CLIMATE CHANGE ADAPTATION IN HISTORIC CENTRES

A reflection on governance conditions required for successful adaptation in cities with a historic centre in the Netherlands

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Conservation of heritage and addressing climate change are both topics I am passionate about. Therefore I was thrilled I got to study both subjects for this study. However, at times, this project took the form of a game of snakes and ladders. Though I love games, this is not a favourite. This particular version required moving the thesis project from start to finish on a game board full of traps and tricks, with snakes to take you down, ladders to take you up – and there were plenty of both snakes and ladders along the way.

Those pesky snakes that were so eager to take me back to square one did so in the form of worry about taking the research down the wrong path, anxiety about approaching potential interviewees, unanswered emails by potential interviewees, apprehension about finishing the project on time while not even halfway (it is never too early to start panicking about deadlines), erroneously interpreting results, missing clues on valuable information in the interviews – and more. Some set me back a little bit, others stopped me from moving along a while longer.

However, there were also plenty of ladders who helped me go up. These appeared in the shape of people, and I would like to thank them. Firstly, my supervisor Carel Dieperink who ensured I left every meeting feeling positive about the project, and with new ideas and insights on what to do next. Also, I would like to thank my second reader Hens Runhaar who made some suggestions to adjust my research proposal. This was helpful in getting a clearer image on the direction the study was going to move in. Moreover, study advisor Pieter Louwman helped greatly regarding study process. Also, I am grateful to the people I got to interview for this study. I am very thankful for your time, and appreciate you sharing your expertise with me.

Although, the biggest ladders are my parents and sister, and my friends Joey and Caroline. Your unending support, love, and laughs have made all the difference. Thank you for everything you do. Twinga, Ingrid and Rob, I appreciate the insights and guidance you have provided me with before and during this project.

This research project culminates in the current report, ending this game of snakes and ladders. It has not always been fun, however I learned a lot from it. I am eager to start a new, different game. Roll on the next one.

Abstract

Climate change is impacting our heritage. This fact is getting more recognition, it even is regarded as one of the most significant threats to our common past by ICOMOS. This study found that heritage in the Netherlands is also at risk of climate change. In order to prepare for changes in climate and their impacts on our heritage, it is necessary to learn which local areas are under threat, what monuments in these areas are particularly threatened and how, and thirdly how this built cultural heritage can be adapted in such a way that its cultural value is kept intact.

A plethora of research exists focusing on adaptation to climate change in general, or more specifically on adaptation to climate change in urban areas. However, there is a paucity of information regarding climate change adaptation in historic urban areas. In particular, there is a lack of information regarding governance conditions. This explorative research studies climate change impacts on heritage and addresses the knowledge gap on insights in governance conditions. From this knowledge gap a research question is formulated: What governance conditions are required for successful adaptation to climate change in historic cities in the Netherlands.

First, this study probes a variety of scientific sources for governance conditions. These are combined in a preliminary assessment framework, which is subsequently tested in a case study. The case study generates empirical knowledge on governance conditions from Breda and a selection of Experts. Based on this empirical research, a revised assessment framework is created. Awareness, knowledge, and access and guidance for information and their governance conditions are highlighted as the most important factors influencing successful climate adaptation in historic centres. Moreover, the study provides some steps that can be taken to ensure successful adaptation of the historic urban landscape.

Abbreviations

ANK	Atlas Natural Capital *(Atlas Natuurlijk Kapitaal)*
CAS	Climate Adaptation Services
CCHWG	Climate Change Heritage Working Group
CHCfE	Cultural Heritage Counts for Europe
CVI	the Climate Vulnerability Index
EEA	European Environment Agency
FP6	European Union's sixth framework programme
HUL	Historic Urban Landscape
ICOMOS	International Council on Monuments and Sites
IenM	Ministry of Infrastructure and the Environment *(Ministerie van Infrastructuur en Milieu)*
IenW	Ministry of Infrastructure and Water Management *(Ministerie van Infrastructuur en Waterstaat)*
IPCC	International Panel on Climate Change
IUCN	International Union for Conservation of Nature
KEER	Climate adaptation, Energy transition, Heritage, and Spatial development (Klimaatadaptatie, Energietransitie, Erfgoed, Ruimte)
KNMI	Royal Netherlands Meteorological Institute (*Koninklijk Nederlands Meteorologisch Instituut*)
NAS	National Climate Adaptation Strategy (*Nationale Adaptatiestrategie*)
NCHA	Netherlands Cultural Heritage Agency (*Rijksdienst voor het Cultureel Erfgoed, RCE*)
OCW	Ministry of Education, Culture, and Science (*Ministerie van Onderwijs, Cultuur en Wetenschap*)
OUV	Outstanding Universal Value
SIM	Subsidy programme for upkeep national monuments (*Subsidieregeling instandhouding rijksmonumenten*)
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WHC	World Heritage Centre

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Chapter 1 – Introduction

This research focuses on governance of historic urban areas, with respect to climate change adaptation. In the past few years, both social and scientific interest in heritage and climate change has grown, as people became more aware of the challenges and risks posed to our built heritage. Governance can be understood in various ways. It can consist of "creating the conditions for ordered rule and collective action or institutions of social coordination. Governance is the structures and processes by which people in societies make decisions and share power" (Folke et al., 2005, 444). Aylett (2015, 5) defines governances as "a focus on how authority and resources are allocated to make possible control and coordinated action". Then there is also the idea of adaptive governance, which focuses on the required underlying characteristics of the governance system to strengthen urban resilience and reduce the vulnerabilities of communities (Leichenko, 2011). Where this study refers to governance it considers the structures and processes that allocate resources and authority to strengthen urban resilience and reduce the vulnerabilities of communities. This implies an interactive governance mode, where public authorities involve local stakeholders and citizens in their adaptation planning and during implementation (Driessen *et al.*, 2012).

Climate change is seen as one of, if not the most, significant and fastest growing threats to peoples' cultural heritage (ICOMOS, 2017) and to their natural heritage (IUCN, 2017). In order to prepare for changes in climate and their impacts, it is necessary to learn which local areas are under threat, what monuments in these areas are particularly threatened and how, and thirdly how this built cultural heritage can be adapted in such a way that its cultural value is kept intact. Governance of the issue to adjust to climate change mostly falls on the shoulders of local municipalities, who are tasked with formulating formal climate adaptation policies as a result of decentralisation (PBL, 2015). Vogel and Henstra (2015, 110) define climate adaptation policies as "courses of action designed to reduce the vulnerability of populations, assets, and operations to climate-related risk".

This research aims to generate knowledge on what governance conditions are required for successful adaptation of built heritage in historic cities in the Netherlands. In the next section, the focus is placed upon climate change and adaptation in the Netherlands. Subsequently, the risks posed to built heritage by climate change are discussed. The third section highlights management of the Dutch historic environment in broad strokes. From this discussion, a knowledge gap on governance conditions leading to successful adaptation is identified. Based on this knowledge gap, the research objective and social relevance of this research are formulated, to be followed by the research questions and the research framework. Next, governance conditions relevant to climate adaptation in historic inner cities are probed from a literature review. Hereafter, the research methods are explained, delving into how the main research question and sub-questions are answered. In addition, the reasoning behind the choice for Breda as case study is explicated. Following this is an analysis of the results. The study ends with a discussion on the findings and some final concluding remarks.

1.1 – Climate change and adaptation in the Netherlands

This research starts out by looking at climate change and climate adaptation in the Netherlands. Firstly, climate change in the Netherlands. The Royal Netherlands Meteorological Institute (KNMI) is a governmental institution, which via its sub-department Research and Development of Weather and Climate models concerns itself with research regarding climate models, including long term climate projections. This research institution has developed the climate change scenarios for the Netherlands, the most recent being the KNMI'14 scenarios. New, more specific scenarios are expected in 2021 (see http://www.klimaatscen arios.nl). The KNMI scenarios show projections for a local scale; other scenarios developed by e.g. the European Environment Agency (EEA) and International Panel on Climate Change (IPCC) focus on trends on larger scales, but do include projections for the area of the Netherlands.

The KNMI'14 yielded a set of four new climate scenarios for the Netherlands, which are also referred to as storylines. These storylines are based on the most up to date knowledge and climate projection models at the time. Feijt and colleagues (2016) acknowledge that there is a large uncertainty involved in the model-based projections, because of a limited ability to mimic the climate system accurately, combined with unknowns about societal developments. However, compared to the 30-year characteristics of the periods 1951-1980 and 1981-2010, the projected scenarios show the anthropogenic influence because the projections exceed the range of estimated natural variability.

The KNMI'14 scenarios are based on IPCC AR5 CMIP5 global projections and scenarios for future global temperature increase and air circulation patterns, as these have a substantial influence on climate change in the Netherlands (KNMI, 2015). Regarding the former, the storylines acknowledge two possible values, being Moderate (in scenarios signified by the letter "G") and Warm ("W"). In the G scenarios, the global mean temperature increase is 1 °C in 2050 and 1.5 °C in 2085 relative to 1981-2010; in the W scenarios the increase is 2 °C in 2050 and 3.5 °C in 2085 relative to 1981-2010. Concerning air circulation patterns a distinction is made between Low value ("L"), where the influence of circulation change is small, and High value ("H"), where the influence of circulation change is large (KNMI, 2015). Together these form four scenarios, being GL, GH, WL and WH (See figure 1).

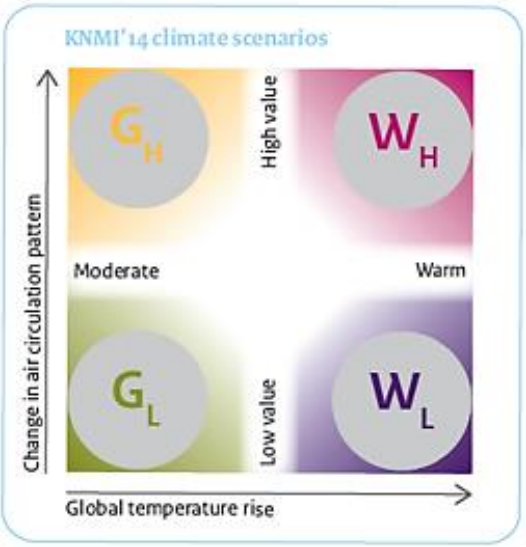

Figure 1 – KNMI'14 climate scenarios

The KNMI'14 storylines focus on five variables, being temperature and precipitation; sea-level rise, and extreme wind; relative humidity, solar radiation, evaporation and drought; and lastly extreme weather (KNMI, 2014). The KNMI'14 report categorises these climate variables differently (KNMI, 2015), but this study uses the distinctions utilised in the 2014 report edited by Van den Hurk, Siegmund and Klein Tank. The KNMI'14 projections form the basis of the 2016 National Climate Adaptation Strategy (Nationale Adaptatiestrategie, NAS) (NAS, 2016).

This next part describes climate change adaptation in the Netherlands. The Dutch national government is decentralising planning for climate adaptation to local governments (Den Exter, Lenhart & Kern, 2015; IenW, 2017). The Dutch adaptation policy comprises two parts: the Delta Programme and its concomitant Delta Plans which focus mainly on the Dutch deltas on the one hand, and the aforementioned NAS. The first Delta Programme was set out in 2010, the current Delta Programme (Delta Programme 2019, 2018) is the ninth version and was first published in 2018. The strategy has been decided upon in cooperation with Dutch municipalities, district water boards, provinces and the national government. It focuses on continuation of the work on the Dutch delta and adaptation the Netherlands to climate change in time (Delta Programme 2019, 2018). The main aim is to improve the governance of climate adaptation, and to equip the Dutch landscape with climate proof measurements to prevent and limit disasters. The three Delta Plans focus on 1) Flood Risk Management, 2) Freshwater Supply, and 3) Spatial Adaptation. The most relevant Delta Plan for this study is the Delta Plan in Spatial Adaptation (Delta Programme 2019, 2019, 56-74). As part of this Delta Plan, local governments are required to have climate adaptation integrated in their policies before 2020. These plans can be made with the help of stresstests. To help inform these stresstests, a National Climate Impact Atlas has been developed, which is provided by Climate Adaptation Services (CAS). This Atlas shows the current situation compared to future climate impacts in 2050 according to the KNMI'14 scenarios. The Atlas contains maps on urban pluvial flooding, heat stress in cities, river and coastal flooding and droughts.

The Deltaprogramme provides policy for climate adaptation in the Dutch delta. For other areas in the Netherlands, the NAS has been developed. The NAS 2016 gives information on the effects and risks of climate change for nine sectors, visualised in conceptual diagrams. Unfortunately, in-depth information and the conceptual diagram for the tenth sector, the built environment, has not been released at this point in time. Regarding the place of heritage within the NAS, references to built and natural heritage are scattered throughout the report, but as a standalone topic built heritage is not addressed. Maybe this will be done in the discussion on impacts for the built environment.

In 2018 the Dutch Council of Ministers adopted the Implementation Programme 2018-2019 of the NAS (UP NAS 2018-2019, 2018). Its focus is on raising awareness and on involving parties that are currently not yet (sufficiently) involved. It identified six priorities:

1. Heat stress
2. Infrastructure
3. Agriculture
4. Nature
5. Built environment

6. Collaborating on provincial and regional strategies and visions

However there are various caveats in the Implementation Programme NAS 2018-2019. The programme does not specify which actions will be taken up by which party, nor which budget is allocated. Another focal point of the Implementation Programme 2018-2019 of the NAS is to keep developing knowledge on climate risks.

Based on the KNMI'14 storylines, NAS identifies four scenarios, being 1) it gets hotter, 2) it gets drier (in summer), 3) it gets wetter, and 4) sea-level is due to rise. These four scenarios should form the focus of adaptation plans. In appendix A, the projections for the five variables, being temperature and precipitation; sea-level rise, and extreme wind; relative humidity, solar radiation, evaporation and drought; and lastly extreme weather (KNMI, 2014) and their consequences are discussed in-depth. This discussion ignores effects on agriculture and health as these do not fall within the scope of this study.

The main takeaways from Appendix A :

1. Temperature and precipitation: average temperatures will increase. Higher chance of warm, summer, and tropical days, less days with frost. Precipitation increases in winter months, decrease in summer.
2. Sea-level rise: expected to increase in all KNMI'14 scenarios. Can be accompanied by higher water-levels in rivers.
3. Extreme wind: wind patterns are expected to change. Higher chance of storminess and windspeeds. Increased salt content in the air.
4. Relative humidity, solar radiation, evaporation and drought: all increase. Relative humidity mainly in winter. Solar radiation increases overall, but especially in summer. Evaporation increases in summer, as does chances of drought.
5. Extreme weather: more thunderstorms. More heavy hailstorms. More fog.

The next section takes these five climate variables, and looks at the potential impacts on built cultural heritage. Moreover, it addresses ways built cultural heritage can be adapted.

1.2 – Possible impacts on built cultural heritage

Over the past ten-fifteen years or so, climate change impact on built cultural heritage has seen increasing interest. Issues regarding acid rain and therewith destruction of heritage were already well documented (UNESCO, 2006; Global Platform for Disaster Risk Reduction, 2013), but other damages caused by climate variables, such as droughts or increase in precipitation, were less well known. To address this knowledge gap, the European Union (EU) funded the research programme "Global climate change impact on built heritage and cultural landscapes" (NOAHS ARK), which ran from 2004 to 2007, as part of the EU's sixth framework programme (FP6) policies. This project aimed to assess the risk to buildings and monuments in various ways. Its main objective was to outline the climatic parameters that affect historical buildings and predict the consequences for the next century (Sabbioni, Brimblecombe & Cassar, 2012). The project sought to outline mitigation strategies for sites, monuments and specific materials that were under risk. NOAHS ARK's results include a database of information for stakeholders to evaluate threats, run different scenarios and predict the effectiveness of various strategies. It also established an advisory panel to prepare recommendations and guidelines for authorities

and policymakers to tackle the effects of different weather phenomena. These guidelines covered four themes, being rainwater and drainage infrastructure, effects on structures, indoor/outdoor interaction, and fourthly effects on building materials. The third main result of the project included the preparation of maps that outlined areas with increased risk, i.e. where deterioration of buildings was most likely to take place (Sabbioni, Brimblecombe & Cassar, 2012).

Concerning Europe, UNESCO (2007a) is particularly worried about increased risks of damage to built heritage due to sea level rise, temperature changes, an increase in precipitation levels and windiness. Moreover, not only EU policy makers acknowledged the risks, a questionnaire distributed among its members by the United Nations Educational, Scientific and Cultural Organisation's World Heritage Centre (UNESCO WHC) found that 72% of the responses pointed out that both their natural and cultural heritage was at risk of being affected by climate change (UNESCO 2007a). This resulted in a change in strategy World Heritage and climate change, focusing on:

- Preventive actions: monitoring, reporting, mitigation
- Corrective actions: adaptation and risk management
- Sharing knowledge: research, education, training, awareness-raising

This strategy change was laid down in a policy document on the impacts of climate change on World Heritage properties (UNESCO, 2007b). The policy document sets out research priorities and how the topic should be framed, legal implications of climate change in provisions of the convention, and addressed the need for mitigation at World Heritage properties. At the same time, UNESCO was working on a change in its attitude towards conservation, from managing objects to "managing thoughtful change" (Veldpaus & van Oers, 2013, 1). Which lead to the adoption of the Historic Urban Landscape (HUL) approach, which besides the object considers intangible features, setting and context, and urban- and sustainable development (UNESCO, 2011). Additionally it frames the cultural heritage within social and economic function of cities (Veldpaus & van Oers, 2013).

A few years later, at the 2015 UN Paris convention, UNESCO organised a side-event focusing on embroidering the research fields of climate change (adaptation) and heritage studies. The past few years the international heritage community has focussed on raising awareness on increasing disaster risk and the impact of climate change, by highlighting its use in sustainable development. It is addressed in the Sendai Framework for Disaster Risk Reduction 2015-2030 (2015), the Habitat III New Urban Agenda (2016) and mentioned in several UN Sustainable Development goals (2015). Most recently, ICOMOS' Resolution19GA 2017/30 (ICOMOS, 2017) called on the heritage community to help meet the challenge of climate change. It emphasised that cultural heritage is both impacted by climate change as well as a source of resilience. Secondly, heritage is an important form of local knowledge that can help inform strategies to address climate change. Plus, cultural heritage-based solutions to climate change mitigation and adaptation have value. This wake-up call has been reiterated by UNESCO at its 42nd session of the World Heritage Committee (UNESCO, 2018), where it implored State Parties to implement the Paris Agreement, and highlighted the need for a holistic approach by seeking collaboration with UNFCCC and IPCC, and requested to work with the latter with the objective of including a specific chapter on natural and cultural World Heritage in future IPCC assessment reports (ICOMOS, 2019).

Additionally, the European Union shows an interest in this topic. Part of its Europe 2020 strategy is to carry out research by the Cultural Heritage Counts for Europe (CHCfE) Consortium (2015) focusing on the role of European cultural heritage as a source of sustainable development. Both UNESCO (2010) and CHCfE (2015) call for more research tackling the issue of climate change and tangible heritage. A recent comparative analysis of safeguarding cultural heritage in the EU underlines the call for more research and awareness. In this research, Bonazza and colleagues (2018) found that there is a need for more integration of cultural heritage requirements into existing research, information and mapping of development programmes. Moreover, the report highlighted the need for better understanding of the complex risk scenarios in urban historic centres regarding climate impacts. In addition, the authors remark that in general, there is a lack of funding, legal measurements, and awareness pertaining to the issue of safeguarding cultural heritage from climate induced risks.

Regarding the future of heritage and climate adaptation, ICOMOS and UNESCO are driving towards a change in perspective, from cultural properties to people. This means that conservation should aim to protect the cultural rights of people affected by climate change (ICOMOS, 2019). Are there things we can learn from other countries? Bonazza and colleagues (2018) concluded, only Bulgaria, France, Italy, Spain, and United Kingdom have developed national climate adaptation plans which take into account the cultural heritage sector. In addition, Ireland has acknowledged the risk of climate change to built and archaeological heritage. The department of Culture, Heritage and the Gaeltacht is preparing an adaptation plan to address the impacts of climate change on built and archaeological heritage (CHG, May 14 2019). For this plan, they have asked the general public to get involved.

Internationally, a few Interreg projects also address this issue. An example is Rock, which has a podcast called 'Green Heritage Futures' which highlights historic city centres as laboratories to demonstrate how Cultural Heritage can be a unique and powerful engine of regeneration, sustainable development and economic growth for the whole city, as well as providing knowledge on what historic sites can tell us about climate change (Latham, March 6 2019). Moreover, the Keeping History Above Water conference has been organised for a few years. This conference highlights specific examples of adaptation planning at the local level. It delves into how historic preservation will be a key catalyst for adapting the built environment. Here, Marcy Rockman IPCC Team Lead Climate Change and Cultural Heritage highlighted the tensions between heritage and adaptation. She noted that many people call heritage 'the panda's and tigers of cities', but highlighted that heritage actually is underfunded and not stressed enough within IPCC policy (Adams, May 21).

