by a lack of capacity to adapt. At the forefront of tackling the vulnerability are municipalities.
Therefore, this assignment focusses on urban municipalities in developing regions. Adaptation is connected to the Sustainable Development Goals in order to offer the opportunity to enhance adaptive capacity through development.

Analysing the enhanced vulnerability of the target group, a new framing method for vulnerability is developed. Most importantly, the capacity to adapt is not merely defined by the availability of resources, but also influenced by the accessibility of these resources connected to the socio-economic status of the accessor.
Next to the factors influencing vulnerability, the factors influencing adaptation efforts are analysed. An ‘optimal’ adaptation process is determined that has to be performed continuously and incrementally.

A case study is executed focussing on the strategy development step of the process. The case study is performed in the context of Semarang in Indonesia that is known for its vulnerability to floods. While Semarang’s adaptation efforts mainly focus on their flood risk, Semarang is also vulnerable to a variety of other climate risks, such as heat stress.
The proposed SDG-inclusive adaptation strategy focusses on decreasing that vulnerability to heat stress. The strategy includes two spatial adaptation measures. It is enhanced by including a variety of SDGs in the process. The implementation of the tree planting should be executed by a tree nursery that is led by local female organisations.

The SDG-Adaptation-Framework developed in this report is directly retrieved from the results of the case study and thereafter generalised. During the case study, a series of steps is performed developing the strategy. These steps form the outline of the framework. Furthermore, a variety of instruments is developed. These are supporting the steps of the process.
During the generalisation of the framework, the influence of contextual factors and choices on the case study result and process are analysed in order to ensure that the framework is robust to these influences. After generalisation, the framework consists of a general overview, a process, and instruments corresponding to each step of the process.

The final framework provides the process and methods to develop SDG-inclusive adaptation strategies that connect SDGs actively to spatial adaptation measures in order to enhance adaptive capacity. The SDG-Adaptation-Framework is, however, a theoretical framework. In order to be well-useable by municipalities, another design iteration focussing on user-friendliness is necessary. Furthermore, the framework must be further validated and tested through case studies performed together with municipalities.
The connection of adaptation to the SDGs is a valuable new point of view. Integration of adaptation into other fields is one of the current challenges in adaptation planning. While this integration is mainly discussed in other sustainability-related fields, such as circularity, energy transition, etc., socio-economic aspects are not often taken into consideration yet. Since these socio-economic aspects cause the vulnerability of developing regions, these considerations would be necessary. The SDGs provide the opportunity to connect adaptation to both other sustainability-related fields as well as socio-economic aspects.
The SDG connection and framework are developed on a relatively high abstraction level. Therefore, next to the further development of the user-friendliness of the framework, some aspects of adaptation and development should be further researched to gain further level of detail.

Key concepts

Adaptation: Adaptation refers to climate adaptation in this report. Adaptation describes the process of coping with acute climate hazards and transforming systems fundamentally to climate change. (Combination of various concepts, see section 2.1.1)

Adaptive capacity: The ability to access and utilise adaptive potential in order to adapt to climate change. Adaptive potential is the mere availability of resources and existing resilience that needs to be accessed and exploited for adaptive capacity. (Combination of various concepts, see section 2.1.1)

Climate change: The "long-term change in the average weather patterns that have come to define Earth's local, regional and global climates" (NASA ,2020c).

Coping: Short-term actions that combat existent climate hazards in order to maintain system functioning (Macchi, 2011).

Exposure: Exposure describes the extent to which a system is present in a setting that can be impacted by climate change, independent of existing resilience (IPCC, 2014a).

Framework: Framework refers to the SDG-Adaptation-Framework in this report. The SDG-Adaptation-Framework is a framework to connect spatial adaptation to the SDGs and it is the final result of this report.

Hazard: Acute shocks and long-term stresses that may cause impacts on human and natural systems (IPCC, 2014a). In this report, hazards refer to climate change-related events.

Impact: The consequences and damages to people's lives, health, livelihoods, property, infrastructure, or ecosystems caused by hazards. The impact of a hazard is related to a system's vulnerability (IPCC, 2014a).

Measure: Measures refer to adaptation measures in this report if not stated otherwise. Adaptation measures can have a variety of attributes, for example a coping or transformational character.

Risk: The likelihood of the occurrence of hazards (IPCC, 2014a). In this report, risk refers to a potential impact that hazards may have depending on a system's vulnerability.

Spatial adaptation: Spatial adaptation refers to adaptation efforts directly altering or indirectly influencing the living environment (Kennisportaal Ruimtelijke Adaptatie, n.d.).

Strategy: Strategy refers to adaptation strategy in this report if not stated otherwise. A strategy is a set of measures combined to tackle a specific climate risk. SDG-inclusive adaptation strategy refers to a strategy that is developed utilising the SDG-Adaptation-Framework.

Development: In this report, development refers to sustainable development which "meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987) In this report, development is the means to enhance adaptive capacity.

Transformation: Long-term actions fundamentally altering system functioning (Macchi, 2011).

Vulnerability: Vulnerability describes the potential to be adversely affected by climate change. It encompasses a variety of aspects such as exposure and resilience to hazards on the one hand and adaptive capacity on the other hand. (Combination of various concepts, see section 2.1.2)

Key abbreviations

100RC: 100 Resilient Cities Network
CKB: Convenant Klimaatadaptief Bouwen Zuid-Holland
HRBA: Human Rights-Based Approach
IPCC: Intergovernmental Panel on Climate Change
NASA: National Aeronautics and Space Administration
ND-GAIN: Notre Dame Global Adaptation Initiative
RT: Rukun Tetangga: A neighbourhood representative responsible for 10-20 households
RW: Rukun Warga: A community representative responsible for 5-10 RTs
SDGs: Sustainable Development Goals by the United Nations
TW: Terboyo Wetan: The focus neighbourhood, located in Genuk, Semarang, Indonesia
UHI: Urban Heat Island Effect

Figure 1: Dry wetlands in Morocco

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INTRODUCTION

Around the world, people start to experience the impacts of climate change (NASA, 2020b). Next to the ambition to mitigate further climate change, people must acknowledge the unpleasant truth that adapting to already existing and future changes is increasingly necessary. This is called climate adaptation (referred to as adaptation).
This master assignment explores the international field of adaptation and develops a framework supporting vulnerable municipalities in their first efforts towards adaptation by connecting spatial adaptation to the Sustainable Development Goals (short: SDGs). The assignment is conducted on behalf of the company &Flux, a fast-growing start-up developing projects in various fields of sustainability.

This introductory chapter should illustrate the context and starting points for the assignment. The first section introduces climate change and the necessity for adaptation as the research background. Afterwards, the client company's core identity is described as well as their relationship with adaptation. Following the client company's objective, the assignment research objective is clarified as well as related research questions and scope. Finally, the overall approach and methods for the assignment is presented together with a reading guide.

01

1.1. Research background

Climate change is one of the most dangerous threats to society. Current local and global climates will be redefined by long-term changes in the world's weather patterns (NASA, 2020c). This will result in more frequent and intense hazardous weather events and natural disasters (NASA, 2020b). As shown in Figure 2, the World Economic Forum described exactly these consequences as the most threatening risks in 2019 (World Economic Forum, 2019).

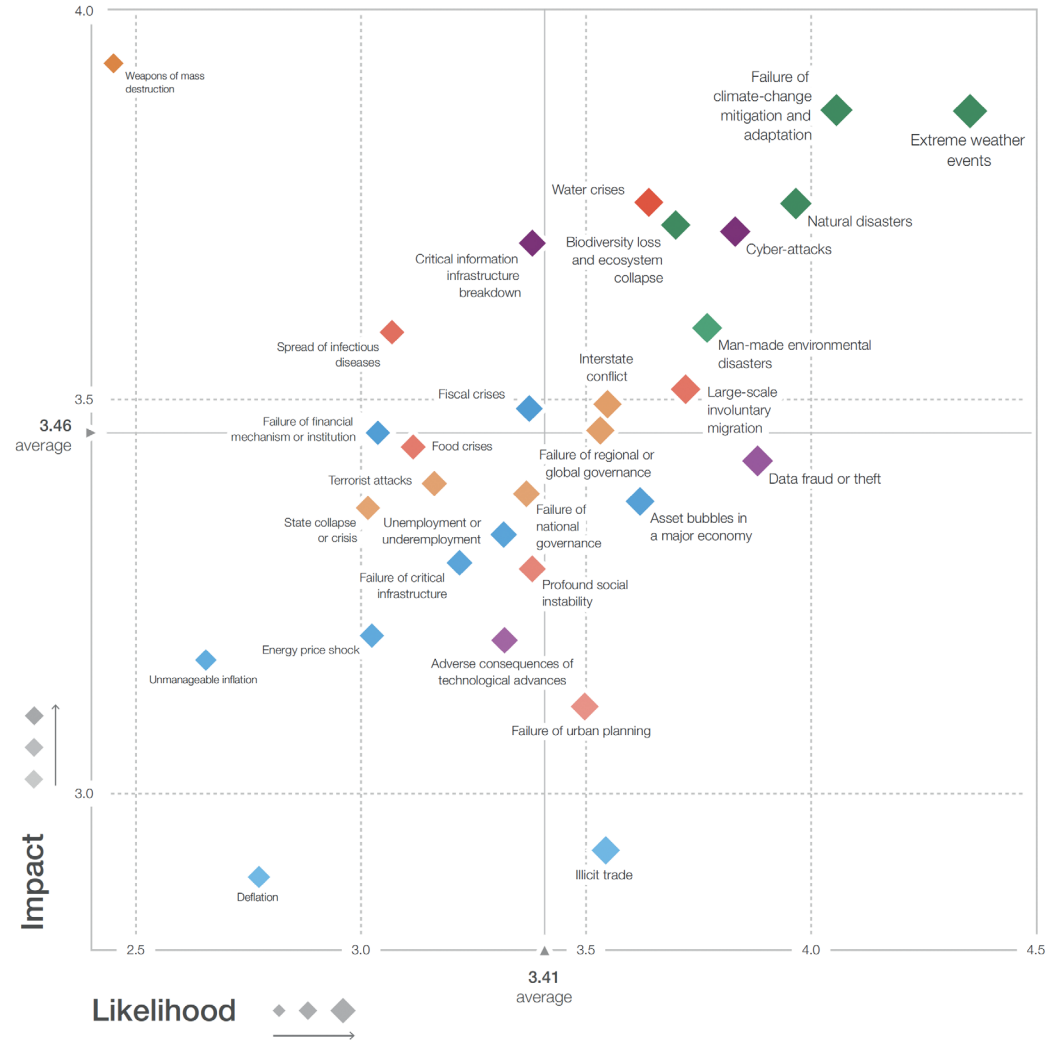

Figure 2: Global risks landscape established by the World Economic Forum (2019)

The cause of climate change is most likely human-induced greenhouse gas emissions (NASA, 2020a). Hence, reducing these emissions is an important strategy for tackling climate change. However, even when stopping to emit greenhouse gasses right now, "humanity is [already] 'committed' to some level of climate change" and therefore its consequences, according to the National Aeronautics and Space Administration (short: NASA) (NASA, 2020d).
Therefore, next to mitigating further climate change through the reduction of greenhouse gas emissions, adapting to the inevitable changes is necessary. As stated by the Intergovernmental Panel on Climate Change (short: IPCC), "[a]daptation and mitigation are complementary strategies for reducing and managing the risk to climate change" (IPCC, 2014d). Only then, sustainability and further sustainable development are achievable, so "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).

Instead of focussing on the complete concept of sustainability or sustainable development, this report is focussing on adaptation to climate change. The definition of such adaptation in this report is as follows:

> *Adaptation describes the process of coping with acute climate hazards and transforming systems fundamentally to climate change.*

1.2. The client company

This section introduces &Flux as the client company for this assignment and describes their identity by breaking it down into its core elements. These serve as points of attention at the beginning of and throughout the whole assignment. Furthermore, the relationship between &Flux and the field of adaptation is described as well as their identified research objective.

1.2.1. &Flux's identity

&Flux is a fast-growing start-up that initially formed a department at the company Bloc and was then split up in January 2020 in order to refocus their efforts in creating sustainable impact. They initiate, facilitate, and build action with impact within the fields of sustainability. Their specific work-fields, as defined by &Flux, are energy transition, material transition, circular economy, and adaptation (&Flux, 2020c). The different work-fields of &Flux all contribute to their final goal; to create a sustainable and future-proof Netherlands.

Initiate – The role of the frontrunner
Aiming at the future-proof Netherlands, &Flux not only executes projects on behalf of their clients but also creates new initiatives and 'value cases' when discovering needs. &Flux therefore often inhabits the role of a frontrunner in their work-fields. (&Flux, 2020b)

Facilitate – Building coalitions
For the creation of new initiatives as well as for transitioning into a sustainable future, partnering is a necessity. Therefore, a core element of &Flux's work is the creation of coalitions. Herein, &Flux again inhabits the role of the initiator, but also the one of the facilitator. When coalitions are formed, &Flux facilitates action of the partners with themselves being in the lead (&Flux, 2020a). Doing so, &Flux works together with companies but more often with governmental bodies such as municipalities.

Build – Ensure real impact
The aim of &Flux does not stop at the creation of initiatives but only at the creation of real impact. All team-members of &Flux have a strong drive to create impact in different fields of sustainability. They aim to ensure that their initiatives and coalitions achieve real action towards a sustainable and future-proof Netherlands.[1]

1.2.2. &Flux's relationship to adaptation

As mentioned before, adaptation is one of &Flux's work-fields. They have initiated and executed various projects within that field. One of the biggest projects that &Flux initiated is the 'Convenant Klimaatadaptief Bouwen Zuid-Holland' (short: CKB). In 2018, &Flux was the driving force in the founding of the CKB in South-

1 This information was derived from a team-building activity on July 1, 2020 and various conversation with team members of &Flux.

Holland. The CKB is a coalition of various parties (the province South-Holland, various municipalities, companies, consultancies, waterboards, etc.). All partners of the covenant agreed to include adaptation in all their spatial planning projects. Working groups have and are still developing various tools that the partners can use in adaptation planning (Convenant Klimaatadaptief Bouwen Zuid-Holland, 2020). For example, a guidebook is developed that shows the various steps necessary when including adaptation in spatial planning processes (Convenant Klimaatadaptief Bouwen Zuid-Holland, 2019a). Furthermore, baseline requirements are established that enable the examination of designs based on different climate risks (Convenant Klimaatadaptief Bouwen Zuid-Holland, 2019b).
The role of &Flux in the covenant reflects their core identity; to initiate, facilitate and create real impact.

1.2.3. &Flux's assignment objective

&Flux's work in the field of adaptation is focussed on the Netherlands. Hence, &Flux does not have a clear overview of adaptation outside of the Netherlands. Therefore, they have an interest in getting to know the status of adaptation in the rest of the world, but also the different approaches that may be applicable to the Netherlands. &Flux's objective for this assignment is to explore the international field of adaptation and consequently determine a relevant focus for this assignment.

1.3. Assignment objective

Since &Flux detected their knowledge gap in climate adaptation outside of the Netherlands, the initial objective for this assignment is to explore the international field of adaptation. That exploration is essential for finding a relevant focus for the rest of this assignment. That focus determines the goal of the framework to be developed as the final result of this assignment.

1.3.1. The initial scope

While the scope of the exploration initially stays rather broad, the core elements of &Flux's identity are utilised to restrict that exploration and the general objective for this assignment as follows.

Initiate – Find the underdog
Since &Flux is comfortable in the role of the initiator, especially locations in which adaptation efforts still must be initiated are analysed in this assignment.

Facilitate – Collaborate with municipalities
&Flux often works together with municipalities and facilitates their adaptation efforts. While adaptation strategies can be developed on multiple governmental levels, vulnerability to climate change is felt on a local scale (NASA, 2020d). Therefore, this assignment focusses on municipalities.

Build – Help the vulnerable
Since &Flux is interested in creating real impact, the locations that are truly vulnerable to climate change are most interesting to explore.

After the definition of the assignment focus, the scope is further detailed in section 2.3.3.

1.3.2. The research questions

Drawing from the initial research objective and scope, the primary research question and secondary research questions for this assignment are as follows:

How can vulnerable municipalities be supported in their first efforts towards climate adaptation?

1. *How does the comparison of the Netherlands with various locations around the world provide insights into factors influencing climate change vulnerability and adaptation?*
2. *How can an adaptation strategy be developed for a vulnerable municipality?*
3. *How can the development of an adaptation strategy for a vulnerable municipality provide insights into a generally applicable framework for similar municipalities?*

1.4. Approach

This section provides an overview of the approach for this assignment and structure of the report. The report is structured into three parts: Part A: Theory, Part B: Example, and Part C: Framework. Each part consecutively addresses one of the secondary research questions.

Part A addresses the first secondary research question through desk research, explorative, semi-structured interviews, and mappings and analysis of the findings. Within Part A, the specific focus for the rest of the assignment and to be developed framework is determined as well as the detailed scope.
Part B revolves around a case study that serves exemplary for answering the second secondary research question. In order to gain an understanding of the specific context and vulnerability of the case study location, desk research and explorative, semi-structured interviews are performed as well as mappings and analysis of the findings. Afterwards, a design process is performed in order to develop a relevant adaptation strategy for the case study location.
Part C draws from the insights of the case study in order to develop a framework and answer the third secondary research question. The final framework is developed through multiple design iterations. During these iterations, the framework is generalised by answering various questions about the influence of different contextual factors on the result and process of the case study. This, in order to ensure the applicability of the framework in different contexts.
Following part C, an evaluation is set up as well as conclusions are drawn.

Figure 3 presents a reading guide simultaneously showing the different chapters of the three parts.

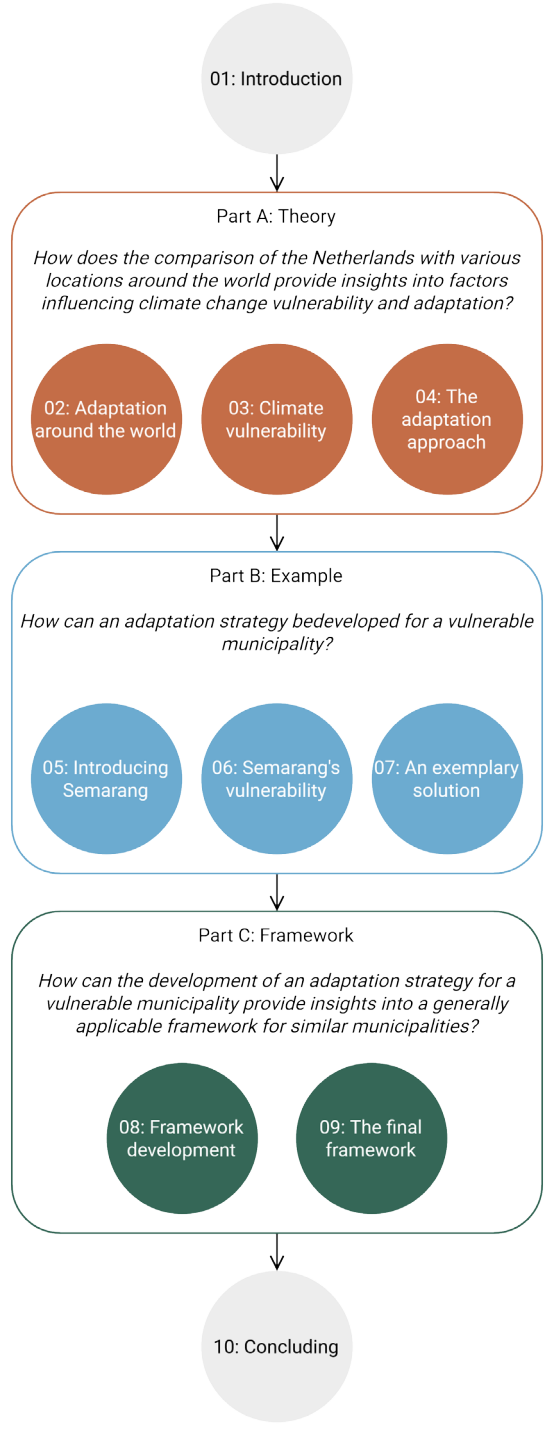

Figure 3: Reading Guide

PART A: THEORY

Part A revolves around the secondary research question: *How does the comparison of the Netherlands with various locations around the world provide insights into factors influencing climate change vulnerability and adaptation?* The research question is answered by exploration through desk research and semi-structured interviews followed by mapping and analysis of the findings. The interviews are referred to as respondent 1,2,3 consecutively. Appendix 1 includes an overview of the different respondents.

During Part A, the focus for this assignment and framework to be developed is defined as well as the detailed scope. Furthermore, a set of factors relevant for adaptation and the framework to be developed are established.

Figure 4: Part A structure

Approach

This part starts in chapter 2 with an exploration of the different concepts around adaptation followed by the comparison of achieved progress in adaptation around the world. Through this, the most vulnerable locations offering opportunities for adaptation can be determined. They form the target group of the framework to be developed and the starting point for the focus of this assignment. This focus is defined at the end of chapter 2.

In chapter 3, through mapping and analysis, a defining set of climate risks is established. Furthermore, a framing method for vulnerability is developed, including various types of risks. The framing method combines different viewpoints on vulnerability.

Finally, chapter 4 explores different categories of adaptation measures as well as adaptation processes in order to conclude with the ‘optimal’ adaptation process and factors relevant to enable adaptation and for the framework to be developed.

ADAPTATION AROUND THE WORLD

While people around the world constantly adapt to their (changing) environment, strategic adaptation effort is not (yet) widespread common practice (Respondent 6). No common ground has been established regarding the associated definitions and concepts around adaptation.

Therefore, the first section of this chapter aims to introduce the different key concepts around adaptation and vulnerability to climate change. These definitions serve as a baseline for further research in chapters 3 and 4.

Afterwards, the progress of adaptation in the Netherlands is described as well as the progress around the world in order to consequently determine the locations that are most vulnerable and achieved least progress in adaptation.

Finally, the focus and further refined scope for this assignment are determined in the last section of this chapter.

02

2.1. The key concepts

Adaptation has, in comparison to its cause climate change, not yet established much attention around the world. In order to illustrate that phenomenon, the amount of publications in 2019 that are related to either of them is compared. When searching for 'climate change', 228 times as many results are received as to when searching for 'climate adaptation'.[2]

This can be explained by various factors, Firstly, while the necessity of mitigation of climate change receives much attention, adaptation to climate change may feel like a defeat when mitigation becomes impossible (Respondent 1). Secondly, before adaptation can receive attention, the truth of climate change must be acknowledged first. Political considerations impact that acknowledgement (Respondent 4). Lastly, the consequences of climate change are felt on a local scale (NASA, 2020d). Most likely, individuals and even governments may already implement adaptation but are not necessarily involved in international collaboration or research. Planned adaptation is still a relatively new concept.

Because adaptation has a novel character, definitions of concepts connected to adaptation still vary. The section below aims to explain the various concept around adaptation and vulnerability and to provide relevant definitions that are used as a baseline for further research throughout the whole assignment.

2.1.1. The concepts around adaptation

Climate adaptation essentially is the adjustment to the (changing) environment and climate. Throughout history, people have adapted to their surrounding environments and climates, but the faster the climate change, the harder adaptation becomes (NASA, 2020d). This, because with climate change, the risk of **hazard**ous events increases. Such events can be **short-term shocks** such as hurricanes, or **long-term stresses** such as reoccurring droughts (Arup International Development & The Rockefeller Foundation, 2015). **Risk**, in this report, refers not only to the likelihood of the occurrence of hazards (IPCC, 2014a) but to any threat that may cause impact depending on a location's vulnerability.

Adaptation must incorporate the threat for risks and hazards and aim to enhance resilience from them. **Resilience** allows a system to return to its initial state after

2 This search was conducted on February 6, 2020 on https://www.scopus.com/

the occurrence of a hazard. Definitions also sometimes incorporate the ability of transformation of the system into a new, more resilient state after the occurrence of a hazard (IPCC, 2014b; NASA, 2020d).
Without incorporating the transformational character of adaptation, a system cannot evolve into an improved state. Therefore, adaptation measures are often differentiated into coping and transformation.
Coping measures aim to resist hazardous events by decreasing their impact and returning to the system's previous state (Eriksen & Kelly, 2007). For example, buying a fan during increasingly strong heat waves in summer is a coping measure.
Transformation aims to change the system fundamentally in the long term (Eriksen & Kelly, 2007). Therefore, a transformational measure for the same problem would be the insulation of the house in order to decrease the inside temperature during a heatwave.
When combining the goals of coping measures and transformation measures in order to describe adaptation, adaptation is defined as follows:

> *Adaptation describes the process of coping with acute climate hazards and transforming systems fundamentally to climate change.*

Adaptation encompasses a variety of coping and transformation measures from different sectors. First of all, a distinction can be made between rural and urban adaptation (Respondent 1). **Rural adaptation** is focussed on the rural environment. A typical measure would be the change of crops for dry periods.
Urban adaptation is focussed on the urban environment. For example, diversifying the economic sectors operating in the city is a typical measure decreasing the city's vulnerability to hazards. When a hazard occurs, only one sector is damaged instead of the whole economy. Another typical example of urban adaptation is the construction of flood defence infrastructure.
Such adaptation measures targeting people's living environment, infrastructure, public space, buildings, etc. are called **spatial adaptation** (Kennisportaal Ruimtelijke Adaptatie, n.d.). While the goal of spatial adaptation is to adjust the living environment to climate change, spatial adaptation measures are typically accompanied by policy measures that also belong to the sector. For example, when implementing greenery in a city, the mere spatial adaptation measure may have to be accompanied by a subsidy system.

Adaptation desirably is a combination of coping and transformation measures in order to adapt to short-term shocks and long-term stresses and to keep the ability to further develop. The adaptation measures can be part of various sectors, one of which is spatial adaptation.

2.1.2. The concepts around vulnerability

Vulnerability to climate change and hazardous events is a key concept within the field of adaptation since it defines the very need for it. Only understanding a location's vulnerability allows planning coping and transformation measures in order to decrease their vulnerability.

The definition of vulnerability to climate change evolved over time (Otto et al., 2017). Current definitions often incorporate three main concepts: exposure, sensitivity, and adaptive capacity (IPCC, 2014b; Notre Dame Global Adaptation Initiative, 2015).
Exposure describes the extent to which a system is present in a setting that can be impacted by climate change (IPCC, 2014a). It is a local factor that is independent of adaptation efforts and socio-economic context (Notre Dame Global Adaptation Initiative, 2015). For example, a system lying in a region with a high probability for a certain hazard is highly exposed to that hazard, independent of their adaptation efforts against it.
Sensitivity describes the status of a system or the extent to which the system can be affected by hazards (Sariffuddin, Astuti, Farhaeni, & Wahada, 2019). This is opposing the earlier described definition of resilience, so the ability to resist a hazard. For example, a system dependent upon one economic sector that is vulnerable to a certain hazard is sensitive to and non-resilient for that hazard.
Adaptive capacity is commonly described as a system's ability to respond, influenced by access to necessary resources (IPCC, 2014a; Otto et al., 2017). However, some definitions also include adaptation efforts already implemented (Notre Dame Global Adaptation Initiative, 2015) but this definition overlaps with the definition of sensitivity. Therefore, in this report, adaptive capacity merely describes the ability to respond and adapt. For example, a system that can utilise their former experience and knowledge of a hazard, has adaptive capacity to that hazard.

Drawing from the insights on the previous page, the definition of vulnerability in this report is as follows:

> *Vulnerability describes the potential to be adversely affected by climate change. It encompasses a variety of aspects such as exposure and resilience to hazards on the one hand and adaptive capacity on the other hand.*

The Notre Dame Global Adaptation Initiative (short: ND-GAIN) developed an index measuring the vulnerability of different countries through the three common indicators exposure, sensitivity, and adaptive capacity. However, next to measuring the vulnerability of countries, the ND-GAIN also measures the readiness of countries to adapt (See Figure 5). This **readiness** is defined as "the ability to leverage investments and convert them into adaptation actions" (Notre Dame Global Adaptation Initiative, 2015). Hence, while the vulnerability describes the potential to be adversely affected by climate change, the readiness describes whether the country is 'ready' to utilise investments in order to decrease their vulnerability. Readiness is closely related to adaptive capacity since adaptive capacity includes, amongst other things, the availability of financial resources coming from investments.

To conclude, vulnerability encompasses the concepts of exposure, sensitivity, and adaptive capacity. Furthermore, in order to adapt and decrease vulnerability, a certain readiness is necessary.

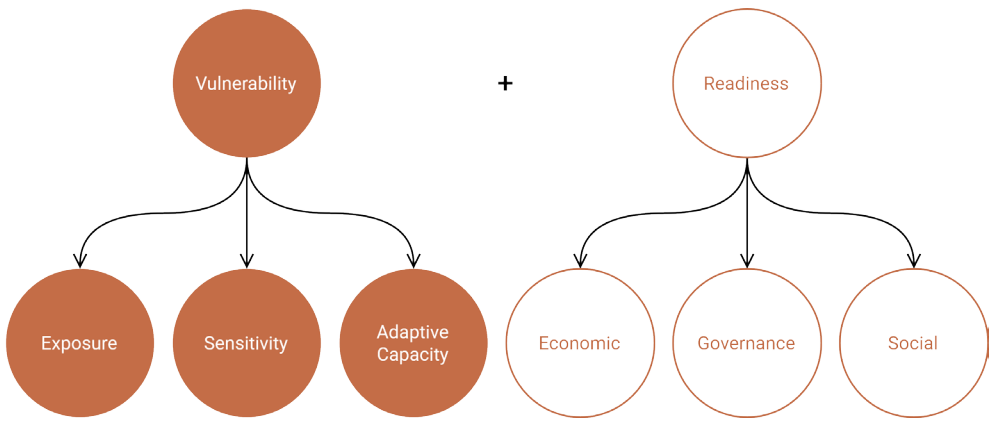

Figure 5: ND-GAIN country index composition, abstracted from Notre Dame Global Adaptation Initiative (2015)

2.2. The progress of adaptation

In this section, an overview of the Dutch adaptation progress is provided as well as a comparison of progress and vulnerability of other global regions. The comparison provides insights into the regions that are more vulnerable than the Netherlands.