However, because the issue is seen as being underfunded and under researched (Raposinho & Mota, 2019; Rodwell, 2018), international cooperation is stepping up: Climate Heritage Network will be launched in October in Edinburgh (see: http://climateheritage.org/launch-2019/). The network aims to disseminate knowledge and best practices, and to raise awareness to the issue.

ICOMOS 2018 Climate Change Heritage Working Group (CCHWG) Work Plan focuses on an update to UNESCO's 2007 policy document on impacts of climate change on WHC,

the draft of a new ICOMOS charter on climate change and heritage to be adopted at the 20th Triennial General Assembly, to connect heritage science and research better with the IPCC climate change science streams, and to further develop the Climate Vulnerability Index (ICOMOS, 2019).

So, what are these climate impacts on cultural heritage these organisations stress? As mentioned, NOAHS ARK furthered the knowledge on climate change impacts on a European level. It delves deeper into specific consequences for architectural heritage due to climate change (Sabbioni, Brimblecombe & Cassar, 2012). The climate variables they distilled can be categorised in precipitation and humidity; biomass changes; temperature changes; and atmospheric pollution. However, for the sake of internal cohesion, the risks will be discussed using the categorisation used in Appendix A.

Table 1 shows the main takeaways of the possible impacts on built cultural heritage discussed in-depth in Appendix B. It highlights generic consequences for individual buildings made from stonework, brick, and other natural material like timber and roof shingles. Focus is on individual building, not city, neighbourhood or street level. It was chosen to centre on solitary monuments because historic town centres, and even neighbourhoods and streets, do not consist of homogeneous edifices. Moreover, it does not include all impacts. Consequences for stained glass and various type of steel and other metal have been left out of account, as there are few monuments in the Netherlands constructed with these specific heritage materials. In Appendix B.1-B.5, these processes are explained in further detail. The main thing to remember is “stranger-danger”, in this case the more climate in the Netherlands changes (the “stranger”) the more risk for and concomitant impact on cultural heritage (the “danger”). Of particular interest in the Netherlands are damages caused by water, temperature and solar radiation. Figures 2 and 3 show potential effects of weather induced damage with an example of flooding at Tegelarije Castle in Roermond, Limburg.

Figure 2 - Tegelarije Castle in Roermond (source: 1Limburg)

Figure 3 - Tegelarije Castle Roermond after flooding, June 2016 (Source: 1Limburg)

Table 1 - Overview of projected impacts on built heritage caused by climate change

Driver of change	Increase/decrease in	Leads to	Damages
Temperature	Higher temperatures → Increase in thermal stress	Weakening of building facades	Aesthetic and structural damage
	Higher temperatures → Increase in drought events	Slight decrease moisture levels sandstone walls	Structural damage
		Decrease moisture levels brick walls	Structural damage
	For north Netherlands: more precipitation, lower decline in frost events	For north Netherlands: increase in decay of clayey materials	Material decay
	Increase in Urban Heat Island effect	Increase in thermal stress	Ultimately, loss of material. Structural and aesthetic damage
	Higher temperatures → Decrease in freeze-thaw events	Freeze-thaw events lead to shattering of porous material	Structural and aesthetic
		Freeze-thaw events lead to soil destruction	Archaeology (buried)
	Higher temperatures →Decrease in wet-frost events	Wet-frost events lead to shattering of porous material	Structural and aesthetic
	For south Netherlands: more precipitation, decline in frost events	Decrease in decay of clayey materials	Material decay
	Increase in thermal stress	Spalling and efflorescence of texture	Cracking, fragmentation, and fracturing of the texture → loss of material
		Cracking and fracturing of surface	Loss of material
Precipitation increase	Increase in landslides	Ground subsidence	Decay of stonework and unstable foundations
	Increase in water volume	Salt crystallisation	Efflorescence, delamination and exfoliation
		Erosion caused by wind-driven rain	Powdering of material and erosion
Temperature and Precipitation increase		Biodegradation	Biomass increase, can be contributor to damage or protector of material
	Decrease in richness of lichen species		
Sea-level and Precipitation increase	Increase in flooding	Erosion caused by water flow	Flooring and walls
		Increase in moisture content	Physical alteration and staining of wooden floorboards, see also above increase in water volume
		Deposit of mud	Staining of floorboards
		Ground heave	Decay of stonework and unstable foundations
		Choice of drying method	Potential loss of intrinsic value
Wind (changes in air circulation patterns)	Increase in storminess	Erosion caused by wind	Deterioration of building material and deterioration of foundation
	Increase in westerly air currents	More salt in the air → Salt crystallisation	Efflorescence, delamination and exfoliation
Relative humidity (and precipitation)		Salt crystallisation	Efflorescence, delamination and exfoliation

	Increase in relative humidity in winter → increase in moisture retention walls	Erosion caused by wind-driven rain	Powdering of material and erosion
		Biodegradation	Biomass increase, can be contributor to damage or protector of material
Relative humidity	Changes in relative humidity	Humidity shocks	Decay of indoor wooden objects by swelling and shrinking
Solar radiation Increase	Increase in thermal stress	Thermoclastism	Microcracking and exfoliation of stone, especially marble and calcite materials
Evaporation and drought increase	Increase in drought in summer	Slight decrease moisture levels sandstone walls	Structural damage
		Decrease moisture levels brick walls	Structural damage
Extreme weather increase	Increase in hail and thunderstorms	Increase in water volume: see above	
		Hailstorms	Roofs (especially tile and slate), other external features such as windows, chimneys.

What are some adaptation opportunities? There are a variety of approaches that can be taken, ranging from low-risk strategies to higher risk. Low-risk include increased emphasis on maintenance and provisions for protection, while higher risk include adaptation of practices or even changes to what we currently find acceptable. Low-risk strategies focus on improving protection from extreme weather events that are already happening and include:

- Prioritising maintenance to ensure buildings are weather proof (Forster et al., 2011, Historic Scotland, 2012)
- Increasing the capacity of drainage systems at roof and ground level (Cassar & Pender, 2005)
- Increasing the capacity of water storage to enhance water security for vulnerable assets, e.g. by increasing urban green (Demuzere et al., 2014) and urban blue spaces and Sustainable Urban Drainage Systems (SUDS) (Voskamp & Van de Ven, 2015)
- Improve the thermal-energy performance of the outer layer of historical/historic built environments, without altering their appearance, through application of cool-coloured and colour-matched mortar. Keeps the inside of the building cool and also mitigates Urban Heat Island effect (Rosso et al., 2017)
- Apply life cycle assessment and 'cradle-to-site' techniques for increased sustainability (Forster et al., 2011)

Actions with a greater risk "may require a philosophical shift in the level of adaptation of a place that we might find acceptable" (Heathcote, Fluck, & Wiggins, 2017, 34). Examples include:

- Changes in land management and flood protection (Heathcote, Fluck, & Wiggins, 2017). Can be informed by SMART Governance approaches which uses open data and geographic information produced in land-administration processes to drawing scenarios and develop strategies and their implementation (Pili, 2018)

- Changes in coastline management: added protection bus also controlled retreat accepting loss of certain assets (Head, 2016, Stojanovic & Ballinger, 2011)
- Physical alterations to historic buildings in areas of high flood risk: focussed on increasing resilience to inundation (Heathcote, Fluck & Wiggins, 2017)

The abovementioned section on climate change in the Netherlands and its impact on built heritage shows that there is a need to understand local risks, and to be prepared to undertake adaptation measures. Governance of adaptation has been decentralised in the Netherlands, and falls under the auspices of local government, i.e. local municipalities. In addition local government is also responsible for its own heritage. Governance of heritage in the Netherlands is the subject of the next section. Moreover, chapter 1.3 identifies the knowledge gap.

1.3 – Heritage management in the Netherlands and knowledge gap

Heritage management in the Netherlands is based on the 1992 Malta Convention (also known as the Valletta Treaty, formally known as European Convention on the Protection of the Archaeological Heritage (Revised) (Goudswaard et al., 2012). Responsibility for safeguarding the Dutch heritage falls under the Ministerie van Onderwijs, Cultuur en Wetenschap (Ministry of Education, Culture, and Science, OCW). OCW is responsible for managing Netherlands' heritage both above and below the ground and under water. Additionally, it has three other main tasks, which are to ensure statutory protection of, to conserve, and to research heritage assets. OCW supervises three independent bodies that are involved with heritage and which have a say in the implementation and are partly responsible for the enactment of these aims. These three bodies are the Erfgoedinspectie (Cultural Heritage Management Inspectorate, CHM), the Raad voor Cultuur (Council for Culture) and the Rijksdienst voor het Cultureel Erfgoed (Netherlands Cultural Heritage Agency, NCHA). NCHA is responsible for designation of monuments, based on five selection criteria, being cultural value, architectural value, group value, rarity of survival, and lastly condition. After designation, national scheduled monuments are listed in the Register of monuments (NCHA, no date).

National policy has seen a few changes over the last couple of years. In 2016 the new Heritage Law came into force. This law incorporates cultural objects, museums, monuments and archaeology on land and in water. This law also gives the definition for designated areas, which can be translated as "Groups of immovable property that are of general interest because of their beauty, their mutual spatial or structural coherence or their scientific or cultural-historical value and one or more monuments are present in these groups". Any plans for development work in a designated area first has to be assessed to prevent any damage to its cultural-historical value. In 2018, this has been followed up by the policy brief Heritage Counts by the minister of OCW, which anticipates the new Environment and Planning Act and discusses energy transition and public involvement. The new Environment and Planning Act has not come into force yet. Its aim is to simplify the laws on the environment and planning and to combine them in a single Environment and Planning Act (IenW, 2017). Existing laws that the Act will replace include the Water Act, the Heritage Act and the Spatial Planning Act. In addition, the provisions of some

other laws will be transferred to the Environment & Planning Act. The new Act focuses on physical environment which includes world heritage and includes protection of cultural heritage. Furthermore, it ensures tackling of climate change. Part of the new Act is that municipalities and provinces have to develop environmental plan containing the rules on the physical living environment (IenW, 2017).

As CHCfE (2015) shows, it is important to note that most heritage-related research does not embrace a holistic view, as it tends to ignore cultural heritage impact in the environmental domain. Alternatively, within cultural heritage management, risk analysis and management have grown in importance, as shown by i.e. NOAHS ARK. Currently, heritage management does take into account potential harm to built cultural heritage caused by climate change. However, classical cultural heritage management sparsely pays attention to the role of built heritage in climate change adaptation and sustainable development. In other words, heritage is regarded as a victim of climate change, an object that must be protected from harm, but it is not seen as a potential actor in climate change adaptation strategies. Recently, however, this viewpoint has started to change. Various attempts have been made to incorporate the issues of climate adaptation and switch to renewable energy in Dutch heritage management. In December 2018, a conference entitled 'Nederland veranderd/t' (Netherlands is changing) was organised by OCW, focusing specifically on the role of heritage within the living environment. One of the topics discussed includes adaptation and how heritage can function as a potential broker and source of inspiration to form solutions (De Zeeuw, 2018). Additionally, a joint enterprise by OCW and Stimuleringsfonds Creatieve Industrie has set up sixteen projects centred on the questions of climate adaptation, energy transition, heritage, and environment (KEER, 2018). The report argues in favour of embedding heritage as a pillar within spatial planning on a local level (KEER, 2018).

Knowledge gap

Regarding the knowledge gap, there is plenty of research which focuses on adaptation to climate change in general, or more specifically on adaptation to climate change in urban areas (see e.g. Bulkeley & Betsill, 2005; Rydin, 2010; Corfee-Morlot et al., 2011). There are also various studies focusing on historic built environment and sustainable development of cities (e.g. Tweed & Sutherland, 2007; Fusco Girard, 2013; Ripp, 2017). In addition, studies have been done pertaining to the governance conditions required for successful and/or effective adaptation (see e.g. Adger, Arnell, & Tompkins, 2005; Runhaar et al., 2012; Den Exter, Lenhart & Kern, 2015). Focus has centred on specific elements of governance conditions, such as knowledge creation (e.g. Pahl-Wostl, 2009), governance capacity (e.g. Carter et al., 2015; Moloney & Fünfgeld, 2015), resilience (e.g. Vandergert et al., 2016) or governance mode (i.e. policy organisation see e.g. Driessen et al., 2012). Good frameworks to assess adaptation exist for specific sectors, e.g. Koop and colleagues (2017) for water governance, and Phillips (2015) for adapting individual monuments. However, studies focusing specifically on governance conditions required for successful adaptation to climate change in historic cities are hard to come by, if not non-existent.

Moreover, as Bonazza and colleagues (2018) highlight, existing strategies and procedures for safeguarding cultural heritage are not exhaustively integrated in national

climate adaptation plans. Furthermore, they specifically point out the deficiency in the "lack of alignment in the involved processes from policy making to practical application" (Bonazza et al, 2018, 163). As KEER (2018) shows, there are some projects in the Netherlands in which local adaptation has been tied to safeguarding heritage. However, this is not national practice yet. Instead, the Netherlands can be seen as a country that Bonazza and colleagues refer to as having a lack of aligning policy-making with practical application.

At present, there is a lack of in-depth knowledge regarding conditions for successful governance of adaptation in Dutch municipalities with historic town centres. A search on Scopus regarding this topic yielded no documents. Hence, for a more holistic view on planning of the historic environment, scientific research needs to bridge the disciplines in order to address the challenges posed in all the domains.

1.4 – Research objective and social relevance

The main objective of this research is to address the knowledge gap identified, namely what governance conditions are required for successful adaptation to climate change in historic cities in the Netherlands. In other words, the objective of this research project is to analyse climate change adaptation in cities with a historical town centre by providing an overview of governance conditions that are required for successful adaptation. This thesis aims to determine these conditions via a literature review, a case study, and expert interviews. The literature research focuses on governance conditions required for successful adaptation to climate change in urban areas, specifically in historic city-centres. On the one hand, it discusses scientific literature regarding climate change adaptation in urban areas, focusing on governance conditions required for successful adaptation in the Netherlands. On the other hand, scientific studies on the topic of the historic built environment and sustainability are concentrated upon. The review aims to distinguish those conditions that are necessary pertaining to successful adaptation to climate change in historic cities. This will generate descriptive knowledge. The conditions found in the literature review will be shown in a preliminary assessment framework.

Next, a case study including interviews with the relevant actors and stakeholders will give insight into current practice from a bottom-up perspective. The case study will analyse and evaluate climate change adaptation policy in the historic city centre of Breda, by addressing modes of governance used (actors, instruments and discourses); and by providing an overview of governance conditions required for successful adaptation (according to the preliminary assessment framework), and evaluating to what extent they are present in Breda. The case study aims to produce qualitative knowledge. Next, helicopter interviews with experts will provide current and in-depth knowledge on urban planning, built heritage, and governance. The interviews with experts will make the findings of the research more generalizable. Combined with the assessment framework, this enables provision of recommendations on what governance conditions are needed for successful adaptation of the historic urban landscape in the Netherlands.

This research has both scientific and societal relevance. Regarding the former, the intention is to add to the current scientific literature on general governance conditions by generating knowledge on specific conditions for successful adaptation to climate change in

cities with a historic city centre. As was identified above, there is a lack of in-depth knowledge regarding this topic. Pertaining to the latter, social relevance is inherently associated with built cultural heritage. Architectural heritage is usually seen as belonging to a community, as something for everyone to enjoy. Thereby, listing of heritage is always subject to a rigorous review of associated values, including its social value. Ensuring that climate adaptation within historic city centres is done with respect to these values guarantees that these values stay intact.

Additionally, raising awareness and involving the built environment sector was one of the core priorities in the Implementation Programme NAS 2018-2019. This study shines a light on potential impacts of climate change for Dutch heritage (see chapter 1.2). Moreover, the results will give-policy makers in Breda insight in their strengths and where they can improve. Other policy-makers may use these lessons to apply to their own governance structure.

1.5 – Research framework and research questions

Following Verschuren and Doorewaard (2010, 65), a research framework is "a schematic representation of the research objective and includes the necessary steps that need to be taken in order to achieve it". The following figure shows the actions that will be taken in each step, ultimately building up to address the aim of the research.

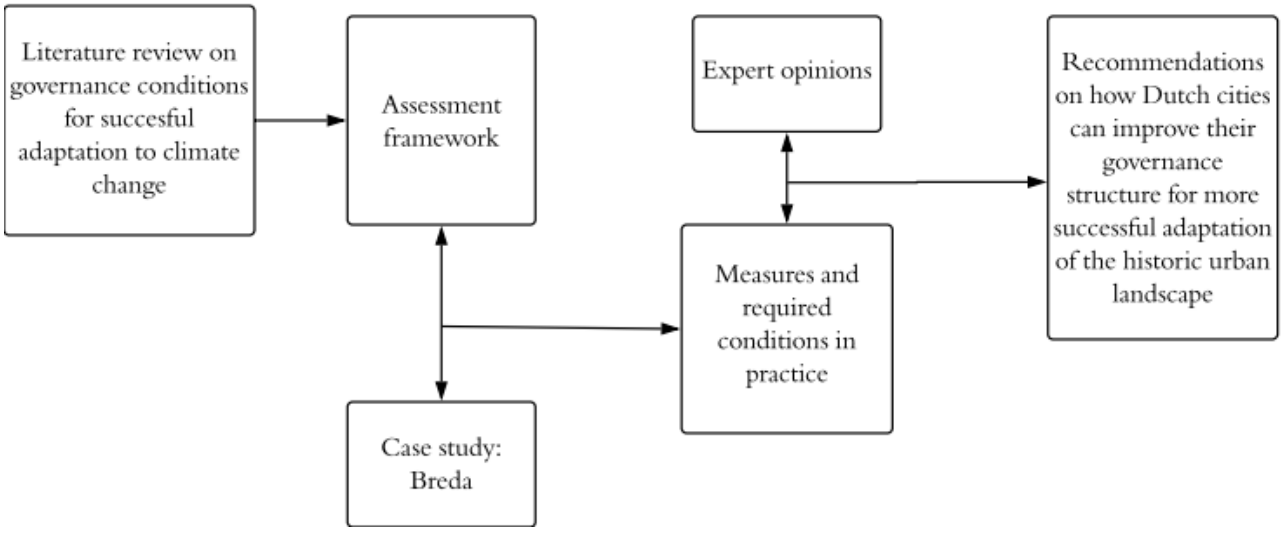

Figure 4 - Research Framework

The central research question is:
What governance conditions are required for successful adaptation to climate change in historic cities in the Netherlands?

In order to answer this question sub-questions have been identified. The first sub-set of questions focuses on establishing an analytical framework. This is the framework that will be used in the case study:

1. What is successful adaptation according to the literature?

2. What are the required governance conditions according to the literature?

The second set of sub-questions pertain to the case study:

3. What are the projected climate change impacts for Breda?
   - *3.1. Which local areas are under threat?*
   - *3.2. What monuments in these areas are particularly threatened and how?*
   - *3.3. How can this built cultural heritage be adapted in such a way that its cultural value is kept intact?*
4. What policies and action programmes exist on different levels and how well are these coordinated across levels and sectors?
5. To what extent are the governance conditions identified in the literature present in Breda?

The sixth sub-question aims to determine experts' opinions:

6. What do experts think about governance conditions for successful adaptation in historic centres?

Outline of the report

The report is structured as follows. Questions 1 and 2 are answered in chapter two, the literature review. Chapter two consists of a short introduction to the chapter, focusing on the goals of the literature review. Sections 2.2 to 2.12 each discuss a relevant source in-depth. Section 2.13 provides a synthesis of these articles, and answers questions 1 and 2.

Chapter three focuses on the methodology used in the remainder of the paper. It expands on the choice for a case study, and gives insight in the data sampling. Moreover, it addresses how research questions three to six are answered.

Next, chapter four focuses on climate adaptation in the historic centre of Breda. Section 4.2 answers research question three and its three sub-questions. Section 4.3 focuses on research question four. This is followed by section 4.4, where the governance conditions found in the literature review are tested to see if they are present in Breda. Sub-sections 4.4.1-4.4.7 each focus on one individual factor of the seven found in the literature review. The chapter ends by answering question 5, *"to what extent are the governance conditions identified in the literature present in Breda?"*.

The following chapter is a discussion chapter. First it discusses the limitations of the method and research. Next, chapter five aims to answer the last of the guiding research questions, question six: *"What do experts think about governance conditions for successful adaptation in historic centres?"*. This is followed by a short assessment of the generalizability of the framework.

Chapter six ends the paper with some concluding remarks. Firstly, the paper refers back to the research objective. Next, the main research question *"What governance conditions are required for successful adaptation to climate change in historic cities in the Netherlands?"* is answered. Moreover, it gives some recommendations on adaptation to climate change in the historic urban area. Lastly, some recommendations for further research are given.