2.2.1. Adaptation in the Netherlands

The Netherlands has a long tradition of adapting (to) their environment. Big parts have always lied below sea level. Therefore, it is not surprising that the Dutch are frontrunners and experts in water management and flood defence. The Dutch are also frontrunners in the governance of water management. Regional waterboards are independent governmental bodies and responsible for regional water management. (World Economic Forum, 2019)
Even with their experience in water management and flood defence, the pressure of global climate change also requires new approaches from the Dutch. While in the past, adaptation mainly focussed on hard infrastructure preventing floods, new approaches are developed.
For example, nature-based solutions such as the 'Sand Engine' where sand was deposited in front of the Dutch coast in order to be naturally distributed to form new dunes for flood defence (van Slobbe et al., 2013). Another example is the 'Room for the river' programme were dikes were lowered in order to allow farmland to be inundated instead of towns (Rijkswaterstaat, n.d.).
Furthermore, climate risks next to water-related risks increasingly gain attention, such as heat stress and droughts (Deltacommisaris, 2018).

Adaptation in the Netherlands is mainly concerned with the spatial sector, so with the built and living environment. For example, &Flux's CKB is focussed on including adaptation in all new spatial planning projects (Convenant Klimaatadaptief Bouwen Zuid-Holland, 2020).

> Within the Netherlands, Rotterdam, the hometown of &Flux, is a local frontrunner in adaptation. Rotterdam is an important port-city close to the sea. Hence, Rotterdam's adaptation efforts, such as the general Dutch efforts, were and are still focussed on water management. However, Rotterdam is increasingly concerned with other climate themes such as heat stress and biodiversity loss (Respondent 2).

Rotterdam is involved in various national and international collaborations. They belonged to the first selection of cities involved in the 100 Resilient Cities Network (short: 100RC) (Respondent 2). 100RC is a network of cities aiming to increase resilience to different (climate-related) hazards. The cities interchange knowledge in order to develop resilience strategies based on a framework by the Rockefeller Center (Arup International Development & The Rockefeller Foundation, 2015). C40 is a similar network that Rotterdam is also part of (Respondent 2). Furthermore, Rotterdam is one of the founding partners of the CKB.

The Dutch are internationally known as frontrunners in the field of water management and adaptation. Their adaptation efforts involve a long experience of protective infrastructure but also the development of new approaches that decrease vulnerability from hazards instead of aiming to prevent them. Most of the Dutch adaptation efforts are focussed on the spatial sector.

2.2.2. Adaptation around the world

While gaining an overview of the Dutch adaptation progress is relatively easy, comparing the progress of the whole world is more challenging. Adaptation strategies vary extremely between locations because the consequences of climate change and individual risks also vary extremely (NASA, 2020d). This makes adaptation progress hard to compare. Therefore, this section aims to compare adaptation progress through the factors connected to it.

However, the IPCC does try to create a global overview by comparing adaptation on a high scale-level. According to them, in all global regions, adaptation strategies are being developed but with different focuses (IPCC, 2014c). For example, while adaptation in Northern America focusses on protection of investments, in Africa, governance systems for adaptation are first established (IPCC, 2014c). This because low-income regions must develop a certain baseline before focussing on detailed adaptation efforts (Respondent 3, 4).
Developing regions have reached less progress in adaptation and are therefore more vulnerable which is a common agreement amongst researchers (Frankhauser & McDermott, 2014; United Nations Environment Programme, 2018; World Bank, 2014).

One explanation for that lower progress is the adaptation deficit (Burton, 2008). The adaptation deficit essentially says that developing regions lack adaptive capacity. Frankhauser and McDermott (2014) explain that phenomenon through the demand effect and partly through the efficiency effect. The efficiency effect says that high-income countries achieve better adaptation results due to stronger institutions. The demand effect says that high-income countries have a higher demand for security and therefore adaptation. Hence, developing regions invest less in adaptation due to their developing status.

Another explanation for the lower progress is found when looking at international investments. While locations with a higher exposure generally receive more foreign investments, the amount of investments also depend on the readiness of the location (Hellmann, Berrang-Ford, Noble, & Regan, 2018). Locations with a higher readiness receive more investments resulting in higher adaptation progress. For example, the member cities of the 100RC network are all part of regions with a certain high readiness (Notre Dame Global Adaptation Initiative, n.d.; Resilient Cities Network, n.d.-b) which is a common phenomenon amongst such city networks (Geldin, 2018).
It is not surprising that there is a correlation between the vulnerability and readiness scores of the ND-GAIN index (Notre Dame Global Adaptation Initiative, n.d.). When a country is less ‘ready’ for adaptation, they receive fewer investments, resulting in less adaptation progress and a reinforcement of their vulnerability. Another reason for the correlation is that adaptive capacity, which is part of the vulnerability indicator, overlaps with readiness since both indicators describe the ability to respond, based on socio-economic and governmental capacities (Notre Dame Global Adaptation Initiative, 2015).

To conclude, there is a clear correlation between readiness for adaptation and adaptation progress. A country with a low readiness first needs to establish a certain baseline of readiness and adaptive capacity in order to enable adaptation (Frankhauser & McDermott, 2014). Figure 6 on the following page shows the three different possible scenarios.

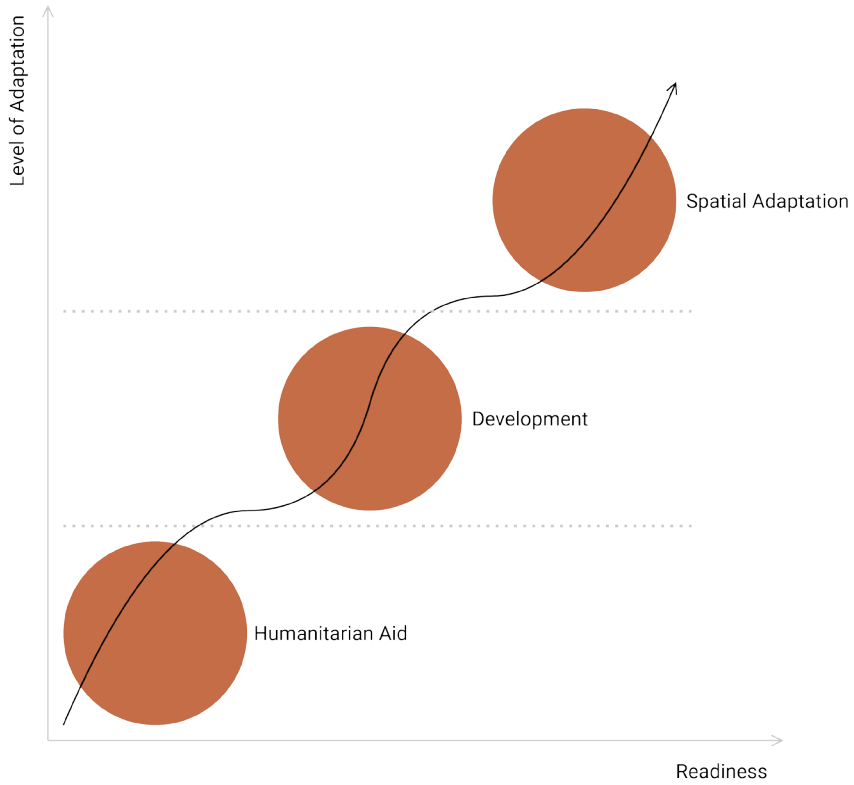

Figure 6: Readiness - Adaptation - Dilemma

1. A country is extremely ‘non-ready’. For example, because they are in a state of violence. This means that the country first needs humanitarian aid to solve their crisis.
2. A country is not yet fully ‘ready’ for adaptation because they are a developing country. This means that adaptation efforts must be accompanied by development measures in order to enhance their readiness and adaptive capacity.
3. A country is ‘ready’ for adaptation and therefore most likely already invests in adaptation, especially in the spatial sector.

This consequently explains why climate adaptation in the Netherlands focusses on the spatial sector. The Dutch vulnerability is primarily sourced in exposure, for example, due to their position below sea level. Their readiness and adaptive capacity, however, are high due to their high development status. Therefore, adaptation measures may focus on decreasing the vulnerability to that exposure.

2.3. Defining the focus

As described in section 1.3, the initial scope of the assignment was kept rather broad in order to be able to explore the international field of adaptation and define a focus accordingly. In order to define that focus, the most vulnerable municipalities still having to initiate their adaptation efforts should be determined. They form the baseline of the definition of the focus.
This section elaborates on the choice of focus as well as refined scope, based on the initial scope described in section 1.3.1.

2.3.1. The target group regions

Section 2.2.2 provides detailed insights into the factors influencing adaptation progress and vulnerability around the world. Based on these insights, indicators are developed, determining the most vulnerable regions that still offer an opportunity for adaptation.

As described in section 2.2.2, the readiness of a location has a strong influence on the adaptation opportunity. Some countries need humanitarian aid before being able to invest in adaptation or even development (Respondent 4). Therefore, countries in a state of violence or political instability are excluded from the target group of this assignment.
The need for adaptation is guaranteed with the occurrence of a certain degree of exposure since the exposure describes the extent to which a system can be impacted by climate change. Locations with a low exposure are excluded from the target group. Furthermore, section 2.2.2 states that locations with a high development status are most likely to already have invested in adaptation. Therefore, these locations are out of the scope of this assignment.
The complete set of indicators defining the groups excluded from the target group for this assignment is shown on the following page.

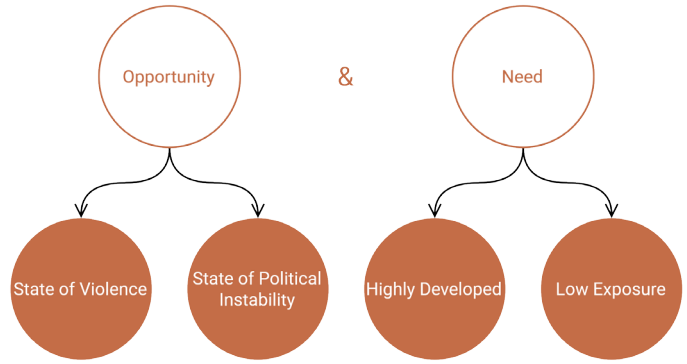

Figure 7: Indicators to exclude from the target group

Based on the four indicators shown above, different existing indexes are utilised to exclude countries from the target group (Notre Dame Global Adaptation Initiative, n.d.; United Nations Development Programme, 2019; Vision of Humanity, n.d.; World Bank, n.d.). Appendix 2 includes a descriptive overview of the indicators and utilised indexes. Figure 8 shows the final target group on a map. The shown countries can all be described as developing countries.

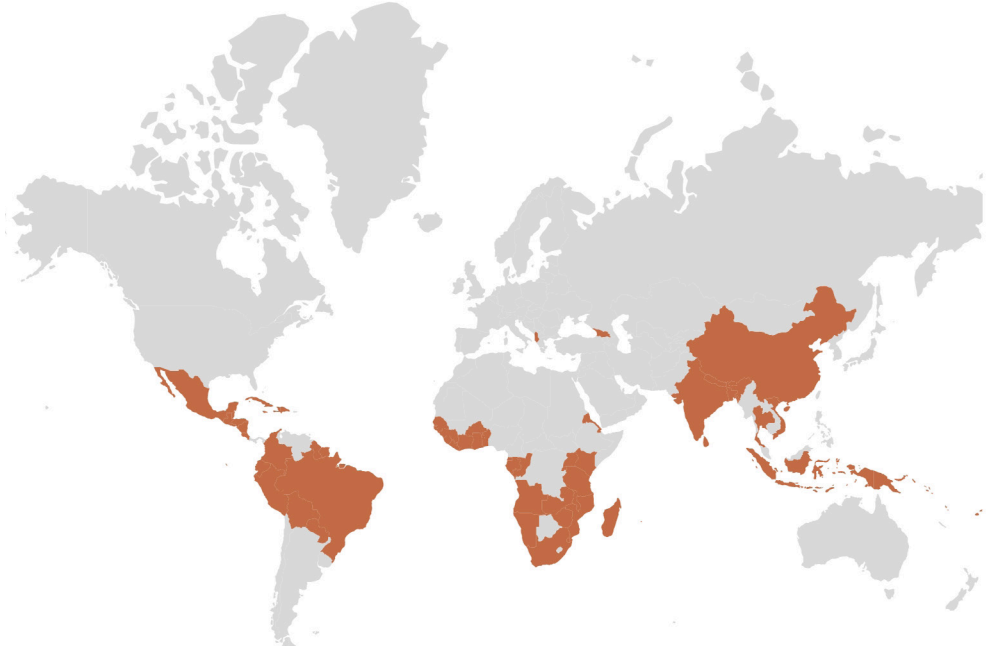

Figure 8: The target group regions

2.3.2. The Sustainable Development Goals

The target group, as defined in the section before, are most vulnerable while still offering the opportunity for adaptation. However, they are not only vulnerable due to their physical vulnerability, so their exposure and lack of resilience but also due to their socio-economic vulnerability, so their overall lack of adaptive capacity and development.
As introduced in section 2.2.2, adaptation in developing regions must always be accompanied by development measures in order to create a baseline for adaptation and allow for the improvement of readiness and adaptive capacity.

A well-known blueprint for development is the Sustainable Development Goals (short: SDGs) by the United Nations (United Nations, n.d.). The SDGs are at the heart of the '2030 Agenda for Sustainable Development' that was adopted by all United Nations member states in 2015 as a call for action.
Because the SDGs are well-known and commonly already part of the agenda of municipalities, other governmental bodies, and international agencies, the SDGs can create a convenient tool to communicate development and also adaptation targets (Respondent 3, 7).
They may ease the alignment of such adaptation targets to development targets. Furthermore, they may ease the communication of adaptation targets with international investors resulting in better accessibility of investments.

The linkage between adaptation and the SDGs can be created through the measures targeting certain risks. As shown in Figure 9 on the following page, these risks behave in a certain context. On the one hand, there is a certain physical risk that can be targeted by adaptation measures. On the other hand, there is a certain socio-economic risk that can be targeted by development measures. When combining the adaptation measure with the development measure, an SDG-inclusive adaptation strategy is created that enhances adaptive capacity, offering a more enabling context for adaptation.

The basic framework as shown in Figure 9 is utilised as the baseline for the framework to be developed. This framework is referred to as SDG-Adaptation-Framework in this report.

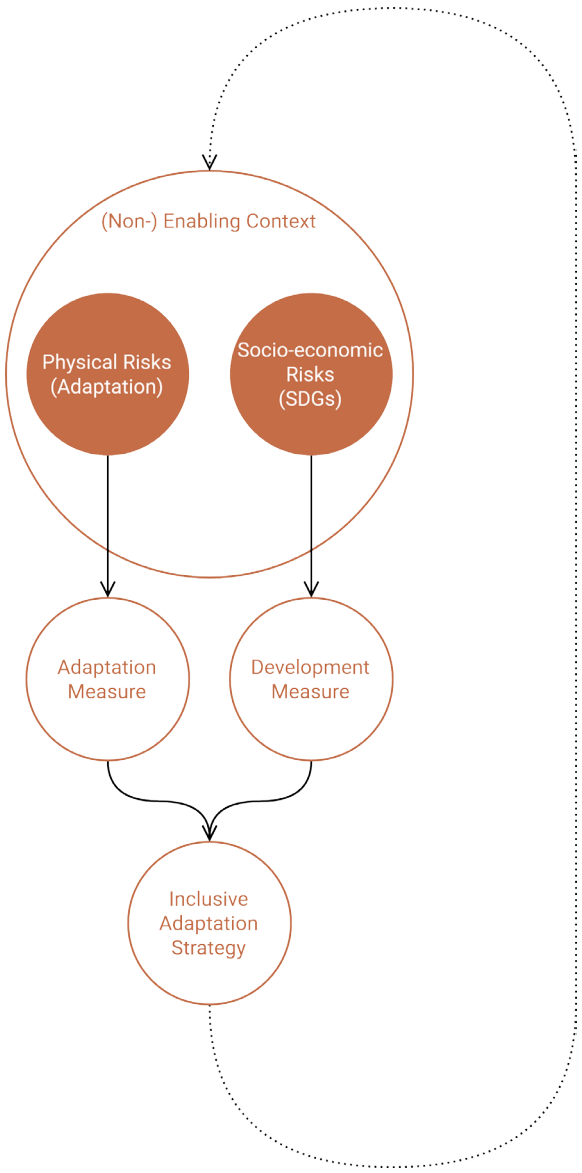

Figure 9: Basic SDG-Adaptation-Framework

2.3.3. The refined scope

In section 1.3.1, the initial scope for this assignment is defined. The scope includes vulnerable municipalities that did not start adaptation efforts yet. However, from the previous sections can be noticed that the scope is still very broad. Therefore, this section aims to refine the scope in further detail.

Firstly, in high-income countries that do not need to include development in their adaptation efforts, spatial adaptation seems the common focus. In this assignment, spatial adaptation is also the focus within the field of adaptation. This because the SDGs offer the opportunity to include adaptive capacity and other adaptation-targets in the strategy development without having to focus on them. They are included via the SDGs.
Secondly, as explained in section 2.1.1, there is a difference between urban and rural adaptation. Because an increasingly big part of the population is living in cities, the cities' vulnerabilities are increasing (Sariffuddin et al., 2019). Therefore, the focus on urban adaptation and urban municipalities is more valuable.
When developing adaptation strategies, the vulnerability to climate change of different neighbourhoods can vary. For example, a neighbourhood close to the sea may be vulnerable to floods while a neighbourhood more inland may be more vulnerable to droughts. In order to create impactful strategies, the SDG-Adaptation-Framework focusses on the strategy development on the neighbourhood-level.

CLIMATE VULNERABILITY

In order to enable the development of adaptation strategies, vulnerability to climate change must be understood. Therefore, this chapter elaborates on the concept of vulnerability that was introduced in section 2.1.2.
Firstly, the various consequences of climate change are mapped and sorted in order to make them concretely depictable. Secondly, the broader concept of vulnerability is introduced by presenting various viewpoints that are not only focussing directly on the consequences of climate change. These different viewpoints are synthesised into a framing method enabling to describe a more complete picture of vulnerability.

03

3.1. The consequences of climate change

It is clear that there will be consequences from climate change. However, these exact consequences and their intensity are still uncertain. Various parties have mapped and sorted the predicted and current consequences into themes. These themes allow describing risks in different contexts.
When investigating the various mappings, three general ways to categorise the climate change themes are discovered: directly by climate change consequence such as the IPCC (2014b), by impact of that consequence such as the Convenant Klimaatadaptief Bouwen Zuid-Holland (2019a), or by adaptation target such as one the partners of the CKB, the BAM, does.[3]
Figure 10 shows the three categorisation methods as well as examples of themes belonging to the distinct method.

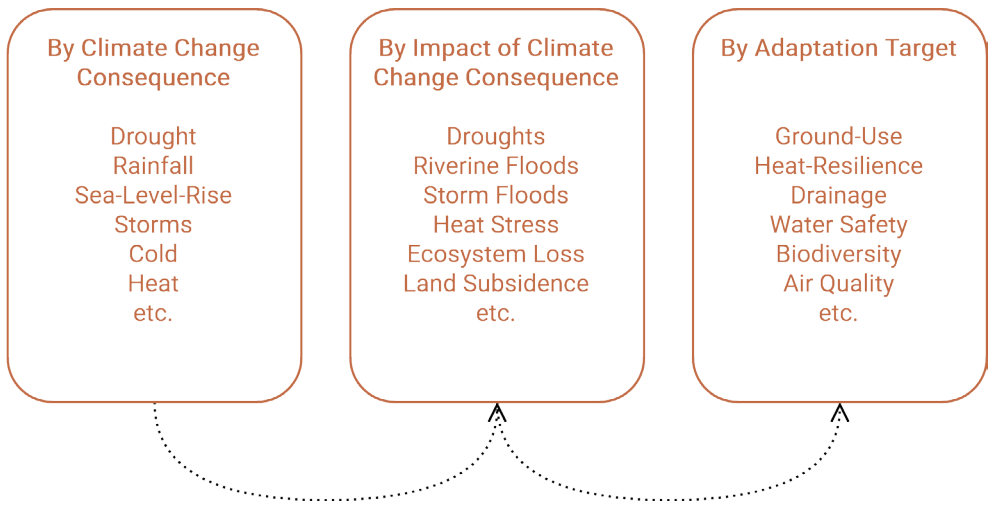

Figure 10: Categorisations of climate themes

The different mappings investigated were all developed within a specific context. Therefore, some mappings include themes irrelevant in some settings or exclude themes relevant in other settings. For example, the CKB by &Flux maps the climate themes in South-Holland as follows: floods caused by rain, floods caused by sea, drought, heat-stress, subsidence, and biodiversity (Convenant Klimaatadaptief Bouwen Zuid-Holland, 2019a). In another setting, floods caused by rain may not be

3 This information was retrieved from a digital sprint-session hosted by &Flux on April 21, 2020.

an issue while strong storms such as hurricanes may be (IPCC, 2014c) and would have to be included in the mapping.
Furthermore, many of the different mappings do not follow a strict categorisation method. For example, while the mapping of the CKB is mainly focussed on the impact of climate change consequences, the framing of biodiversity is rather an adaptation target.

For this report, the climate themes are sorted by their impact, so the second-mentioned categorisation method. This method allows for the best understanding of the need for adaptation while describing the direct climate change consequence can stay too abstract. However, there is a certain overlap between categorising by climate change consequence and by its impact. For example, droughts are a direct consequence of climate change but also a felt impact.
Furthermore, various different themes are interlinked and consist of various sub-themes. Therefore, defining a relevant set of themes is an iterative process in order to ensure that the themes can allow for a complete analysis of the vulnerability to climate change. Figure 11 shows the six main climate themes finally defined for this report. Appendix 3 provides an overview of the sub-themes linked to these main themes.

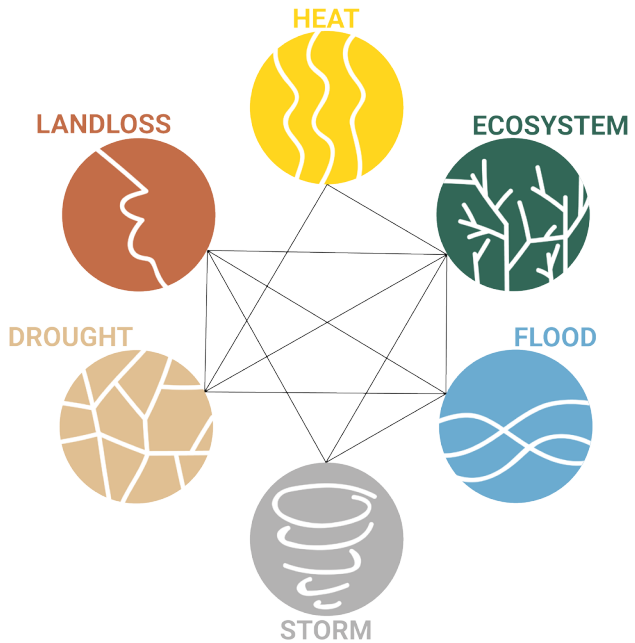

Figure 11: Climate themes

3.2. Framing Vulnerability

Many different viewpoints have been established aiming to describe vulnerability to climate change in different contexts. This section sorts the different viewpoints in order to develop a framing method that consequently serves as a tool to describe vulnerability and its different aspects during this assignment.

3.2.1. The different viewpoints

In order to describe and explain the different vulnerabilities of locations, many different framing methods for vulnerability have already been developed. The framing methods differ in terms of the context, in terms of scale, so on the household level, community level, or country level, and in terms of focus or viewpoint. In general, a distinction can be made in between three viewpoints: the impact viewpoint, the disaster viewpoint, and the social viewpoint (Malone, 2009; Sariffuddin et al., 2019). All viewpoints are explained in detail below together with some examples.

Impact Viewpoint

The impact-oriented vulnerability viewpoint focuses on researching the impact of climate change and is sourced in climate research. Framing methods from the impact viewpoint generally include the three common factors exposure, sensitivity and adaptive capacity as explained in section 2.1.2. An example of this viewpoint is the method by ND-GAIN (Notre Dame Global Adaptation Initiative, 2015).

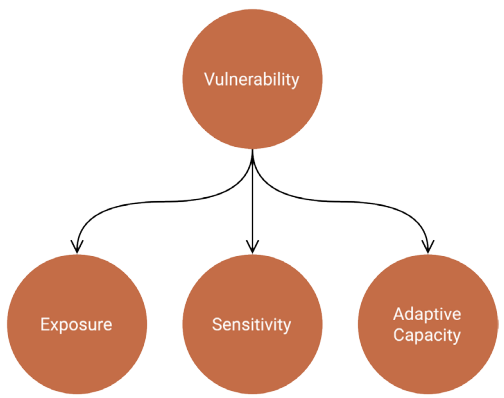

Figure 12: The three common factors of vulnerability

Disaster Viewpoint
The disaster viewpoint focusses on the hazards caused by climate change or other disasters. Framing methods from this viewpoint focus on the ability to cope with hazards, so focus mainly on resilience (Malone, 2009).
The newest report of the IPCC merges the earlier impact viewpoint with the disaster viewpoint, focussing on risk from climate change. That risk is caused by a combination of exposure, vulnerability, and the hazard itself (IPCC, 2014b). This is called the risk propeller and is depicted in Figure 13.

Social Viewpoint
Framing methods from the social viewpoint aim to identify which groups of people are most vulnerable to the impacts of climate change and why. This viewpoint acknowledges the fact that adaptive capacity is dependent not only on the availability of resources but also on the accessibility of resources by socially vulnerable groups (Respondent 8). This is depicted in Figure 14.
A lack of access to resources can be caused by internal factors such as race, gender, age, etc. and by external factors such as education, housing, quality, political power, etc. (Otto et al., 2017). For example, people that are marginalised due to their gender or age may have difficulties accessing resources necessary to effectively adapt.

Figure 13: Risk propeller, modified from IPCC (2014b)

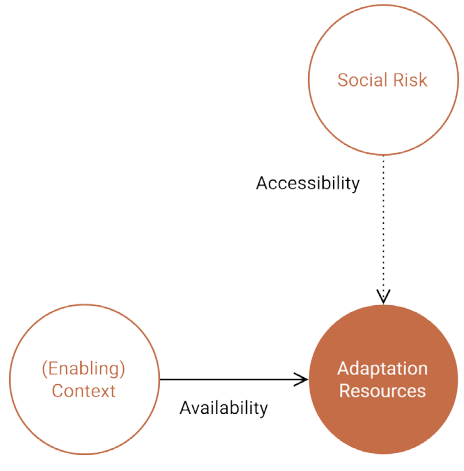

Figure 14: Availability and accessibility of resources in adaptive capacity

3.2.2. The framing method

This section describes the development of a framing method for vulnerability that enables the analysis of a municipality's vulnerability. The three viewpoints described in the section before are incorporated in that framing method. Because of the refinement of the scope on urban spatial adaptation (see section 2.3.3), the framing method focusses on the vulnerability of the living environment.

When analysing the impact and disaster viewpoint, it is not clear who's vulnerability the viewpoints represent, especially because the terminology does not describe concrete risks or factors. Therefore, the new framing method aims to represent a location's vulnerability by mapping its concrete aspects.

As shown in Figure 15, the living environment is the centre of the framing method. This living environment has a certain status which is mainly caused by the context. For example, in the context of a developing country, the overall construction quality is likely lower than in a high-income country. Due to its status, the living environment is impacted to a certain degree by the various risks it is exposed to. For example, a flood is likely to cause more damage to a neighbourhood with poor quality flood defence than to a neighbourhood with high quality flood defence.