Chapter 2 – Literature review

2.1 – Introduction

This literature review aims to answer the first two research questions, *being "What is successful adaptation according to the literature?"*, and *"What are the required governance conditions according to the literature?"*. These questions are framed by the main research question by focusing on the local and/or urban scale, and on historic urban areas. The literature search combined these themes. The search was carried out using two databases. Firstly, SCOPUS was queried, a database overview for peer-reviewed, global, interdisciplinary scientific data and literature, across all research fields. Secondly, Utrecht University's library collection was consulted.

Hence, relevant literature on local governance and governance conditions was found using the following combinations of key-words:

- "Successful urban governance"
- "Governance conditions"
- "Urban governance" AND "climate change adaptation"
- "Local governance" AND "climate change"
- "Urban governance" AND "governance capacity"
- "Urban governance" AND "climate change adaptation" AND "governance conditions"

Then, a search was carried out regarding climate-related adaptation in (historic) cities:

- "Urban climate change adaptation"
- "Climate change adaptation in cities"
- "Climate change adaptation" AND "Historic cities"
- "Climate change adaptation" AND "Historic urban areas"

The resultant output has been checked on relevance of the abstract and key-words, and on number of citations. Then, these articles were verified on content. Additionally, the bibliographic information of relevant articles has been scanned for other sources of possible interest.

The literature review discusses the governance conditions each of ten sources outline explicitly and implicitly. Some articles discuss 'barriers' or 'stimuli' to change instead of favourable conditions for adaptation. In this literature review barriers and stimuli are phrased as governance conditions. The main line of reasoning for finding favourable conditions is:

"The chance that adaptation measures are undertaken is higher when [*governance condition*] is present"

The literature review aims to evaluate the claims made in these articles, and checks whether they are and empirically validated. A synthesis will infer preliminary governance conditions required for successful adaptation in historic cities from these sources.

2.2 – Multilevel governance and urban politics of climate change

Firstly, the 2005 article "Rethinking sustainable cities: multilevel governance and the 'urban' politics of climate change" by Bulkeley and Betsill will be discussed. In this research, the authors query to what extent cities and local government can address challenges of sustainability. According to the authors, the 1987 Brundtland report functioned as a catalyst in sustainable development of cities. Bulkeley and Betsill point out that cities are central in achieving national targets, because they have the capacity to address environmental issues. They give four reasons why cities are key to addressing challenges of sustainability:

1. Cities have high consumption and production → they can control and influence this
2. Cities have agenda setting capability
3. Cities are key-actors in co-ordinating action
4. Cities have experience in addressing issues → are used to undertake measures and execute strategies to reduce impact

However, Bulkeley and Betsill argue against looking at cities in isolation. Instead, focus should lie on interlinkages between urban scale and other scales through which environmental governance is conducted. Research should engage with processes that shape local capacity and political will for sustainable development at multiple sites and scales.

In this article, the authors look at the planning level at which cities can address sustainability issues. To study to what extent cities and local government can address challenges of sustainability, the authors use a multilevel governance perspective to examine the barriers to the creation of sustainable cities. Here, the multilevel perspective exists of multiple tiers of government and spheres of governance. Governance can be hierarchical (type 1) with a focus on distributing competences and authority between different levels, or polycentric (type 2) with authority shared between equal partners involved in governing particular issues. Type 1 stimulates an increase in local competence, e.g. via networks which link cities. The authors argue that such alliances and partnerships show a strong hierarchical structure. Decentralisation of power increases local authority by giving local government power to implement stricter management measures. However, this last point is strongly tied to discursive issues, i.e. framing and interpretation of the issues. Construction: actor and institutional coalitions, over multiple scales.

In type 2 (polycentric) authority is shared between state and non-state actors. This discussion also forms the arena for framing and interpretation of urban sustainability. The authors state that

> *"governance is being conducted both through relations between nested tiers of governance, and through a number of 'spheres of authority', including multiscalar coalitions of state and non-state actors advocating particular discourses of urban development, national planning guidance and its interpretation within the local planning system, transnational networks of municipalities and the funding opportunities and policy priorities of the European Commission" (Bulkeley & Betsill, 2005, 59).*

Bulkley and Betsill (2005) discern material and discursive barriers with implementing climate protection. Cities set policy principles and inform policy guidance, i.e. give

practical strategies and measures to conform to principles. The authors look at how climate change considerations have been interpreted and implemented though the planning process in two case studies, in order to examine the influence of material and discursive contests over achieving sustainable development for cities.

From these case studies, the authors find two key factors which prevented climate protection being interpreted and implemented on the ground:

1. The (lack of) powers and competencies of local authorities
2. Discursive struggles, i.e. how urban development and transport problems were framed

Regarding the first factor, the authors show that in both case studies the local authorities did not have enough authority and autonomy to act. They did not have legislative back-up to favour sustainable solutions over others. Bulkeley and Betsill argue that local authorities can gain additional influence by collaborating with other actors, e.g. actors that operate on a higher tier than national government (e.g. EU institutions).

Concerning the second factor, discursive struggles, Bulkeley and Betsill show that various coalitions of actors and institutions are involved in framing and interpretation at the planning level. The authors argue that in their case studies, in the debate surrounding urban planning, environmental considerations were side-lined by entrenched policy communities which have hogged these discourses. Whenever such interests groups form a discourse coalition and oppositional coalitions are not able to frame urban development and transport problems, the authors argue that solutions that favour climate protection will be put on the back burner.

In conclusion, Bulkeley and Betsill (2005) argue that interpretation and implementation of sustainability are shaped by governance on various geographic scales. The chance that adaptation measures are undertaken is higher when:

1. Urban governance involves relations between levels of state (local, provincial, and national) and new network spheres of authority.
2. Local competencies are increased via the use of networks
3. Authority is shared between actors in new network spheres
4. Discourse power of local government is high, i.e. local government is able to frame goals for climate protection into policy implementation

2.3 – Four tools of governing for sustainable urban development

Second, Rydin's (2010) book entitled 'Governing for sustainable urban development' is discussed. This work is mainly a conceptual analysis on social learning within governing processes for sustainable urban development. Rydin argues that urban sustainability is not about creating a self-contained environmental system, i.e. a closed loop system where waste products are recycled internally, and resources are locally sourced. Instead, she argues that urban sustainability has three aspects, being activities leading to unsustainable outcomes, possibilities for sustainable economic development, and thirdly using local governance to act and show commitment to the sustainable development agenda (Rydin 2010). She points towards the social and environmental impact of growing urban economic activity as a driver for unsustainability of urban areas. The environmental impact dimension of urban sustainability is mainly related to climate change. On the one hand, urban activity has high greenhouse gas emissions, due to demographics and behaviour. On

the other hand, climate change affects urban sustainability in the way it influences areas to cope with consequences of changes in climate. Rydin argues that urban areas have high potential to address climate change due to economy of scale, high resource and energy efficiency, and because urban areas are hubs of innovation and entrepreneurial activity. She argues that these stimuli can be used to mitigate climate change and build resilience to climate change impacts. However, she argues that local political systems have a large influence, mainly because of which priorities they focus on, and the choices they make balancing environmental, social and economic dimensions. By looking at how urban development is produced, Rydin shows the limits of relying on market systems to deliver on social and environmental dimensions of sustainability. She argues there is a need for regulation and broader, more holistic, spatial planning to ensure that social and environmental dimensions are considered, in order to avoid irreversible damage.

Rydin structures her discussion of governing for sustainable urban development according to four different types (see Table 2).

Table 2 - Tools for governing (Rydin, 2010, p. 57)

	Action required to overcome resistance			
Tools for governing	**Build the will to act**	**Build capacity to act**	**Counter resistance by individuals or groups of actors**	**Change incentive structures**
Information and persuasion	Change actors' perceptions of reasons to act	Show that change is possible	Counter information provided by actors; undermine legitimacy of their behaviour/stance	Knowledge is power
Financial incentives	Provide an incentive for action	Provide financial resources for action	Restructure the resources available to certain actors and thereby reduce their power	Restructure incentive structures
Collaborative action	Creating networks to create agenda for action	Releasing resources within networks	Controlling actors within networks through soft sanctions and overcoming conflict	Altering the established relationships between actors and perception of incentives
Regulation and planning gain	Set out the expectations arising from regulation and the potential benefits	Establish a route to achieving outcomes	Control actor's behaviour through regulatory action	Alter the balance of costs and benefits through established regulation

Rydin's main argument is that learning is central to governing for sustainable development. Delivering on sustainable urban development can be increased by reinforcing importance of networks and relationships between actors. Rydin considers actors to be civil society and government. Engagement between actors can produce outcomes of higher quality, due to processes of learning and use of knowledge. Here, Rydin argues that it is important to consider the "conflicts and contestations over knowledge" (Rydin, 2010, 71) and how this know-how is being used to steer towards sustainable development, and if so, what kind of sustainable development. She argues that framing of issues plays a large part, as it guides not only the perception of the problem, but also the appropriate or possible solutions to it. Moreover, she points out the issue of social construction of knowledge (the conflicts and contestations) and whether that knowledge had the right form, i.e. expert or lay, to produce change.

Rydin argues that knowledge often needs to be translated to lay-man's terms in order to be shared between networks. She laments the assumption that provision of information will directly change behaviour, i.e. the "information-deficit model in which there is an information gap, limiting [...] behaviour [...] and that the provision of information fills this gap or deficit" (Rydin, 2010, 73). Instead, she shows there is a normative process at work where information has to be recognized as such in a social context. Before knowledge can change behaviour, it has to be recognized as factual, it has to have relevance for the specific actor, and the actor has to feel responsible or have capacity to act on the knowledge. However, she points towards to influence of knowledge on the long term, as some forms can become embedded within governmental arrangements, thereby shaping perception, interaction, and behaviour.

Regarding types of knowledge, Rydin argues that most knowledge is technological, where solutions and their effects can be calculated and measured. She argues that this may have consequences for social and environmental sustainability issues which are more based on values rather than scalar measurements, as these dimensions are not served well by informational policy tools. The emphasis on technical dimensions marginalises other definitions and expertise on urban sustainability. In addition, the framing of urban sustainability within a technological-economic paradigm emphasises the role of rational decision making. Here it is assumed that people will make more rational decisions if they had more information available about new technological options. Rydin rightly points out that there is a need to translate this information to make it usable for people, for example in the form of indicators or standards. However she also points out the pitfall of sticking too rigidly to such definitions and framing of sustainable urban development indicators, of overemphasising the technological dimensions of information provided, as this may create an imbalance in what is considered sustainable. Using the example of smart metering within homes, Rydin shows that the "institutional arrangements surrounding actors' practices will be central in determining whether the provision of information does have an impact" (2010, 132).

Moreover, she is critical of using examples of best practices as solutions and means of knowledge exchange. Rydin argues that best practice offers downplay "the way that particular sets of actors come together in a specific sustainable urban development project and have to engage with site- and area-specific physical circumstances" (2010, 85). Furthermore, she highlights the tensions between transferring tacit knowledge in one place to codified and generalized knowledge, and apply it in another development and locality.

Rydin argues that there is no guarantee that people learn from others. She points out differences in learning styles, where some learn from reflection and experience, i.e. from doing, whereas others learn from deliberation, i.e. from working with and learning from others.

Regarding financial incentives, Rydin points out the assumption of economic rationalities that drives market-based instruments like taxes and subsidies. Use of such instruments requires knowledge on valuation of environmental and social costs and benefits. Rydin is critical of economic expertise for economic and social dimensions of sustainable urban development. Firstly, she argues there is a lack of transparency in using economic expertise to frame policy issues. Secondly, she warns for misrepresentation of environmental and social values by framing actors' relationships with their surroundings only in monetary terms. She shows that financial tools have to be calibrated to fit actors' everyday behaviour.

The third tool consists of governing through spatial planning and regulation. Rydin argues that spatial planning and regulation can counter the reliance on technological solutions in two ways. Firstly, because it considers all impacts, all costs and benefits of proposed development, and takes into account the social dimension. She believes this to be a more holistic approach to what sustainable urban development is and how it may be achieved. Secondly, spatial planning not only relies on professional and techno-economic decisions, but also involve multiple stakeholders. Rydin discusses seven urban systems and shows that to make spatial planning effective, networks and social capital within those networks is essential. Output of spatial planning, i.e. knowledge, can be transferred to other networks in the form of planning documents.

The fourth tool of governing that Rydin discusses is collaborative action. Rydin refers to this set of tools for governing as "the purest governance tools since they refer to measures by which collaborative action is facilitated, encouraged and promoted" (2010, 58). The creation of arenas for collaboration, such as networks and partnerships, can help foster a mutual agenda for action. She argues that collaborative action encourages a sense of common purpose and problem ownership. In addition, creating this sense of mutual common purpose can help overcome resistance. However, Rydin concedes objections from other authors who warn against looking at this with rose-coloured spectacles on. Building consensus can happen through these forms of collaboration, deliberation and mediation, but it is not a guarantee. To counter these remonstrances, Rydin argues that overcoming resistance from actors within the network can also happen with help from cultural resources embedded in the network. Consequently, this may result in a change in practice, where the common goals of the network will surpass individual goals. However, she does not expand on what these embedded cultural resources are, so it remains unclear.

Moreover, collaboration within networks builds capacity for action by releasing various resources to participating actors. These forms of capital range from financial incentives, to social capital. A potential downside is the social control and peer-pressure to conform, which may limit actors' freedom. Moreover, Rydin points towards the collaborative action problem as a downside. This problem is created when a singular actor does not see the benefits of involvement or undertaking action, therefore not seeing how their involvement is essential for the collective outcome to be achieved. This can result in actors free-riding on the efforts of others. Rydin argues that successful networks, i.e. where co-working and collective action is achieved, address the issue of perceived imbalance of

costs and benefits of participating within the network. This can be fostered by focussing on embedding three norms. Firstly of mutuality, where self-interests are aligned with the collective agenda, ensuring that ideas and solutions originating from the network are implemented. Secondly of reciprocity, where an actors' contributions to the network are balanced by other actors reciprocating with ideas or other forms of capital of their own. In this way, reciprocity builds strategies and compromises. Thirdly, trust should be embedded within the network. Rydin argues that trust is essential for everyday functioning of the network, encouraging communication and practices. The two former norms require trust, but reciprocity and mutuality can also build more trust resulting in a virtuous cycle of collective action. However, the opposite can also happen.

In conclusion, the chance that adaptation measures are undertaken is higher when:

1. There are technological resources available for adaptation. High resource and energy efficiency
2. Financial resources to support policy measures and autonomous adaptation, and to build the will and capacity to act are available
3. Plans and policy instruments are in place to increase ability of individuals to act
4. Individual views of effectiveness and costs of adaptation are addressed. Also, change actors' perceptions of reasons to act, counter resistance by individuals or groups of actors
5. Expectations and potential benefits arising from regulation are set out
6. A pathway to achieving the vision is established
7. New network spheres of authority are created, which set agenda for action, release resources within networks, control actors to overcome resistance and conflict, increase idea of shared ownership of the problem

2.4 – Vulnerability, adaptive capacity, and legal and urban planning systems

The third article discussed is by Corfee-Morlot and colleagues (2011), who centre on climate policy at city-scale. The aim of the article is to establish a multilevel risk governance framework for good decision-making. The authors stress the need for local urban policies regarding climate change in order to ensure that the urban built environment can withstand predicted climate changes, as well as warranting improvement pertaining to energy and emission performance. The authors highlight that urban planning is central to both adaptation and mitigation efforts. In their view, adaptation includes "disaster management to limit vulnerability to current and future hazards"(Corfee-Morlot et al., 2011, 170), which should address the physical drivers of vulnerability, build capacity to adapt, and alter legal and urban planning systems.

To make this framework, this paper draws on an interdisciplinary literature review focusing on the cross-scale, multilevel governance linkages between national and local policy for adaptation. Regarding the urban policy challenge, the focus lies on "Why, what and how might national policy assist and empower local governments to become more effective actors in the climate policy arena?" (Corfee-Morlot et al., 2011, 171). Firstly, the authors focus on collective action regarding resources. Corfee-Morlot and colleagues oppose the view that the issue of climate change is a problem of collective action, or a challenge of the global commons. Instead they argue that recent empirical research has

shown that there are two main drivers behind successful collective action. The first being that the common resource problem is present on a small or medium scale, the second driver is that either the consequences of inaction are negative, or there are clear benefits to action. The researchers take collective decision-making as a central focus point from which to look at adaptation policy on an urban scale. In this view, collaborate action is seen as a process of co-construction in various fields. First, the process of knowledge creation, where scientific and expert information are integrated with local knowledge to support decision-making. Second, co-construction exist in a decision-making context where institutional structures blend with non-governmental actors.

In their analysis, Corfee-Morlot and his colleagues (2011) combine the theory on collective action with the influence of individual values and perceptions on decision-making processes. Moreover, they recognise the need to include local values, culture and context in decisions about how to address adaptation to climate change. Together, this informs their multilevel climate risk governance framework. Consequently, the researchers use this framework to understand the relationships between various scales of government as well as across a range of governmental and non-state actors. Its multilevel risk governance framework exists of the vertical dimension, i.e. level of governance, where local adaptation can be constrained by national policy, and the horizontal dimension, i.e. inclusiveness of civil society actors in the policy process.

Corfee-Morlot and his fellow researchers (2011) find three benefits for working at a local level. First, local authorities have close relationships with local stakeholders which enable a better understanding of values, culture and context in decisions about how to respond to climate change. Moreover, municipal governments can create "'policy space' for a deliberative-analytical exchange that links local stakeholders and the expert community" (Corfee-Morlot, 2011, 177). In addition, the authors argue that on a local scale, stakeholders are more homogeneous making it easier to create a common understanding on climate change.

Based on their literature review, Corfee-Morlot and colleagues (2011) advocate participatory governance and the use of transnational networks. From this literature study, the authors found several key obstacles (See Table 3) to local adaptation action. These barriers are of a legal/institutional, political, economic, or technical nature.

Table 3 - Key obstacles to local adaptation action (Corfee-Morlot, 2011, 178)

Jurisdictional and institutional	Lack of mandate to address climate issues
	National or regional laws, rules or regulations that lead to mal-adaptation to increase vulnerability over time
	Ill-adapted institutional designs to convene or coordinate across relevant issues (vertically and/or horizontally)
Political	Local authorities "too close" to different interests
	Pressures of short-term electoral cycles on effective risk management and long time lag to reap full adaptation benefits
	Lack of willingness to accept costs and behavioural change
	Pressure to maintain BAU development pathways
	Distribution of perceived and real costs and benefits

Economic and budgetary	Lack of resources or funding to address the problems identified
Technical or scientific	Scientific uncertainty
	Inadequate understanding or ignorance of climate change risks
	Lack of technical capacity or access to expertise
	Lack of scale relevant scientific or technical information

Corfee-Morlot and fellow researchers (2011) argue that developing capacity to counter these key barriers to local adaptation is essential for developing urban climate policy. In their analysis, they group the dimensions of legal/institutional and political together, forming three types of capacity. From their literature review, the authors find three different types of drivers, that operate across scales of governance, to shape local scale climate action. These institutional drivers are government functions and roles, other non-governmental key actors and institutions, and tools to support decision-making (see , next page)

Table 4 – Institutional capacities and other drivers of local scale climate action (Corfee-Morlot, 2011, 179)

	Capacities and drivers of change	Jurisdictional and political capacity	Financial capacity	Coordination/ planning capacities (including technical capacity)
Drivers	Government functions	Local authorities: Public: city, county or other public authorities		
		Implement local decisions as foreseen under national or regional law Establish local climate policy framework – near & long-term goals – to coordinate strategically across sectoral and with other local jurisdictions in the same metropolitan area Seek new authority where necessary to achieve goals	Seek and establish support for locally adapted policies and measures e.g. public private partnerships and local fiscal policies	Identify local priorities – enhance local/regional understanding by working with local actors Where authority exists – act autonomously e.g. through land use planning, decision on local infrastructure (e.g. local roads, urban planning and zoning, flood control – storm water drainage systems, water supply, local parks/reserves/green spaces, sanitary and waste management) Raise awareness, create deliberative "space" for participatory decision-making
		National and/or regional authorities: state or provincial governmental authorities		
		Clear delineations of jurisdiction Adjust the degree of decentralisation of necessary policy competences and authorities Prioritise & set out time frames for local action (e.g. by sector) Centre-region (local) contracts	Provide incentives and funding to enable local action on climate change Fund core analytic inputs to facilitate local decision-making, including scientific research	Ensure that local decision-makers have the tools, information & appropriate institutional context to deliver good decisions

	Other non-governmental actors	Semi-autonomous public research or technical institutions (e.g. national universities or research institutions; water resource management boards)		
			Private sector: local industry & business, tourists, households	
				Local environmental or consumer organisations Local & regional experts (universities, consultants)
	Tools to support decision-making	Legal advice and contractual tools	Robust contractual mechanisms for public-private investment (e.g. for infrastructure development) Economic and financial assessment information and tools	Local vulnerability mapping or full climate risk assessment Deliberative and processes designed to support local decision-making (e.g. analytic-deliberative model) Link scientific and economic assessment of climate impacts with ongoing urban planning processes (e.g. land-use and infrastructure development)

Corfee-Morlot and his colleagues (2011) focus on technical and scientific capacity and tools to support decision-making in particular. They highlight the need for urban planners to have knowledge of local impacts of climate change and scale relevant technical and scientific information to understand and assess adaptation options and to undertake action. The authors mainly discuss the analytic-deliberative process that supports local adaptation decisions, highlighting the role of boundary organisations in facilitation local science-policy assessment.