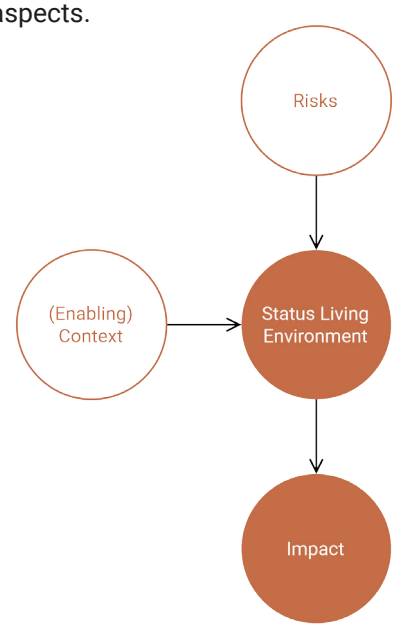

Figure 15: Impact on the living environment

However, Figure 15 does not yet include the social viewpoint of vulnerability. As explained in section 3.2.1, the social viewpoint is depending on adaptive capacity. That adaptive capacity is the extent to which resources are available due to the context and the extent to which people can access these resources due to their social status. The mere existence of resources and certain status of the living environment can better be described as the adaptive potential that only becomes adaptive capacity when the context and social status allow the access to it (see

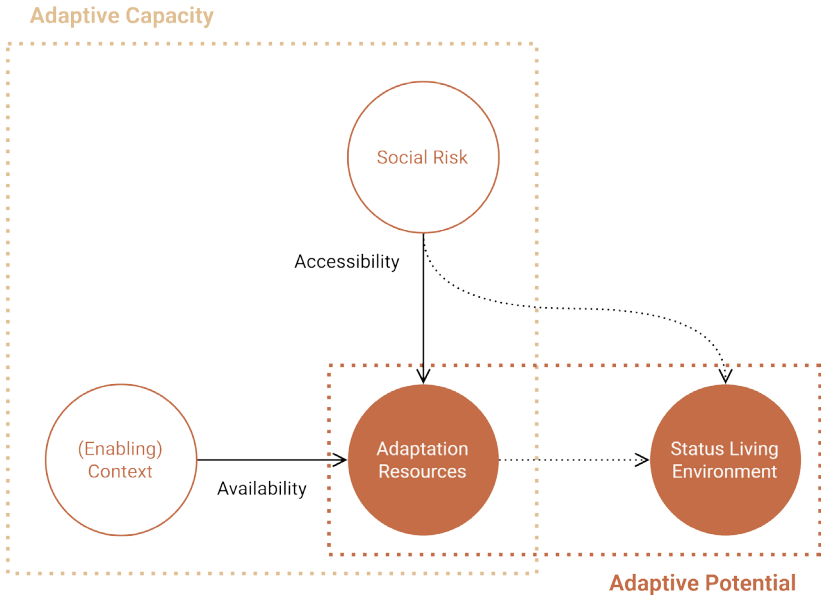

Figure 16: Social vulnerability

Figure 16). Hence, adaptation strategies should aim to focus on increasing the access to resources of the most vulnerable groups of people.
When adding this new viewpoint to Figure 15, vulnerability can be framed as depicted in Figure 17 on the right. For each of the elements of the new framing method, a set of possible indicators is developed. Some examples are mentioned below, but the complete sets can be found in Appendix 4.

On the top layer of the framing method, there are the various risks that may cause an impact on the living environment or adaptive potential. While the climate risks may be described through the themes determined in section 3.1, physical risks describe risks impacting the status of the living environment while not being climate-related. For example, the lack of a garbage treatment system is a physical risk. Social risks originate in the social viewpoint of vulnerability and limit access to adaptive potential. For example, unemployment or informal employment status can be a social risk.
The already mentioned adaptive potential is the second layer of the framing method. Essentially, the adaptive potential is the status of the living environment together with the available adaptation resources. These resources can be sorted into social capital, human capital, natural capital, financial capital, and physical capital (Macchi, 2011). Appendix 4 includes a detailed overview of the different resources. The availability of these resources and the status of the living environment are influenced by the context. For example, the context of a low-income country may result in little access to financial resources for adapting the living environment.
Finally, the status of the living environment determines the impact a climate risk may have. For example, floods can cause a risk to any location, but whether flood defence infrastructure is implemented determines the impact of that flood risk. The risks can also be reinforced by an occurring impact. For example, when a flood damages existing flood defence infrastructure, the risk for future floods is increased.
(Spatial) adaptation can decrease vulnerability to risks by enhancing the status of the living environment or increasing the availability and accessibility of resources through strengthening the context and social status of the inhabitants.

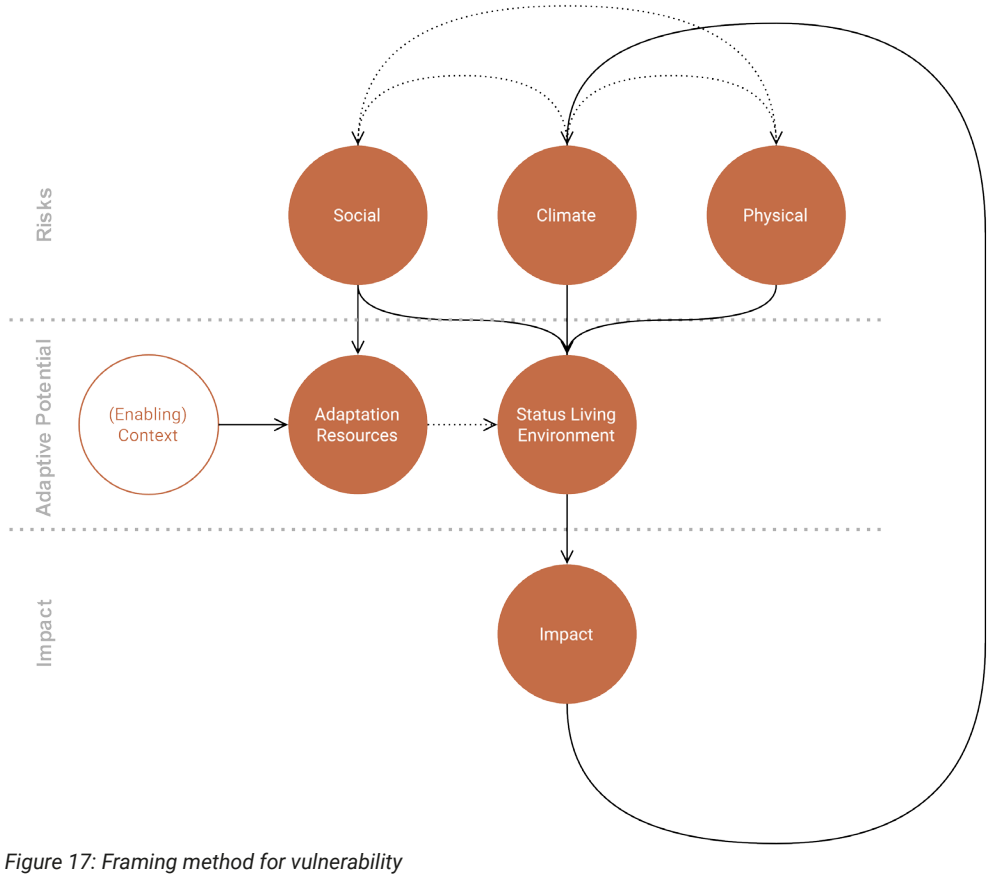

Figure 17: Framing method for vulnerability

THE ADAPTATION APPROACH

After the previous chapter dived deeper into the complexity of vulnerability to climate change, this chapter dives deeper into adaptation. With various locations around the world setting up adaptation efforts, there are various adaptation approaches and processes involved.
The first section investigates different categories of adaptation measures and approaches including examples.
Afterwards, adaptation planning and spatial planning processes are compared and synthesised in order to determine an 'optimal' adaptation process.
Finally, synthesising the insights from this chapter as well as previous chapters, factors are determined relevant for successful adaptation efforts as well as factors relevant to the development of the SDG-Adaptation-Framework.

04

4.1. Adaptation categories

Adaptation, as discussed in section 2.1.1, is a concept consisting of various sectors. Spatial adaptation is only of them. Furthermore, as introduced in section 3.2.1, different viewpoints are influencing not only the analysis of vulnerability but also the adaptation approaches. For example, a researcher from the field of disaster management may focus adaptation measures on coping with otherwise impactful hazards, while a researcher from the field of climate research may focus on mitigating further climate change and transforming to long-term climate changes. This leads to various approaches and categories of adaptation measures. In this section, the various categorisations of adaptation measures are mapped in order to develop an overview supporting adaptation efforts. A brief overview of the categorisations discussed in this section is shown in Figure 18.[4]

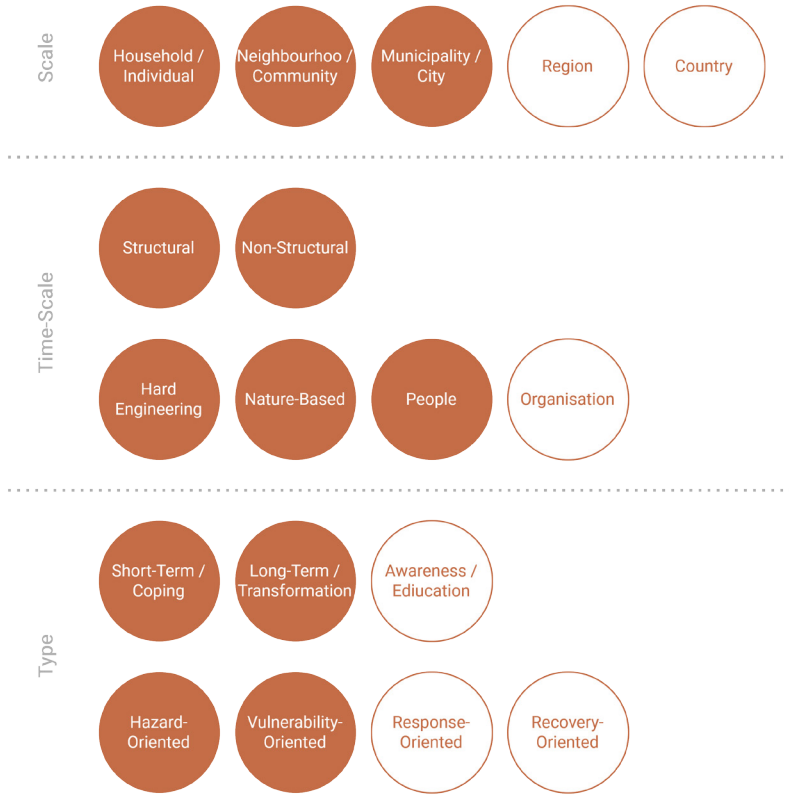

Figure 18: Adaptation categorisations

4 These categorisations were retrieved from a digital lecture by Flacke, J at the University of Twente on June 8, 2020 if not referred to otherwise.

Scale

First of all, adaptation measures can be distinguished by their scale-level of implementation: national, regional, municipal, neighbourhood, and household level. With the focus on urban spatial adaptation, only the different scale-levels from the municipal or even neighbourhood level are relevant (see section 2.3.3). While a city level measure may be the construction of city-wide coastal protection infrastructure, an individual level measure may be the construction of higher shelves to protect valuables during a flood.

Type

The examples just mentioned are both structural adaptation measures. Opposing them are non-structural adaptation measures. These non-structural measures are non-physical adaptation measures accompanying structural measures within the scope of spatial adaptation.

Directly linked to structural and non-structural measures is a more detailed categorisation of adaptation measures; the categorisation into hard engineering, nature-based, and people measures (World Economic Forum, 2019). Hard engineering and nature-based measures are structural while people measures are non-structural measures. A dam is an example of a hard engineering measure while the creation of urban wetlands is a nature-based measure. Smart use of nature-based measures is often at the centre of adaptation (Respondent 5).

An example of a people measure is the relocation of people into areas with a lower risk.

When looking at the climate risks established in section 3.1, a variety of other measure types can be determined since measures against heat stress are obviously different from the measures against floods.

Figure 19 shows an overview of the categorisation of adaptation measures by type with all its sub-categories to provide quick guidance.

Added to Figure 19 are organisation measures accompanying structural adaptation measures. For example, setting up an institution responsible for communication of coping measures to inhabitants. In the past, adaptation measures that were not merely physical often have achieved greater success since they enhance adaptive capacity (Jayanimitta et al., 2018).

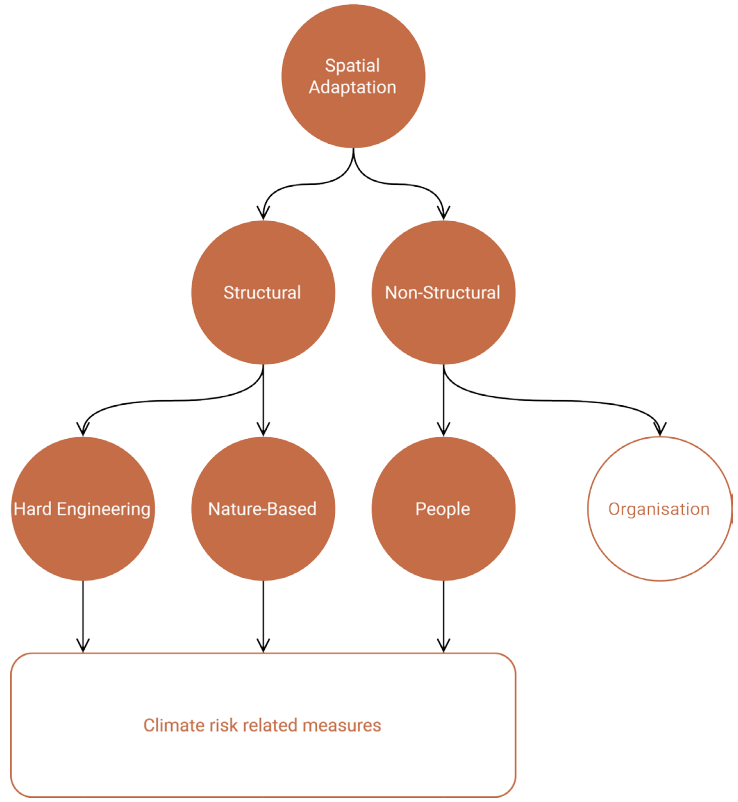

Figure 19: Adaptation measures by type

Time-scale

Another way to categorise adaptation measures is by their time-scale-level. This time-scale-level does not only enable the description of the temporal dimension of adaptation measures, but also the extent of their interference with the system. For example, a short-term measure like the construction of higher shelves is a coping measure with low interference. A long-term measure like the construction of coastal protection infrastructure is a transformation measure with high interference. Only when combining coping and transformation measures, an adaptation strategy enables to react on already occurring risks as well as future risks without increasing the vulnerability to either of them (Eriksen & Kelly, 2007). However, a necessary step even before coping with risks is achieving awareness of the risks (Respondent 3). Therefore, the three necessary steps of an adaptation strategy are awareness, coping, and transformation, as depicted in Figure 20 on the following page. Furthermore, by connecting the measures to the SDGs, adaptive capacity can be developed.

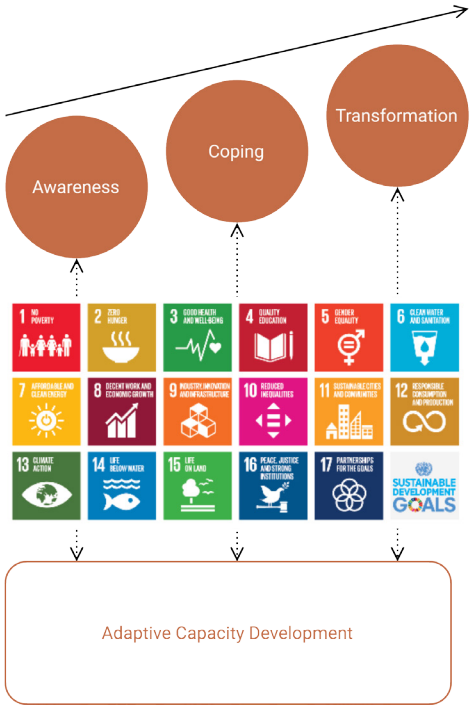

Figure 20: Elements of an adaptation strategy

Another possible categorisation describing the time-scale of adaptation measures is rooted in disaster research and describes the steps of disaster management: hazard-oriented measures aim to avoid hazards, vulnerability-oriented measures aim to reduce vulnerability to hazards, response-oriented measures provide mechanisms for reacting to occurring hazards, and recovery-oriented measures provide mechanisms for recovering after a hazard. While response- and recovery-oriented measures rather belong to the field of disaster management, hazard- and vulnerability-oriented measures describe approaches utilised in adaptation.
Many adaptation efforts in the past aimed to avoid the occurrence of hazards, so were hazard-oriented (World Economic Forum, 2019). For example, the extensive flood defence infrastructure constructed in the Netherlands. However, new approaches developed in the Netherlands, as introduced in section 2.2.1, aim to reduce the vulnerability to hazards, so are vulnerability-oriented (World Economic Forum, 2019). For example, the creation of urban wetlands that may flood to protect the buildings and streets nearby.

With the increasing extent of climate change, hazard-oriented measures become decreasingly feasible. Decreasing the vulnerability to and impact of occurring hazards is a more valuable approach that allows for further adaptability of the measures in the future.

4.2. Adaptation as a process

In this section, an ‘optimal’ adaptation process is developed in an iterative process. The input for this process are various conversations at the client company as well as an analysis of different processes evolving around adaptation planning and spatial planning (see Appendix 5).

The starting points for the development of the ‘optimal’ process are the steps of the adaptation process as communicated by &Flux: awareness and initiation, analysis, strategy development, and detailing. However, from the Industrial Design Engineering perspective, at least two steps are missing in that process: implementation, and evaluation. Evaluation is also a step that researchers have determined as essential for successful adaptation efforts (Geldin, 2018; IPCC, 2014c).
When analysing the processes as described in Appendix 5, it becomes clear that both Dutch and international adaptation and spatial planning approaches depend heavily on multiple steps of decision making and analysis. Therefore, in the ‘optimal’ adaptation process, the analysis step is split up and included in both the strategy development and detailing step.

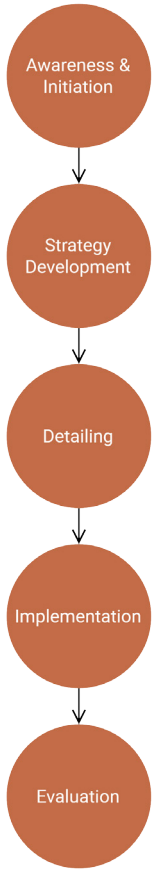

Figure 21: Simple adaptation process

Consequently, the steps of the 'optimal' adaptation process are as follows:

1. The first step in the adaptation process is a moment of awareness in which the community becomes aware of the problem of climate change and the necessity for adaptation after which the adaptation planning can be initiated.
2. The next step is the development of a strategy by first analysing the vulnerabilities, choosing a focus, and developing a strategy for that focus.
3. The following step is detailing of the strategy. Detailed calculations and analysis are performed in order to ensure the best functioning of the measures.
4. After detailing, the adaptation strategy can be implemented.
5. A final evaluation ensures learning so that the process can be enhanced in the future.

This provides an overview of the steps of the 'optimal' adaptation process.
While most adaptation processes describe the steps linearly, adaptation processes can, in fact, better be described as iterative and circular.
This because climate change consists of a variety of risks so that multiple iterations of solving these various risks are necessary.
Furthermore, iterations within the different steps of the process are necessary in order to develop the best solution.
But most importantly, because the climate is changing, adaptation strategies have to change with it, repeatedly performing the process. Adaptation is a process itself that has a highly incremental and iterative character.
Therefore, the actual 'optimal' adaptation process is circular as shown in Figure 22.
Figure 22 shows that strategy development is only one step in the adaptation process. As already established in the research questions in section 1.3.2, the assignment and SDG-Adaptation-Framework focus on strategy development and therefore merely on that step of the adaptation process.

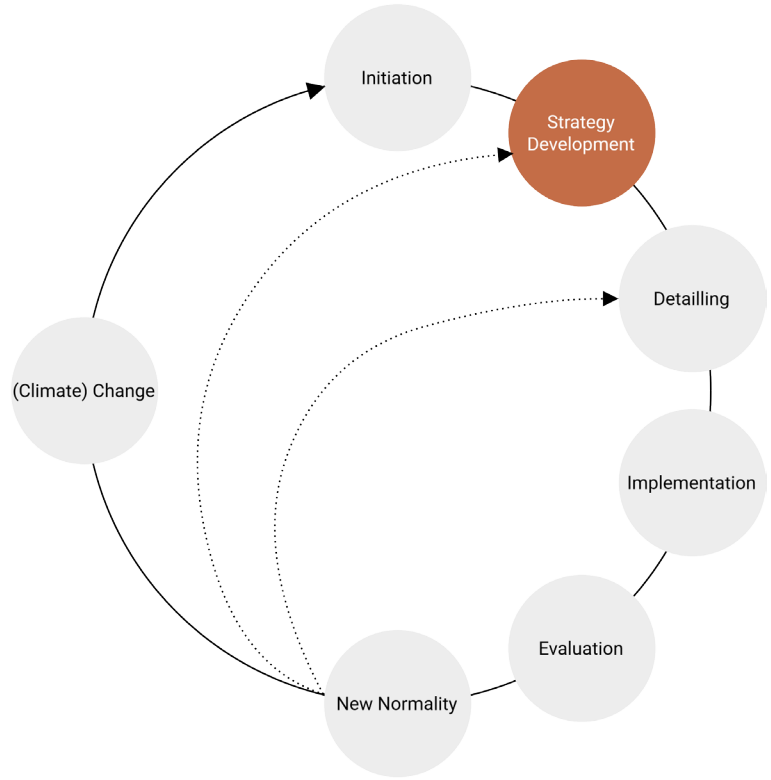

Figure 22: The 'optimal' adaptation process

4.3. Solution factors

During the previous sections and chapters, adaptation progress around the world, climate vulnerability and adaptation approaches were investigated through expert interviews, literature research, mappings, and analysis. Furthermore, the focus for the rest of this assignment is determined to be the development of a framework that connects spatial adaptation to the SDGs in order to enhance adaptive capacity. The insights gained during the investigation are mapped and merged into two types of factors: factors that are enabling adaptation and factors relevant for the to be developed SDG-Adaptation-Framework. This section provides listings of both types of factors.

4.3.1. Adaptation enabling factors

During desk research and interviews performed during the investigations in previous chapters, a variety of factors were repeatedly mentioned as factors

enabling successful adaptation. From mapping and combining these, a final set of adaptation enabling factors is determined. Figure 23 shows the resulting set. The adaptation enabling factors form relevant points of attention when developing an adaptation strategy.

Figure 23: Adaptation enabling factors

Awareness, urgency & prioritising
Adaptation starts with the awareness of the need for it. Awareness can be created by urgency, so when climate change consequences can be felt, but it can also be created by education. Understanding the need for adaptation and prioritising it, is extremely important for adaptation action (Respondent 1, 3).

Knowledge sharing & collaboration
Networks like 100RC and C40 are built upon this factor. They believe that knowledge sharing and collaboration between cities ease and enhance adaptation efforts of participating cities (Resilient Cities Network, n.d.-a). This is aligned with &Flux's drive to build coalitions (&Flux, 2020a).
Especially small municipalities can lack the resources and capacity to elaborately analyse their vulnerability and formulate strategies, so the opportunity to collaborate and learn from other cities that are further in the adaptation process is especially valuable for them (Geldin, 2018).

Stakeholder & community engagement
This factor is also aligned with &Flux's drive to build coalitions (&Flux, 2020a). While it is important for successful adaptation to collaborate with other cities, it is equally important to collaborate with other stakeholders within the city as well as the community (Geldin, 2018). This creates another way of knowledge sharing, for example, when collaborating with local construction companies that have knowledge in the field of adaptation. Furthermore, it creates a support base for implementation.

Evaluation & learning
Aligned with learning and collaborating with others is the ability to learn through evaluation. As mentioned in 4.2, adaptation is a continuous, iterative process. When evaluation is part of that process, a municipality can learn from previous mistakes and successes. It is also connected to the adaptability of adaptation measures since adaptability depends on the continuous and incremental evaluation and development of adaptation measures. (Geldin, 2018; IPCC, 2014b)

The new normal & synthesis
The goal of &Flux's CKB is to include adaptation into each new construction project and to eventually make adaptation 'the new normal'.[5] Many cities in the Netherlands have formulated adaptation strategies, but following up on these adaptation strategies is another challenge. Furthermore, the synthesis with other relevant targets such as energy transition, social inclusivity, mobility, etc. and attention to the potential of adaptation can significantly increase the success of adaptation because it enhances the efficiency on both sides (Respondent 2, 3).

Local leadership
Many adaptation actions have only accelerated when a local 'hero' became involved in the project (Measham et al., 2011; Respondent 3), so when a well-

5 This information was retrieved from various conversation with van der Wal, S. at &Flux.

respected local leader supervised and communicated the adaptation efforts with the local inhabitants.
The 100RC network recognises the importance of local leaders with responsibility as they appoint a 'Chief Resilience Officer' in every partnering city (Arup International Development & The Rockefeller Foundation, 2015).
In a more informally organised community, the local leader does not have to be a governmental personality but may be an informal leader as long as they have awareness for the priority of adaptation and the capacity to steer their community.

4.3.2. Framework factors

All information gathered in the previous sections and chapters also provides insights into requirements relevant for the development of the SDG-Adaptation-Framework from a theoretical and useability perspective. The list below includes the set of requirements relevant for the SDG-Adaptation-Framework.

The SDG-Adaptation-Framework should:

Assignment scope

1. Support first adaptation efforts
2. Support cities in their adaptation efforts
3. Focus on spatial adaptation
4. Focus on capacity development next to spatial adaptation
5. Focus on the connection of spatial adaptation to the SDGs
6. Focus on strategy development

Theory

1. Incorporate short-term and long-term strategies in the form of coping and transformation
2. Incorporate continuous awareness creation
3. Incorporate a focus on reduction of vulnerability instead of avoidance of hazards
4. Support clarification of connections between risks
5. Consider the concepts of availability and accessibility around adaptive capacity
6. Incorporate attention for the contextual factors influencing the success of adaptation efforts
7. Assist in clearly identifying and focussing on the most vulnerable groups of people
8. Incorporate a clear focus on the implementability of the adaptation strategies
9. Assist in understanding the local context and vulnerability
10. Include the adaptation enabling factors

Usability

1. Be useable for a variety of municipalities in developing regions
2. Allow for adjustment of the process to the local context
3. Provide a clear overview of the necessary and optional steps to follow
4. Provide clear examples of adaptation solutions
5. Include a manageable amount of information

Conclusion Part A

The goal of Part A was to provide insights into the factors influencing climate vulnerability and adaptation.
After establishing the increased vulnerability of developing regions due to their lack of adaptive capacity, the focus for the rest of the assignment and framework to be developed was determined. This focus is the connection of spatial adaptation to the SDGs in order to enhance adaptive capacity.
A detailed framing method for describing the vulnerability of the living environment was developed as a foundation for the development of adaptation strategies.
Such development of adaptation strategies is only one step of the 'optimal' adaptation process. The SDG-Adaptation-Framework to be developed focusses on that step of the 'optimal' adaptation process.
Part A forms the theoretical baseline for both the case study in Part B as the SDG-Adaptation-Framework development in Part C.

PART B: EXAMPLE

Part B addresses the second secondary research question: *How can an adaptation strategy be developed for a vulnerable municipality?*
In order to answer this question, a case study is executed during which the complete process of developing an SDG-inclusive adaptation strategy is performed. The case study mainly serves as an example that can be utilised to translate and generalise the approach taken in order to develop a framework for similar municipalities.
The focus of the SDG-Adaptation-Framework to be developed is the connection of spatial adaptation to the SDGs as described in section 2.3. This focus also serves as a focus for the case study and guides choices performed during the case study. The specific case study focus is determined in section 6.2.
All information assembled during this case study is gathered during literature research and expert interviews. These interviews concerning the case study are referred to as respondent 11,12,13 consecutively. Appendix 1 includes an overview of the different respondents. The appendix also clarifies nuance in the opinions of the experts by showing statements contradicting with other experts and literature.
The vulnerability framing method, introduced in section 3.2.2 serves as a baseline for understanding the various vulnerabilities and their connections.

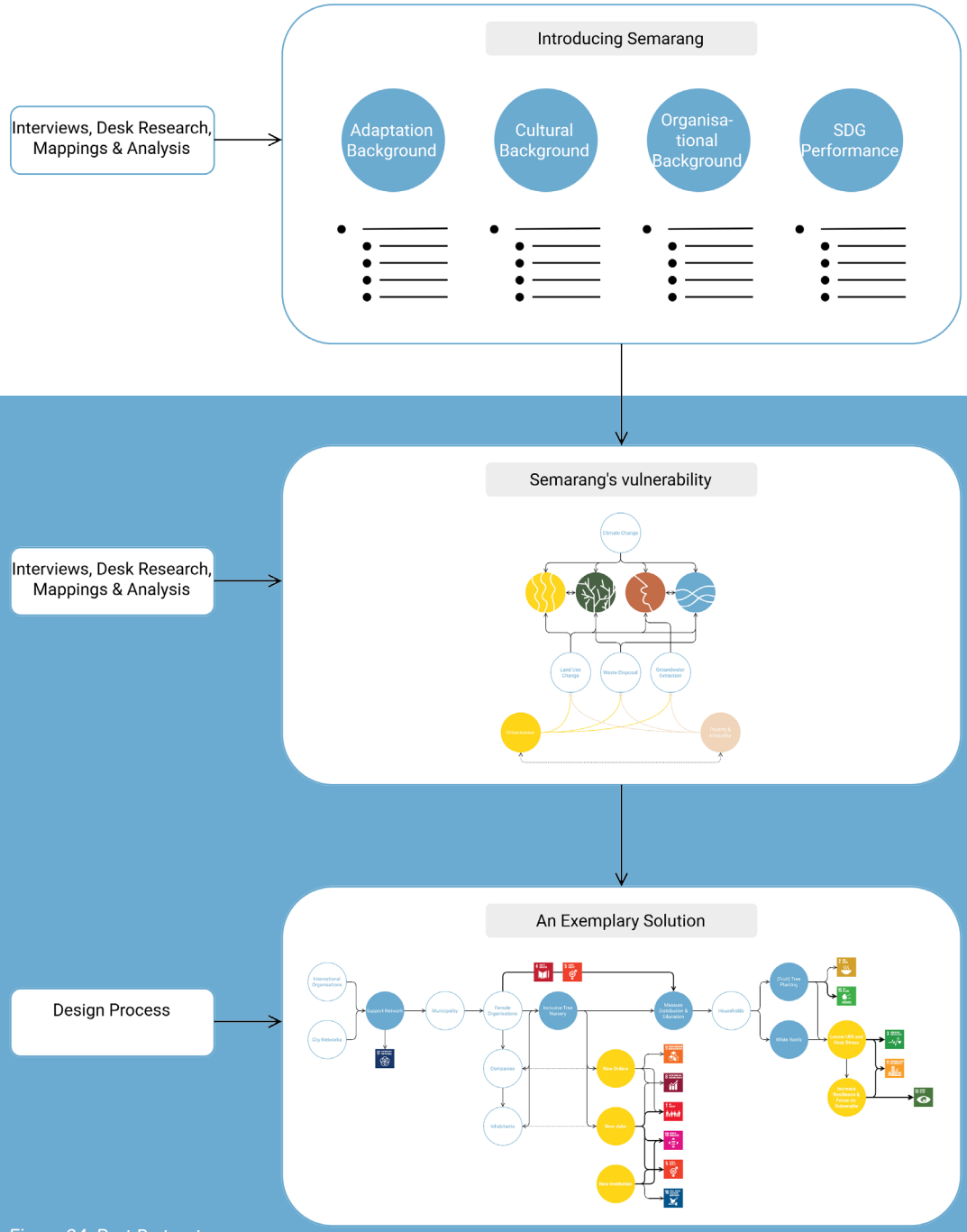

Figure 24: Part B structure

Approach

This part starts in chapter 5 with background information concerning the case study location Semarang by providing information about adaptation, culture, and organisation as well as an overview of Semarang's SDG performance.