Drawing from expert literature, the researchers argue that establishing a science-policy competence by engaging experts and decision-makers in a process of knowledge exchange is important (Corfee-Morlot et al., 2011). To create credible and legitimate knowledge, boundary organisations may help, as they enable a dialogue between experts producing knowledge, and public actors and other stakeholders who are potential users of the information. Such direct contact between producers and users of knowledge help define what type of knowledge is needed, so the questions are better framed and the results are more useful in a local context. Moreover, boundary organisations disseminate accessible and salient scientific knowledge in a political context. In this manner, boundary organisations enable growth of networks of relationships, trust and understanding. Other aspects that feature are the geographic scope of adaptation, origin of funding, and the type of stakeholder involvement. Boundary organisations have the technical know-how as well as the funds to operate on a local level, and are capable of engaging actors in local partnerships and decision-making on adaptation. The authors conclude that boundary organisations are able to facilitate local partnerships, engagement, and decision-making on adaptation.

Finally, Corfee-Morlot and fellow researchers (2011) conclude from the literature and their analysis that two aspects are key to successful local decision-making. The first being civic engagement and understanding of the issues in local contexts. The more public stakeholders understand and engage with the issue, the higher the public will to undertake action. The other is credible, legitimate and salient science-policy assessment, which may

be created with help of aforementioned boundary organisations. The authors cite that this leads to a political will to take action, an increase in knowledge exchange about adaptation, to develop local climate adaptation plans, and lastly to disseminate the information gained and refine approaches to be more successful in the future. The authors conclude that for a 'good' local adaptation policy agenda, it is necessary for state government to work with lower-tiered governance authorities in order to overcome barriers to local adaptation and to advance capacity for adaptation. The authors argue that successful adaptation of the urban development to climate change depends on an interactive governance mode, with room for input from transnational networks, boundary organisations and other stakeholders.

Following Corfee-Morlot and colleagues' line of reasoning, it can be concluded that the chance that adaptation measures are undertaken is higher when:

1. There is knowledge exchange between producers of scientific and technical knowledge and potential users. Scientific assessment should be tailored to local needs in a deliberative-analytical process.
2. National or sub-national regional governments empower urban planners by providing institutional support for the development of credible, legitimate and salient science-policy assessment and deliberative-analytic processes.
3. Local boundary organisations that have access to regional and local research institutions and engage with other stakeholders are created. These organisations should be interdisciplinary.
4. Civic engagement and understanding of the issues is high. This may lead to public will and pressure to undertake action.
5. Local authorities determine long and short-term goals in a local climate policy framework, to coordinate across jurisdictions. National and regional authorities support this by ensuring clarity about jurisdiction, decentralise policy competencies and set out time frames for local action.
6. Local authorities increase financial capacity by seeking and establishing support for local adaptation via public private partnerships and local fiscal policies. National and regional authorities support this by providing incentives and funding for action and scientific research.
7. Local authorities increase their planning and technical (scientific) capacity by identifying local priorities, raise awareness and create space for participatory decision-making. National and regional authorities support this by providing local decision-makers with the tools and information to undertake successful adaptation actions.

2.5 – Stimuli and barriers to adaptation

Runhaar and colleagues' (2012) article "Adaptation to climate change-related risks in Dutch urban areas: stimuli and barriers" was selected because it gave specific insight in governance conditions present in the Netherlands. Here, the conditions were formulated as stimuli and barriers to climate change adaptation. The authors were interested in getting insight in how urban planners perceive and deal with risks posed by climate change, and why. The risks included in their analysis are heat stress and flooding from rainfall and rivers. First, Runhaar and colleagues identified stimuli and barriers from

policy and planning literature on adaptation. Next, in order to answer why and how urban planners actually plan for risks associated with environmental change, the authors collected their empirical data from two sources. First, Runhaar and colleagues (2012) gained general insight via expert interviews and attending workshops and conferences. Second, the authors interviewed thirteen urban planners at ten municipalities to gain in-depth knowledge about stimuli and barriers.

Regarding the results, the researchers look at barriers and stimuli for problem recognition on the one hand, and implementation of adaptation measures on the other, for both heat stress and flooding (Runhaar et al., 2012). Regarding problem recognition, the authors state that "[g]overnance of climate change-related risks starts with the recognition of these risks" (Runhaar et al., 2012, 780). At the time these issues were not seen as urgent problems. Runhaar and colleagues argued the reason behind this was that there is no clear problem recognition. No real awareness of why the issue is problematic, and there was no real sense of urgency. The main reason that municipalities do not perceive heat stress and flooding as urgent issues, is that there is no clear problem owner. Moreover, lack of political will, lack of financial and legal incentives for actors to deal with environmental risks, and lack of information about potential benefits are seen as barriers to problem recognition. Other barriers to adaptation are found in the nature of the problem, being uncertainties about local impacts, resistance to change by local actors or interest groups, and uncertainties in scientific evidence.

Alternatively, the authors found various stimuli that increased problem recognition. From a political viewpoint, political or institutional support or pressure, and leadership, i.e. the will to be a frontrunner regarding mitigation and adaptation, increases chance of adaptation. Financial incentives and involvement in networks, where resources are shared among participants, also increased problem recognition. Additionally, the authors found that whenever measures are expected to improve environmental and spatial quality, i.e. have additional benefits, the chance of uptake in existing policies is higher. Also of importance are windows of opportunity, being legal obligations and incentives regarding construction plans, resources drawn from research programmes, and a sense of urgency due to historical experiences with the risks. Another stimuli to recognise potential problems is cities' responsibility for water management, as other actors lacked urgency and will to act, and the municipalities do not want to be seen as responsible for future flooding events.

Regarding barriers to development of adaptation plans, Runhaar and his fellow researchers (2012) found that low salience of the issue is a main explanation for a lack of measures. Other barriers include lack of public or political support pressure or pressure, lack of leadership, and no clarity about responsibility, i.e. problem ownership is unclear which is observed in the reluctance of actors to act at building level (no public problem ownership). Moreover, concerning resources, low financial support, limited knowledge about adaptation measures, and lack of collaboration between actors, i.e. institutional complexity or fragmentation and low external cooperation, form barriers to adaptation. Also important are area-specific problems to adaptation, being inflexibility of the urban area, which is associated with high costs, and path-dependency of existing plans.

Pertaining to stimuli to development of adaptation plans, Runhaar and colleagues (2012) found that legal responsibility is the main driver behind uptake of counter measures. Moreover, adaptation enhances environmental and spatial quality, meaning

counter measures are seen as having co-benefits, or as no-regret measures. However, this means that environmental risks are seen as an additional reason to adapt to climate change, instead of the main reason. Other political drivers to development of adaptation plans are the wish to be an adaptation leader, problem recognition and sense of urgency, public support or pressure, a political will to act, and the recognition and use of windows of opportunity. Overall, Runhaar and his fellows (2012, 786) conclude that there is a "gap between the scientists' perceived urgency of proactive adaptation to climate change and the perception of the planners".

Following Runhaar and colleagues' line of reasoning, it can be concluded that the chance that adaptation measures are undertaken is higher when:

1. Problem recognition is high
2. Resource availability is high; there is enough financial and informational support
3. Leadership structure is clear; there is an adaptation leader
4. Policy integration is high
5. Problem ownership is clear
6. Urgency is recognised; problem has salience, agenda-setting
7. There is public or political support or pressure in favour of adaptation measures
8. There are co-benefits to adaptation (or no-regret measures)
9. There is legal responsibility
10. There is a window of opportunity
11. Existing urban areas are flexible (which designated areas usually are not)

2.6 – Influence of placement of climate policy and multilevel relations on output performance

Next, the 2015 article titled "Governing climate change in Dutch cities: anchoring local climate strategies in organisation, policy and practical implementation" by Den Exter, Lenhart & Kern is discussed. This article aims to provide a systematic overview on local climate policy regarding mitigation and adaption. It does so by analysing local climate strategies in 25 Dutch cities and determining the level of anchoring in policy, organisation, and practical implementation. Here, anchoring "refers to how climate policy is structurally placed within policy, organisation and practical implementation" (Den Exter, Lenhart & Kern, 2015, 2). The main research question is "how climate change mitigation and adaptation are anchored in the organisation, policy and practical implementation of the largest Dutch municipalities, and how do these factors, and the horizontal and vertical relations of cities, influence their performance?" (Den Exter, Lenhart & Kern, 2015, 2). The authors use a different set of indicators to measure the level of anchoring in the three fields.

Based on their literature review, Den Exter, Lenhart & Kern (2015) identify the following indicators to measure the level of anchoring in organisation:

1. Organisational structure. Organisational structure is evaluated by scoring the integration of climate strategies within municipal organisation.
2. Awareness of goals and linking policy fields by a single actor within the organisation. This indicator implies the presence of one actor according to authors, but this role can also be shared among employees. The more power this actor has, the higher the chance of policy incorporation within an institution.

2. The third indicator is task-division. Clear division of tasks at the management level anchors climate strategies within the organisation. This will improve internal support and coordination.
3. Division of responsibility between actors within the organisation should be clear. This is linked to incorporation of policy (see indicator 2) in the sense that responsibility and competence should lie with a powerful actor to ensure a higher chance of integrating climate policies within the organisation.
4. Integrating adaptation and mitigation in organisation, which has co-benefits and is cost-effective, while also making them more attractive to stakeholders.
5. Involve stakeholders. This leads to cooperation between government and society and ensures that the issue stays on the agenda (i.e. policy window).

The authors give support to justify the use of these indicators. However, the argument could have been strengthened by showing examples of how e.g. internal support benefits from clear task-division.

Next, the researchers discuss the indicators used to measure anchoring in policy:

1. Integration in overarching plans. Addressing climate mitigation and adaptation in other plans in different sectors (e.g. health, education) ensures a higher sense of ownership and responsibility within the whole organisation.
2. Integration of climate strategies at the strategic level in plans e.g. long term goals.
3. Integration of climate strategies at the operational level in plans e.g. short term goals or daily tasks.
4. Integration across all relevant sectors, e.g. planning, transport, or water management, by referencing to climate strategies within policy documents for these sectors.

The researchers do not expand much further on the indicators than this, so the difference between the first and the fourth indicator remains unclear. Also, the researchers do not elaborate on the benefits of integrating at the strategic or operational level.

Thirdly, Den Exter, Lenhart and Kern (2015) outline five indicators to measure anchoring in practical implementation from their literature review:

1. Internal support. What the authors describe as internal support can also be interpreted as leadership, as they refer to the idea that one leading actor may spur on others within the organisation to support climate policies.
2. External cooperation with key stakeholders ensures effective practical implementation. This concerns outreach of municipal climate policy and incorporating it within a larger activities.
3. Societal support is also critical to ensure anchoring in practical implementation. Societal support can also be interpreted as public problem ownership. Civic engagement can increase the chances of policy being implemented.
4. The presence of sufficient capacity and resources e.g. manpower, knowledge, skills, and finances is another indicator that determines practical implementation.
5. Finally, the authors mention monitoring as a precondition for effective practical implementation. The authors suggest following progress, which ensures actors can step in to steer take up of climate policies.

As is the case with the indicators to measure anchoring in policy, here the authors also do not discuss these five indicators in depth.

Next, Den Exter, Lenhart and Kern (2015) discuss the multi-level relations of climate governance. They define two dimensions, horizontal and vertical. Vertical includes interaction with levels higher than local government. Main goal is to get support: financial, legal, and policy guidance. The vertical level also determines level of authority: with decentralisation local authorities have autonomy to set targets. Horizontal level includes interaction on same level, e.g. (trans)national city networks, or regional partnerships. Here the aim is to exchange knowledge and engage in a dialogue. Partnerships can also give technical support, or increase chances of successful lobbying at international level.

Hereafter, Den Exter, Lenhart and Kern (2015) apply their conceptual framework with the indicators to measure level of anchoring. They conducted in-depth interviews, but they do not expand on the scoring system they have used. They scored output performance, i.e. tangible policy measures such as taxes or subsidies, and not outcome performance, i.e. results attributed to policy implementation such as effects of a specific strategy, as these are harder to measure in a systemic way. The researchers asked participatory cities to self-assess their performance compared to the other cities involved in the study. However, they do not give the criteria used to determine scores e.g. when to score integration in strategic plans as 'low' or 'high'.

Based on this assessment, Den Exter, Lenhart and Kern (2015) argue that there are three trends visible in governance of climate change in Dutch cities. Firstly decentralisation within municipal organisations, where local authorities gain more power. This is linked to the governance condition of authority. The second trend the authors discuss is externalisation initiatives that place climate policy outside the municipal organisation. This mainly pertains to stakeholder involvement and sharing responsibility i.e. problem ownership. Externalisation can be beneficial to increase problem ownership with non-state actors, but too much externalisation can erode internal support. Therefore the municipality must keep a steering role. Lastly the researchers find an increase in regionalisation with neighbouring municipalities and the provincial government. More partnerships are formed on a horizontal level. This increases learning capacity and financial capacity of cities to act. Den Exter, Lenhart and Kern (2015) conclude that structural integration of climate mitigation and adaptation is limited in Dutch cities, i.e. low fulfilment of governance conditions for successful adaptation.

Following Den Exter, Lenhart and Kern's (2015) analysis, it can be concluded that the chance that adaptation measures are undertaken is higher when a city scores high on the fifteen indicators found in the literature review, and when a local authority has strong vertical and horizontal relationships.

2.7 – Built cultural heritage and its contribution to sustainable urban development

Christopher Tweed and Margaret Sutherland (2007) main focus is on understanding how people interact with the urban environment and its heritage. The authors highlight that more often than before, governments recognise what built cultural heritage contributes to the social well-being of various groups living in cities. The authors argue that heritage is seen as a major component of quality of life, but the two main methods of identifying and protecting built heritage in use at the time are insufficient. These two methods are the listing of individual monuments and buildings, and secondly the designation of

conservation areas. From the authors' perspective both are unable to deal with less tangible features of townscape, such as street patterns. Tweed and Sutherland argue that tangible and intangible features are important signifiers of a city's cultural identity and give inhabitants a sense of belonging. Civilians should have a say in what is considered cultural heritage, as it concerns their living environment.

In their paper entitled "Built cultural heritage and sustainable urban development" (2007), Tweed's and Sutherland's research aim is to examine the role that built cultural heritage can play within sustainable urban development. Firstly, the authors look at definitions of built heritage and how these have changed over time. In this section, the authors argue that definitions of built cultural heritage should move on from focusing on architectural and historical value, which they consider to be too narrow. Moreover, not all urban quarters that can be perceived as a cultural area are incorporated within such definitions, because sometimes ensembles of edifices have a cultural value that the individual buildings that make up the urban district do not have. Moreover, the authors are of the opinion that built cultural heritage should consider phenomena that used to be categorised as low or popular culture. They argue that the process of valuation should be more democratic in order to fully incorporate people's sense of belonging and cultural identity.

Next, Tweed and Sutherland (2007) outline the contribution built heritage can make to sustainable urban development. According to the authors, built heritage has a role to play in all three dimensions of sustainable development, being economic, social, environmental. The environmental focus on built heritage includes technical problems such as the impact of atmospheric pollutants on the maintenance of building fabrics. The main contribution to the social dimension is monetary, as heritage attracts tourists. Thirdly, the authors pose that built heritage address the social dimension in the sense that preserving of heritage ensures that all groups and generations have fair access to this resource. However, the authors note that despite being involved in these three dimensions, built heritage is not addressed by either of the two European procedures used to assess the impact of urban plans and projects on the environment: Strategic Environmental Assessment (SEA), and Environmental Impact Assessment (EIA). The authors, together with other European researchers, investigated the potential for existing legislation based on SEA and EIA to incorporate cultural heritage in the EC-funded SUIT project. As part of this SUIT project, the researchers looked at how the built environment contributes to the satisfaction of human needs by providing symbolic meanings that bind cultural groups and communities across generations. "Built heritage conveys different meanings to different groups of people and these meanings are likely to be important in the future growth of towns and cities and so need to be considered part of sustainable development" (Tweed & Sutherland, 2007, 65). For this SUIT project, the authors developed a survey technique to use as an assessment tool for determining the value of built heritage at the scoping stage of SEA and/or EIA. The survey method sought to examine three main groups of indicators and collect relevant socio-economic background information:

- Indicators associated with perception. These included the respondents' awareness of the surroundings, mood, familiarity with the space and the perceived quality of the space.
- Indicators associated with proposed interventions. These included respondents' recognition of proposed changes to the appearance of the space as shown in digitally

altered photographs, attitudes to these changes, and opinions about what would constitute positive intervention.

- Categorical indicators. These included standard measures of respondents' socio-economic group and education level, as well as purposes in visiting the survey space.

Concluding from the results of this survey method, Tweed and Sutherland (2007, 67) argue that involvement of the public will lead to "greater sensitivity and sustainability in the introduction of new constructions, additions and infill within historic towns, and thereby minimise negative impacts on the perceptions of those people who use the space". They underscore this point by looking in depth at a case study, which concerns urban regeneration in Belfast, Northern-Ireland. In this case study, the authors criticise the planning and legal process regarding the regeneration of Victoria Square. Victoria Square had been a vibrant and prominent meeting place, but fell into decline. None of the buildings in the square met requirements of heritage by designation. However, two places, The Kitchen Bar and the medieval street entry to the square, Telfair Street, were considered heritage by appropriation. In this instance, the authors pose that only considering objections in the Public Inquiry made it harder for the general public to make their voice heard. Moreover, the emphasis lied on the economic benefits and regeneration impact on the rest of the city. Therefore loss of heritage was unheeded during the assessment phase of planning proposals, until the provincial Ulster Architectural Heritage Society raised this issue at the earliest moment of participation, when the preferred scheme had already been chosen. This involvement lead to a rejection recommendation in the Public Inquiry report. However, the Minister for Social Development intervened, citing concern about losing economic benefits of regeneration. This intervention in local planning from the national level meant that the chosen scheme was approved. Moreover, the Belfast planning department decided not to hold a full Public Inquiry into the planning application which would have provided a space for a full public debate on the regeneration scheme. Tweed and Sutherland (2007) state that tensions between heritage and regeneration of Victoria Square address the three factors of sustainability. The authors question whether trading in social and cultural character of a place in favour of the economic benefits can be considered sustainable.

From this discussion the authors conclude that listing is not always a good indication of the value of an historical area in a city (Tweed & Sutherland, 2007). Ensembles are sometimes as important as individual buildings or monuments. When these shortcomings are not addressed, important contributions to urban character fall between the categories of listed building and conservation area, leading to a mismatch in perceived views of inhabitants on their environment and how people actually interact with the urban area and its heritage. As suggested above, the built environment exerts a major influence on citizens' everyday experiences. A greater understanding of the complex and multi-level interactions between people and the built environment increases the chance that regeneration of an area appreciates its cultural and social character, and thus can be considered sustainable. The lack of understanding about these interactions is reflected in the absence of legislation. Tweed and Sutherland (2007) argue that understanding peoples' relations with their environment and the meanings they enshrine in built heritage leads to solutions for new development that integrate environmental and social dimensions of sustainable development.

Following Tweed's and Sutherland's (2007) analysis, it can be concluded that the chance that adaptation measures are undertaken is higher when:

1. users of a space are aware of the impact of adaptation, i.e. changes to a place
2. citizens feel included in planning decision-making, which in turn underpins condition 1
3. urban planners have a holistic understanding of the social and cultural value of a city district
4. potential loss of heritage is addressed in the planning and legal processes

2.8 – Management of historic urban landscape

Pereira Roders and Van Oers (2011) research management of world heritage cities. With this approach they aim to enhance the conservation and management of cultural heritage assets for the benefit of present and future generations, which in their view constitutes sustainable management of world heritage cities. Pereira Roders and Van Oers (2011, 282) define the historic urban landscape (HUL) "as the urban area understood as a historic layering of cultural and natural values, extending beyond the notion of 'historic centre' or 'ensemble' to include the broader urban context and its geographical setting". This wider context includes the site's topographical setting and surroundings, use of resources, social and cultural practices and values, economic processes, and intangible values like provision of identity and economic resources (economic capacity). The main aim of the HUL is to preserve the quality of the environment while enhancing the function of urban space. The HUL approach tries to link conservation of the urban environment to sustainable social and economic development. Pereira Roders and Van Oers state this is a complex process due to expected issues: changes in end-use, changes in surroundings due to urban development, increase in stakeholders and more different types of stakeholders, and fourthly upsurge in competing demands pertaining to environmental, economic, and socio-cultural requirements. According to Pereira Roders and Van Oers, a sustainability approach to HUL should integrate conservation with social and economic development, and the natural environment with the man-made environment.

The main problems for World Heritage Cities identified by Pereira Roders and Van Oers (2011) are the threats posed by urban design on the one hand, and tourism on the other. Pertaining to the former, potential damage may result from urbanisation processes, regeneration programmes, modern adaptations that do not respect the traditional fabric, and new constructions, especially the building of tall buildings that affect the protected views and thus the integrity of the HUL. Regarding the latter, Pereira Roders and Van Oers (2011) point towards the difficulties in integrating tourism development and traditional lifestyles. They argue that the best approach is a holistic approach, where the cultural significance, i.e. the range of values attributed to the historic city, is taken into account in the decision-making process regarding the development of the HUL. The resulting policy should optimise the economic potential of the built cultural heritage, while maintaining or possibly enhancing its cultural significance. The latter is of more importance for cities inscribed on UNESCO's World Heritage List, as for these urban areas sustaining and enhancing the outstanding universal value is the main objective.

Moreover, this holistic approach entails "a thorough understanding of the property by all stakeholders; a cycle of planning, implementation, monitoring, evaluation and

feedback; the involvement of partners and stakeholders; the allocation of necessary resources; capacity building; and an accountable, transparent description of how the management system functions, put down in a commonly agreed management plan" (Pereira Roders & Van Oers, 2011, 281). However, the authors find that at the time of writing there is still a gap between policy development and the practice of management.

In conclusion, according to Pereira Roders and Van Oers, the chance that adaptation measures are undertaken is higher when:

1. Stakeholders have knowledge on the values of the HUL
2. There is enough economic capital for adaptation
3. Acknowledge that urban development (i.e. adaptive measures) may threaten World Heritage Cities
4. Values attributed to HUL is taken as a source to inform the decision-making process
5. There are co-benefits to development: e.g. economic potential is increased while also enhancing cultural significance
6. There is constant monitoring of, evaluation of, and feedback on the state of the urban area
7. A variety of stakeholders is involved in the planning process
8. Clear-task division for the people involved in management of the HUL

2.9 – Built cultural heritage and climate resilient cities

Matthias Ripp (2017) focal point is how built cultural heritage can contribute to resilient cities. He starts out by listing various phenomena which are expected to influence the development of cities. Ripp cites environmental concerns, such as changing weather patterns, social concerns, e.g. an ageing population and diversifying needs of inhabitants of urban centres, and thirdly technological innovation in mobility that will lead to further changes in cities. Ripp states that historical cities, and more specifically their old town centres, are characterised by enduring uses and conservation. He poses that the demands of future change and risks associated with development can contradict endurance and conservation of a place. In his paper, he looks at the extent to which the concept of urban resilience, here defined as "the ability of individuals and social groups to compensate systems or properties that incurred damage (such as by restoring their lost functionality) or the ability to respond flexibly to threats and thereby ward off potential damage (Ripp, 2017, 101), can be useful in this context of studying climate resilient historical cities.

Next, Ripp (2017) discusses the concept of resilience in urban planning. In his view, resilience thinking does not get enough consideration in the field of urban planning. He argues that instruments of planning, e.g. societal developments or availability of resources, can become more resilient by including diversity and flexibility thinking. In addition, he sees urban resilience not as a fixed state but as a continuous process. Built cultural heritage becomes a factor of resilience in dealing with resource scarcity. Ensuring longevity of buildings is a way to conserve resources. In addition, the ability to repair incurred damage to built heritage is linked to the availability of natural resources.

Ripp (2007) continues by questioning how resilience can be implemented in practice through land use and development plans. He looks at opportunities and limitations of resilience of urban heritage, through examination of how and under which circumstances certain typologies, construction methods, craftsmanship and other factors

have proved resilient. He looks at resilience potential of historical city centres in four categories, being design and construction, materiality, use, and fourthly planning.

First, he focuses on resilience by way of design and construction. He analyses that for most buildings, the economic circumstances of the time greatly influenced the construction style and materials chosen. Moreover, it influenced spatial arrangement of buildings, due to the need to achieve energy efficiency as heating was very costly, and thus energy-efficiency ensured long-term usability of the building. Ripp (2007) argues that solid construction techniques using wood or stone, and tile roofing materials ensured resilience to outside influences. To keep historical districts functional, the author argues that regeneration to facilitate modern needs, e.g. modern transport or flood protection, should be sensitive of their relational structure.

Secondly, Ripp (2017) discusses resilience by way of appropriate materials. This is strongly linked to the first factor, as it also touches upon longevity of a building. Usability of a historical monument is in part determined by the material. Historic building materials are often easily repaired with traditional and artisan methods. Moreover, materials like wooden floors, clay tiles, clay plasters, wooden windows, can easily be replaced because they exist of individual elements. Therefore, traditional materials have high adaptability. However, the downside is that these artisan-made materials require specialised craftsmanship and it is a challenge to ensure this knowledge is passed on to future generations.

The third circumstance under which aspects of built heritage have proved resilient is by way of adapted uses. Ripp (2017) argues that this is probably the most significant factor of resilience. He argues that historical spaces can be adapted quite easily to serve other functions. He poses that historical buildings have often served several purposes simultaneously, and that urban renewal projects show that these constructions can take on new functions readily. By ensuring longevity through adaptability, Ripp (2017) argues that this quality shows that resilience can be achieved at little cost. Although, he cautions that design plays a large role, and that some building types and design features entail considerable cost to accommodate them to modern living standards. Ripp argues that resilience through adaptability of historical buildings also applies to other characteristics of historical town centres, such as market squares and courtyards. Being able to meet various needs ensures this urban fabric is resilient. Moreover, the author points out that often historical centres are praised for their aesthetic quality and provision of urban identity. Distinctive architecture ensures the area pulls people to visit, thereby serving other uses such as tourism, retail, and work. In other words, historical town centres are resilient by way of providing space for other uses.

Lastly, Ripp (2017) looks at resilience factors in planning. The author is critical of top-down and sectoral planning approaches, as they provide partial and selective views on the problem. He argues that to balance various interests and requirements, the planning process should involve multiple stakeholders. He argues that in order to keep the structural and urban fabric robust, a long-term perspective is necessary. This perspective should take into account risks, and be regularly re-examined. This guarantees risk factors and hazards are assessed to meet local adaptation strategies.

The author concludes that "[s]ince resilience is based on a systemic approach, integrated conservation and development strategies can only be realized by crossing the frontier of sectoral policy" (Ripp, 2017, 111). Because risks and challenges to urban areas

are multi-dimensional, so should the governance of response strategies be. Incorporating built heritage in holistically integrated planning can contribute to resilient cities in the sense that safeguarding buildings and ensuring its associated values stay intact means the building still has function, thus no damage to the system is incurred.

In conclusion, according to Ripp, the chance that adaptation measures are undertaken is higher when:

1. Endurance and conservation of the area are included in plans to address future change and risk
2. Instruments of planning include diversity and flexibility thinking
3. Conservation is seen as a continuous process which includes the indemnity of natural resources in order to repair incurred damage
4. Regeneration (and adaptation) is sensitive of the relational structure of buildings in historical districts
5. Appropriate (i.e. traditional) materials are used in adaptation.
6. Knowledge of how to use traditional materials is passed on to future generations
7. Adapted re-use ensures longevity, while keeping the option open to accommodate to other functions in the future
8. Development projects provide opportunity for the historical space to meet other needs and serve other uses
9. A variety of stakeholders are included in the planning process
10. The planning process has a long-term perspective which ensures that local adaptation strategies account for local risk factors and hazards
11. Policy-makers from various backgrounds are involved in the making of conservation and development strategies
12. It is acknowledged that the longevity of the building/area has been proven and thus warrants future protection as continued use is likely due to design and construction, materiality, use, and planning

2.10 – Building adaptive capacity and reducing vulnerability to decrease climate risk

In their vast study, Carter and colleagues (2015) focussed on climate change and cities. This specific paper outlines the outcomes of the EcoCities collaborative research project, which combined research on climate science, environmental planning and urban design to investigate climate change hazards, vulnerabilities and adaptation responses in the Greater Manchester area. Their main objective was to study how cities can increase their adaptive capacity and how to reduce their vulnerability to risk associated with climate change. In their study they refer to the IPCC 2007 definition of adaptation: “adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities” (cited in Carter et al., 2015, 5). Within their analysis, they have seen that adaptation over the years has seen the inclusion of resilience. Carter and his fellow researchers give the definition set by the United Nations Office for Disaster Risk Reduction (UNISDR), where resilience “means the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects on the hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions” (Carter et

al., 2015, 5). Carter and colleagues' analyse that adaptation is increasingly conceived of as the management of climate risk. Carter and his co-researchers state that risk is a combination of hazards, vulnerability (of urban structures, communities, natural environment) and adaptive capacity (information and resources; stakeholders, institutions and governance). The authors argue that IPCC and UNISDR do not treat adaptive capacity as a separate notion, which they see as necessary. Therefore, the authors do single out adaptive capacity, as it helps formulating policies and to assess barriers to implementing adaptation strategies. Hence, the researchers apply an urban climate change vulnerability and risk assessment framework based on Rosenzweig et al. (2011) and Mehrotra et al. (2009).

Reducing vulnerability and building adaptive capacity can help to reduce risks (Carter et al., 2015). Adaptive capacity is underpinned by process management, best practice i.e. knowledge exchange, and stakeholder engagement. Ergo, places that have the ability to withstand shocks to urban system have high resilience. Based on a literature review, the authors find various conditions underpinning adaptive capacity, which can be grouped as follows:

1. Financial (income levels),
2. Knowledge (availability of, access to and distribution of resources; availability of and access to information on climate change impacts and potential adaptation responses; technological capacity and range of technological adaptation options available; human capital including skills and education)
3. Problem recognition (awareness and perception of climate change risks),
4. Situational (environmental factors; infrastructure quality and provision)
5. Organisational (organisational and institutional capacity to implement adaptation responses; quality and transparency of decision making processes; society's ability to act collectively and implement adaptation responses (problem ownership & external coordination)

Besides the aforementioned factors, the researchers find other governance conditions that are harder to group. One of them is spatial planning, the development and use of land in cities. Regarding spatial planning, a variety of dynamics come into play, being the regulatory role of local government, stakeholder engagement, integration of infrastructure planning, future orientation, and wide scope of issues and spatial scale. Another condition which is important is multilevel governance. Authors point to critics who argue that "there is no spatial framework to coordinate development and infrastructure activity taking place between national and neighbourhood scales. For issues including adaptation to climate change, where a tiered spatial approach addressing different themes at different spatial scales is needed, this presents a problem" (Carter et al., 2015, 8). Moreover, according to the authors this lack of spatial framework combined with deregulation means that local action to tackle climate change to meet national targets depends on voluntary action based on political will. To counter such trends, the authors state that a repositioning of adaptation to enhance political support is needed. This translates itself into increasing traction around urban development agenda. Carter and colleagues outline five themes that can be used to reposition adaptation (i.e. what underpins agenda-setting).

The first theme focuses on localising adaptation. The authors found that there is a need to generate data and insights on a local scale. This knowledge increases the ability of policy-makers operating at the urban scale to develop tailor-made adaptive measures

instead of a one-size-fits-all approach. The author argue that context-specific measures are more effective.

Second, adaptive measures should safeguard future prosperity. Carter and colleagues (2015) argue that adaptive measures that show to have added benefits for economic capacity and social improvement, they can reduce people's perceived risk.

In addition, the study found that a vulnerability based approach is merited (Carter et al., 2015). A vulnerability based approach aims to protect the most vulnerable people in society. The authors state that future climate change projections inherently cause uncertainty for vulnerable groups as they are more at risk than others. They link this to social justice and inequality. In their view, adaptive measures should also address these issues. Ergo, policy on adaptation should be integrated with other points on the agenda, such as social planning.

Furthermore, integration of adaptation with urban infrastructure development will increase political will to take up adaptive measures. The authors argue that when adaptation is linked to building resilience of critical infrastructure, the uptake can be higher, because of the inherent socio-economic importance of infrastructure. What is needed is a transition to policy for climate resilient infrastructure in which adaptation plays a role (Carter et al., 2015).

Lastly, the authors found that the science-policy interface plays a large role in advancing political will. Carter and his fellow researchers found that decision-makers need suitable data: requires information-fit, interplay of new knowledge with existing knowledge; level and quality of interaction between producers and users. This development of useful data is dependent on knowledge creation between local government, academia, business, third sector and communities. Together, they brings expertise, resources and connections which increases local adaptive capacity. Additionally, the research points out that building of collaborative partnerships for creation of knowledge benefits both sides, researchers and research end users.

Finishing, the authors point out the main requirements needed for adaptation. Firstly, institutional leadership is required to deliver on goals focused on resilience and adaptation. Plus, adaptation needs agenda setting, i.e. internal coordination. Also, to increase adaptive capacity, cities need more research and co-creation of knowledge, and transferable learning.

Concluding from this research by Carter and colleagues (2017), the chance that adaptation measures are undertaken is higher when:

- Adaptation measures are context-specific and take into account local environmental factors
- Adaptation measures take into account quality and provision of infrastructure
- Adaptation produces economic benefits
- Adaptation comes with social benefits
- Adaptation planning and social planning are integrated to protect the most vulnerable in society
- It means that critical infrastructure becomes more climate resilient
- The creation of climate science and climate data fits the needs of policy makers, making it easier for them to use it in their planning
- Interaction between producers and users of climate science and data is of high quality

- Knowledge creation involves many stakeholders from different backgrounds (e.g. academia, government, business, third sector, local communities)
- Users and producers of climate data and climate science form collaborative partnerships

2.11 – Analysing adaptive capacity to climate change at heritage sites

In her study on capacity to adapt to climate change at heritage sites, Phillips (2015) points out that the historic environment in itself is a non-renewable resource, made up of physical, natural and intellectual resources. She notes that heritage is important to a place's sense of identity, contributes to aesthetic quality, and provides space for recreation. Besides these social-cultural factors, heritage also provides economic benefits as it attracts tourists and provides employment. In this light, the author argues that it is important to safeguard this resource for the benefit of present and future generations.

Phillips draws on other research to highlight that currently, cultural heritage is neither prepared nor adapted to the expected future climate. Conversely, she notes that much tangible heritage has experienced and survived past climate-related changes, and therefore it is possible that these sites are able to show resilience in the future. In addition, it is possible that researchers may find indicators of past adaptation to climate change in the historic fabric. Such knowledge of how people used to adapt their living environment could be useful for current and future adaptation efforts. On the other hand however, Phillips explicates that heritage sites can be at risk of climate instability. But reading between the lines it is likely that the current rate of change may also impact the resilience of a heritage site to climate-related changes in a negative manner.

To help safeguard heritage in light of climate change, Phillips (2015) sets out to investigate adaptive capacity to climate change in the field of cultural heritage management. She mentions that climate change not only negatively affects physical features of built structures, archaeology and designed landscapes, but also changes visitor behaviour. Additionally, she points out that adaptations to mitigate effects of climate change may result in adverse implications on heritage significance. In her view, "the vulnerability of cultural heritage sites is a function of their exposure, sensitivity and adaptive capacity to present and potential future impacts of climate change. The capacity to adapt is a critical element in the process of adaptation" (Philips, 2015, 119). The author analysed existing theories and deems there is a lack of research on the capacity of heritage management systems to adapt, as she found only one study that addresses adaptive capacity and cultural heritage. To address this knowledge gap, Philips set out to develop a framework that can guide analysis of adaptive capacity to climate change.

First, Phillips (2015) undertook a scoping study in which she interviewed site managers, policy makers, and adaptive capacity researchers at various World Heritage Sites in the UK. This yielded generic indicators of adaptive capacity, which informed the criteria for case study selection. Secondly, the author sent out a questionnaire to managers of UK World Heritage Sites including questions on the impact of past weather events, what actions were either undertook or planned to adapt prevent future damage, potential impacts of climate change on the site in the future. Third, the author analysed existing frameworks on adaptive capacity. Here, she found two studies of main importance: Yohe

and Tol's (2002) framework on adaptive capacity and Gupta and colleagues' (2010) Adaptive Capacity Wheel. These frameworks were combined with a synthesis of literature on cultural heritage management. This information, plus data collected in the scoping study plus data derived from the questionnaire informed an initial conceptual framework. This framework consisted of four determinants, each with three indicators. This initial framework was used to focus subsequent data collection and analysis.

In the second stage of her research, Phillips (2015) tests the initial conceptual framework by carrying out three case studies. Sampling of case studies was based on their experience at the site of impacts from severe weather the years prior, and where the site managers thought the site was vulnerable to climate change. For this part, the author collected her data from interviews with site managers, documentary evidence, and expert interviews. She designed semi-structured interviews based on past events and adaptive actions, which were then coded using an inductive approach. The initial conceptual framework formed the coding basis for the first case study. During this process, the coding system was adapted, informing the framework for the second case study, and idem for the third. Through the analysis at each case, combined with the data collected from the expert interviews, Phillips (2015, 122) formed a revised conceptual framework which "includes determinants which were found to be relevant at the three cases, and [is] also informed by the literature, national/international level data and the survey of all UK World Heritage Sites". The author explicitly states that the framework is not intended to be a way of scoring or measuring adaptive capacity, but instead employs the experience and knowledge of stakeholders to show how site managers experience changing conditions, and how they make decisions about how to adapt, and the capacity to do so. The framework lays out six distinct yet interrelated determinants of adaptive capacity. The processes which shape these determinants are very much interdependent. Adaptive capacity is generated by the interactions of the different determinants (Phillips, 2015, 123).

There is an underlying assumption that positive impacts on the determinants in the framework (see Table 5) should enhance the systems' adaptive capacity. However, it must be acknowledged that this assumption of positive impacts may be contested, due to the uncertainties relating to some of the determinants of adaptive capacity: "For example, stronger policy on adaptation may define a clearer legislative framework but could stifle the capacity to adapt autonomously, or may result in adaptations which damage heritage significance" (Phillips, 2015, 123). Adaptive capacity is dependent on a range of socio-economic variables for which there are specific uncertainties e.g. the development/diffusion of technology for adaptation, economy/prosperity. The framework is focused predominantly at a local level, although national level factors will influence these local determinants, and assessing certain determinants e.g. policy context and leadership may involve a consideration of national level factors.

Table 5 – Framework to analyse Adaptavi Capacity relevant for heritage management (Phillips, 2015, 123)

Factor	Sub-factors	Description/definition
Resources	Technological	The technological resources that are available for adaptation
	Financial	Availability of financial resources to support policy measures and autonomous adaptation

	Human	Availability of skills, expertise, manpower, local knowledge and experience.
Authority	Plans and policy instruments	Availability of plans and policy instruments to increase the ability of individuals to act
	Political will	The political mandate to foster adaptation and raise resources
Access to information	Futures thinking	Access and use of information such as scenarios of future conditions, in order to inform long term decision making
	Guidance and information	Access to the necessary information, guidance and tools to support decision makers
	Monitoring	Monitoring which provides information to inform how to act and to check progress on targets
Learning capacity	Institutional memory	Memories and knowledge which transcends the individual
	Heritage as a learning resource	Tapping into what can be learnt from heritage itself
	Single loop learning	Ability to learn from past experiences and improve routines
	Double loop learning	Learning which questions values, assumptions and policies
Cognitive factors	Individual risk appraisal	Individual assessments of the probability and severity of potential risks
	Perceived adaptive capacity	Individual perceptions of the efficacy and costs of adaptation
	Approach to uncertainty	Openness to the uncertainties around climate change and adaptation
Leadership	Buy in from the top	Commitment to adaptation at a senior level within organisation
	Motivators/champions	Existence of individuals who are motivated and enthusiastic, who act as a catalyst for action
	Creation of a vision	Long term visions which include adaptation
	Holistic management approach	Incorporation of a systems thinking approach; managing system as a whole rather than in parts
	Communication and collaboration	Good internal and external communication, and collaboration e.g. through formal/informal networks

Phillips argues that there is still a significant gap in knowledge on climate change adaptation and cultural heritage management and much more work is needed. In particular there is scope for further in-depth study of many of the individual determinants which are affecting the capacity to adapt.