Afterwards, Semarang's vulnerability is analysed in chapter 6. The analysed neighbourhood within Semarang is Terboyo Wetan. Insights from the neighbourhood Kemijen are utilised because of their more elaborate experience with adaptation. Within chapter 6, the focus of the case study is determined to be heat stress with a specific focus on low-income households. The vulnerability for heat stress is further investigated utilising insights from flood management projects in Kemijen. Chapter 6 ends with an overview of possible SDG connections as well as a list of interfaces for the strategy design process.

This strategy design process is described in chapter 7 and results in an exemplary solution for Semarang. It includes brainstorming and most importantly the connection of spatial adaptation measures to the SDGs.

INTRODUCING SEMARANG

Various locations are considered as context for the case study. The considerations are based on the target group regions defined in section 2.3.1. Finally, Semarang in Indonesia is selected because it has a history of both socio-economic and climate-related vulnerability as well as adaptation, and offers a sufficient amount of data. The detailed boundaries and process of the selection can be found in Appendix 6.

While Semarang serves as the context of the case study, the strategy development is performed from a distance due to the Covid-19 pandemic in 2020. Hence, understanding the context of Semarang is important for the assignment and reader of this report. Therefore, this chapter introduces Semarang's cultural, organisational, and adaptation background followed by a brief overview of Semarang's SDG performance.

05

Figure 25: Semarang, retrieved from europeanspaceagengy on flickr.com on November 18,2020

***Profile**:*

Where:	*Central-Java, Indonesia*
Climate:	*Tropical with monsoon and dry season (World Health Organization, 2015)*
Inhabitants:	*1.9 million (World Population Review, 2020)*
Economy:	*Upper-middle income (World Bank, n.d.)*

5.1. Background

The city Semarang is the capital of the Indonesian province Central-Java and lies on the Northern coast of the Java island. Semarang is a port-city that is known for its industry and innovation (Khadiyanto, Soetomo, & Hadi, 2015). However, next to its economy, Semarang is also known for its regular floods and has a long history of adapting to them.

Figure 26: Flood in Semarang, retrieved from john_arns on flickr.com on October 20, 2020

The following sections are introducing Semarang in further details on three dimensions: adaptation, culture, and organisation.

5.1.1. Adaptation background

Semarang has a long history of adaptation. The districts and villages close to the sea have experienced daily floods in the past while multiple adaptation efforts aim to decrease the flood risk (Ham, Schuller, Heikoop, Pratiwi, & Wahyudi, 2015). However, both by sea-level rise and land subsidence, the flood risk is increasing (Sariffuddin et al., 2019).
Due to rapid urbanisation, the land use, especially within the outer districts and villages, is constantly changing (Sariffuddin et al., 2019), which is creating an increasing disruption of the local ecosystem. Increasing population density and the loss of greenery are increasing the problem of the urban heat island effect, so the difference of the temperature in the city from the temperature in rural areas (Kluck et al., 2020; Pamungkas, Munibah, & Soma, 2019). Together with generally heating temperatures and an increase of frequency and intensity of heatwaves, this increases negative impacts on the health and well-being of Semarang's inhabitants (Arifwidodo & Chandrasiri, 2020; Kluck et al., 2020).

Facing these numerous challenges, Semarang is a frontrunner in adaptation within Indonesia and part of multiple international networks such as 100RC. Semarang released its resilience strategy together with 100RC in 2016 which mainly highlights Semarang's flood risk in terms of climate vulnerability (100 Resilient Cities, 2016).
Many of Semarang's adaptation efforts focus on the touristic old city centre (Respondent 13). However, due to the high flood risk, districts close to the sea also gain attention for adaptation. Two districts relevant in this report are Timur and Genuk and in particular the villages Kemijen in Timur and Terboyo Wetan (short: TW) in Genuk. TW serves as the specific case study location while Kemijen serves as a source of further insights.

Kemijen in Timur
Kemijen is one of Semarang's villages with the highest flood risk. It is one of the poorest areas wile daily floods having driven many businesses out of Kemijen (World Water Atlas, n.d.).

However, in collaboration with a Dutch water board, a polder system and local water board named BPP SIMA have been set up decreasing the flood risk to once in ten years (World Water Atlas, n.d.). Problems like garbage disposal, land subsidence and heat stress remain, but the neighbourhood is flourishing (Jayanimitta et al., 2018; World Water Atlas, n.d.).

Terboyo Wetan in Genuk
Terboyo Wetan is one of the villages in Genuk which is majorly utilised as an industrial area but also faced with informal settlement growth. Many inhabitants of TW are migrant workers seeking opportunity in the industrial area. That industrial area is one of the lowest paying in Semarang (Respondent 15). Also, TW is faced by extreme flood risk that is recently lowered by implementing yet another polder system (Jayanimitta et al., 2018). Remaining problems are similar to the problems in Kemijen but partly increased due to the socio-economic status of TW's inhabitants.

Figure 27: Kemijen, Timur and Terboyo Wetan, Genuk, modified from google.com/maps on October 19,2020

5.1.2. Cultural background

In order to describe the cultural context of Indonesia, the 6 dimensions of Hofstede's cultural dimension theory (Hofstede, 2011) are utilised. Describing the cultural context from the perspective of a whole country using merely 6 dimensions has its limitations. However, the descriptions of the six dimensions are an approximation and enriched by information gathered in additional literature and interviews.

Power distance

Indonesia scores high on the dimension of power distance, meaning that there is considerable inequality between rich and poor (Hofstede Insights, n.d.-b). Rights are unequally divided such that people from a lower hierarchy level are depending on the higher levels (Respondent 13).
This influences adaptation in two ways. Firstly, the power distance of the poor results in an increased vulnerability because they can neither access resources nor decision making. Secondly, this also results in a necessity of involving the top-layers to achieve political power. (Respondent 12, 13)

Individualism

Indonesia has a very low score in this dimension meaning that Indonesia is a collectivist society most strongly visible within families (Hofstede Insights, n.d.-b). The collectivist characteristic of the Indonesian society is reflected in 'Gotong Royong' which is communal work often organised by neighbourhood-wide male and female organisations (Sariffuddin et al., 2019). Examples of 'Gotong Royong' are clean-ups of trash or water after a flood (Respondent 12). This has implications for adaptation since 'Gotong Royong' can be utilised for implementation of adaptation measures.

Masculinity

Indonesia has low masculinity compared to other Asian societies which means that Indonesia is more driven by solidarity and especially the outer appearance than driven by competition (Hofstede Insights, n.d.-b).
This is reflected in both the hierarchical and the collectivist characteristic, so will result in the same implications for adaptation.

Uncertainty avoidance

Indonesians feel a relatively low threat from unknown situations, so direct conflict resolution is experienced as threatening (Hofstede Insights, n.d.-b). This has implications for the evaluation of adaptation efforts since Indonesians have a tendency to avoid conflict and hide criticism (Hofstede Insights, n.d.-b). Furthermore, it can already affect the implementation of adaptation since people may avoid participation when they are not sure of their superior's opinion on it (Respondent 13).

Long term orientation

Indonesia's high score in long term orientation means that Indonesia has a pragmatic culture. Instead of depending on traditions, Indonesians will adapt to changed conditions quickly (Hofstede Insights, n.d.-b).
A pragmatic culture can ease adaptation efforts since inhabitants will be more open to change that can improve their current situation. This pragmatism also results in the quick organisation of informal settlements into a semi-formal structure (Respondent 13).

Indulgence

Indonesia's score for indulgence means that Indonesia has a culture of restraint (Hofstede Insights, n.d.-b). Societies with an inclination towards restraint have a tendency for pessimism and the belief that "what happens to me is not my own doing" (Hofstede, 2011).
Especially the feeling of powerlessness can influence adaptation efforts of individuals since they may feel unable to adapt to climate change themselves.

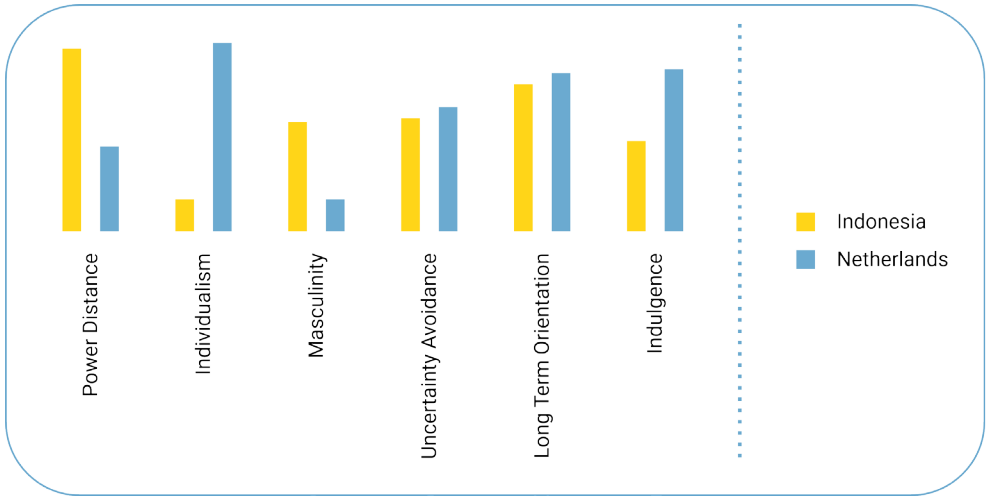

Figure 28: Comparison of Indonesia and the Netherlands, adapted from Hofstede Insights (n.d.-a)

A quick comparison of Indonesia to the Netherlands is performed in order to clarify the difference of the cultural context for readers inhabiting a Dutch perspective (Hofstede Insights, n.d.-a). The detailed analysis can be found in Appendix 7.
The most important insight from that analysis is that the difference in scores is mainly reflected in the first three dimensions of Hofstede as well as Indulgence.
The difference in power distance shows that Dutch inhabitants with a low social 'status' have better access to political power and decision making than Indonesian inhabitants. Furthermore, Indonesia is clearly a collectivist society in comparison to the Netherlands while the Netherlands has an even more feminine society driven by solidarity instead of competition. This means that collectivist adaptation efforts may be more successful in Indonesia when actually benefitting the Indonesian inhabitants.
The higher score of the Dutch on Indulgence reflects the more optimistic character of Dutch inhabitants in comparison to Indonesians.

5.1.3. Organisational background

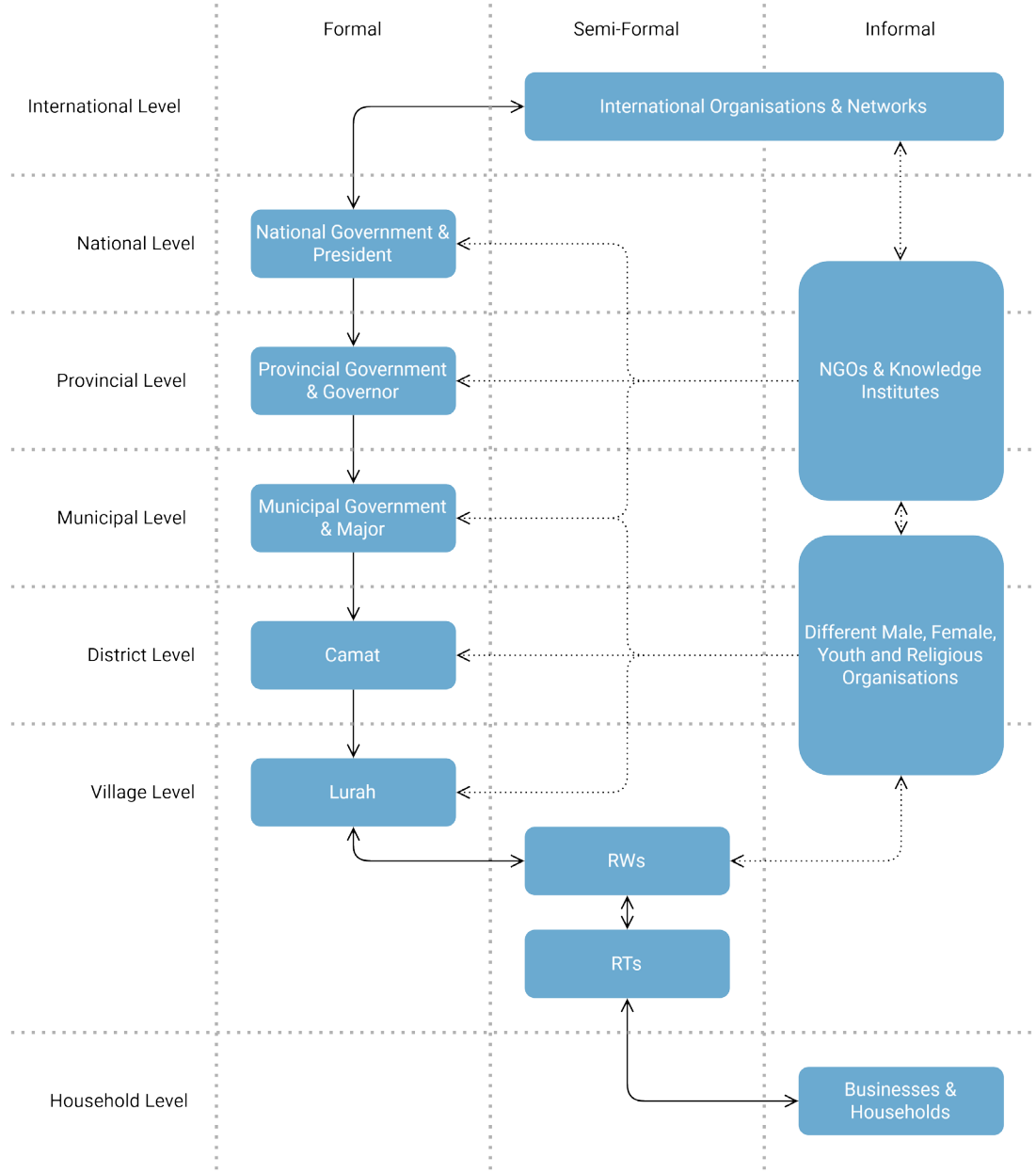

Figure 29: Semarang's organisational background

Indonesia is generally hierarchically organised (Ham et al., 2015; Hofstede Insights, n.d.-b).
Figure 29 on the previous page shows the different layers of Semarang's hierarchy. In the formal part of the organisation, the national government and president are on top of the provincial government, municipal government and the major of Semarang. Within the city, each district has an elected Camat that communicates with the Lurahs of each village. (Ham et al., 2015)
Semi-formal are the Rukun Wargas (short: RW) and Rukun Tetanggas (short: RT). RTs are elected members of the community that represent around 30 households and each RW represents multiple RTs. The RTs and RWs organise community meetings and participation, and communication with the Lurah. (Ham et al., 2015)

Next to the formal and semi-formal organisation, there are multiple influential informal organisations such as male, female, youth and religious organisations that can act influential in adaptation efforts (Ham et al., 2015). Female organisations, for example, are responsible for educational programmes in the villages (Ramaker, 2013). However, women cannot participate in other official organisations, so, have a higher distance to power and decision making (Ramaker, 2013).
At the household level, there are the various inhabitants and businesses located in TW in Genuk. According to Sariffuddin et al. (2019), the inhabitants of Genuk can be categorised into three groups: Informal workers. Industrial workers, and wealthy. The three different groups have distinct relationships to adaptation and their environment. While informal workers do not have the necessary capacity and understanding to contribute to adaptation, the wealthy on the other hand do not have a big concern for the environment. The industrial workers generally have a middle educational background and are often most active in environmental adaptation and community organisations. (Sariffuddin et al., 2019)

The different layers of hierarchy just described, can be instrumentalised for the organisation of adaptation and are necessary for accessing political power. High levels of the hierarchy must be involved in adaptation efforts. Financing of adaptation projects must come either from the national government or international organisations since the municipal government does not have a sufficient budget (Respondent 12).
Furthermore, people may avert participation in adaptation when it is induced by an outside organisation instead of a well-established member of the community. This means that adaptation needs a local leader to achieve the participation of the household level (Ley, 2016; Ramaker, 2013).

5.2. SDG performance

The focus of the assignment and case study is the connection of spatial adaptation to the SDGs. In order to connect spatial adaptation to the SDGs, an overview must be gained of the connections that may be relevant and of the overall SDG performance.
National data is used to investigate Semarang's SDG performance since there is no (public) data available on a local level. It is important to note that not every indicator of the SDG targets has access to data. Therefore, the performance of many SDGs are approximations.

Figure 30 shows Indonesia's overall SDG performance. A green symbol would mean that the SDG is achieved while a red symbol means the SDG is a major challenge. As obvious, Indonesia has not achieved any of the SDGs yet. However, some SDGs require even more attention than others. The worst performing SDGs in Indonesia are *SDG 9: Industry, innovation and infrastructure, SDG 10: Reduced inequalities* and *SDG 15: Life on land* with 15 even decreasing according to Sachs et al. (2019). This means that these SDGs require most attention in order to be achieved by 2030.

Figure 30: SDG performance Indonesia, adapted from Sachs, Schmidt-Traub, Kroll, Lafortune, and Fuller (2019)

SEMARANG'S VULNERABILITY

After gaining a general overview of the context of this case study, understanding the vulnerabilities of the case study location is an important first step of developing an SDG-inclusive adaptation strategy against these vulnerabilities.
In this chapter, an overview of Terboyo Wetan's vulnerability is provided followed by the choice of the specific focus for this case study. Heat stress is selected as that specific focus. It is further investigated by also utilising knowledge from water management projects. Finally, an overview of the possible SDG connections is provided together with a set of interfaces for the strategy development process.

06

6.1. General vulnerability

Before being able to select a specific focus for the strategy development, a general vulnerability analysis is necessary. In this analysis, the vulnerability framing method developed in section 3.2.2 is utilised to create a connection of the various elements of TW's vulnerability. Appendix 8 shows exemplarily how the main climate risks behave in their vulnerability frame.
In this section, these main climate risks are explained first followed by the socio-economic risks relevant in TW.

6.1.1. Climate risks

Climate risks are obviously the most important to analyse when developing an adaptation strategy. They are naturally interlinked with other risks and are also interlinked with each other. Therefore, the most relevant climate risks in TW are grouped into two sets of risks: 'Flood and land subsidence', and 'heat stress and ecosystem loss'.

Flood and land subsidence

Flood can be regarded as the most influential climate risk in TW and Semarang in general (100 Resilient Cities, 2016; Khadiyanto et al., 2015).
The regularly occurring floods cause damage to infrastructure and buildings. They cause economic disruptions such that businesses leave areas that are often inundated (Jayanimitta et al., 2018). Furthermore, the floods can cause health issues through the spread of infectious diseases from inundated wastewater (Jayanimitta et al., 2018).

Important to note is that the floods are merely a symptom of two underlying problems: sea level rise and land subsidence. Sea level rise is caused by global warming and climate change while land subsidence in TW is mainly caused by groundwater extraction, increased population density and land-use change (Respondent 16).
The flood risk in TW is also connected to the missing garbage treatment system. The inhabitants of TW often dispose of their garbage in the streets and canals of the polder system. This garbage disposed of in the canals can clog the pumps of the polder system, increasing the flood risk (Sariffuddin et al., 2019).
There is also a linkage of floods to the water quality, but indirectly. The water

pumped through wells is nor treated when extracting it and neither when disposing of it. This leads to bad drinking water quality and degradation of the environment (Respondent 16). Figure 31 shows the interlinkage of the most important risks and problems connected to floods and land subsidence.

The coping capacity of TW's inhabitants is relatively high. However, since many inhabitants of TW are migrant industrial workers, their experience of the environmental challenges is lower than of native inhabitants. Coping strategies involve simple measures such as storage of belonging on higher shelves or closing the drainage during high tide. A bigger investment is necessary when raising the house or more commonly the ground floor of the house. Furthermore, some households have their own water pumps. (Adi & Wahyudi, 2018; Sariffuddin et al., 2019)

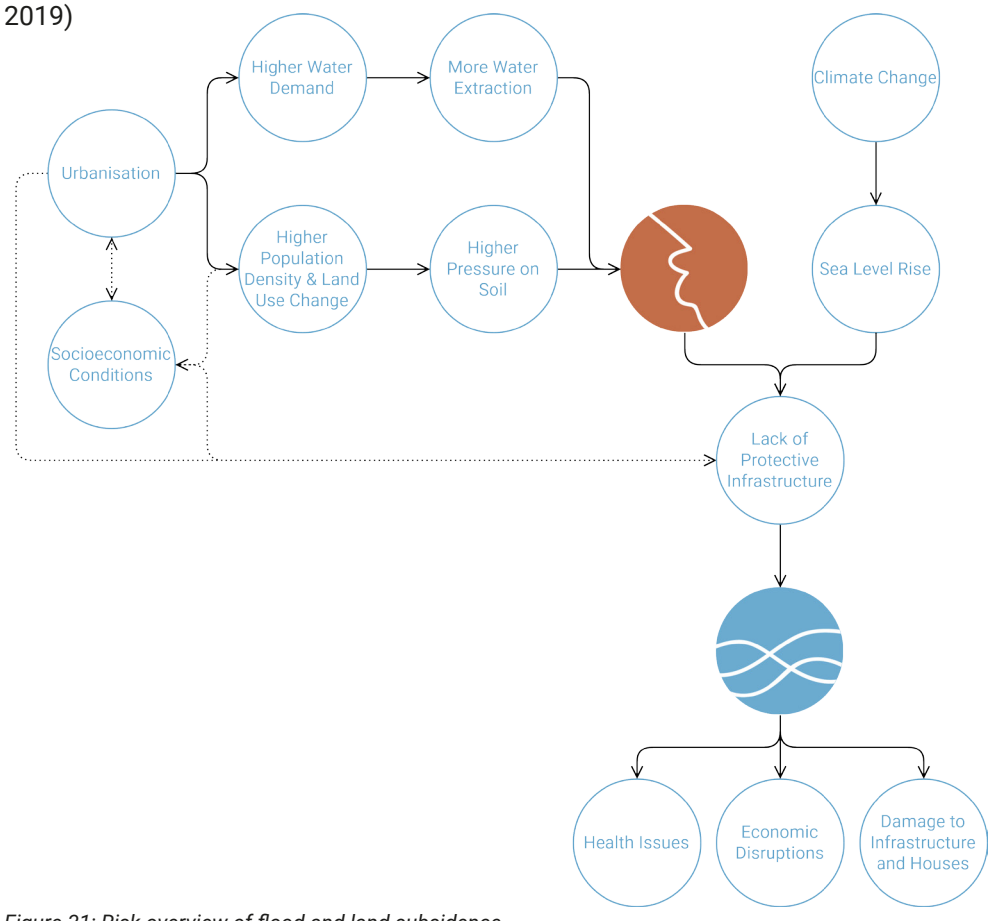

Figure 31: Risk overview of flood and land subsidence

Heat stress and ecosystem loss

Heat stress, so the negative effects of extreme heat, increasingly gains attention as a climate-related risk around the world. An Australian study even states that heat is the most threatening climate risk in their country (Longden, Quilty, Haywood, Hunter, & Gruen, 2020). In Semarang, heat stress has not received much attention as a climate risk yet since inhabitants are used to extreme heat (Respondent 14, 15).

However, next to heat-related mortality, heat stress simply harms human health, comfort, productivity and contributes to infrastructure damages and bad air quality (Kluck et al., 2020; Pamungkas et al., 2019).

Next to climate change causing more frequent and intensive heat waves, urban heat stress is accelerated through the Urban heat island effect (short: UHI) that results in warmer temperatures in the cities, especially during the night (Pamungkas et al., 2019).

Due to land-use change, higher population density and greenery decrease, the UHI is increasing in TW (Pamungkas et al., 2019). The decrease of greenery also contributes negatively to the ecosystem services such as the lack of garbage and wastewater treatment polluting Semarang's ecosystem (Respondent 16).

Furthermore, heat stress is related to poverty (Arifwidodo & Chandrasiri, 2020). Inhabitants with a low socio-economic status often live in densely populated areas with a small amount of greenery. That is increasing the risk of heat stress. Furthermore, the housing quality of inhabitants with a low socio-economic status is often decreased (e.g. no insulation) and they are more likely to perform physical labour (Arifwidodo & Chandrasiri, 2020; Sariffuddin et al., 2019).

Most importantly, the adaptive capacity of inhabitants with a low socio-economic status is decreased since they cannot access the necessary resources to cope and adapt. However, since the climate in TW often leads to high and extreme temperatures, inhabitants have a relatively high coping capacity, for example by staying out of the sun or taking breaks during noon (Respondent 15).

Figure 32 on the following page shows an overview of the most important problems and risks connected to heat and ecosystem services.

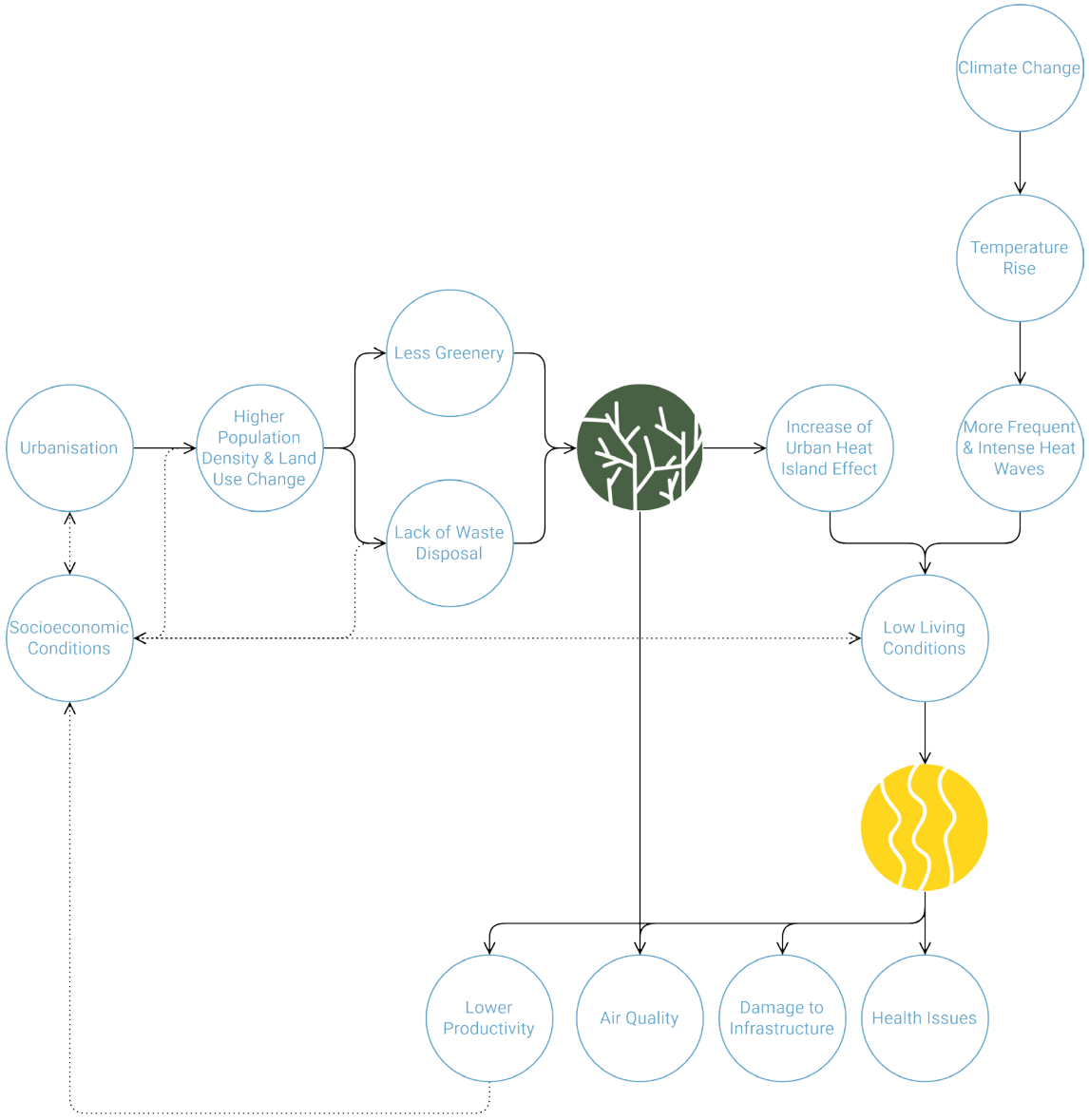

Figure 32: Risk overview of heat stress and ecosystem loss

6.1.2. Socio-economic vulnerabilities

Climate risks are clearly connected to socio-economic vulnerabilities, as discussed multiple times before. Consequently, it is important to understand the socio-economic vulnerabilities of the location's inhabitants.
Some socio-economic vulnerabilities are relevant for all climate risks and locations while others might be only influential for a specific climate risk. For example, while industrial workers have an increased vulnerability especially for heat stress due to their working conditions (Pamungkas et al., 2019; Puspita, Kurniawidjaja, & Ramdhan, 2016), people with a low income are always more vulnerable due to their lack in adaptive capacity (Respondent 8).
In TW, there are various groups of people vulnerable to specific climate risks and in general. They are described below.