Based on Phillips framework, the chance that adaptation measures are undertaken is higher when:

1. the technological resources for adaptation are available
2. the financial resources to support policy measures and autonomous adaptation are available
3. people with skills, expertise, manpower, local knowledge and experience are available
4. plans and policy instruments to increase the ability of individuals to act are available
5. political mandate to foster adaptation and raise resources is available
6. information such as scenarios of future conditions are accessed and used in order to inform long-term decision-making
7. site managers have access to necessary information and have guidance and tools to support their decisions
8. there is monitoring which provides information about how to act and to check progress
9. memories and knowledge which transcends the individual is present and used
10. heritage is used as a learning resource
11. site managers learn from past experiences to improve future management
12. site managers use their and others' experience to question values, assumptions and current policies
13. individual site managers assess risks of vulnerability and impact
14. individual site managers consider the efficacy and costs of adaptation
15. are open to uncertainty about future climate change
16. the top management of a site is committed to adaptation
17. there are individuals within the system management that motivate others to take action
18. plans for site management include long-term visions
19. plans for site management are holistic, manage the site as a system rather than in parts
20. there is good communication both internally between different factions of site management, as well as externally e.g. through formal/informal networks

2.12 – Water governance framework

In their 2017 article, Koop and colleagues assess the governance capacity of cities to address challenges of water, waste, and climate change within cities. The authors argue that there are various issues that may impede adaptation, e.g. fragmented scopes, viewpoints and responsibilities of stakeholders and multiple governance layers. The author consider five governance challenges, being water scarcity, flood risk, wastewater treatment, solid waste treatment and urban heat islands. In order to solve these challenges, the authors argue "that what is necessary is an iterative process that requires governance capacity to find integrated long-term solutions that are supported by flexible intermittent targets to anticipate changing situations and adapt to emerging barriers" (Koop et al., 2017, 3428). The authors aim to find the key conditions determining the governance capacity to find solutions to the governance challenges.

Koop et al. (2017) argue that the current integrated concepts in use, Integrated water resources management (IWRM) and Adaptive management (AM), are insufficient in providing guidelines for application to address governance challenges. The authors argue that these concepts are difficult to implement, consist of undefined and complex processes, and tend to focus on technical solutions. In their formulation of the knowledge gap, Koop and colleagues outline that there is no coherent framework which is consistent in its assessment of governance in various contexts to enable comparison between institutions and organisation, which provides indicators for social factors and conditions that impact urban governance processes, and which searches for learning practices which enable knowledge exchange to increase governance effectiveness. Koop et al. aim to address this knowledge gap by looking at the most important enabling conditions that determine governance capacity in order to overcome governance challenges.

In this paper, Koop and colleagues consider governance capacity to include how institutional setting, rules, and regulations enable collaboration between actors to address problems, and the role of resources and discourses in order to enable effective change. The authors do operate under a limited definition of effectiveness, stating that "the kind of change that is effective is context-dependent" (Koop et al., 2017, 3430). However, they do find that definitions of governance capacity have three shared themes. Firstly, they focus on cooperation between actors to identify and act on problems. Secondly, governance capacity is about actors' interactions formed by allocation of resources and social-institutional settings. Thirdly, the capacity is about actors' frame of reference which influences interactions between actors and influence collaboration on and addressing of shared problems. In total, the authors find 27 indicators that underpin the water Governance Capacity Framework, Table 6.

Table 6 - Governance Capacity Framework (Koop et al., 2017, 3431)

Dimensions	Conditions	Indicators
Knowing	1 Awareness	1.1 Community knowledge
		1.2 Local sense of urgency
		1.3 Behavioural internalisation
	2 Useful knowledge	2.1 Information availability
		2.2 Information transparency
		2.3 Knowledge cohesion
	3 Continuous learning	3.1 Smart monitoring
		3.2 Evaluation
		3.3 Cross-stakeholder learning
Wanting	4 Stakeholder engagement . process	4.1 Stakeholder inclusiveness
		4.2 Protection of core values
		4.3 Progress and variety of options
	5 Management ambition	5.1 Ambitious and realistic management
		5.2 Discourse embedding
		5.3 Management cohesion
	6 Agents of change	6.1 Entrepreneurial agents
		6.2 Collaborative agents
		6.3 Visionary agents
Enabling	7 Multi-level network. . potential	7.1 Room to manoeuvre

		7.2 Clear division of responsibilities
		7.3 Authority
	8 Financial viability	8.1 Affordability
		8.2 Consumer willingness to pay
		8.3 Financial continuation
	9 Implementing capacity	9.1 Policy instruments
		9.2 Statutory compliance
		9.3 Preparedness

The nine conditions identified are well defined, and the authors pull from an exhaustive list of sources for the indicators. However, the definition of each condition by three indicator, if useful and clear, feels a bit arbitrary. Using Likert-type scoring means the scoring is very transparent, and shows the gradual levels of governance capacity. For each of the 27 indicators the criteria for scoring have been made available, therefore the transparency of the scoring system is high.

Concluding from Koop and colleagues' (2017) analysis, the chance that adaptation measures are undertaken is higher when cities score well on these nine conditions.

2.13 – Synthesis: Framework to analyse adaptive capacity to climate change in historic cities

This literature review was carried out to answer the first two sub-questions, being:

1. What is successful adaptation according to the literature?
2. What are the required governance conditions according to the literature?

Pertaining to the first sub-question, most scholars do not give a definition of what successful adaptation entails. This is odd, especially considering most papers (e.g. Carter et al. and Corfee-Morlot et al.) refer to best practices as source of information for adaptive measures. So what do they mean when they refer to *successful* adaptation? Koop et al. (2017, 3433) state that for adaptation to be called successful, management ambitions need to "match the dominant values, discources, and principles". But whose dominant values, and discourse between which partners? Also, they refer to management ambitions, and not to policy outcomes, so successful adaptation in this sense refers more towards an increased capacity of planning for climate adaptation. This is also underlined by Den Exter, Lenhart and Kern (2015, 2), who refer to the classification used by NL Agency, which "suggests that successful execution of local climate ambitions should start with anchoring climate policy in all aspects of the organisation". Other governance articles link success to incorporation of a variety of stakeholders, on integration within the organisation, on including networks and working in partnerships, and in the co-creation of knowledge by producers and end-users of climate science.

However, the point of interest here is successful adaptation within historic urban areas. In the articles centring on heritage (Pereira Roders & Van Oers, 2011; Phillips, 2015; Ripp, 2017; Tweed & Sutherland, 2007), the authors highlight holistic management, and using the heritage as a learning source to inform development, i.e. adaptation planning. In addition, they highlight that heritage management which seeks out co-benefits in planning is more successful. The main takeaway is that any adaptive measure should be mindful of

the outstanding cultural-historical value of the urban area. Therefore, successful adaptation may be defined as: long-term, holistic management of environmental risk by introducing adaptive measures that are mindful of the historic-cultural value of the urban area, where the policy process incorporated a variety of stakeholders on various levels and scales, and heritage was used as a learning resource.

Regarding the second question, the studies discussed above put various emphases on which conditions are deemed important. To make matters more interesting, also the jargon used differs per article, mostly due to the scientific background of the authors. However, several themes and conditions are found to be key for enabling adaptation. These conditions are summed up in Table 7. This table uses the main outline set by Phillips (2015). Her research focussed on individual monuments, however, a designated area within a city-centre, i.e. a historical town-centre, could also be taken as an individual monument. Therefore, her division of factors is taken as a base. However, where parts of her analyses have been lacking, or where other authors developed similar ideas, the framework has been adjusted with information from other articles. In addition, the table lists the common chances that increase uptake of adaptation measures as find in the literature study.

Table 7 - Governance conditions: assessment framework for adaptation in historic cities based on the literature review (Based on: Bulkeley & Betsill, 2005; Carter et al., 2015;Corfee-Morlot et al., 2011; Den Exter, Lenhart & Kern, 2015; Koop et al., 2017; Pereira Roders & Van Oers, 2011; Phillips, 2015; Ripp, 2017; Runhaar et al., 2012; Rydin, 2010; Tweed & Sutherland, 2007)

Sub-factors	**Description/definition**	**Chance that adaptation measures are undertaken is higher when**
FACTOR: RESOURCES		
Technological	The technological resources that are available for adaptation High resource and energy efficiency	There are technological resources available for adaptation of historical inner-cities
Financial	Availability of financial resources to support policy measures and autonomous adaptation, to build the will and capacity to act	Financial resources to support policy measures and autonomous adaptation, and to build the will and capacity to act are available Local authorities increase financial capacity by seeking and establishing support for local adaptation via public private partnerships and local fiscal policies There is enough financial support Adaptation produces economic benefits Stakeholders evaluate the efficacy and incurring costs of adaptation

Human	Availability of skills, expertise, manpower, local knowledge and experience/competence	Local authorities increase their planning and technical (scientific) capacity Local authorities have enough manpower, with the right knowledge and skills to tackle the issues
Situational	Environmental factors, infrastructure quality and provision Understanding of cultural value	Local priorities are determined Existing urban areas are flexible Users of a cultural space are aware of the impact of adaptation Adaptation measures are context-specific and take into account local environmental factors Adaptation means that critical infrastructure, i.e. the valued heritage, becomes more climate resilient
FACTOR: AUTHORITY		
Plans & policy instruments	Availability of plans and policy instruments to increase the ability of individuals to act Policy integration and guidance	Plans and policy instruments are in place to increase ability of individuals to act The planning and legal process addresses the potential loss of heritage The adaptation policies address conservation of the historic area There is legal responsibility to adapt/have adaptation planning Policy-makers from various backgrounds are involved in the development of conservation and adaptation strategies for the area
Political will & mandate	The political mandate to foster adaptation and raise resources Decentralisation of power, local government has power to implement stricter management measures	Discourse power of local government is high, i.e. local government is able to frame goals for climate protection into policy implementation National or sub-national regional governments empower urban planners by providing institutional support for the development of credible, legitimate and salient science-policy assessment and deliberative-analytic processes National and regional authorities support local authorities by ensuring clarity about jurisdiction, decentralise policy competencies and set out time frames for local action
FACTOR: ACCESS TO INFORMATION		
Futures thinking	Access and use of information such as scenarios of future conditions, in order to inform long term decision making	Information on future change and concomitant risks for the area are available for all stakeholders The creation of climate science and climate data fits the needs of policy-makers, making it easier for them to use it in their planning Scenarios on future conditions are accessed and used to inform long-term decision-making

Guidance and information	Access to the necessary information, guidance and tools to support decision makers. Information transparency and knowledge cohesion	There is knowledge exchange between producers of scientific and technical knowledge and potential users. Scientific assessment should be tailored to local needs in a deliberative-analytical process Local boundary organisations that have access to regional and local research institutions and engage with other stakeholders are created Local governments get guidance to how information can be used
Monitoring	Monitoring which provides information to inform how to act and to check progress on targets	Monitoring of the HUL provides information whether action is needed Progress on implementation of adaptive measures is followed to ensure actors can step in to adjust the course of action if necessary
FACTOR: LEARNING CAPACITY		
Institutional memory	Memories and knowledge which transcends the individual Learning is central: reinforce relationships between actors	Knowledge creation involves many stakeholders from different backgrounds Memories and knowledge which transcends the individual is present and used
Heritage as a learning resource	Tapping into what can be learnt from heritage itself	It is acknowledged that the longevity of the building/area has been proven and thus warrants future protection as continued use is likely due to design and construction, materiality, use, and planning Knowledge of how to use traditional materials is passed on to future generations Heritage is used as a learning resource e.g. knowledge on what type of environmental protections have been since long been in place
Single loop learning	Ability to learn from past experiences and improve routines	Actors learn from their own past experience: self-reflection Actors learn from others: learning on a horizontal level in partnerships
Double loop learning	Learning which questions values, assumptions and policies Normative processes are at work, social and environmental knowledge can be based on values	There is public or political support or pressure in favour of adaptation measures Urban planners have a holistic understanding of the social and cultural value of a city district Adaptation of the area is sensitive of the relational structure of buildings in historical districts Knowledge on the (traditional) materials used informs protection of natural resources to repair incurred damage to ensure conservation Stakeholders use their experience to question values, assumptions, and current policies
FACTOR: COGNITIVE FACTORS		

Individual risk appraisal	Individual assessments of the probability and severity of potential risks Local sense of urgency	Civic engagement with and understanding of the issues is high Problem has salience: urgency
Perceived adaptive capacity	Individual perceptions of the efficacy and costs of adaptation Change actors' perceptions of reasons to act, to show that change is possible, and to counter resistance by individuals or groups of actors: undermine the legitimacy of their behaviour or stance	Individual views of effectiveness and costs of adaptation are addressed
Approach to uncertainty	Openness to the uncertainties around climate change and adaptation Problem recognition	Problem recognition is high Stakeholders are open to uncertainty about future climate change
FACTOR: LEADERSHIP		
Buy in from the top	Commitment to adaptation at a senior level within organisation Integrate adaptation and mitigation in organisation and in existing plans, legal responsibility and ownership	Responsibility and competence lie with a powerful actor Senior level of organisation commits to adaptation
Motivators/ champions	Existence of individuals who are motivated and enthusiastic, who act as a catalyst for action	There are individuals (at local authority or from civil society) who inspire others
Creation of a vision	Long term visions which include adaptation at strategic level, but also short-term operational planning Give practical strategies and measures to conform to principles. Set out expectations arising from regulation and the potential benefits and establish a route to achieving outcomes	Local authorities determine long and short-term goals A pathway to achieving the vision is established
Holistic management approach	Incorporation of a systems thinking approach; managing system as a whole rather than in parts Anchor policy across all sectors	Policy integration is high between sectors The co-benefits to adaptation are considered
Communication	Good internal and external communication Clear task-division	There is a clear task-division at the management level of local authorities The policies are brought to the attention of the public
FACTOR: MULTI-LEVEL GOVERNANCE		
Collaborative action	Urban governance involves relations between levels of state (local, provincial, and national) Shared problem ownership External coordination	The local authority has strong relations between levels of state The local authority has strong horizontal relationships: cooperation between government and society and ensures that the issue stays on the agenda Implementation of policy is done in tandem with stakeholders

Creation of networks	New network spheres of authority, create agenda for action, release resources within networks, controlling actors within networks through sanctions to overcome resistance and conflict, and alter established relationships between actors to change incentive structures Shared problem ownership International lobbying	Authority is shared between actors in new network spheres Networks set agenda for action, release resources within, control actors to overcome resistance and conflict, and increase idea of shared ownership of the problem Public problem ownership has been established, civic engagement can increase chances of implementation of devised policies Users and producers of climate data and climate science form collaborative partnerships

Table 7 - Governance conditions: assessment framework for adaptation in historic cities based on the literature review *(Based on: Bulkeley & Betsill, 2005; Carter et al., 2015;Corfee-Morlot et al., 2011; Den Exter, Lenhart & Kern, 2015; Koop et al., 2017; Pereira Roders & Van Oers, 2011; Phillips, 2015; Ripp, 2017; Runhaar et al., 2012; Rydin, 2010; Tweed & Sutherland, 2007)*has also been visualised, see Figure 5. This way, the key concepts from the analytical framework are visible at a single glance.

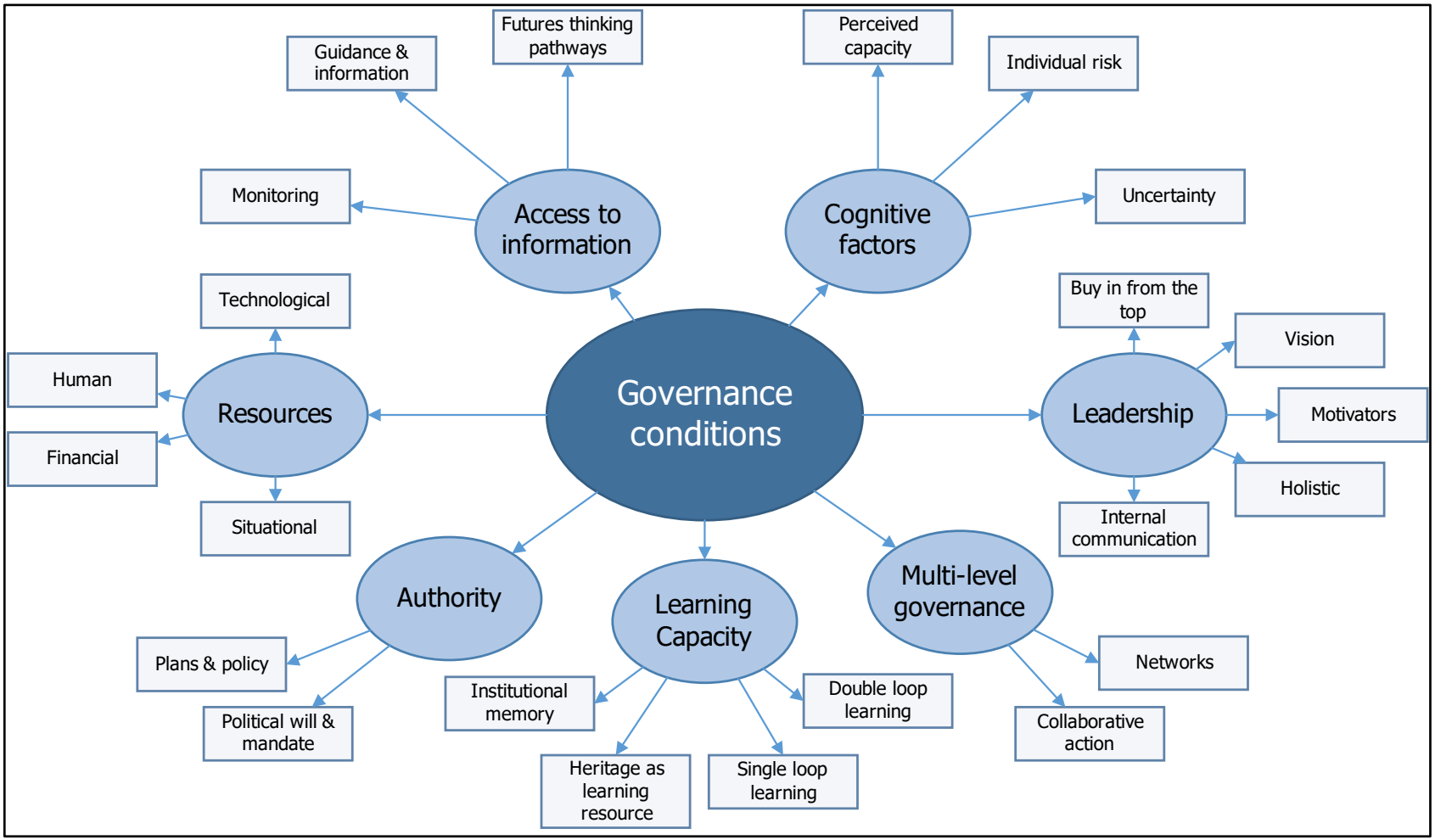

Figure 5 - Framework Governance Conditions for adaptation at historic cities

2.14 – Conclusion

In this chapter, ten articles and a book were discussed with the aim of answering questions one and two. Their topics range from local adaptation governance and governance conditions on the one hand, to climate-related adaptation in (historic) cities on the other. These articles were probed for governance conditions, and 'barriers' or 'stimuli' to climate change adaptation in historic centres. In this literature review barriers and stimuli are phrased as governance conditions. The main line of reasoning for finding favourable conditions was:

"The chance that adaptation measures are undertaken is higher when [*governance condition*] is present"

The synthesis answered questions one and two. Regarding the first question, "*What is successful adaptation according to the literature?*" it was found that many authors do discuss *success* or *successfulness* but do not give a clear definition of what they mean by that. This research takes *successful adaptation* to mean: long-term, holistic management of environmental risk by introducing adaptive measures that are mindful of the historic-cultural value of the urban area, where the policy process incorporated a variety of stakeholders on various levels and scales, and heritage was used as a learning resource.

Pertaining to question two, "*What are the required governance conditions according to the literature?*", the synthesis structured governance conditions found in the literature review across seven Factors, each partitioned into supporting sub-factors. They were combined in an assessment framework found in Table 7. Moreover, the factors were visualised so the relationships between the concepts are visible at a single glance.

The next chapter highlights the methodology for the remaining chapters. It introduces the case study and data selection. Furthermore, it goes into how research questions three to five are answered. Additionally, the internal and external validity of the research method are addressed.

Chapter 3 – Methodology

3.1 – Introduction

Various methods will be used to answer the research questions set out in chapter one. Regarding questions one and two, being *"What is successful adaptation according to the literature?"*, and *"What are the required governance conditions according to the literature?"*, these have been answered in the literature review. Together, the answers to these questions form an assessment framework. This framework functions as the foundation for the case study. This method section first explains the choice to use a case study, and introduces the cases. Next, it outlines how each research question is answered. Moreover, the validity of the research method is queried.

3.2 – Explaining the choice for a case study

A case study is used to research governance conditions in a real-world context. Sub-questions three to six underpin the case study. Furthermore, a case study aims to generalise the features of a single unit across a larger class of similar phenomena (Gerring, 2007). In this study, the unit of analysis is the framework with the governance conditions needed for successful adaptation in historic cities.