Firstly and most importantly, TW is a poor neighbourhood that can officially be categorised as informal settlement (Respondent 12) because of the partly informal status of the inhabitants, poorly constructed homes and high population density (Faniza & Pradoto, 2019; Habitat for Humanity, n.d.). The industry in TW is one of the lowest paying in Semarang (Respondent 15). While inhabitants with a low income always belong to the most vulnerable people because of their lack in adaptive capacity (Brouwer, Akter, Brander, & Haque, 2007; Otto et al., 2017; Pandey et al., 2018), the vulnerability of low-income households in TW is especially high because of the high power distance in Indonesia (Hofstede Insights, n.d.-b). Someone from the lower level of hierarchy with little connections above them has difficulties influencing the decision making, increasing their vulnerability (Sariffuddin et al., 2019).

Secondly, since TW is formed by rapid urbanisation, many inhabitants of TW are migrants with less experience of climate risks and coping mechanisms (Sariffuddin et al., 2019). While informal settlements in Indonesia are generally quickly organised compared to informal settlements in other parts of the world (Respondent 13), the migrants in TW are less likely to already be organised in community organisations.

Thirdly, women are significantly vulnerable for similar reasons as low-income inhabitants. While there are influential female organisations, the positions of RT

and RW are always male-inhabited. Women are excluded from many decision-making processes in Indonesia (Ramaker, 2013). Therefore, they have a higher power distance and higher vulnerability.
The vulnerability of women is also especially increased in terms of heat stress because women often stay home to manage the household (Jayanimitta et al., 2018). With poorly insulated houses, women are strongly exposed to heat stress.

Lastly, especially in terms of heat stress, elderly experience a higher vulnerability when being exposed to climate risks, due to lower overall health (Arifwidodo & Chandrasiri, 2020).

6.2. Defining the case study focus

In order to develop an actionable adaptation strategy, the strategy should consist of a clear focus while taking into account the various risks and vulnerabilities connected to that focus. Therefore, one of the discussed climate risks is selected as the focus of this case study and is further investigated in the following sections. This section describes that choice followed by the choice for the specific target group as well as relevant SDGs.

6.2.1. The choice for heat stress

Figure 33 on the right shows an overview of the different climate risks in Terboyo Wetan in Semarang and a brief overview of their linkages to other vulnerabilities. From the shown risks, heat stress is selected as the focus risk of the case study. While flood is an extremely pressuring risk in TW, a variety of adaptation efforts has already been set up. Heat stress has not yet received much attention in TW. This allows for the complete process of strategy development in this case study.

6.2.2. The specific target group

As discussed in section 6.1.2, various socio-economic vulnerabilities are threatening different groups of people.
Because of the increased vulnerability of industrial workers for heat stress, TW's industry could form an interesting target group. However, most information available regarding TW and Semarang in general is framed around households. Therefore, the target group is selected within the households.

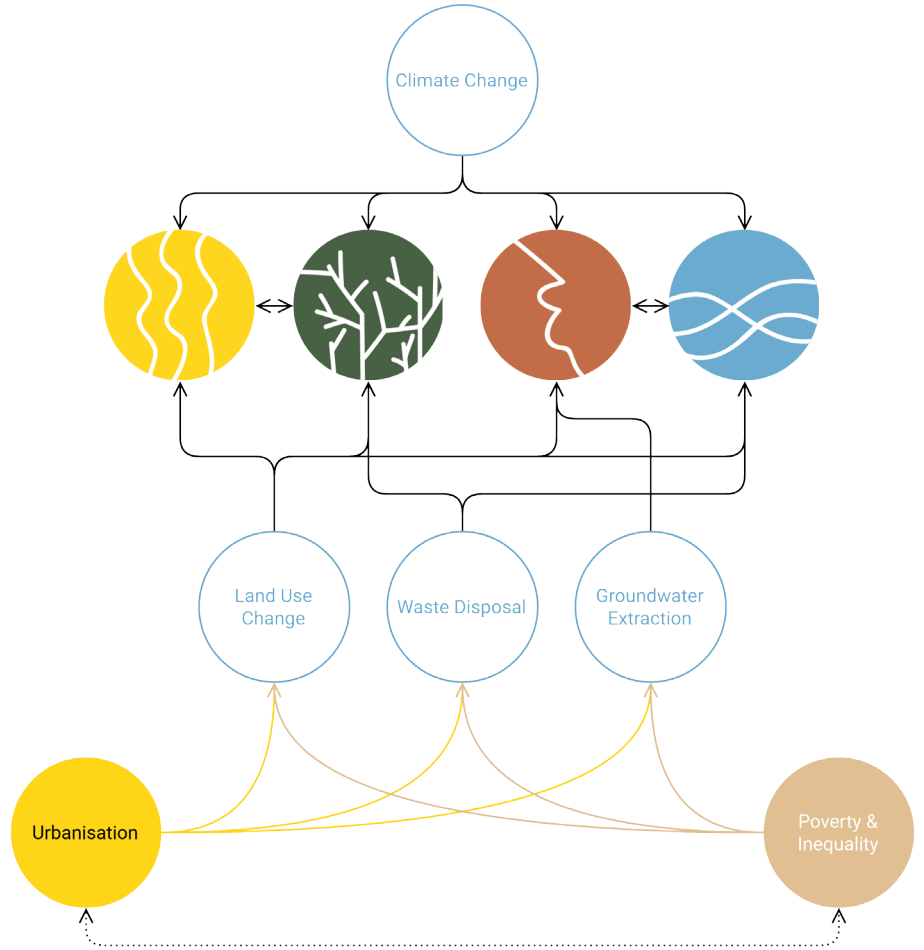

Figure 33: Overview of specific focus options

As explained in section 6.1.2, low-income households are generally most vulnerable to climate change. Section 5.2 defines *SDG 10: Reduced inequalities* as one of the worst-performing SDGs in Indonesia. The low-income households in TW are one of the groups most threatened by the inequality and power distance reflected in SDG 10. Especially women form a threatened group because of their even higher power distance.

Therefore, low-income households with a specific focus on women are selected as the specific target group of the SDG-inclusive adaptation strategy to be developed.

6.2.3. The choice of SDGs

Following both the choice for heat stress and the target group, the focus-SDGs can be selected that are related to those choices.

Directly impacted by heat stress is *SDG 3: Good health and well-being*. Directly impacted by adaptation efforts in general are *SDG 11: Sustainable cities and communities* and *SDG 13: Climate action* since adaptation is part of the SDG's sub-targets (United Nations, n.d.).

SDG 4, 16, and 17 are general adaptation requirements because of the adaptation enabling factors described in section 4.3.1. *SDG 4: Quality education* targets the increase in awareness and adaptation knowledge. *SDG 16: Peace, justice and strong institutions* targets local leadership by strengthening leaders and institutions. *SDG 17: Partnership for the goals* targets international knowledge sharing and collaboration.

As explained in section 5.2, the worst performing SDGs in Indonesia are SDG 9, 10, and 15. Therefore, they are selected as case-specific requirements to be included. Since low-income households and especially women are impacting *SDG 10: Reduced inequalities, SDG 1: No poverty* and *SDG 5: Gender equality* are also included as case-specific requirements.

Figure 34 presents the final set of selected SDGs that should be connected to adaptation measures in order to develop an SDG-inclusive adaptation strategy.

Figure 34: The selected set of SDGs for Terboyo Wetan, adapted from United Nations (n.d.)

6.3. Heat stress vulnerability

The increase in average temperature and increase in frequency and intensity of heatwaves are some of the consequences of climate change (IPCC, 2014d). They are already noticeable. The years 2016 to 2020 has been the warmest 5 year period ever recorded (World Meteorological Organization, 2020). These changes contribute to an increasing risk of heat stress in TW.

In order to be able to develop a relevant adaptation strategy against heat stress, the risk must be understood as well as possible measures against it. Section 6.1.1 already explores TW's vulnerability to heat stress. However, this section aims to dive deeper into that vulnerability by understanding patterns of heat stress. Furthermore, lessons learned from flood management projects are utilised for better understanding case- and adaptation-specific vulnerabilities.

6.3.1. Understanding heat stress

The consequences of heat stress on TW are already explored in section 6.1.1. Therefore, this section revolves around relevant terminology as well as the functioning of heat stress.

Heat stress describes the consequences of extreme heat, so the discomfort and illness associated with exposure to heat (Arifwidodo & Chandrasiri, 2020). Some definitions not only include the influence of extreme heat on human health but also economy, ecosystems, and the built environment. They define heat stress generally as the consequence of extreme heat (Arifwidodo & Chandrasiri, 2020).

Extreme heat itself describes an extreme weather event that can occur during a heatwave. Such an extreme weather event causes a highly increased risk of heat stress, especially to vulnerable groups such as elderly (Arifwidodo & Chandrasiri, 2020).

Extreme heat and heat stress are not only a matter of actual temperature but also of the **felt temperature** (Kluck et al., 2020). For example, when someone is exposed to a temperature of 30°C, the felt temperature may be lower when there is ventilation.

Concerning the causes of extreme heat, not only the temperature rise and increase of heatwaves is relevant but also the **Urban Heat Island Effect** as mentioned before.

The UHI describes the phenomenon that urban areas are hotter than rural areas (National Geographic, n.d.; Pamungkas et al., 2019).
A report published by the Hogeschool van Amsterdam (Kluck et al., 2020) states that the UHI is caused by the storage of heat in buildings during the day. The radiation of that heat during the night hinders the city to cool down again. In this report, this phenomenon is defined as the **UHI during the night**.
Kluck et al. (2020) state that the UHI merely influences the temperatures during the night. However, the temperature and felt temperature in cities is also higher during the day, but due to different causes. Therefore, others define the UHI generally as the temperature difference of urban and rural areas both during day and night (National Geographic, n.d.).
During the day, the UHI is caused by a lack of shadow and evaporation from greenery, reflection of sunlight from tall buildings, and also radiation of heat from buildings, utilities, cars, people, etc. (National Geographic, n.d.) In this report, this phenomenon is defined as the **UHI during the day**.

Both UHIs increase the risk of heat stress in the city next to warming temperatures and the increase of heatwaves. In TW, the UHI is increasing due to land-use change, increase of population density and decrease of greenery.

6.3.2. Adaptation lessons learned from flood management

In order to understand the specific vulnerabilities in adaptation projects and determine points of attention for future adaptation projects, knowledge from flood management is utilised, especially the Banger Polder project in Kemijen in Timur.

As already introduced in section 5.1.1, Kemijen was threatened by floods daily. Since the implementation of the Banger polder, no flood has occurred yet (Respondent 12). However, land subsidence and sea-level rise continually increase the flood risk. The implemented polder system is tackling the symptoms instead of the problem. Also, problems with garbage and water treatment are still threatening Kemijen. (Ley, 2016)
When analysing risks, it is important to understand the causes and connections of the risks analysed in order to ensure treatment of the problem instead of the symptoms. Furthermore, the future behaviour of the risks must be understood. When focussing on the cause, connection, and future change of the risk, synthesis and problem understanding of the different risks and targets can be achieved, as depicted in Figure 35.

Next to the implementation of the polder system, a local water board named BPP SIMA was founded. That water board was supposed to maintain the polder and collect taxes just as the Dutch example (Ham et al., 2015). However, BPP SIMA did not establish a strong position within Kemijen. They criticise the lack of community participation by inhabitants (Ham et al., 2015). As a non-governmental organisation, it is extremely difficult to establish authority within the hierarchical Indonesian society. With the involvement of local leaders and female organisations, BPP SIMA has gained some prominence and authority within Kemijen (Jayanimitta et al., 2018).
The lack of community participation cannot only be explained by the lack of authority of BPP SIMA but also by the scale-level of the flood risk. When a flood occurs, likely the whole neighbourhood is threatened by it. Also, adaptation measures must tackle the flood risk in the whole neighbourhood. Individual households do not have the opportunity to tackle the flood risk in such a way that their household is safe from the floods because of the higher scale-level of the problem. Therefore, individual households do not feel the ownership of implementing individual adaptation measures on their scale-level. This is depicted in Figure 36.

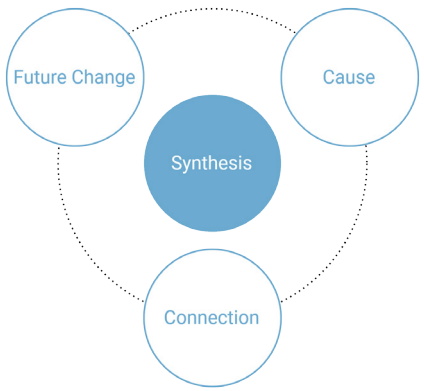

Figure 35: Boundaries for synthesis

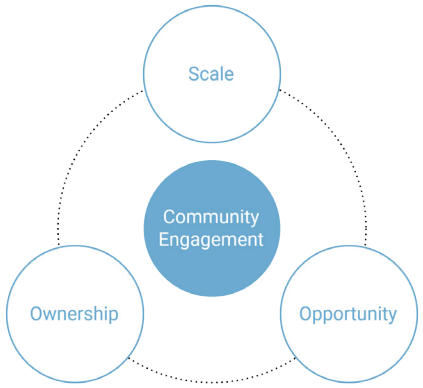

Figure 36: Boundaries for community participation

6.4. Interfaces for strategy design

In order to be able to design an SDG-inclusive adaptation strategy against heat stress in TW, the information gathered during the vulnerability analysis in this report is synthesised into an overview of possible SDG connections as well as interfaces for adaptation that serve as starting points for the strategy design.

6.4.1. Heat and SDG overview

Since the focus of this assignment is to connect spatial adaptation to the SDGs, Figure 37 provides an overview of how the problem and solution for heat stress can be connected to the SDGs selected in section 6.2.3. The problem connection is based on the insights from earlier sections. The weight of the arrows illustrates the intensity of the connection that is assumed or desired.

Climate change has a direct influence on the risk of heat stress because of temperature rise and increase of heatwaves. Urbanisation increases the risk through land-use change and the increase of population density. The population density and living conditions are connected to *SDG 1: No poverty, SDG 5: Gender equality* and *SDG 10: Reduced inequalities* because they are connected to poverty. The land-use change and greenery loss are connected to the decreasing *SDG 15: Life on land*.

All these four SDGs are case-specific requirements together with *SDG 9: Industry, innovation, and infrastructure*. Always included as required SDGs as well are SDG 4, 16, and 17, as explained in section 6.2.3. These required SDGs must actively be included in the adaptation solution.

Furthermore, heat stress has a direct impact on human health, so *SDG 3: Good health and well-being*. Therefore, also the adaptation solution directly impacts SDG 3. *SDG 11: Sustainable cities and communities* and *SDG 13: Climate action* are also directly impacted by the adaptation solution as explained before.

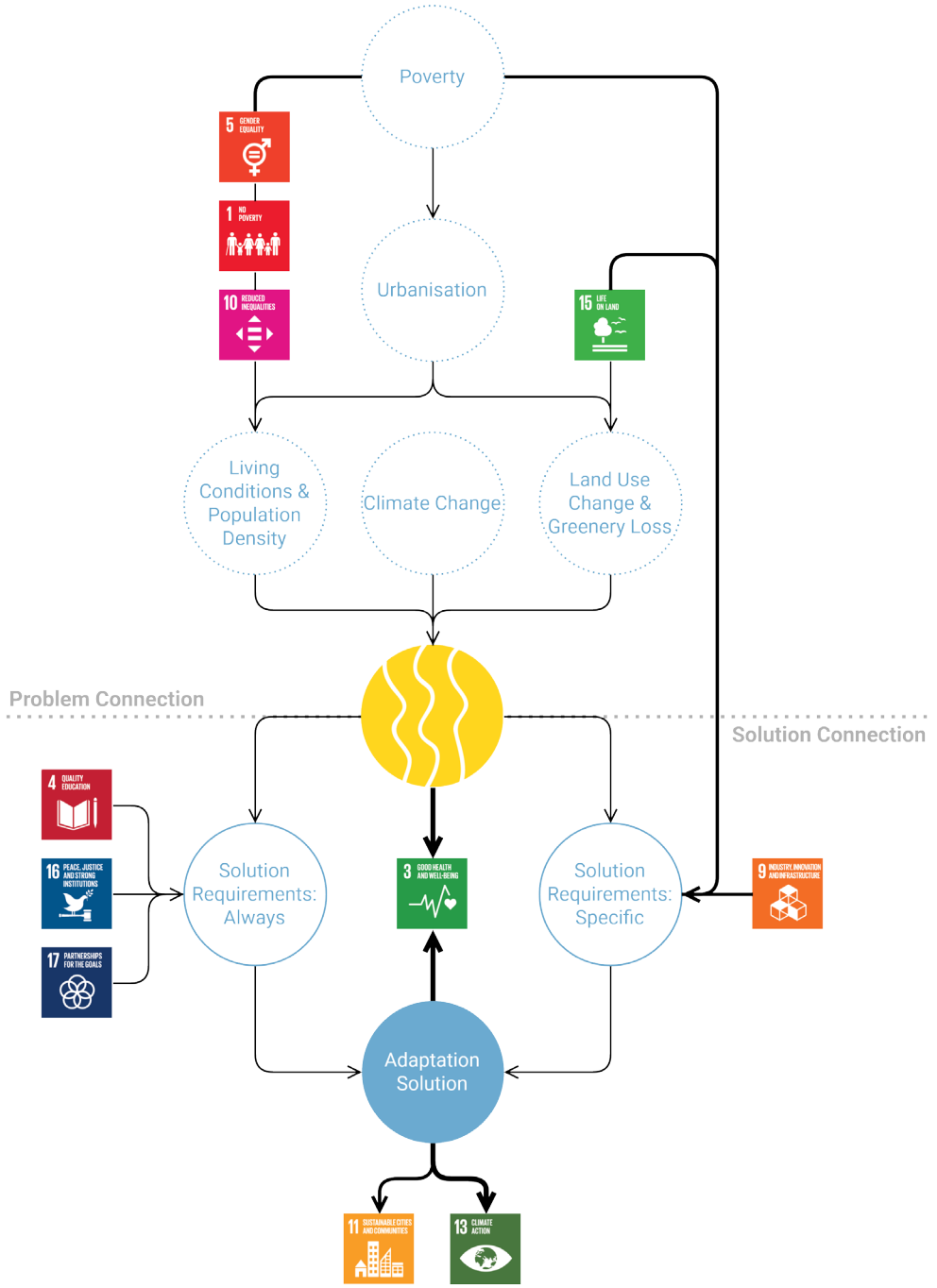

Figure 37: Overview of heat SDG connections

6.4.2. Interfaces for adaptation

The findings gathered in this chapter are accumulated into interfaces for adaptation that serve as starting points for the strategy design in the following chapter. The interfaces are composed of strengths of Terboyo Wetan helping adaptation efforts, opportunities in TW serving as the actual interfaces for improvement, and points of attention that are composed of weaknesses and threats that are relevant for the SDG-inclusive adaptation strategy.

Strengths

- Indonesia is a collectivist society
- Gotong Royong can be utilised for adaptation efforts
- Communities in Indonesia are quickly organised
- Indonesians are pragmatic
- Individuals have developed several coping mechanisms against heat stress
- Influence and support of local organisations and leaders can be utilised for adaptation efforts

Opportunities

- Awareness for heat stress
- Empowerment of vulnerable groups (Target group: low-income households, especially women)
- Temperature in buildings
- Temperature on streets
- Increase of greenery

Points of attention

- Adaptation efforts should be aligned with existing hierarchical structures and organisations
  - The involvement of local leaders can increase prominence and authority of a project
  - Non-governmental organisations must be aligned with governmental organisation in order to gain authority
  - RTs have an important stand in the community and can address problems at higher hierarchies
  - Adaptation efforts can be more successful when applied top-down
  - There is a significant power distance of the target group
- The correct scale-level of the adaptation measure can determine whether or not community participation can be achieved
  - The scale of the adaptation measures must match the scale of the problem
  - The scale of the adaptation measures must be on household level when wanting to achieve community participation
- Financing must come either from the national government or international organisations since the municipal government of Semarang does not have a sufficient budget
- The community in TW is relatively new and therefore less experienced with their environment
- There is a high population density in TW
- TW is a low-income area
- The housing quality in TW is low, so houses can be instable
- Industrial workers are most active in environmental management
- Problems must be very big to be perceived as a problem (urgency)

Next to these starting points, some general requirements for the final SDG-Adaptation-Framework are retrieved from the research during previous chapters of Part B. These are listed below.

- It is important to understand the cause and connections of risks in order to create a synthesised and effective adaptation strategy
- The correct scale-level of the adaptation measure can determine whether or not community participation can be achieved

AN EXEMPLARY SOLUTION

The formulated interfaces for adaptation serve as starting points for designing the SDG-inclusive adaptation strategy against heat stress for Terboyo Wetan. The selected SDGs are utilised to enrich the ideation process and final strategy.
This chapter starts with the ideation process during which general approaches against heat stress are discussed and ideas for adaptation measures are developed together with possible SDG connections. Afterwards, the final SDG-inclusive adaptation strategy for TW is developed and presented.

07

7.1. Ideation

This section is dedicated to the process of ideation. Before brainstorming for adaptation measures, general approaches against heat stress are explored. During ideation, ideas for spatial adaptation measures against heat stress are developed. Afterwards, the measures are enriched through the connection of the SDGs in a few examples.

7.1.1. Approaches against heat stress

The earlier introduced report by the Hogeschool Amsterdam describes four common approaches against heat stress in the city: evaporation, shadow, ventilation, and reflection (Kluck et al., 2020). However, these approaches are focussing on the public space. Another important approach is the insulation of houses in order to decrease heat stress inside buildings (Bosch, Solcerova, & Mulder, 2018).

While insulation can decrease temperatures and heat stress inside buildings, it can also increase the UHI, especially during the night. Insulated buildings store more heat than non-insulated buildings which they consequently radiate towards the outside (Wonorahardjo et al., 2020). Popular measures against heat stress are green roofs. However, they barely decrease inside temperature as well as outside temperature (Bosch et al., 2018).

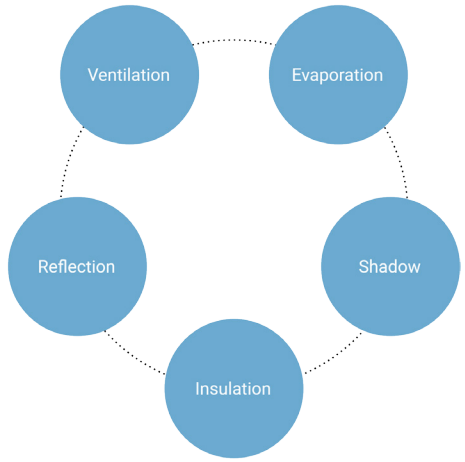

Figure 38: Approaches against heat stress

Kluck et al. (2020) mapped various popular spatial adaptation measures against heat stress as well as studies testing the effectiveness of these measures. By attributing the four approaches to these measures, they were able to determine the most effective approaches against heat stress in the city.
To decrease the average temperature in cities, evaporation is most effective. Evaporation measures are, for example, greenery, water fountains, canals, etc. (Kluck et al., 2020).

To decrease the felt temperature in cities, shadow is most effective. Shadow measures are, for example, trees, roofed over pathways, window blinds, etc. (Kluck et al., 2020). Shadow is also a very effective measure to decrease heat stress inside buildings as well as reflection (Bosch et al., 2018).

7.1.2. Brainstorming spatial adaptation measures

Drawing from the insights regarding approaches against heat stress, various ideas for spatial adaptation measures are generated and mapped. A mindmap showing a variety of ideas can be found in Appendix 9. They are based on the approaches explained in section 7.1.1 and inspired by available mappings of measures (Bosch et al., 2018; Kluck et al., 2020).

Shown in Figure 39 on the right is an overview of various ideas retrieved from the mindmaps in Appendix 9. They are sorted by the approach they use to tackle heat stress according to section 7.1.1. However, the overview does not aim to be complete. There is likely a big variety of other measures against heat stress that are not included in this figure.

7.1.3. Two examples of SDG connections

In order to show how the SDGs can enhance adaptation measures and finally strategies, two measures from the previous section are selected exemplarily. The sections on the following pages describe how different SDGs can create SDG-inclusive adaptation strategies by enhancing the selected measures. More ways to connect the SDGs to the heat risk are shown in a mindmap in Appendix 9.

Figure 39: Ideas for spatial adaptation measures against heat stress

From parks to inclusive community gardens
Parks are a way to create a cool spot within a city while also offering a recreational spot for inhabitants (Kluck et al., 2020).

The creation of a park is automatically linked to the SDGs 3, 11, 13, and 15 since *SDG 11: Sustainable cities and communities* and *SDG 13: Climate action* are always impacted by adaptation, *SDG 3: Good health and well-being* is impacted when tackling heat stress and *15: Life on land* is impacted when implementing greenery.
Ways to enhance that measure against heat stress are for example by including SDG 2,4, and 10 as shown in Figure 40. *SDG 2: Zero hunger* enhances the solution when implementing fruit trees instead of regular trees, so the park becomes a community garden. When that garden is set up as an educational garden, for example for people with a handicap, *SDG 4: Quality education* and *SDG 10: Reduced inequalities* are included.

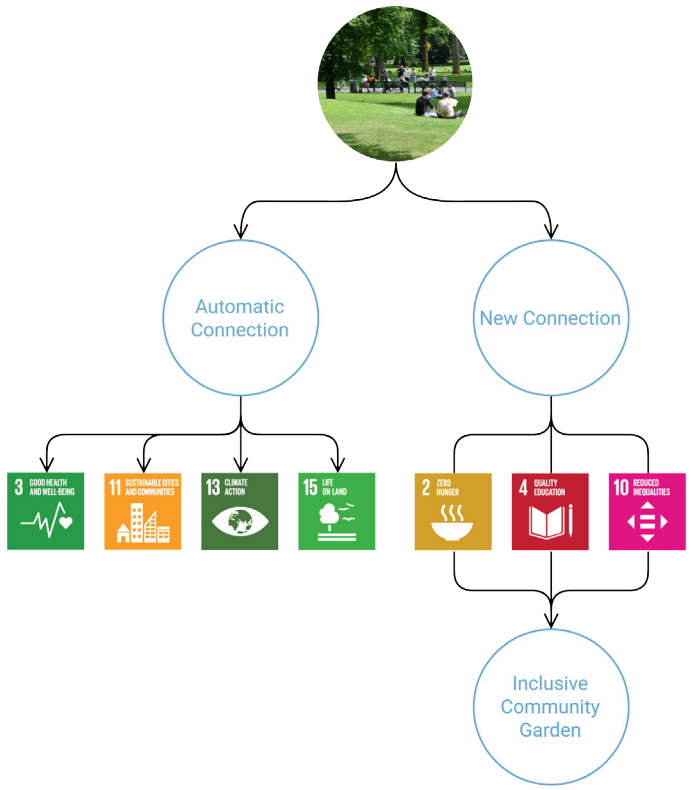

Figure 40: SDG connection for inclusive community gardens

From flowing water to educational water playground
Flowing water is a promising measure to tackle heat stress since evaporation from the water surface cools the temperature around (Kluck et al., 2020). In TW, small canals are already running through the whole neighbourhood because of the polder system.

However, as shown in Figure 41, the mere measure can be enhanced by integrating other SDGs. SDG 3, 11, and 13 are automatically connected because of the effects of adaptation measures in general.
However, when integrating, for example, *SDG 4: Quality education* and *SDG 12: Responsible consumption and production*, the canals can lead up to and be transformed into a playground utilising the water for play. Children could, for example, learn about responsible consumption of water. The same playground could offer drinking water spots where inhabitants and especially children can consume clean drinking water, which is consequently impacting *SDG 6: Clean water and sanitation*.

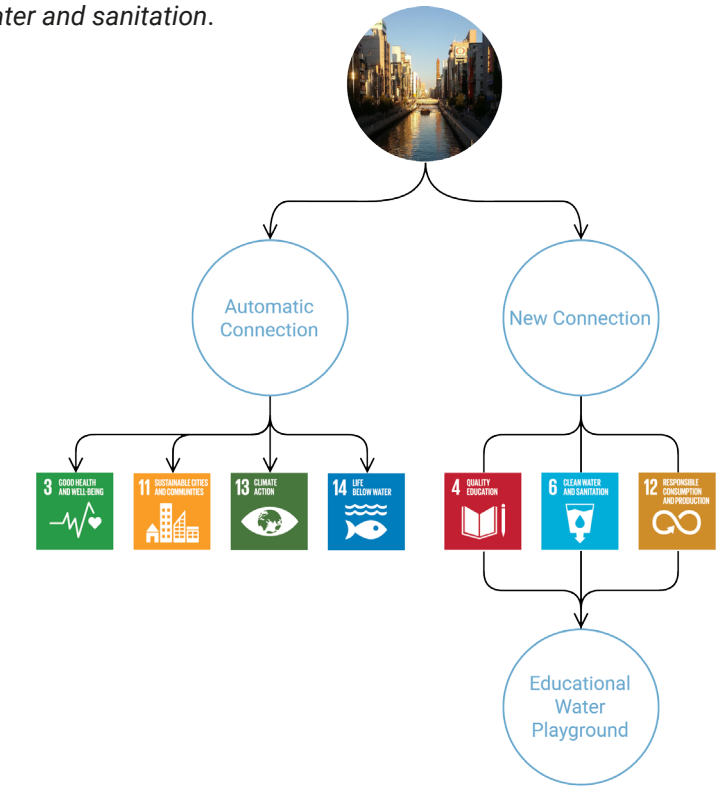

Figure 41: SDG connection for educational water playground

These two examples should show that the SDGs can allow for a new mindset through which 'simple' adaptation measures can create more meaning by finding clever connections. These connections are not only achieved automatically but by actively including the SDGs in the brainstorming process. Various other connections are possible and shown in the mindmap in Appendix 9.

7.2. Strategy formulation

After brainstorming for spatial adaptation measures against heat stress and ways to connect the SDGs to these measures, the SDG-inclusive adaptation strategy against heat stress is formulated in this section.
In a regular design process, various concepts are developed followed by the choice for one concept. In this case study, instead of developing concepts, in the second iteration of the design process, the most fitting measures are selected and then actively connected to the required SDGs when designing the organisational aspects of the adaptation strategy. This because every measure allows for a big variety of SDG connections.
The measures and organisational aspects are based on considerations related to the requirements determined in Part A and during the case study.

7.2.1. Measure Selection

In this section, a variety of considerations is described followed by the selection of the spatial adaptation measures that form the baseline of the SDG-inclusive adaptation strategy for TW. The considerations are as follows.

Firstly, the SDGs selected in this case study (see section 6.2.3) must be connectable to the selected spatial adaptation measures.
SDG 1: No poverty, SDG 10: Reduced inequalities, and *SDG 5: Gender equality* revolve around the selected target group for the case study. This target group are low-income households requiring affordable measures. The selected SDG most relevant for the spatial adaptation part of the strategy is *SDG 15: Life on land* because it targets physical aspects of the strategy. Nature-based solutions targeting SDG 15 should be selected for the strategy.
The SDGs 4, 9, 16, and 17 are mainly taken into consideration during the design of the organisational aspects of the strategy.

Secondly, the effectiveness of the different adaptation approaches and measures are a relevant consideration.
As discussed in section 7.1.1, evaporation is the best functioning approach to reduce the overall temperature while creating shadow is the best functioning approach to reduce the felt temperature outside as well as the temperature inside. Furthermore, reflection is a relevant approach to decrease the inside temperature as well.

Lastly, a variety of considerations is necessary according to general adaptation requirements. According to section 4.1, an adaptation strategy should consist of coping and transformation measures as the two time-scale-levels. Therefore, one measure each should be selected.
Furthermore, according to section 6.3.2, the scale-level of the measure determines whether the measure allows for community engagement. Only a measure from the household scale-level also allows for engagement of the households. Since community engagement is desirable for successful adaptation according to section 4.3.1, the selected measures should match the household scale-level.
In order to allow for measure selection according to the required scale-level and time-scale-level, Figure 42 on the following page maps the measures generated during the brainstorm into a matrix. On one axis, the measures are sorted by their time-scale-level. On the other axis, the measures are sorted by their scale-level of implementation.

Taking all the considerations into account, whitening of the roofs is selected as coping measure and tree planting as transformation measure.
Whitening the roofs utilises the approach of reflection in order to decrease the inside temperature. It is an affordable measure for low-income households.
Tree planting utilises the approach of evaporation and shadow in order to decrease the outside and inside temperature when the trees grow big enough. Tree planting is relevant for *SDG 15: Life on land* and a very effective measure against heat stress.
Both spatial adaptation measures belong to the household scale-level and therefore enable community engagement (see section 6.3.2.). They form the baseline of the SDG-inclusive adaptation strategy for TW.

Figure 42: Heat stress measure matrix

7.2.2. Design of the organisational aspects

The organisation and implementation of the adaptation measures is an important part of the SDG-inclusive adaptation strategy. Many SDGs are not connected to the spatial aspects of the strategy, but to the organisational aspects.
In order to develop these organisational aspects and SDG connections, a variety of considerations is performed.

Firstly, the SDGs that need to be connected to the organisational aspects of the strategy are SDG 1,4,5,9,10, and 16 as described in section 6.2.3 and 6.4.1.

Secondly, the target group must be incorporated and is already connected to SDG 1,5, and 10 as explained before.
Thirdly, the local hierarchies, local organisations, and Gotong Royong should be incorporated as well as the points of attention established in section 6.4.2.

Taking into account these considerations, the complete SDG-inclusive adaptation strategy is developed as depicted in Figure 43 on the following pages. The organisational part is depicted on the left side of that figure. It starts with setting up a support network of international organisations for funding and other cities for knowledge support. This is connected to *SDG 17: Partnership for the goals*.
Then, the municipality should contact local female organisations for support. They can consequently contact local companies and inhabitants in order to set up what is called an 'inclusive tree nursery'. This tree nursery essentially grows the trees that are distributed in TW. The tree nursery should employ people with low income and should be led by leaders of the female organisations. This results in new orders and income for the tree nursery and companies involved, new jobs to the low-income inhabitants, and a new institution with influence in the neighbourhood. Figure 43 shows how these impacts influence the connected SDGs.
The female organisations together with the employees of the tree nursery distribute the spatial adaptation measures to the households increasing awareness for the heat problematics.

The measures selected in the first part of the strategy design, so the spatial adaptation measures themselves, are depicted on the right side of Figure 43. The tree planting has a direct impact on SDG 2 and 15 when selecting local fruit trees. The white roofs and tree planting together impact SDG 3,11, and 13 by decreasing the UHI and heat stress as well as by decreasing general vulnerability for climate change.

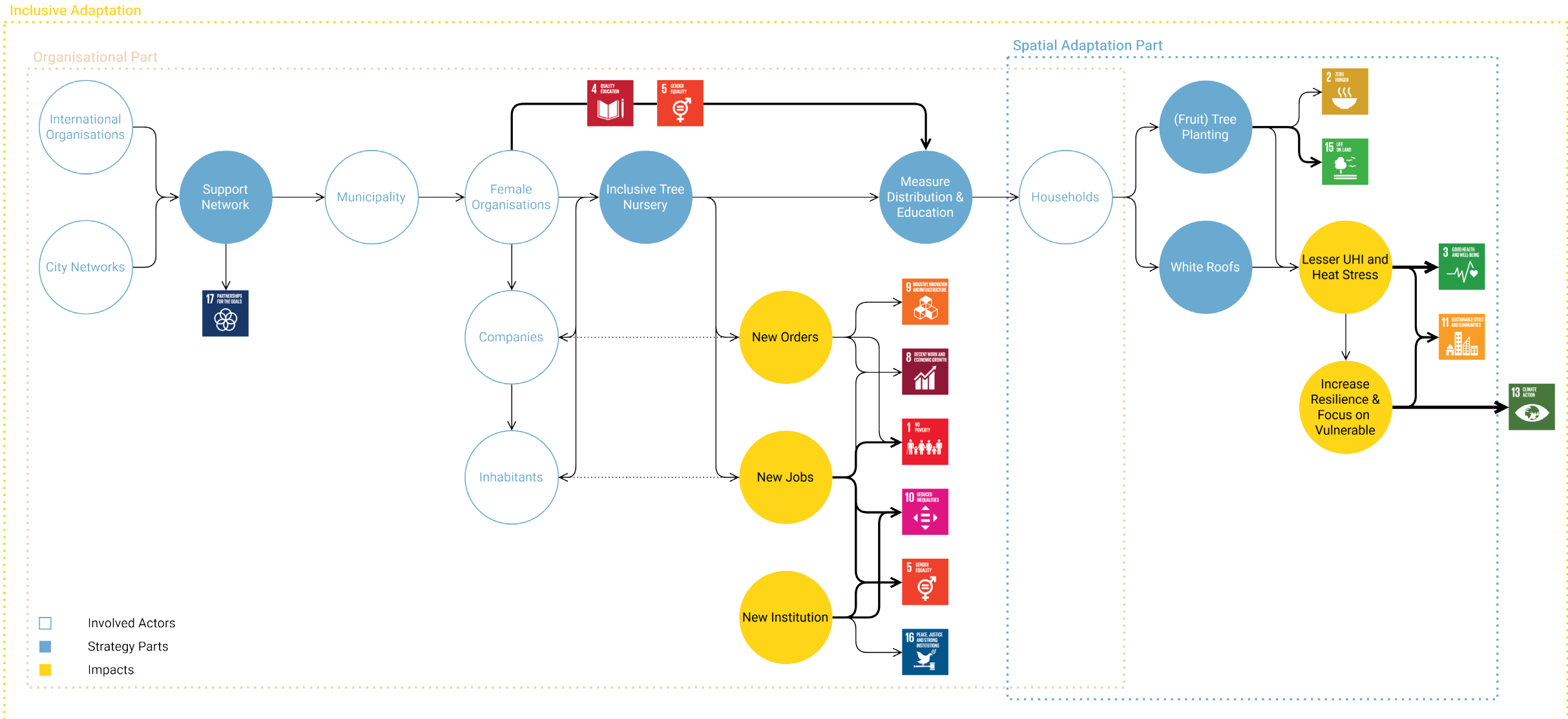

Figure 43: Final SDG connection

The SDG-inclusive adaptation strategy depicted in Figure 43 is the result of an iterative process of selecting measures and actively connecting the selected SDGs. While the strategy shows the implementation steps, some detailing steps must be performed before implementing the strategy. The detailing steps and implementation steps are listed in the figure below.

Detailing Steps

1. Determine the most vulnerable spots for heat stress with experienced consultancies or through surveys
2. Discuss measures with inhabitants and adjust when necessary
3. Determine details of implementation (e.g. determine fitting plants to implement)
4. Validate the improvement of heat stress vulnerbality and SDGs in detail

Implementation Steps

1. Apply for funding at international organisations
2. Contact local leaders from female organisations for support
3. Contact local businesses through leaders from female organisations to produce adaptation measures or alternatively set up new business
4. Contact inhabitants through leaders from female organisations to hire
5. Educate local leaders about coping and transformation measures
6. Set up funding system so households can apply for subsidies
7. Distribute adaptation measures through local leaders

Figure 44: Detailing and implementation steps

Conclusion Part B

Part B revolved around the development of an SDG-inclusive adaptation strategy against heat stress in the context of Terboyo Wetan in Semarang, Indonesia.
The context of Semarang is explored as well as their main vulnerabilities. Semarang is highly vulnerable to floods and has a long history of adapting to them. However, heat stress is an increasing risk and does not receive much attention yet. Therefore, the developed adaptation strategy focusses on tackling heat stress in TW. Low-income households and women are especially vulnerable to heat stress, because of their type of employment, living standards and overall adaptive capacity. Therefore, the strategy focusses on low-income households as a target group. Based on the selected target group and overall performance, the SDGs to be connected are selected. After further analysing the risk for heat stress and extracting insights from earlier flood management projects, a set of adaptation interfaces is developed that serves as starting points for the development of the SDG-inclusive adaptation strategy together with the selected SDGs.
In multiple iterations, ideas against heat stress for TW are developed and connected to the required SDGs. Finally, whitening the roofs and planting trees are selected as coping and transformation measures forming the baseline of the adaptation strategy. The SDGs are connected in the strategy in various ways: automatically through the problem itself, through the spatial adaptation measures, and through the organisational aspects of the strategy.
In order to implement and validate the strategy, further detailing steps are necessary, but the developed strategy shows exemplarily how the SDGs can enhance the brainstorming process as well as the adaptation strategy.
This SDG-inclusive adaptation strategy serves exemplary as the baseline for the SDG-Adaptation-Framework to be developed in the following part.

PART C: FRAMEWORK

Part C revolves around the third secondary research question:
How can the development of an adaptation strategy for a vulnerable municipality provide insights into a generally applicable framework for similar municipalities? The goal of this part is the development of the SDG-Adaptation-Framework.
In order to answer the research question, the results of the case study are utilised to retrieve and generalise the framework in an iterative process.

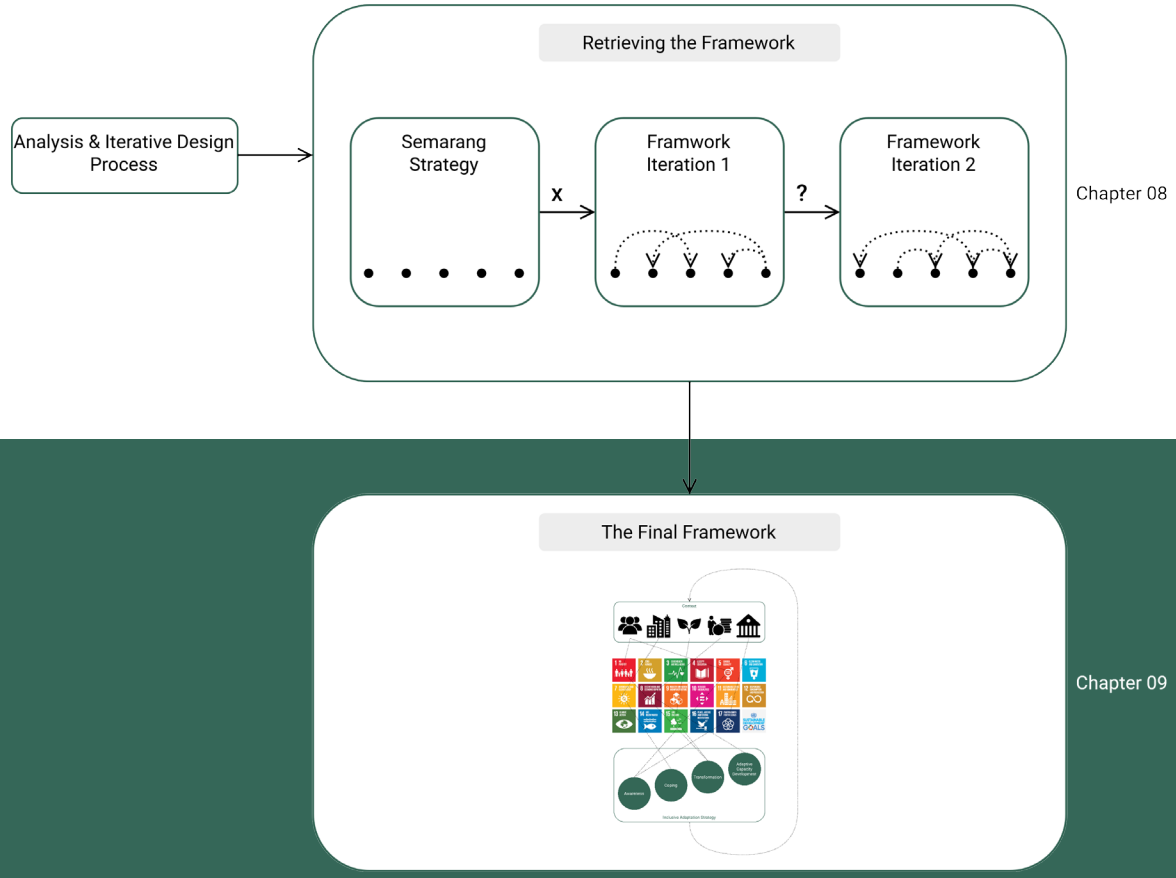

Figure 45: Part C structure

Approach

Chapter 8 describes the iterative process of the development of the SDG-Adaptation-Framework. In the first step, the framework is extracted from the results of the case study. Afterwards, the extracted framework is generalised utilising pre-determined questions concerning the factors influencing the result and process of the case study. The input from these questions is, together with insights from an evaluation session, applied in the second design iteration. In chapter 9, the final version of the framework is presented.

08

FRAMEWORK DEVELOPMENT

The goal of this chapter is the development of the SDG-Adaptation-Framework. The final framework should support urban municipalities in developing regions in their adaptation efforts by connection spatial adaptation to the SDGs.
This chapter starts with the retrieval of the first version of the framework directly from the results of the case study. By questioning the influence of contextual factors and performed choices on the process and results of the case study, the framework is generalised. Together with the results from an evaluation session with experts (see Appendix 12), this results in the final version of the framework that is presented in the following chapter.

8.1. Retrieving the framework

During the case study, an SDG-inclusive adaptation strategy against heat stress in the context of Semarang is developed. During that case study, a series of steps is performed with each step achieving intermediate results, finally synthesised in the adaptation strategy. Additionally, a selection of instruments is utilised supporting each step. These instruments were partly developed during earlier sections of this report, for example, the vulnerability framing method in section 3.2.2.
The results of the case study, as well as the instruments, are sorted and attributed to a simplified series of steps that forms the baseline of the SDG-Adaptation-Framework. Figure 46 provides a brief overview of these steps together with a few examples of the intermediate case study results in the top layer and the instruments in the bottom layer. The figure represents the methodology utilised in this first step of the framework development. Part B provides thorough insights into all results and instruments utilised during the case study. In the following section, the main elements of the final framework are retrieved using the methodology depicted in Figure 46.

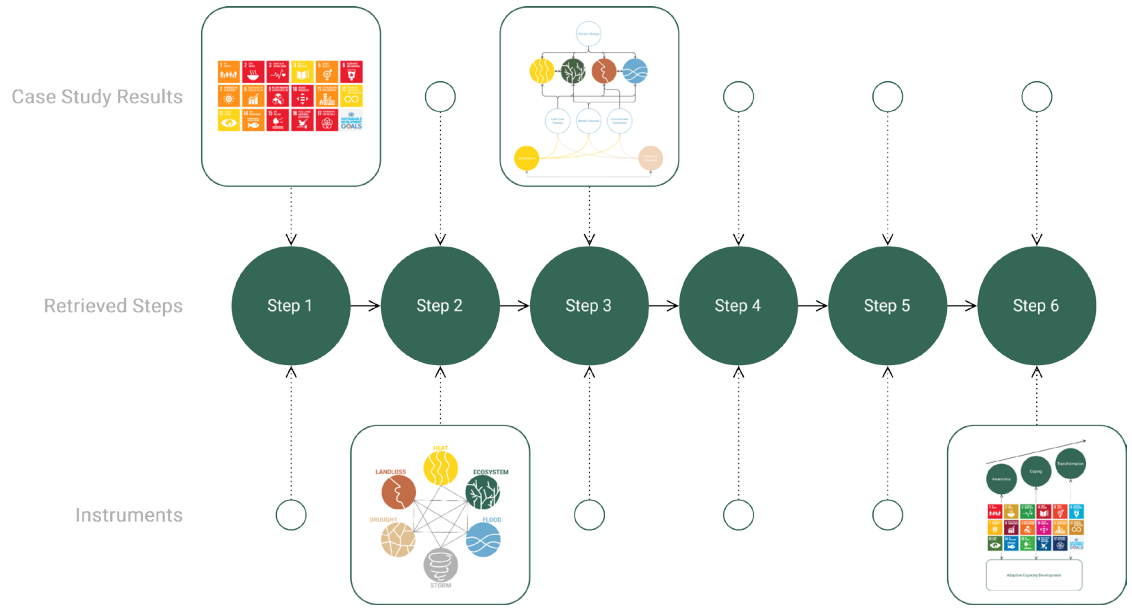

Figure 46: Overview of the framework retrieval

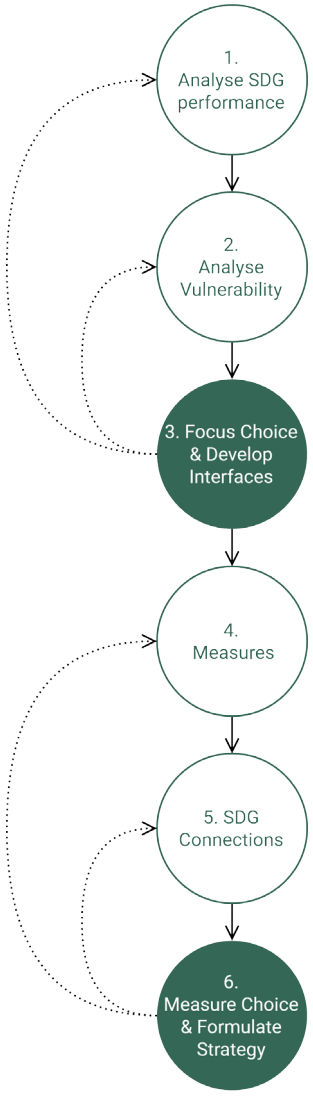

Figure 47: Simple strategy development process

8.1.1. The strategy development process

Figure 46 on the previous page shows a series of steps performed during the case study that forms the baseline of an important element of the SDG-Adaptation-Framework: the strategy development process.
While the steps depicted in Figure 46 suggest a linear process, the actual strategy development process is characterised by iterations.
During the case study, multiple iterations of the vulnerability analysis are performed. In a first iteration, the SDGs and vulnerabilities are analysed globally resulting in the choice for a specific focus. Afterwards, the SDGs and vulnerabilities connected to that focus are analysed in order to develop a set of interfaces for adaptation.
These interfaces are relevant during the design of the adaptation strategy. The strategy design is also performed in an iterative process during which brainstorms for spatial adaptation measures are performed, the measures are connected to the SDGs, and the SDG-inclusive adaptation strategy is finally formulated.
Combining these sets of steps, the strategy development process can be described as depicted in Figure 47 with the arrows clarifying the iterative character of the process.

8.1.2. The framework overview

In Part A, the basic framework is depicted representing the main goal of the SDG-Adaptation-Framework: To connect spatial adaptation to the SDGs in order to create SDG-inclusive adaptation strategies.
Drawing from the insights from Part A and B, the basic framework is adjusted as shown in Figure 48. Most importantly, the adaptation time-scale established in section 4.1 is included in order to ensure that the developed adaptation strategies consist of all necessary elements. Furthermore, the top layer of the framework shows the various risks according to the vulnerability framing method developed in section 3.2.2.
These vulnerabilities are connected to the SDGs and influencing the choice for the SDGs to be included and connected to the spatial adaptation measures in the strategy design. A more detailed image of the SDG connection instrument developed in the first framework design iteration can be found in Appendix 10.

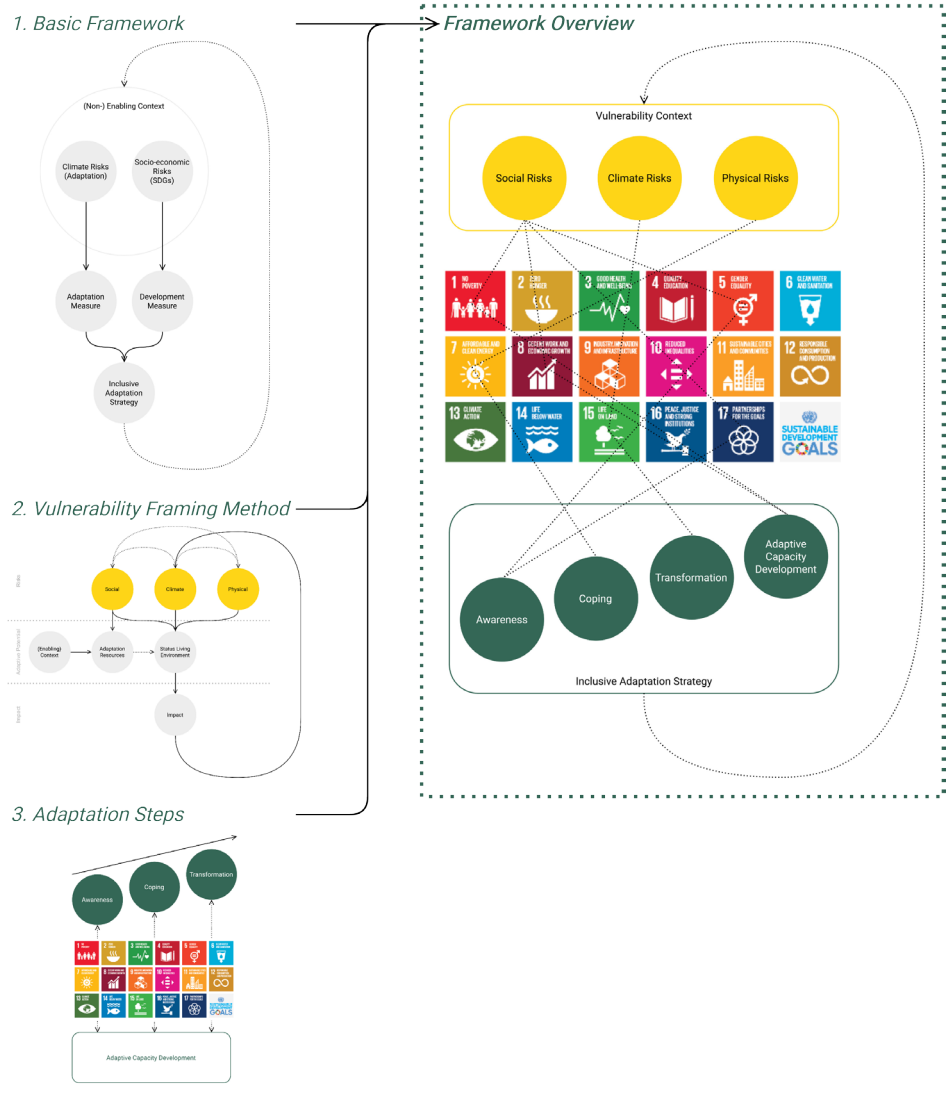

Figure 48: Development of the framework overview

8.2. Generalising the framework

The goal of the SDG-Adaptation-Framework is to support various urban municipalities in their adaptation efforts. However, the just presented parts of the framework are retrieved from merely one case study. Multiple case studies are desirable in order to ensure the applicability of the framework for various contexts. However, within the scope of this assignment, the framework is generalised using different methods. Figure 49 shows the two methods utilised to generalise the framework. The influence of contextual factors is questioned as well as the influence of choices on the process and result of the case study. Appendix 11 shows the complete analysis while the following sections only present the most important insights. The analysis results in recommendations utilised in the second iteration of designing the framework.

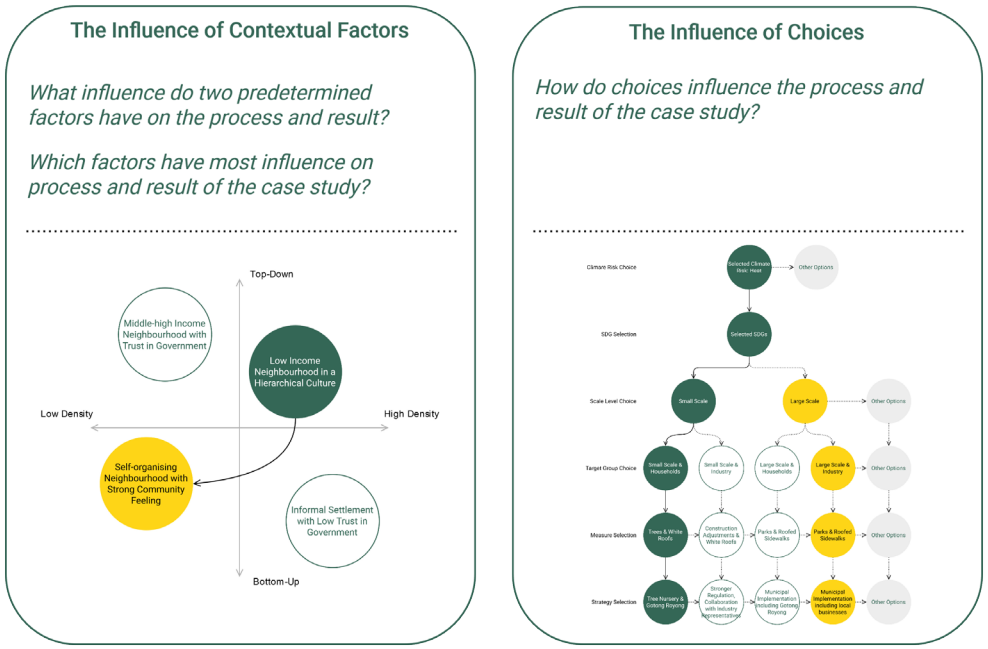

Figure 49: Two methods for generalisation

8.2.1. The influence of contextual factors

As described during the development of the vulnerability framing method, the context has a high influence on the vulnerability of the location and therefore on the results of a case study.
The first method to generalise the SDG-Adaptation-Framework is by questioning the influence of specific context factors on the results and process of the case study. This influence is questioned in two directions: in one direction by analysing the influence of two predetermined contextual factors and in the other direction by analysing what factors may have the biggest influence.

The two predetermined factors are selected before the execution of the case study in order to ensure the most unbiased selection of factors likely to have the most influence. The two selected factors are the level of self-organisation describing whether adaptation strategies are likely to be applied top-down or bottom-up, and population density defining the availability of space for spatial adaptation measures. Figure 50 shows a matrix in which the two factors define four possible scenarios. These scenarios only exemplarily describe the new context in order to show the possible influence of the two contextual factors.