Following Gerring (2007) there are various characteristics that determine the type of case study. The first question you have to ask, does the study generate or test hypotheses? This research aims to test the framework of conditions found in the literature review. A case study method gives the opportunity to study these conditions in real-world application. In this study, the population consists of a sample of case 1 Breda and case 2 Experts. There is no temporal variation, but there is spatial variation cross the two cases. The population is homogeneous as the cases both involve specialists on spatial adaptation in urban areas. The case looks at probabilistic causal relationships. This type of relationship assumes that a cause increases the likelihood and magnitude of an outcome. In this case, the presence of governance conditions found in the literature review increases successful adaptation to climate change in historic inner cities. Based on these characteristics, the method used is comparative method.

Breda is chosen as sample case 1. This city is interesting as it has a long history, with various types of heritage present in the inner city. Moreover, Breda is part of the Zuiderwaterlinie, the water defence line in the south of the Netherlands. Therefore, Breda has an interesting history with water management. According to the NCHA monuments list (as of August, 2019), there are 548 monuments within Breda municipality of national importance. Of these 548 monuments, 479 are in the city of Breda. Within the city-centre ZIP code 4811, which comprises the part of the designated area located within the inner city, there are 289 listed monuments. Of these 289 buildings, 231 are houses and housing complexes, and fourteen are religious buildings. The other listed buildings include municipal and military architecture.

Figure 6 shows the designated area of Breda (area outlined in pink), this area comprises the city centre, i.e. the 4811 ZIP code, excluding parts of the *Schorsmolen*, *Chassé* and *Fellenoord* city districts. The designated area also extends south of the city-centre district, but this part was left out of the research. As can be seen on the map, there is much built heritage that is either of national importance, or of local importance. Lots of it is concentrated within the "*Centrum*" (City-centre) neighbourhood, and along the historical streets (yellow lines).

Next, Breda has not yet been the subject of an in-depth study on governance conditions, so this study can address this knowledge gap. Moreover, Breda is interesting because it has developed adaptation plans besides its mitigation plans. Most Dutch local governments have mitigation but no adaptation plans (Reckien et al., 2018). Additionally, Breda is involved in partnerships focussing on climate change. The city is one of fifteen partners in the "Brabant Health Deal". Two of its four focal points concern firstly a healthy human environment, and secondly attractiveness and liveability of the area. Climate change is a challenge to maintaining standards in these two areas, so climate adaptation is one of the main interests of the Brabant Health Deal. Secondly, Breda is a partner in the "City Deal klimaatadaptatie" (City Deal Climate Change Adaptation) network working on governance, financial issues, and innovative solutions for climate adaptation in cities. Given the prevalence of municipal knowledge on this topic, Breda is thought to have a good understanding of climate adaptation, and thus merits forming a test case for the study of the governance conditions.

Case 1 Beda is compared to the other part of the sample, Case 2 Experts, to see which governance conditions are required for successful adaptation in historic cities. As Gerring (2007) points out, the logic of cross-case research is premised on some degree of cross-case comparability . Therefore, the Expert case study shares characteristics with case 1 Breda. The experts have experience with adaptation and/or heritage management. Similar to Case 1 Breda, they have knowledge of governmental policy regarding urban development and/or heritage management. Moreover, they partake in networks various levels and scales.

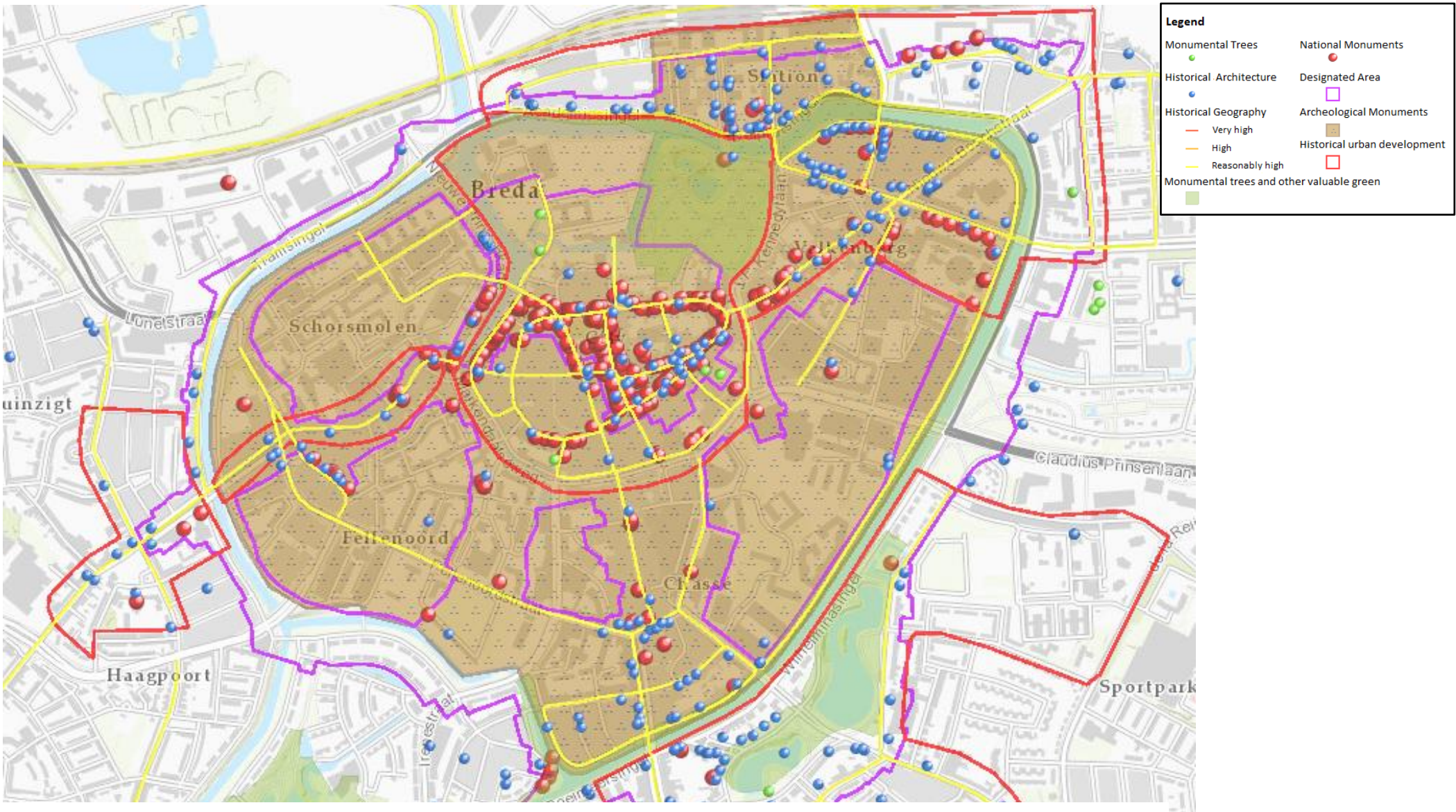

Figure 6 - Cultural-historical value Breda (CHW Province North-Brabant, 2015)

3.3 – Answering the research questions

The case study is used to answer questions three to six. In this study, the objects of local adaptation analysis are policy content and policy process. Policy content is defined by Vogel and Henstra (2015, 112) as "the specific courses of action chosen by governments, and the means by which these are implemented". Policy process concerns the conditions that enable and/or constrain development and implementation of adaptation policy (Vogel & Henstra, 2015, 112).Questions three and four cover projected local climate change impacts and options for adaptation, existing policies and action programmes and their integration.

Question three concerns the projected climate change impacts for Breda, and its impact on local areas, monuments located in this areas, and how this built cultural heritage can be adapted:

- What are the projected climate change impacts for Breda?
  - *Which local areas are under threat?*
  - *What monuments in these areas are particularly threatened and how?*
  - *How can this built cultural heritage be adapted in such a way that its cultural value is kept intact?*

Data used to answer this question consists of a triangulation of desk research and interviews. Desk research include study of climate change projections, NCHA list of monuments and sites, information found in policy documents, and newspaper articles. Climate projections for Breda are based on KNMI'14 projections, the Province of North-Brabant online climate portal, a special report focusing on weather in North-Brabant in three cities, including Breda (Bessembinder & Grond, 2016), and climate maps provided by various Dutch research institutions. These maps have been downloaded and have been input into ArcMap, a GIS-type computer programme to analyse geographical data. Maps that were utilised are listed in Table 9, to be found in Appendix E. Maps holding information over climate are superimposed over maps showing the cultural heritage value of Breda. There are two maps that show the cultural-historical value of Breda, one is the map made by municipality Breda, the other is the cultural-historical value map made for the Province of North-Brabant. Combining these maps not only shows the area impacted by specific climate effects, but also what type of structure (building or a tree, national or municipal monument) can be found in that location and what its heritage value is.

An additional source of information are the policy-documents. These documents include information on ambitions and challenges. They provide formal policy on how to achieve Breda's goals pertaining to spatial development, heritage management, and sustainability. Policy-documents consulted are:

1. Breda stresstest klimaat 2010 (Breda climate stresstest 2010)
2. Uitvoeringsplan klimaat 2017-2020 (Climate execution plan (UPK) 2017-2020)
3. Impuls ruimtelijke adaptatie Breda (Impulse spatial adaptation Breda)
4. Erfgoedvisie Breda 2008-2015 (Heritage Vision Breda 2008-2015)
5. Concept Erfgoedvisie "grondstof voor de toekomst" (Concept Heritage vision: "heritage as building block for the future")

6. Bouwstenen op weg naar omgevingsvisie Breda 2040 (Building blocks on the road to municipal environmental strategy Breda 2040)
7. Bestuursakkoord 2018-2022 (Memorandum of understanding 2018-2(022)
8. Duurzaamheidsvisie Breda 2030 (Sustainability vision Breda 2030)
9. Structuurvisie Breda 2014 (Local Plan Breda 2014)

Furthermore, local newspapers were consulted for information. These were looked at for information on what is happening 'in the real world'. Relevant articles were searched for on Nexis Uni. The main term used is "*klimaatadaptatie"* (climate adaptation). The search set to find articles posted between january 1st 2019 till july 11th 2019. The results list was further narrowed down by looking for the keywords "Breda" and *"erfgoed"* (heritage). This yielded not many results, as well as some doubles. A second research was carried out using the term "*erfgoed*", same date range, and search within results for the keywords "Breda", and using a Boolean operator to search for "*klimaatverandering"* (climate change) OR "*klimaatadaptatie"*. The results yielded by both searches were scanned for relevance. Few results came up that were usable. All in all, the following newspaper articles were found to focus (in part) on climate change and adaptation related to heritage in Breda:

1. Paul Verlinden. (26 juni 2019 woensdag). Vier ton Europese Unie-subsidie voor erfgoed en water in Breda. BN/DeStem.
2. Nico Schapendonk. (29 juni 2019 zaterdag). Steeds meer extremen. BN/DeStem.
3. Edine Wijnands. (27 mei 2019 maandag). Kleine groene oases tussen steen en blik. BN/DeStem
4. Paul Verlinden. (22 maart 2019 vrijdag). In Breda kunnen de bomen straks tot in de hemel groeien. BN/DeStem
5. Palko Peeters. (21 maart 2019 donderdag). Duurzame aanpak van Stationsweg. BN/DeStem.

The last source of information used to answer question three are interviews. Regarding the interviews with stakeholders for the Breda case, the main actors were identified first. These include municipal policy-makers in the department of spatial development and heritage. Secondly, the *Wijkraad Stadshart Valkenberg* (Neighbourhoord council Stadshart Valkenberg), was approached. This is an advisory council constituting of volunteers, who are inhabitants of the Stadshart and Valkenberg quarters which fall in the designated area of Breda. The *Wijkraad* aims to promote the living environment of the inner city (Stadshart and Valkenberg neigbourhoods only) by coordinating with inhabitants, Breda municipality, local law enforcement, event organisers and representatives for hotel and catering industry, shop owners, and real estate owners. Thirdly owners and managers of two main public monuments in Breda, being the *Grote of Onze-Lieve-Vrouwe-Kerk* (Church of Our Lady), and the *Begijnhof* (Beguinage) were approached.

A total of six interviews were organised for the Breda case study. These conversations took the form of semi-structured interviews. This type of interviewing technique enables a more free-flowing conversation where it is possible to ask follow-up questions and expanse on issues brought up by the interviewee(s) (Brinkman, 2014). It was not possible to discuss all seven factors in-depth during each interview. All interviews took an hour or longer. After approval of the interviewee(s), the interviews were recorded and transcribed. Transcriptions of the interviews were then send to the interviewees for corrections and

amendments. After transcription of the first interview at the Begijnhof, it was decided to set up a second interview to focus more on the conservation and adaptation aspects. This second interview has been used in this thesis; the results of the first interview have not been explored in the analysis. The quotations in this research are translated from Dutch to English. Therefore, phrases and syntax used in the original are adapted to make sense in English. A list of interviewees and interview guides can be found in Appendix C and D respectively.

Question four focuses on gaining insight on policy content:

- What policies and action programmes exist on different levels and how well are these coordinated across levels and sectors?

This question is answered using desk-research and interviews. Desk-research includes information taken from policy-documents and newspapers. These are the same as used to answer question three. Idem for the interviews.

Question five tests the framework based on the literature review:

- To what extent are the governance conditions identified in the literature present in Breda?

The main source of information to answer this question is the interviews, because this question is evaluative in nature. The same interviews employed to answer questions three and four were used. It was also possible to complement data from interviews with data from the document analysis. Question five aims to determine to what extent the governance conditions identified in the literature are present in Breda. This question focuses on policy process, on the conditions that enable and/or constrain development and implementation of adaptation policy (Vogel & Henstra, 2015, 112).

Pertaining to question five, this question is answered in section 4.4 Sub-sections 4.4.1 – 4.4.7 each focus on one of the seven main Factors found in the literature review. The evaluation of the presence of the governance condition was informed by the frameworks in Phillips (2015) and Koop et al. (2017). As Phillips indicated, her framework not intended to be a way of scoring or measuring adaptive capacity, but instead, by exploring how site managers experience changing conditions and how they make decisions about how to adapt, the framework highlights how existing systems could be improved to optimise adaptive capacity. Contrariwise, Koop and colleagues do use a scoring system. They have based the scoring system on a Likert-type evaluation, where evaluative criteria are given to score indicators.

At the end of each sub-section a table is given with a reflection on the presence of the factor. This is not done using a scoring system, e.g. a Likert-type evaluation, with evaluative criteria. Climate adaptation within and of historical inner cities is still in its infancy, meaning that it is fairly new on the agenda and as such not fully understood nor institutionalised in the same way as 'normal' climate adaptation or climate proofing are. Therefore, there is not enough data to base a scoring-system on as it is considered to be too soon to decide what the appropriate metrics for evaluation are. Instead, to what extent the

governance condition is present is determined by a simple yes/no/somewhat. Moreover, to what extent governance conditions are present within Breda can to a certain degree evaluate the state of climate adaptation in the *historical area* but it should be stressed that this study cannot make statements on the actual capacity of the city for climate adaptation for the whole municipal area.

A combination of interviews and desk-research is used to answer the sixth question:

- What do experts think about successful adaptation and governance conditions?

The framework outlined by the literature review is used to inform interview questions, while they were also influenced by the results obtained during the interviews for Breda. Using interviews to gather data can mean that different results are achieved, depending on selection of the interviewees. The expert interviewees are chosen strategically, keeping in mind the time constraints, but this does mean that talking to a different expert might yield other insights. Experts chosen resemble a broad background, so cover the various bases of the research. To put Breda in a wider context, candidates for expert interviews were taken from different levels. On a micro level, experts at the city of 's-Hertogenbosch were approached. 's-Hertogenbosch also lies within the Province of North-Brabant, and shares with Breda that the municipal organisation has a large heritage department. On the meso level, experts at the Province of North-Brabant and the Province of Utrecht were interviewed, to look at how local climate adaptation strategies are embedded within strategies set out on this level. On the macro level, experts on national strategies, solutions, and policies were interviewed. This way, expert interviews yield information about how local policy is enshrined within and informed by strategies on higher scales. A list of experts interviewed and interview guide can be found in Appendix C and D.

The information presented by the expert interviews was complemented with desk-research. Desk-research contains interviews found online, grey literature, policy-documents and newspaper articles. Online interviews contain an interview with the CEO of the National Cultural Heritage Agency S. Lammers, an interview with Boerman, manager at IJssel-Vechtdelta Waterboard, and the speech minister Van Engelshoven of OCW gave at the acceptance of the *Erfgoeddeal* (National deal on heritage).

Furthermore, newspapers were consulted for information. These were looked at for information on what is happening 'in the real world'. Relevant articles were searched for on Nexis Uni. The main term used is "*klimaatadaptatie"* (climate adaptation). The search set to find articles posted between january 1st 2019 till july 11th 2019. The results list was further narrowed down by looking for the keywords "*stad*" (city) and *"erfgoed"* (heritage). This yielded not many results, as well as some doubles. Therefore, a second research was carried out using the term "*erfgoed*", same date range, and using a Boolean operator to search within results for the keywords "*klimaatverandering"* (climate change) OR "*klimaatadaptatie"*. The results yielded by both searches were scanned for relevance. Again, few results came up that were usable. All in all, the following newspaper articles were found to focus (in part) on climate adaptation and historic town centres:

- Michiel Kerpel. (3 juli 2019 woensdag). Vitamine Groen zorgt voor een gezonde stad.Reformatorisch Dagblad.

- Merten Simons. (28 februari 2019 donderdag). Zutphen moet de boer op om 's-Gravenhof autovrij te krijgen. De Stentor.
- (14 mei 2019 dinsdag). Burgers mogen meedenken over toekomst van erfgoed. AD/Haagsche Courant.
- (10 juli 2019 woensdag). Het klimaatproof maken van de stad Zwolle zit in kopgroep steden. De Peperbus.
- Pieter Lalkens. (11 juli 2019 donderdag). Steden moeten voortaan zonder Rockefeller-geld veerkrachtig worden. FD.nl.
- Peter Bruijns. (14 januari 2019 maandag). Gun Heerlen groene longen. Dagblad De Limburger.
- Vikkie Bartholomeus. (29 maart 2019 vrijdag). Profiteren van de wilde Maas. Dagblad De Limburger (PL)
- Ton Rooms. (2 januari 2019 woensdag). Dromen van een mooier Boxtel. Brabants Dagblad.
- Ivar Penris. (30 Oktober 2018 dinsdag). Groene stad is koele stad. AD/Utrechts Nieuwsblad.
- Mark Moorman. (10 November 2018 zaterdag). Hoog water. de Volkskrant.

Additionally , a You-tube video released by the municipality of Kampen on climate adaptation of Bolwerk Schans has been analysed.

3.4 – Validity of the research method

There are two types of validity, internal versus external validity (Gerring, 2007). Validity of the research strategy concerns the extent to which a method measures what it is intended to measure. On the one hand there is internal validity, which involves quality of conclusions concerning the group of subjects that are actually studied (e.g. the causal link between outcome and treatment). On the other hand, external validity determines the generalisability of the study's results (in time, space, and subjects) (Verschuren & Doorewaard, 2010). The study looks specifically at governance conditions in the Netherlands, so results may be generalised for Dutch municipalities. However, since the subject of the study is historic urban landscape, it must be noted that this varies across the Netherlands, thus also across cities, which means that the results should be generalised with caution. Cities that share characteristics with Breda may benefit from the conclusions in this research. In other words, the results could be generalised to a municipality like Middelburg but not to a more modern city like Almere.

Chapter 4 – Climate adaptation in Breda's historic inner city

4.1 – Introduction

The previous chapter has indicated the research methods used to answer the research questions. Here, these methods are put into practice. This chapter focuses on answering questions three to five:

3. What are the projected climate change impacts for Breda?
   3.1. Which local areas are under threat?
   3.2. What monuments in these areas are particularly threatened and how?
   3.3. How can this built cultural heritage be adapted in such a way that its cultural value is kept intact?
4. What policies and action programmes exist on different levels and how well are these coordinated across levels and sectors?
5. To what extent are the governance conditions identified in the literature present in Breda?

To answer these questions, a combination of mostly desk-research supplemented with information from interviews has been used. Desk-research includes a consultation of policy-documents concerning Breda, future climate projections for the city, and climate effect maps and cultural-historic value maps, and newspaper articles. Section 4.2 and 4.3 focus on questions three and four respectively. Section 4.4 discusses each of the seven Factors found in the literature review in-depth, giving a total appraisal of the presence of the governance factors in section 4.3.8. The chapter ends with a short conclusion.

4.2 – Projected climate impacts for Breda

In this section, questions three is answered. Question three aims to determine the projected climate change impacts for Breda. It has three sub-questions:

1. *Which local areas are under threat?*
2. *What monuments in these areas are particularly threatened and how?*
3. *How can this built cultural heritage be adapted in such a way that its cultural value is kept intact?*

These sub-questions are answered in sections 4.2.1 – 4.2.3 respectively. Firstly, what are the projected consequences of climate change for Breda? Projected climate change impacts Breda can be deduced from the Climate Impact Atlas that shows projections for 2050 according to the KNMI 2050 WH scenario (the most extreme). Additionally, Bessembinder and Grond (2016) made a special report focusing on weather in North-Brabant in three cities, including Breda. Of the four scenarios in the NAS, there are three that will have an impact for Breda being it will be hotter, wetter in winter, and drier in summer months. Figure 7 shows an imaginary weather forecast for the south of the Netherlands for 2050.