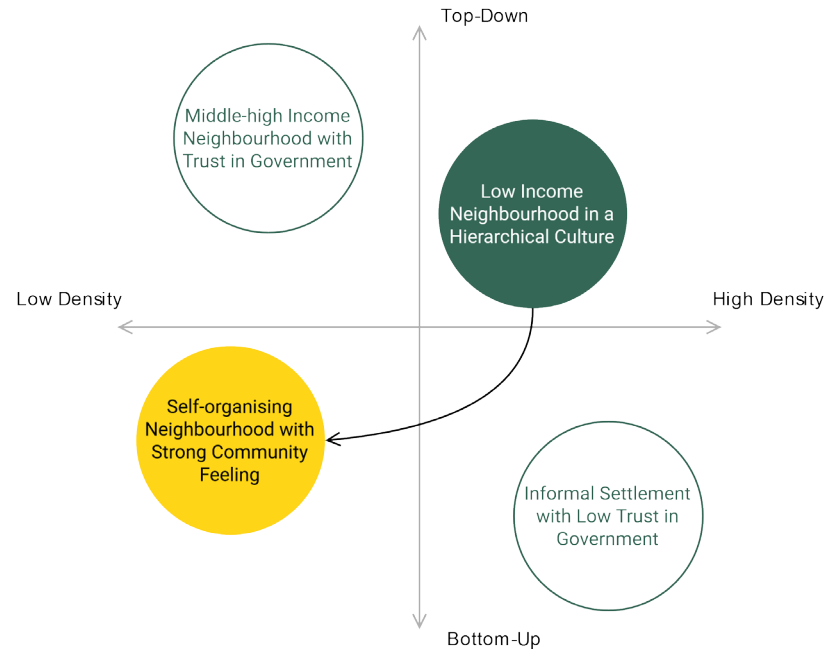

Figure 50: Generalisation matrix

The case study in Semarang can be placed in the upper right corner. The most opposing scenario would be the bottom left corner. This scenario is most likely a neighbourhood with a very strong sense of community in which adaptation strategies are initiated as grassroots initiatives. Appendix 11 describes this new scenario in further detail. This bottom left scenario serves as the baseline for the following analysis.

The analysis shows that mainly the level of self-organisation influences the process and result of the case study. In a highly self-organised community, the top-down approach developed for Semarang is not feasible because no support-base in the community would be established. The adaptation strategy must be developed together with the community in this new scenario.
The population density does not influence the process of strategy development. The detailing step includes further development of the adaptation strategy and a higher level of detail. In the detailing step, the availability of space would be more relevant.

Next to questioning the influence of the two predetermined factors, it is interesting to analyse whether other factors are more influential on the results and process of the case study.
On the process of strategy development, contextual factors can have the most influence. For example, the Covid-19-pandemic has a strong influence on the development of adaptation strategies since community participation is only possible in a distancing or digital environment.
On the result, the specific climate risk has the most influence. Obviously, an adaptation strategy against heat stress is different from an adaptation strategy against floods.
Furthermore, the type of the selected SDGs influences the adaptation strategy strongly. For example, the way *SDG 15: Life on land* can be connected is very different from the way *SDG 1: No poverty* can be connected. As depicted in Figure 51, five different categories of SDGs can be formed: Ecological, physical, social, economic, and institutional. The SDGs are attributed to the best fitting category. However, some SDGs have aspects of multiple or all categories and could therefore be attributed to multiple categories.

To conclude, the framework should clarify the influence of contextual factors during the vulnerability analysis and development of the adaptation interfaces. Furthermore, the importance of early community participation should be stressed in order to allow for early support in bottom-up organised communities. Lastly, the different categories of SDGs should be incorporated into the framework and SDG connection.

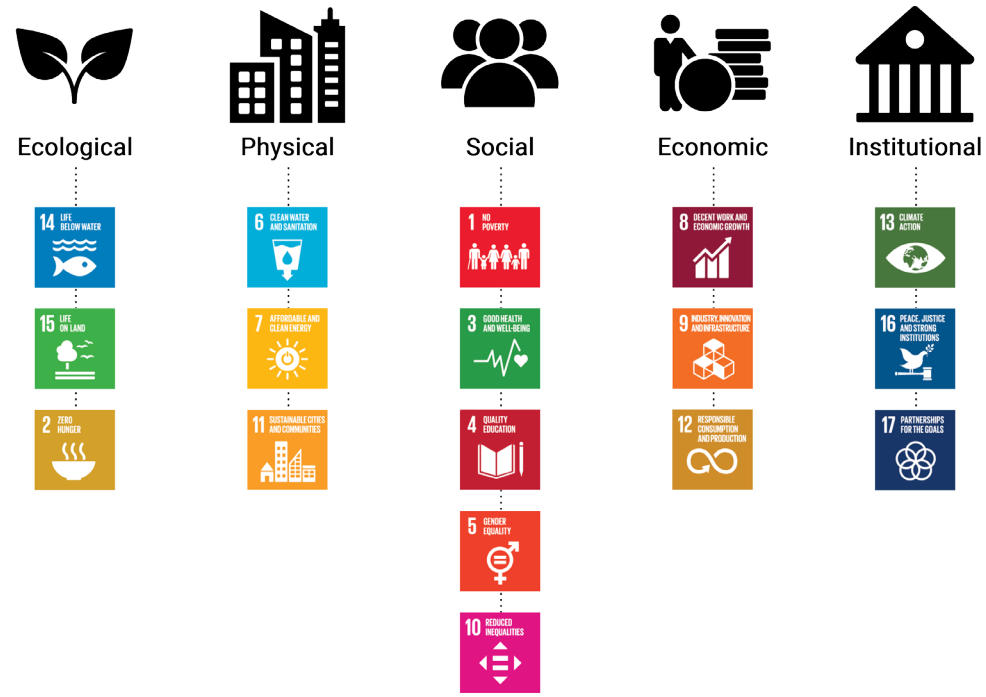

Figure 51: SDGs sorted by category

8.2.2. The influence of choices

The case study in the context of Semarang was accompanied by a multitude of choices. Therefore, it is interesting to analyse how these choices influenced the result and process of the case study. Figure 52 provides an overview of the most important choices and possible pathways. The pathways arising from other choices regarding the climate risk and SDGs are excluded because of the multitude of options.

The green path represents the case study scenario and the yellow path the most opposing scenario. In that new scenario, the choice was made for a large-scale adaptation measure for the industrial area in TW. Possible selected measures could be the construction of parks or roofs over sidewalks. They would be implemented by the municipal government together with local businesses. This shows that early choices highly influence the strategy and case study result. It is also important to note that such large-scale solutions are not likely to decrease the heat stress of the industrial workers inside the factories.
Furthermore, the analysis reveals a distinction between actual choices and selections. While the focus risk is a thoroughly considered choice, the SDGs are selected based on the context's vulnerabilities. Figure 52 indicates which steps are choices and selections.

To conclude, the framework should clearly differentiate between simple selections and choices that should be incorporated into the process. Selection of measures and SDGs may be supported by an instrument such as the instrument in Appendix 10.

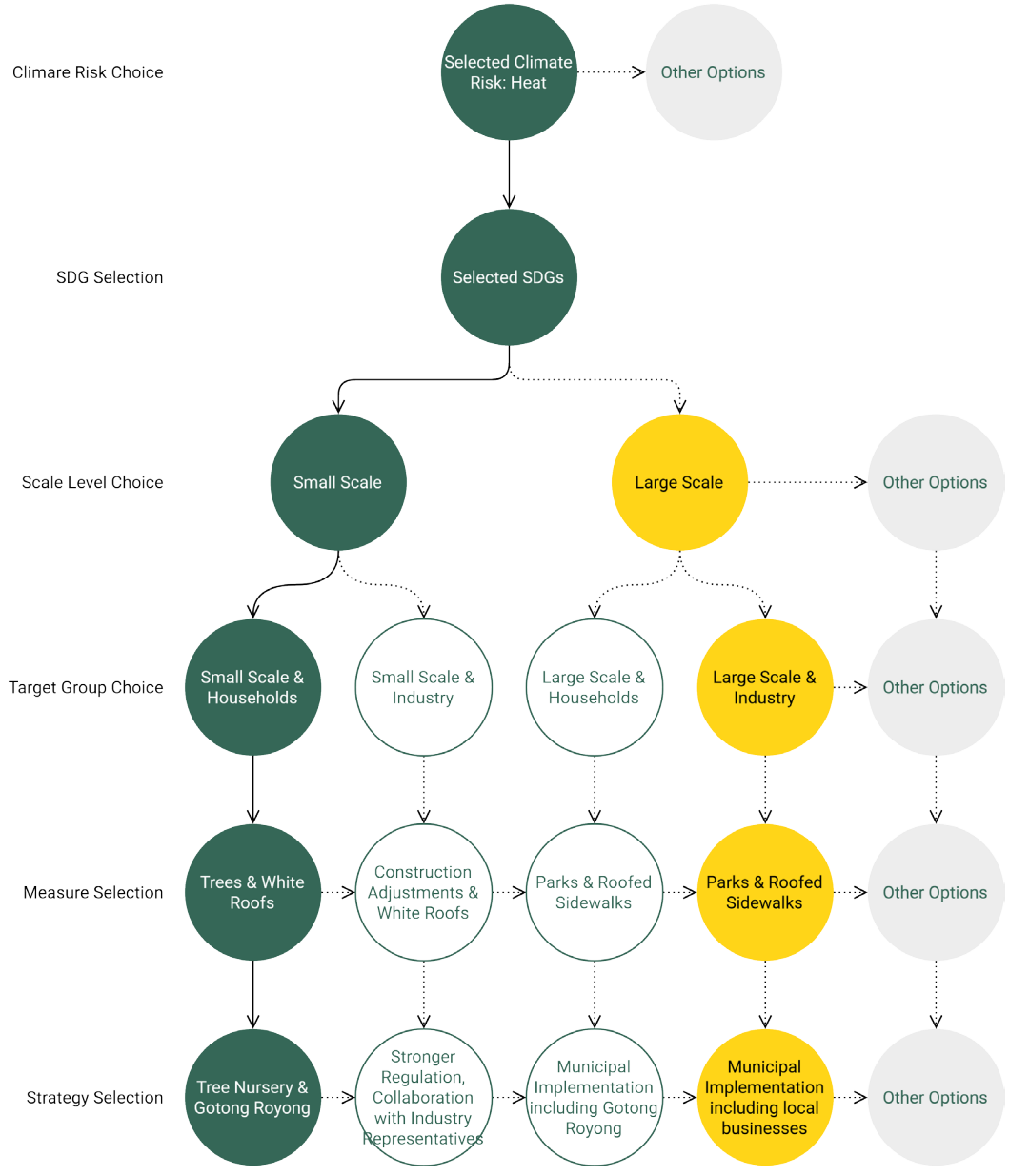

Figure 52: Choice pathways

THE FINAL FRAMEWORK

Based on the insights from the generalisation and an evaluation session with experts (see Appendix 12), the final SDG-Adaptation-Framework is developed in another design iteration. The final framework is a theoretical framework supporting municipalities in their first efforts towards adaptation by actively connecting SDGs to spatial adaptation.
This chapter shows the final framework while briefly discussing the changes with respect to the first iteration of the framework.

09

9.1. The framework overview

The essential goal of the SDG-Adaptation-Framework is the connection of the SDGs to the specific vulnerabilities of the context as to the spatial adaptation measures in order to develop SDG-inclusive adaptation strategies.
Figure 53 depicts that essential goal in the final framework overview. The representation of the vulnerabilities now includes the categories defined when analysing the SDG types; Respectively social, physical, ecological, economic, and institutional. When describing the vulnerabilities through the same categories, the connection of these vulnerabilities to the SDGs is clearer.
The bottom layer shows the necessary elements of the final SDG-inclusive adaptation strategy as well as their connection to the SDGs.

Figure 53: Framework overview

9.2. The strategy development process

Depicted in Figure 54 is the ‘optimal’ adaptation process as developed in section 4.2. The strategy development is only one step of that adaptation process. The focus of the SDG-Adaptation-Framework lies on that strategy development step.

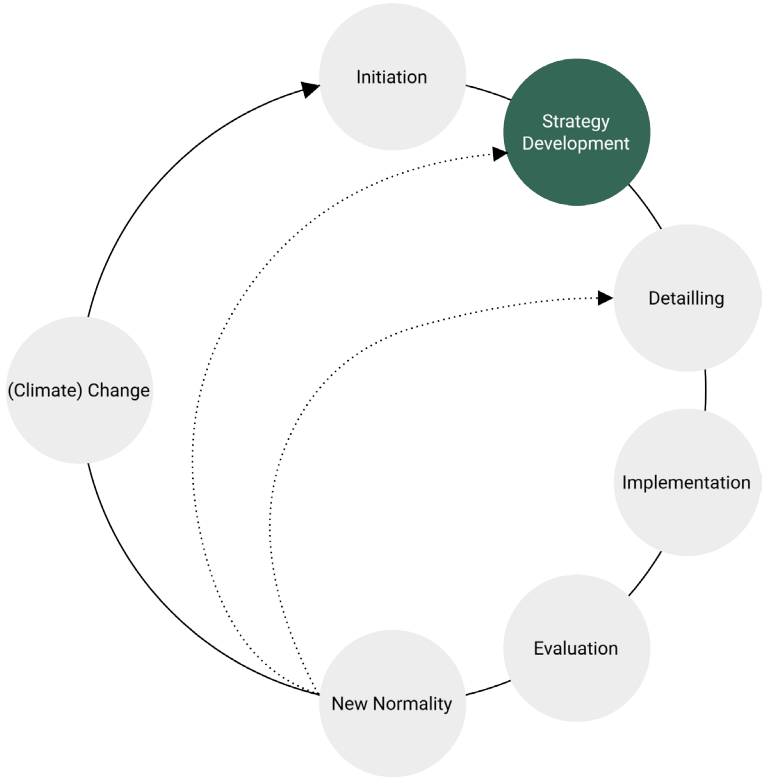

Figure 54: The ‘optimal’ adaptation process

Figure 55 shows the final version of the strategy development process as developed in the second design iteration.
The first loop of the process revolves around diagnosis. With respect to the first iteration of the framework, the first two steps of the first loop are swapped in order to ensure that the SDGs are selected based on the vulnerabilities of the location and that they can be easily connected to the vulnerabilities.
The first loop consists of two iterations. During the first iteration, the vulnerabilities and SDGs are analysed broadly in order to show the variety of options for focus. After choosing a focus, the second iteration focusses on the analysis of

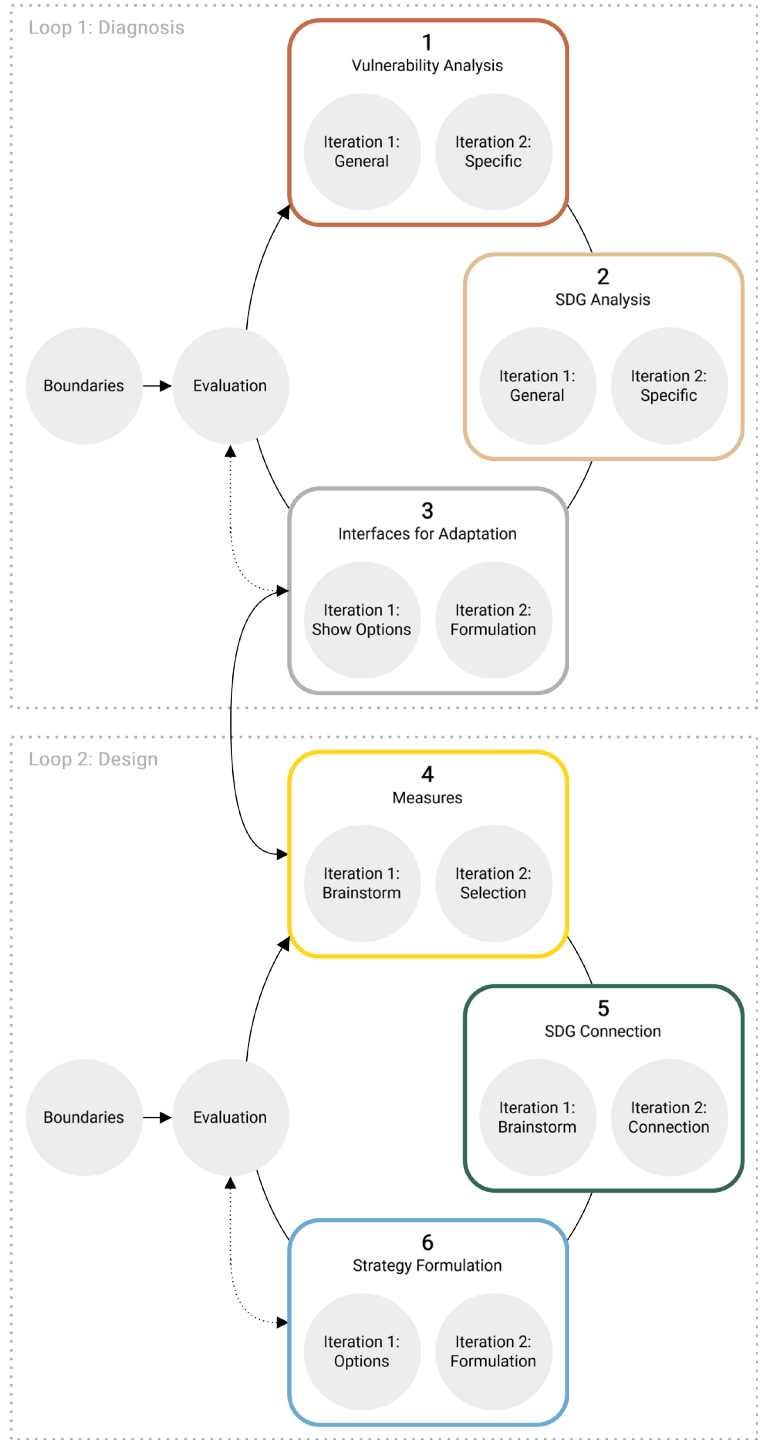

Figure 55: The strategy development process

vulnerabilities and SDGs connected to that focus. Finally, a SWOT analysis defines the interfaces for adaptation utilised in the strategy design loop.

The strategy design loop is the second loop in figure 55. It also consists of two iterations. The first iteration revolves around brainstorming while the earlier selected SDGs are utilised to enhance the brainstorming process and develop more SDG-inclusive adaptation strategies. During the second iteration, the final measures are selected, and the adaptation strategy is formulated. In that strategy, all selected SDGs are connected to either the spatial adaptation measures or the organisation of the implementation. The second loop is concluded in the steps to follow during detailing and implementation of the SDG-inclusive adaptation strategy.

Important in both loops are the evaluation points that are added to the strategy development process. During these evaluation points, the findings and choices are evaluated, utilising boundaries that are set during the initiation of the project and during diagnosis. The boundaries are essentially requirements. Examples for such boundaries will be presented in later sections of this chapter.

9.3. Steps and instruments

The previous section introduces the sets of steps that must be performed when developing an SDG-inclusive adaptation strategy. To each step, an instrument is attributed. These instruments are partly developed during Part A of this report and partly during the case study discussed in Part B. The following sections discuss each step and associated instrument in further detail.

9.3.1. Step 1: Vulnerability analysis

Step 1 is the most elaborate step of the first loop. The main question to ask here is how vulnerable the location is and why? Next to the main vulnerabilities and risks, the most vulnerable groups of people should be determined.
This step should be conducted in collaboration with various stakeholders, inhabitants and desirably consultancy firms.

During the first iteration of step 1, the general vulnerabilities and risks are established. During the second iteration, the analysis focusses on the chosen focus risk.

The utilised instrument of step 1 is the vulnerability framing method developed in section 3.2.2. The framing method should not be treated and 'filled in' as a canvas but serve as a mindset to utilise when analysing the vulnerabilities. Figure 56 presents the final vulnerability instrument in which the different categories of SDGs are replacing the earlier described risk categories in order to ease the connection of the vulnerabilities to the SDGs. These categories are respectively: Institutional, economic, social, physical, and ecological. The latter describes the climate risks defining the focus of the SDG-inclusive adaptation strategy.

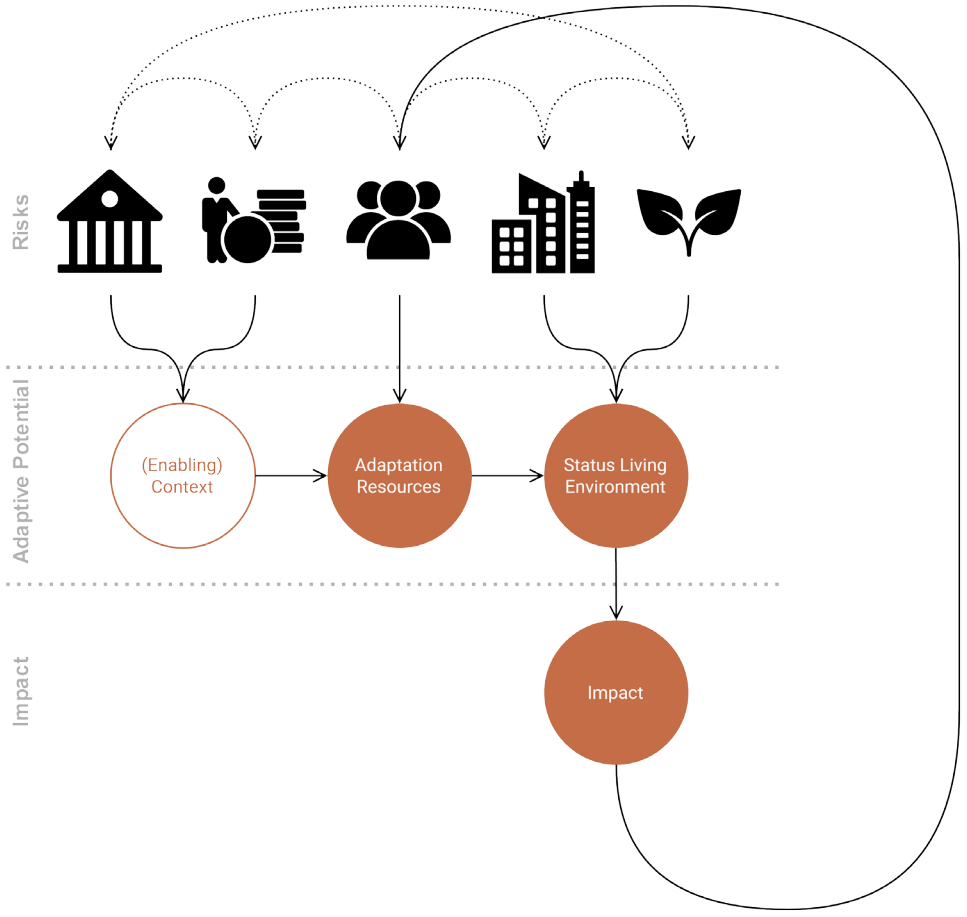

Figure 56: Instrument 1: Vulnerability framing method

9.3.2. Step 2: SDG analysis

The main question to ask during step 2 is what SDGs must be included during strategy design? This step should also be performed in close collaboration stakeholders and inhabitants. National data on SDG performance may be utilised without access to local data. The previous vulnerability analysis enhances the analysis of SDG performance with further insights.

While during the first iteration, the general SDG performance of the location is analysed, the SDGs are selected and connected to the vulnerabilities in the second iteration.

Figure 57 shows the instrument utilised during step 2.
Some SDGs must always be included in the development of SDG-inclusive adaptation strategies and some SDGs must be included due to the vulnerabilities of the location, so are trade-offs.
The SDGs that are always included can either be automatically connected such as *SDG 11: Sustainable cities and communities* and *SDG 13: Climate action* or they can be adaptation requirements (see section 6.2.3). These adaptation requirements are *SDG 4: Quality education* to enhance awareness and adaptive capacity, *SDG 16: Peace, justice and strong institutions* to enhance institutional capacity, and *SDG 17: Partnership for the goals* to allow for collaborations with stakeholders but also international partners.
Interesting are the SDGs that are location-specifically included, so the trade-offs. Must-haves are SDGs that represent strong vulnerabilities of the location, for example, *SDG 10: Reduced inequalities* in the case of Semarang. Nice-to-haves are SDGs that represent a weaker vulnerability or are easy to connect to the chosen climate risk, for example, *SDG 2: Zero hunger* that is easy to connect when implementing fruit-carrying greenery.
A variety of SDGs is likely to be out of scope for the SDG-inclusive adaptation strategy because they are not relevant in the specific location.
At the end of iteration 2, the selected SDGs should be attributed to their according category and connected to the chosen climate risk.

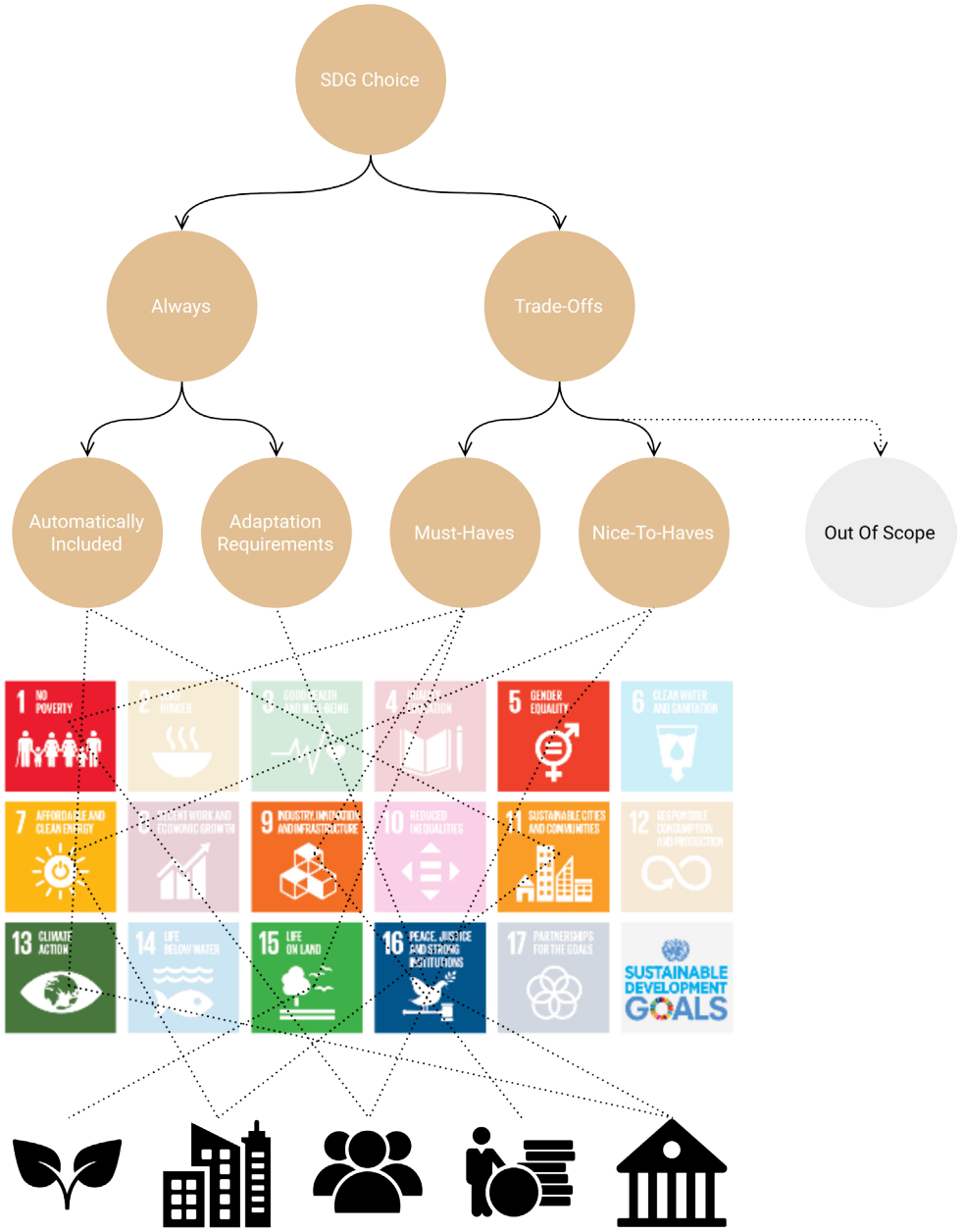

Figure 57: Instrument 2: SDG selection

9.3.3. Step 3: Interfaces for adaptation

The main question of step 3 is based on the connected instrument: What are strengths, weaknesses, opportunities, and threats for the strategy development process? Answering these questions leads to an overview of the interfaces for adaptation, priotities and requirements for the strategy design.

In the first iteration of this step, the different opportunities are listed followed by choosing one of the opportunities, so one of the climate risks as a focus. In the second iteration, the requirements are extracted from a SWOT analysis.

Hence, the instrument supporting this step is essentially a SWOT analysis but with adjusted questions.

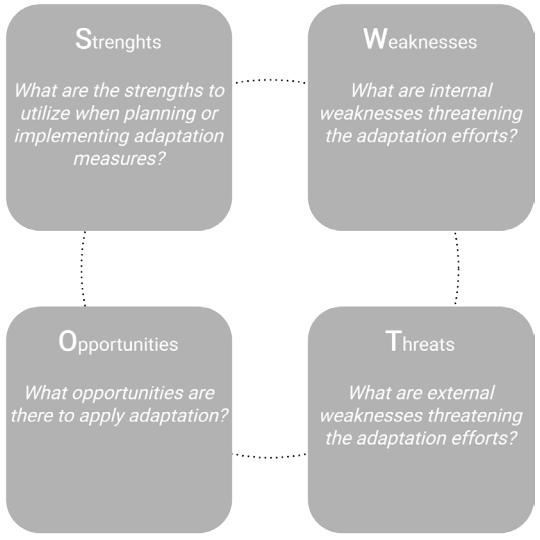

Figure 58: Instrument 3: SWOT analysis

Strengths – What are the strengths to utilise when planning or implementing adaptation efforts?

Weaknesses – What are internal weaknesses threatening the adaptation efforts?

Opportunities – What opportunities are there to apply adaptation?

Threats – What are external weaknesses threatening the adaptation efforts?

9.3.4. Evaluation Loop 1

The evaluation in the first loop focusses on the results of the diagnosis. The final result of the loop should be the interfaces for adaptation based on the chosen focus risk as well as a set of selected SDGs connected to that focus risk. Furthermore, the most vulnerable groups should be detected and selected as the target group.

Boundaries can be utilised in order to ensure the results incorporate the adaptation enabling factors (see section 4.3.1) and requirements set in the initiation step of the project.
Examples for such boundaries are: the inclusion of local leaders in the diagnosis process, the collaboration of stakeholders and inhabitants in the diagnosis process, or achieved synthesis of risks and targets.
Figure 59 shows that such synthesis can be achieved through a threefold to be incorporated in the vulnerability analysis: analysis of future change, cause, and connection of the risks (see section 6.3.2).

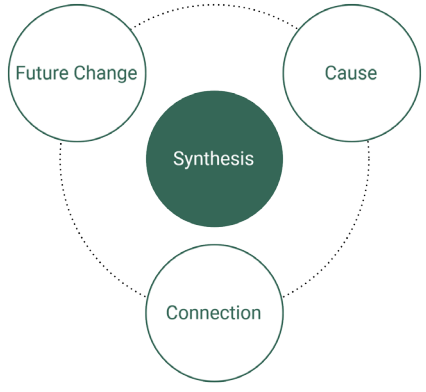

Figure 59: Example boundary: Synthesis

9.3.5. Step 4: Measures

Step 4 is dedicated to brainstorming possible spatial adaptation measures. The main question here is what different measures can tackle the selected climate risk? In order to be able to develop relevant measures, the chosen climate risk is analysed in the first loop. However, during this first step of the second loop, further research might be necessary in order to determine the best measures against the specific climate risk. Collaborations with other cities that already tackled the same risk can be useful. Collaborations with stakeholders and inhabitants should be incorporated through co-design session in order to create early support within the community.

During the first iteration, a variety of measures are developed while during the second iteration, the final spatial adaptation measures are selected.

The instrument developed for this step is a brainstorm support tool showing various categories of spatial adaptation measures based on section 4.1 and section 7.1.1. Figure 60 shows the instrument specifically supporting the brainstorm of measures against heat stress.[6] Other climate risks require other adaptation approaches and would result in a different instrument specification.

6 The top of the instrument shows the set of climate risks developed in section 3.1. with the front symbol representing heat stress.

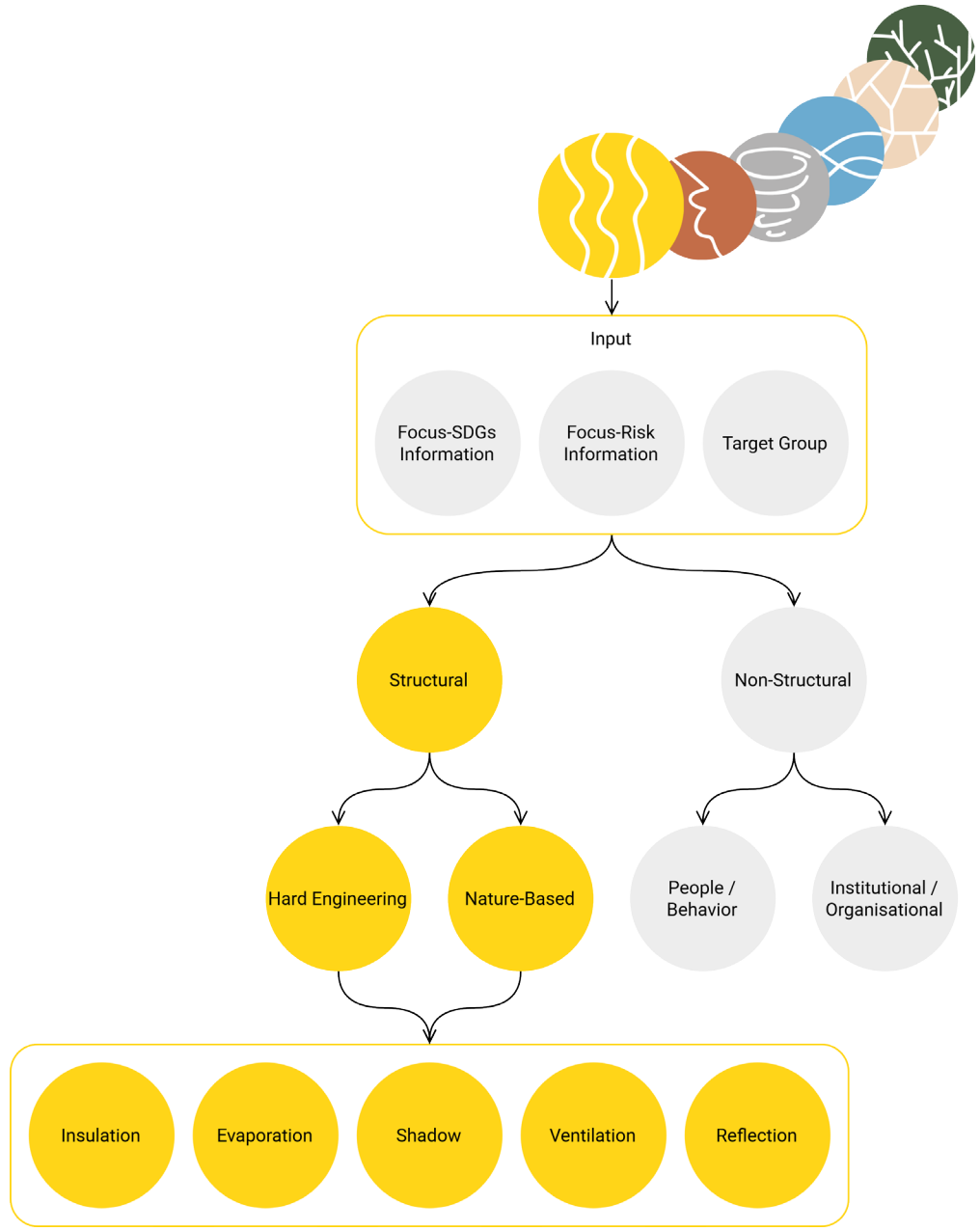

Figure 60: Instrument 4: Brainstorm support tree for heat stress

9.3.6. Step 5: SDG Connection

The main question of step 5 is how the SDGs can be connected to the adaptation strategy in order to enhance that strategy? Therefore, this step is the most essential with respect to the main goal of the framework. It follows up on the second step of the first loop, during which the SDGs to be connected in this step are selected. This fifth step shows how that connection can be established.

During the first iteration of step five, different ideas how to connect the various SDGs to the spatial adaptation measures are developed as well as ideas how to connect the SDGs to the socio-economic risks. During the second iteration, the adaptation strategy is finally connected to the SDGs.

Figure 61 depicts the instrument developed for this step. It depicts the different methods SDGs can be connected to adaptation strategies. Firstly, there can be an active and a passive connection.
The passive connection is essentially an automatic connection that is gained simply by tackling the climate risk. For example, *SDG 3: Good health and well-being* is passively or rather automatically connected to any adaptation strategy against heat stress.
The active connections can enhance the adaptation strategy beyond the scope of spatial adaptation and achieve the development of adaptive capacity.

The type of connection mostly depends on the category of the SDG as discussed in section 8.2.1.
One type of active connection can be achieved through the spatial adaptation measure and connects SDGs from the ecological or physical domain. For example, *SDG 15: Life on land* can be connected to the implementation of greenery or *SDG 7: Affordable and green energy* can be connected to measures producing energy.
Another type of connection can be achieved through the integration of the target group in the organisation of the strategy. For example, *SDG 1: No poverty* can be connected when the cultivation of trees is performed by and provides jobs to the poorest inhabitants. This type of connection includes SDGs from the social domain.
The last type of connection can be achieved as a consequence of the organisation of implementation. For example, while a specific target group may cultivate the trees that are planted, the organisation of such is connected to *SDG 9: Industry, innovation and infrastructure* because a local business is strengthened through the implementation. This type of connection contributes to SDGs from the economic or institutional domain.

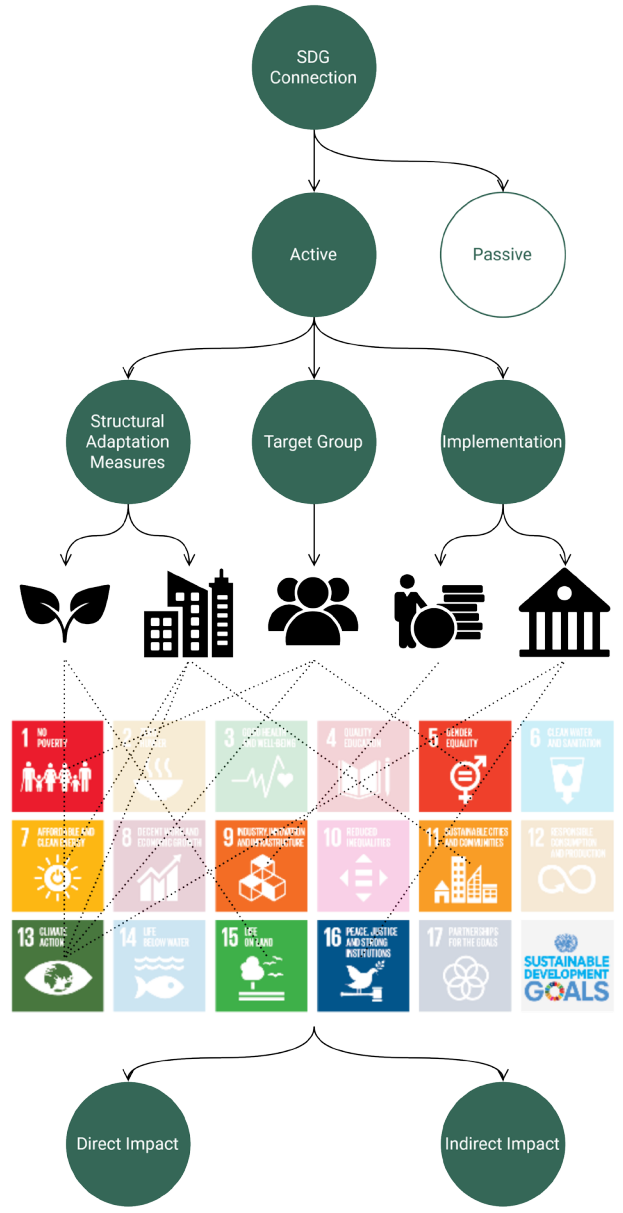

Figure 61: Instrument 5: SDG connection

9.3.7. Step 6: Strategy formulation

The main question of step 6 is how the SDG-inclusive adaptation strategy can be formulated while taking into account all previous findings and steps?
Together with step 4 and step 5, this is an iterative process of selecting and combining measures and connecting them to the selected SDGs. During the first iteration, the different options are mapped while during the second iteration, the final SDG-inclusive adaptation strategy is formulated.

Relevant during the formulation of this SDG-inclusive adaptation strategy is not only the inclusion of all vulnerabilities and SDGs but also of the elements necessary for a complete adaptation strategy, as formulated in section 4.1. Figure 62 shows these necessary elements of the adaptation strategy. The organisation steps are relevant to the connection of the SDGs, successful implementation of the adaptation strategy and achievement of adaptive capacity development.

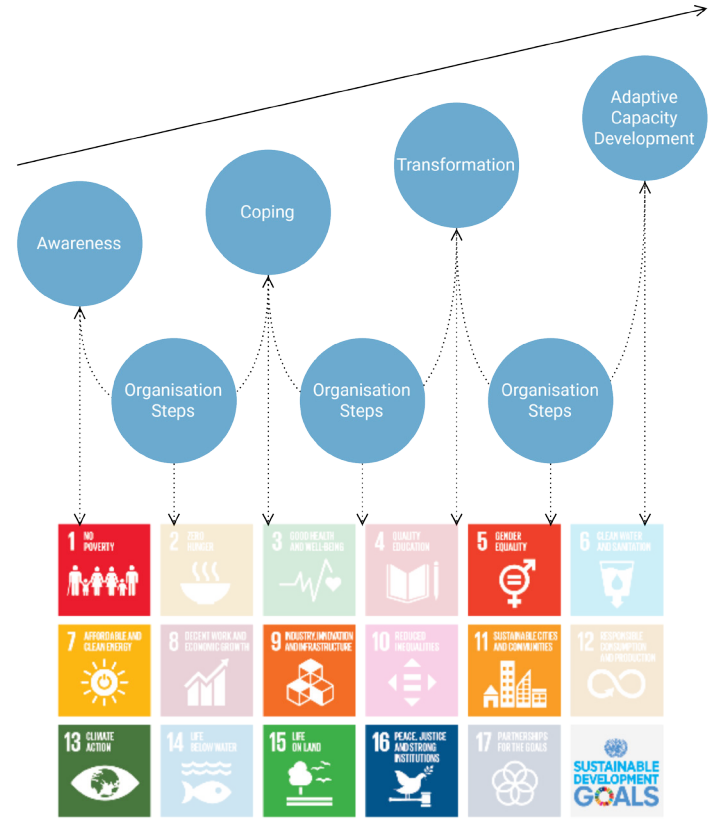

Figure 62: Instrument 6: Strategy elements

9.3.8. Evaluation Loop 2

As a result of the second loop, there should be an SDG-inclusive adaptation strategy including all relevant elements as shown in Figure 62. Furthermore, a complete list of steps is desired including the steps necessary during detailing and implementation. Desired is as well an overview showing how exactly the SDGs are connected to the spatial adaptation measures and organisation such as the overview developed for Semarang in section 7.2.2.

Again, boundaries are necessary to assess whether the adaptation strategy incorporates attention to the adaptation enabling factors and requirements. Examples for such boundaries are: achievement of community engagement, focus on awareness, or the engagement of local leaders in the organisation.
Figure 63 shows that community engagement can be achieved when the correct scale-level of measure is selected. When the scale-level matches the level of the community, this creates opportunity and ownership, leading to community engagement (see section 6.3.2).

Figure 63: Example boundary: Community engagement

Conclusion Part C

This part was dedicated to the development of the SDG-Adaptation-Framework. The results from Part B were utilised to extract the first iteration of the framework. Afterwards, the results were generalised by questioning the influence of contextual factors and choices on the process and result of the case study. Together with input from an evaluation session, the final framework was developed in a second design iteration.
The final framework consists of a framework overview and strategy development process enriched by instruments useable during the consecutive steps of the process.
The next chapter elaborates on the conclusions drawn up from the three report parts followed by a discussion of the results.

CONCLUDING

This chapter summarises the results gathered in Part A, B, and C of this report. The chapter starts with conclusions regarding the secondary and afterwards the main research question. Then, specific aspects of the results and conclusions are discussed. These aspects are: the author's bias, the wide field of adaptation, the case study, the framework, and the connection to the SDGs. Finally, recommendations are drawn up from the discussion, showing further steps.

10

10.1. Conclusion

This thesis is dedicated to the development of a framework that connects spatial adaptation to the Sustainable Development Goals by the United Nations in order to answer the research question:

How can vulnerable municipalities be supported in their first efforts towards climate adaptation?

This question has been answered through three secondary research questions that were consecutively addressed during the three parts of this report. In this section, the findings from these three parts lead to answering the secondary research questions. Finally, the main research question is answered clarifying the value of this research.

How does the comparison of the Netherlands with various locations around the world provide insights into factors influencing climate change vulnerability and adaptation?

This first secondary research question is addressed in Part A of this report. It illustrates the broad scope of especially the first part of this assignment. When comparing the overall status in adaptation and vulnerability of the Netherlands to other regions around the world, the frontrunner status of the Netherlands, especially compared to developing countries, is clarified. The increased vulnerability of developing countries is not only caused by higher exposure to climate change and hazards but mainly by a lack of adaptive capacity of institutions and individuals. Therefore, in order to support municipalities in developing countries, this research focusses on the connection of adaptation to the Sustainable Development Goals.

After the definition of the focus for this research, the factors influencing vulnerability and adaptation are researched in further detail in chapter 3 and 4. The just mentioned adaptive capacity, which is the main cause of the enhanced vulnerability of developing countries, can be described as the availability and accessibility of resources by vulnerable and marginalised groups. Hence, adaptation strategies, aiming to enhance adaptive capacity, must strengthen the capacity of the most vulnerable groups of people as discussed in chapter 3.

Chapter 4 focusses on the variety of approaches and processes around adaptation. It shows the 'optimal' adaptation process in which strategy development is only one step. It also shows factors enabling successful adaptation. These factors are a combination of awareness, urgency and prioritising, stakeholder and community engagement, knowledge sharing and collaboration, local leadership, the new normal and synthesis, and evaluation and learning.

How can an adaptation strategy be developed for a vulnerable municipality?

This question is addressed in Part B of this report by performing a case study exemplarily. Semarang in Indonesia was selected as the case study location because they are threatened by both climate-related and socio-economic vulnerabilities. During the case study, an SDG-inclusive adaptation strategy is developed by performing two consecutive development loops.
During the first loop, the vulnerability of the case study location is analysed together with the SDG performance. During that analysis, heat stress is selected as the focus risk because of Semarang's high vulnerability to it. Finally, a set of interfaces for the strategy design is developed.
This strategy design is performed in another iterative loop. Spatial adaptation measures are enhanced by active connection of the SDGs to the measures. This active connection can be achieved through the spatial adaptation solution itself and the organisation of the implementation in a certain way. Furthermore, some SDGs are automatically connected to the adaptation strategy. The final SDG-inclusive adaptation strategy consists of awareness-increasing, coping, and transformation elements.

Adaptation strategies for vulnerable municipalities can be developed by following an iterative process of analysing vulnerability, connecting vulnerabilities to the SDGs, brainstorming for spatial adaptation measures, and enhancing these measures by actively connecting the measures to the SDGs. The executed case study, therefore, contributes to answering the second secondary research question.

How can the development of an adaptation strategy for a vulnerable municipality provide insights into a generally applicable framework for similar municipalities?

This last secondary research question is answered through the retrieval and generalisation of the framework from the case study results. The approach and results of the case study provide necessary insights for the generally applicable framework.
Firstly, the process necessary to develop an SDG-inclusive adaptation strategy is retrieved. The process is characterised by two consecutive, iterative loops. The first loop is dedicated to the vulnerability analysis and development of the adaptation interfaces for the strategy design during the second loop. During this second loop, the SDGs serve as a mindset enhancing the brainstorming process as well as the final SDG-inclusive adaptation strategy.
Secondly, the various instruments utilised to support the process of strategy development also serve as instruments supporting the several steps of the process.

The results from the case study not only directly served as a baseline for the retrieval of the framework but also indirectly by serving as a baseline for the generalisation of the framework. This generalisation is performed through analysing the impact of contextual factors and choices on the result and process of the case study.

How can vulnerable municipalities be supported in their first efforts towards climate adaptation?

The three just answered secondary research questions together answer the main research question through the development of the SDG-Adaptation-Framework.

The developed framework supports vulnerable municipalities in their first efforts towards adaptation by providing them with a strategy development process as well as instruments. During that process, the municipality must assess their vulnerability and consequently develop a fitting adaptation strategy.
The target group of the framework are vulnerable municipalities. The most vulnerable are municipalities in developing regions because of a lack of adaptive capacity. The enhanced vulnerability of developing regions receives attention

by connecting the SDGs to spatial adaptation measures. Thus, the developed adaptation strategy does not only decrease vulnerability to climate change through spatial adaptation measures but also through strengthening that adaptive capacity.

Not only does the adaptation strategy strengthen adaptive capacity, but the overall sustainable development. Adaptation can be connected to a variety of problems and targets that a municipality might have. This integration of adaptation into other municipal processes and targets is one of the currently most pressuring issues in adaptation planning. However, this integration is mainly discussed for other sustainability-related fields, such as circularity, or energy transition. Socio-economic aspects are not often taken into consideration yet. Herein, the connection of the SDGs provides a valuable new point of view by connecting both other sustainability-related fields as well as socio-economic aspects.

In some existing adaptation strategies, the SDGs are already included as a description of the impact of the adaptation strategy. However, the only connection to the SDGs that is currently made, is after the development of the adaptation strategy. The active involvement of the SDGs, as described in this report, is not a common practice. Therefore, this research can provide insights and value not only for the municipalities but also in the field of adaptation and academia as well as for &Flux.

The framework and instruments synthesise a wide variety of concepts from the field of adaptation. The case study provides a practical example of reality showing the functionality of the theoretical framework developed in this report.

10.2. Discussion

In the previous section, the research questions defined at the beginning of this report were answered. This section discusses a variety of aspects of the conclusion and report in order to show limitations and draw up recommendations. Input from evaluation sessions with experts is utilised to enrich this discussion. The complete evaluation can be found in Appendix 12.

Author's bias

In Part A of this report, the vulnerability and adaptation status in different regions around the world are compared. It is established that developing countries are most vulnerable to climate change due to their lack of adaptive capacity. This enhanced vulnerability can therefore be decreased by enhancing the adaptive capacity through incorporating development in the form of SDGs in the adaptation efforts. While this statement is grounded in research, it is important to realise that such viewpoints are affected by the researcher's bias. Some statements and choices may even mainly be based on such bias without notice.
The bias is especially relevant regarding the case study performed in the context of Semarang. The case study had to be performed from a distance by doing expert interviews and literature research. By performing thorough analysis and comparisons of statements, a general overview of Semarang's context could be drawn. However, a nuanced picture can only be drawn when being part of the actual context.
Therefore, the limitations caused by the author's bias and distance from the target group should be regarded. Future case studies, validation, and framework development must be performed within the actual context and together with the final users.

The wide field of adaptation

Adaptation to climate change is an extremely wide field just like the field of development. Finding a specific focus within that field was the main challenge of this research. Many aspects of adaptation and development are out of the scope of this assignment but could potentially elevate the research further. A variety of these aspects will be highlighted in the recommendations.
When making scope-choices during the assignment, trade-offs had to be made between abstraction and detail. The assignment includes the aspects that should

find the balance between such abstraction and detail in order to ensure the development of a framework that is generally applicable as well as practical for the municipalities.
While during the development of the framework, the influence of choices on the result and process of the case study were analysed, the influence of scope-choices on the result and process of this whole research would be interesting to analyse as well.

The case study

The case study is an important part of this research. The SDG-Adaptation-Framework is directly extracted from the results of the case study.
As mentioned before, the case study is limited by the author's bias and distance from the actual context. This influenced the approach and level of detail of the case study results.
Both the effectiveness of the adaptation strategy as well as its support within the community could not be validated. However, the research stresses the importance of community engagement not only during the implementation of adaptation strategies but also during the development of them.
The generalisation of the case study is performed by questioning the influence of contextual factors and choices on the process and results of the case study. This is performed in order to allow for an estimation of the robustness of the case study results and adjustment of the framework accordingly. However, a variety of practical case studies would be desirable to allow for a more robust generalisation.

The case study serves exemplary as the base for the framework. The generalisation allows for better estimation of the robustness of the case study results and framework. Other case studies are necessary to improve and validate the framework.

The framework

The SDG-Adaptation-Framework is faced with the same dilemma as this complete research: The trade-off between abstraction and detail. A detailed framework is applicable in a small variety of specific contexts but very useable in these contexts. An abstract framework is applicable in a multitude of contexts but not as useable. The developed SDG-Adaptation-Framework is very abstract. Therefore, it is applicable in multiple contexts but more complicated and less useable. In order to increase the useability, the framework must be developed into a user-friendly tool and another iteration of testing and design is necessary.
However, instead of developing such a new tool, the theoretical framework developed in this report could also be incorporated into an already existing framework or tool in another design iteration.

The connection to the SDGs

The connection of the SDGs to adaptation is the most important part of the developed SDG-Adaptation-Framework. Therefore, a variety of aspects can be discussed.
The first discussable question is whether the SDGs are the best fit to include development and vulnerability from a socio-economic point of view. The SDGs are a very popular blueprint to describe development goals, including socio-economic goals and targets. However, not all socio-economic risks and nuances can be described through the SDGs. In order to ensure that the framework does not miss relevant socio-economic vulnerabilities, the vulnerability analysis is not framed from the perspective of the SDGs. However, in order to enhance the SDG-connection, adding that perspective on top of the current vulnerability analysis may be valuable.
The incorporation of a development approach like the Human Rights-Based Approach (short: HRBA) could also provide significant value from the socio-economic perspective. The HRBA aims to allow the 'right-holders' to claim their rights, meaning that inhabitants could claim adaptation resources (UNSDG Human Rights Working Group, 2003).
Furthermore, the SDG-perspective could be further improved when analysing the SDGs on target level. Within the scope of this thesis, the SDGs and connections are analysed on the goal level in order to allow for an understandable connection method. Analysing the SDGs on target level would allow for further level of detail and the development of more concrete goals and strategies.
Moreover, it is discussable whether the direction of the SDG connection is correct. One of the reasons the SDGs are selected as development connection is their popularity around the world. The SDGs are the most popular blueprint for development. This popularity may accelerate the success of the adaptation measures when the SDGs serve as the starting point. However, in the SDG-

Adaptation-Framework, adaptation is the starting point to which the SDGs are connected to. When starting from the SDGs instead of adaptation, the focus shifts from adaptation to development, not allowing for focussed adaptation strategies. To conclude, the SDG connection offers a valuable mindset but can be more detailed in another iteration.

10.3. Recommendations

The development of the SDG-Adaptation-Framework has been conducted following the specific focus and scope established in chapter 1 and 2. The framework can be further improved and supplemented beyond the scope of this thesis. Therefore, this section presents a variety of recommendations for further research and development.

Validation

First of all, the SDG-Adaptation-Framework should be validated by testing it in another case study. This case study should be executed together with a municipality while utilising the framework in the strategy development process. However, since the framework is not yet a user-friendly tool but a theoretical framework, another design iteration focussing on useability and user-friendliness should be performed before testing it within an actual case. First validation can be achieved by setting up a workshop with some experts and employees of municipalities going through the strategy development process and discussing the results.

Developing a tool from the framework

As just mentioned, the developed SDG-Adaptation-Framework is merely a theoretical framework offering a mindset and general process to follow. In order to develop a user-friendly tool from the framework, some changes are recommended:

1. Next to the general guideline, a clear example should be provided that shows how to utilise the framework. The performed case study or a new case study can serve as such an example.
2. The framework is based on terminology developed during the assignment. This, in order to clarify the different viewpoints the framework takes. However, using known terminology can improve the understanding of the users. For example, the adaptive potential may be reframed as adaptive capacity if that is beneficial for the user's understanding.
3. A variety of instruments is developed and provided together with the process. More instruments and methods are already developed and could enhance the strategy development process. Existing instruments should be researched and recommended in the final tool.
4. In order to ease the measurement of vulnerability and success of the adaptation strategy, a set of indicators should be developed that can be utilised for measuring. These indicators should be adjustable to the specific context.

Further research

Next to these recommendations concerning user-friendliness of the final tool, a variety of recommendations can be made regarding further research in order to enhance the theoretical framework. As already mentioned, adaptation is a very wide field as well as development. Many elements were researched within the scope of this assignment. However, other aspects can improve the SDG-Adaptation-Framework further:

1. The 'optimal' adaptation process is based on processes of spatial planning and adaptation. However, because of the inclusion of the SDGs, the framework also belongs to the field of development. Hence, development processes could also be incorporated into the definition of the 'optimal' process.
2. Next to the incorporation of development into the 'optimal' process, development approaches could also be further researched and incorporated in the framework such as the HRBA mentioned before. The SDGs merely serve as a baseline for a new mindset, but to create a more robust linkage between adaptation and development, actual development approaches can be beneficial.
3. The framework focusses mainly on the strategy development step of the adaptation process. An analysis of the other steps and the influence of the strategy development step may be valuable.
4. The framework shows a variety of adaptation approaches. However, likely not all adaptation approaches are incorporated in the framework yet. Further research regarding adaptation approaches could be incorporated into the framework.
5. A set of boundaries is established based on the research in Part A of this report. This set is, however, not aiming to be complete. In order to ensure that

both loops of the strategy development can be evaluated with a robust set of boundaries, these could be further researched

6. The SDGs are analysed on the goal level. An analysis of the goals on target level could be performed in order to enhance the level of detail of the connection and adaptation strategy.
7. The vulnerability analysis is performed without including the SDGs yet. The connection of the SDGs to the vulnerabilities is performed in the following step. In order to enhance the connection of the SDGs to the vulnerabilities, it could be investigated whether the vulnerability analysis can incorporate an SDG perspective.
8. Lastly, the SDGs are selected as the blueprint to be connected to adaptation because of their popularity. One of the assumptions is that this can ease the gathering of investments for adaptation efforts. This should be further researched and validated in order to ensure that the connection does allow for investments.

Figure 64: People cooling off, retrieved from Paul Moody on flickr.com on November 27. 2020

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