Figure 7 - Video by Province North-Brabant showing imaginary weather forecast for August 2050 (Dutch only) (YouTube)

Regarding temperature, the expected temperature increase for 2050 compared to 1981-2010 is 1,0 – 2,3 °C. Max temperatures during extremes will increase more than average temperatures. For Brabant as a whole, more tropical days where temperature exceeds 30 degrees Celsius are projected. Regarding Breda area, the city-centre is expected to have 12-15 tropical days a year, compared to the current 3-6 days a year. It should be noted that these projections do not take into account the fact that temperatures in cities are usually higher than those on the country side due to UHI, so there could be more tropical days in the future. Regarding temperatures in cities in Brabant, it is expected that the heat island effect will increase in the summer months, most notably during night-time. For the summer months, CAS projects an increase in tropical nights (nights where temperature is at least 20 degrees Celsius), especially pertaining to the town centres of larger agglomerates. Currently, Breda centre experiences circa seven days where temperature during the night does not drop below 20 degrees Celsius. Under the 2050 WH scenario, the area will experience circa 21 tropical nights a year. Noticeably, the large green space that is Park Valkenberg is the one part of the centre that stays cooler, experiencing around 17 tropical nights a year. Contrarily, some good news is that there will be less days where the temperature drops below zero degrees. This means that freeze-thaw cycles will occur less in the future.

For the second scenario, it gets wetter, it is noted that currently precipitation events are more heavy than in the 20th century. Rainfall is expected to be more intense in 2050. A precipitation event that is currently T = 100 (85 mm in 24 hours) will be more intense (85-100 mm in 24 hours) plus will also happen almost three times in 100 years. Those are numbers for extreme events, but the number of days with precipitation classified as very wet will also increase, from one to two days a year currently to at least three days a year in the 2050 WH scenario. The local effect of precipitation is influenced by an increase in impervious areas in the district. Areas with much green space where water can be stored are better prepared to deal with rain than districts with impervious surface areas where the water cannot be captured by the sewerage or infiltrate into the ground.

When it comes to drought, it is harder to determine what the effects will be for Breda. The expectation is that Breda will experience more drought in the future, but what the consequences are for the historic area is hard to determine. Most of the maps focus on the effects of drought on agriculture and not really on cities. Some good news for the city

centre is that most soil subsidence will happen at the edge of the municipal area, and there is little to no subsidence projected for the historic centre. However, during extreme periods of drought it may be possible that buildings in the city are affected. For water level management, the centre depends on groundwater and precipitation. The potential maximum precipitation deficit is expected to increase in 2050 WH; both the average as well as an extreme event occurring once every ten years. An increase in precipitation deficit usually leads to a decrease of water availability of ground and surface water. Therefore, because less water is available in the canals and the water quality is less, it could have an impact. Moreover, if there is less water available for evaporation, the energy is instead used to heat up the air, meaning that air temperatures will increase. Contrarily, according to the projections, average lowest groundwater-level is not expected to change in 2050 WH compared to current levels.

Then there are some weather types that are not included in local projections. Examples include increase in extreme wind (see appendix A.3 and B.3), changes in relative humidity and solar radiation (see appendix A.4 and B.4), and an increase extreme weather events such as hailstorms (see A.5 and B.5). However, for Breda these changes in weather patterns are expected based on national trends, and thus also impact on the historic built environment.

4.2.1 – Local areas under threat

So, what does this all mean for Breda? Which local areas are under threat by these scenarios? This can be answered with the help of climate projections and maps. The maps consulted are listed in Appendix E. Appendix E also contains figures that were created specifically for Breda by superimposing climate maps onto Breda's cultural-historic value map and North-Brabant's cultural-historic value map. These are figures 19-35, and show which local areas are under threat. The resolution of some climate maps is too low to show specifics for the inner-city, see for example figure 25 and 26 regarding annual evaporation. Other maps that did not show details include annual precipitation, days with 15 and 25 mm precipitation, average precipitation in mm in winter, number of warm, summer and tropical days, number of cold days, and potential maximum precipitation deficit. For these climate effects no maps have been generated.

Bearing this in mind, for the projection of more rainfall, the depth in cm for a precipitation event T = 1:100 is used, see figures 20, 21, 22, and 23, as well as the potential development of nuisance caused by groundwater levels – 2050 WH, figures 33, 34, 35. Depth in cm for T = 1:100 was chosen over T=1:1000, as the latter is more rare, while the former already shows salient impact. Moreover, the T = 1:100 is based on current climate conditions. The expectation is that a rainfall event with > 70 mm in two hours will have a higher chance of happening in the future, making the problems of standing water more pressing.

Besides, for temperature increase (increase in number of warm, summer, and tropical days, and decrease in cold days), the UHI map was substituted. The UHI map is made using the UrbClim model that employs median year temperatures, so it does not take into account extremely hot summer days or nights. Instead, the UHI shows the summer mean temperature difference between urban and rural areas. For the inner-city, it shows the areas that are significantly hotter. As the summer mean temperatures will increase,

this UHI map is chosen as a substitute because of its high resolution shows the places that are currently vulnerable to temperature impacts. Ergo, future increase will only enhance their vulnerability, ceteris paribus. UHI temperature maps are shown in figures 27, 28 and 29. When it comes to drought, a suitable map to use for determining effects for the urban area has not been identified. Therefore, the impact of drought cannot be researched in detail.

4.2.2 – Specific monuments that are threatened

The second sub-question aims to find information on what monuments in these areas are particularly threatened and how. For precipitation, this is shown on figures 20, 21, and 22, and 32 and 33. The areas of interest are accentuated by red circles. For temperature, see figures 26 and 27. These maps show the same areas of interest, also in red circles.

The monuments situated in these areas of interest include nationally listed monuments as well as municipal monuments. As can be deduced from the maps, there are a lot that are situated in these areas of interest. This study cannot possibly address all of them, therefore a few monuments have been selected to look at in depth. One example regards street level, the other an individual monument. These are the Catharinastraat (see centre of bottom-right circle figure 21) and 'Witte Huisjes' (White Houses) at Fellenoordstraat, figure 22 bottom circle.

The Catharinastraat is one of the oldest streets of Breda (Hendriks, Otten & Böschen, 2008). The NCHA has listed 26 buildings located at the Catharinastraat. This includes the *Begijnhof*, which is listed as one building even though it is an ensemble of over 20 houses. Of the 26 listings, 21 are private homes and housing complexes, two have a religious function, and one is the Begijnhof. The other two listings are a former department store, and two gas lighting fixtures from the mid-nineteenth century. These monuments are made of various type of brick and natural stones, and date from the fifteenth century to the early 20th century. The buildings are listed due to their architectural values, or ensemble values, or socio-cultural values as they say something about the development of Breda through the years. The Catharinastraat is projected to have to face with > 30 cm water depth, and increased chance of groundwater nuisance in 2050 (figures 21 and 32). Impact due to excessive rainfall will impact brickwork and stonework. Moreover, excessive rainfall can overflow eaves gutters, and enter the building. The increase in water will lead to more salt crystallisation, and thus efflorescence, delamination and exfoliation. Moreover, increase in rain in combination with changing wind-patterns leads to more erosion and thus powdering and loss of material. This is likely exacerbated by the fact that the Catharinastraat is fully paved, with little green space. However, to the north of the *Begijnhof* Park Valkenberg, is a a large dark blue spot. Idem south of the Catharinastraat, the circle of darker blue, which is a 'stadstuin', municipal garden. These large public green spaces should be large enough to offer surface drainage, so something must be preventing water runoff. What could be the cause of this is groundlevel. If you walk Catharinastraat towards the east, you end up at the *Grote Markt* (market square) and the Church-of-our-Lady, the heart of the city. This heart naturally lies a little higher than the surrounding streets, so excess water runs down those streets due to gravity. You can see this effect in

figure 21, where the streets crossing the market square or those running parallel are projected to have to deal with higher water depths.

Regarding temperature, the UHI map (figure 26) shows that the Catharinastraat is one of the hottest streets in the inner city. This is due to the fact that there are a lot of impervious surfaces, and the street is fairly small meaning winds cannot blow freely, and temperature lingers in and between buildings. However, a benefit of a smaller street is that buildings throw shade over one another, so in that way they have a little cooling effect. Additionally, as figure 29 shows, Park Valkenberg and the municipal garden have a cooling effect to the north and south of the Catharinastraat. However, the walls at the Catharinastraat themselves will be affected by the higher temperatures. Moreover, the bleaching green at Begijnhof does not provide much shade, and neither does the park on the south side of the Catharinastraat, so solar radiation will impact walls, causing an increase in thermal stress in the south facing walls particularly.

The second example, *Witte Huisjes* is a national listed monument, number 519000. It consists of fourteen former homes for non-commissioned officers, constructed of brick painted white, hence the name. The NCHA has listed the barrack houses based on architectural merits, as an example of a typical Dutch barrack building. Furthermore, it has ensemble values: it is important because of the high quality of the buildings and the historical-spatial relationship with the surrounding green areas and roads on the (former) military area. Moreover, it is a rare example of military housing in the Netherlands. However, the fact that it is threatened by high water depth (figure 22) as well as potential groundwater nuisance (figure 33) is odd, as the *Witte Huisjes* are situated near a lot of green space. Besides, large trees line the Fellenoordstraat in front of the houses. This should enhance the drainage capacity of the area. So, more likely, something else is going on that impacts this projection; maybe sewerage capacity is insufficient? That being said, impact due to excessive rainfall will impact the brickwork. The increase in water will lead to more salt crystallisation, and thus efflorescence, delamination and exfoliation. Moreover, increase in rain in combination with changing wind-patterns leads to more erosion and thus powdering and loss of material.

Regarding temperature, because the Witte Huisjes are surrounded by so much green space, UHI effect is low (see figure 27), as the green space has a cooling effect (figure 30). Moreover, the buildings have large trees near the southern facades, which block sunlight thus lessen the impact of solar radiation increase. However, overall an increase in average mean summer temperature can still lead to excess thermal stress in the walls, and thus potential aesthetic and structural damage. For more information regarding common potential climate change impacts on built cultural heritage, see Appendix B.

4.2.3 – Adapting built cultural heritage

The third sub-question is *"How can this built cultural heritage be adapted in such a way that its cultural value is kept intact?"*.

Regarding adaptation projects in the inner city, the following were addressed as successful in the documents:

- Green facades with ivy at Haagdijk and St. Annastraat

- Oude Vest, where parking spaces have been removed and trees have been planted
- The greening of the school square at St. Josephstreet, were tiles were removed and green spaces were created
- Green facade at the Barones shopping mall
- Kasteelplein, a large, fully paved square where part of the square was renovated as a water playground with fountain.

However, pertaining to the Kasteelplein example, there is a discrepancy in evaluation of the success of the adaptive measure. Policy documents and interviewees Breda 2 and Breda 4 counted it as a successful endeavour, whereas Breda 3 highlighted that some residents were less enthusiastic.

Adaptive options at street level include more green like trees and bushes. Also constructing fountains helps, as evaporation of water takes more energy than heating up air, therefore fountains and other blue areas may help keep temperatures down. Moreover, changes to sewerage can help alleviate problems arising during excessive rainfall. What also helps in such instances are chances at the way streets in Breda are constructed, for example the Catharinastraat may consider adding more green facades. Another option for streets in the inner city (especially those that run down from the market square) is to lower street level further compared to the sidewalk and first floors of buildings to alleviate chances that water enters the buildings. It is necessary to drain standing water as soon as possible, because water will penetrate the walls of monumental buildings readily, and changes in water volume of walls is a main cause of damage (see Appendix B.1).

At building level, it is necessary to create shadow. This can be done with the help of leafy trees, which offer shadow in summer but light in autumn and winter. Such measures are sometimes referred to as no-regret measures, as there are no obvious downsides to them.

Other options include application of sunscreens, although this is more complicated. Screens spanning streets are usually not preferred in historic towns, as they block views and thus impact outstanding cultural value of the area. Adding sunscreens to a building is also usually not preferred, as it can damage the fabric. Although it is important to keep in mind that conservation of heritage also depends on it keeping its function, so to keep a building in use is also important (See also Ripp, 2017). Keeping interior rooms at a pleasant temperature with help of screens improves quality of interior spaces, meaning that the building will stay in use.

Regarding waterlogging, it is vital that drainage systems are checked regularly. Moreover, with the expectation of more heavy precipitation events in the future, it may be necessary to increase the size of eaves gutters. However, this is something that should be looked at on a national level. This holds also true for application of silicone ‘paints’ to outdoor stone and bricks for protection against e.g. water. There are various types of silicone adhesive and not all are appropriate for use. Suitability depends on type of brick/stone, i.e. the geophysical make-up, plus type of bond and type of material used for jointing. At the moment there is not enough operable knowledge on use and behaviour in the Netherlands to apply this. Moreover, it should be noted that most silicones are manmade, and do not fit into the trend of using biobased building materials, something that is looked at more for retrofitting and renovation of heritage buildings.

4.3 – Policies and action programmes

In the policy document 'Spatial Adaptation Breda', Breda's viewpoint on achieving spatial adaptation is explained. Mostly a visionary document. States that Breda wants to be climate resilient by 2050, and CO2-neutral by 2044. In this viewpoint, they combine Spatial Adaptation to climate change with nature and green spaces in and around the city, and health. See Figure 8 - Framework for Spatial Adaptation in Breda.

The focus does not lie on regulating, normative requirements, and jurisdiction. Instead, the city focuses on combining themes and agendas, and to facilitate, stimulate, and entice new forms of action and thinking. Moreover, Breda wants to achieve this with multi-level governance: not just local government, but in tandem with citizens, corporations and knowledge institutions. Breda wants to increase awareness, commitment and effort among these stakeholders.

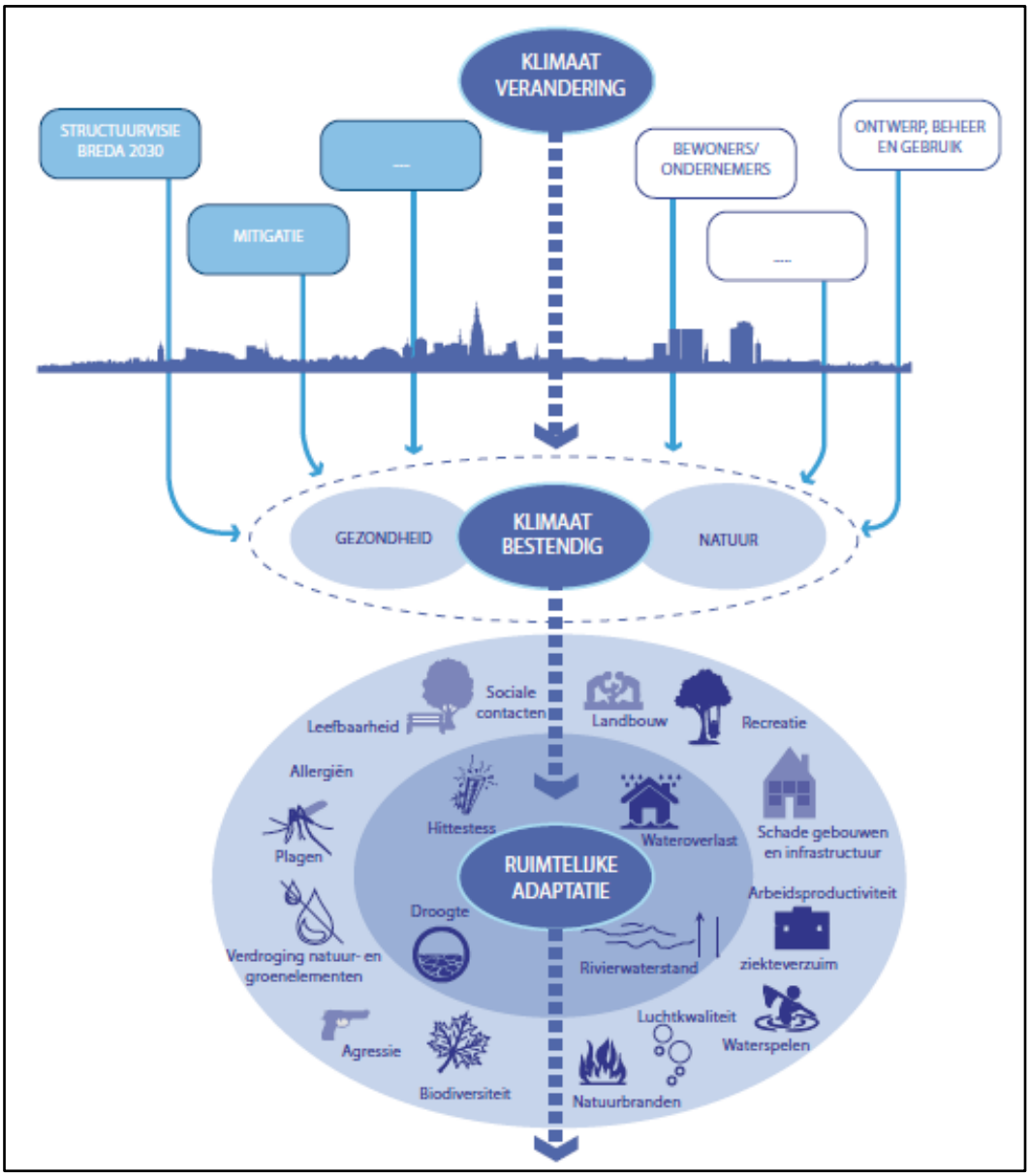

Figure 8 - Framework for Spatial Adaptation in Breda

Breda considers a climate resilient city to have the following: measures in place against flooding, drought, and heat. Can be realised by innovation and spatial adaptation. Moreover, Breda wants more participation and collaboration, and knowledge exchange.

Ambitions are worked out in the Impulse for spatial adaptation document. These are part of Breda climate execution plan (Uitvoeringsprogramma Klimaat, UPK) 2017-2020. This is the third of its kind, others are UPK 2013-2016 and UPK 2009-2012. The UPK is a part of Structuurvisie Breda 2014 and Duurzaamheidsvisie Breda 2016. It focuses on six themes, being:

1. Sustainable government
2. Clean and sustainable energy
3. Clean and energy-efficient mobility
4. Built environment
5. Sustainable entrepreneurship
6. Climate change adaptation

Main aim of the UPK 2017-2020 is firstly to be CO2 neutral. Secondly, to achieve a climate resilient and sustainable inner-city. This third UPK puts more notion on climate change adaptation due to perceived and expected climate change.

The following tasks from UPK 2017-2020 are relevant for the inner-city:

1. More environmentally sustainable buildings: increase uptake among individuals, companies, and housing corporations
2. Increase sustainability of energy infrastructure, including district heating network
3. Climate change adaptation: integrate within all spatial planning
4. Increase sustainability within government: more sustainable buildings, LED street lightning, green public procurement

To achieve this, Breda wants to increase participation with city partners, so more participatory governance and shared responsibility. Partners are entrepreneurs, citizens, local government, and education and other knowledge institutions. Breda wants to facilitate collaboration, stimulate bottom-up initiatives, and share knowledge. For larger tasks Breda takes a leading role. For other tasks, there is a possibility within UPK for stakeholders to present project proposals. Breda supports applicants with knowledge, help, and expertise. If necessary also financially, if the project fails to get market-based funding.

Regarding the six themes, the following programmes from UPK 2017-2020 are relevant:

1. Sustainable government: make buildings owned by the municipality more sustainable by insulation, placing triple glass, replacing boilers, and LED lightning. If possible, place solar panels. Additionally, influence behavioural change of employees to act more sustainably. Also, a coordinator sustainability has been put in place to integrate sustainability thinking within the municipal organisation.
2. Clean and sustainable energy: cluster solar energy could be relevant. Focuses on local generation of energy, could also mean solar panels in inner city.
3. Clean and energy-efficient mobility: smart mobility to achieve 30% CO2 reduction. Focus on orgware, software, mindware, hardware. See also mobility execution

programme (UPM) in hardware: create bicycle fast lanes, and redraw infrastructure for cars.

4. Built environment: improve current housing. Mainly focuses on homeowners and energy-efficiency. Availability of two EU-subsidised projects, See2Do (focus on thermography) and Triple A (focus on awareness and energy motoring). UPK focuses on communication, to increase awareness of homeowners of energy efficient housing and to guide them in achieving this.
5. Sustainable entrepreneurship: three clusters, being monitoring and advise, workshops, and innovation projects. Focus lies mainly on energy and saving energy.
6. Climate change adaptation: to incorporate climate change adaptation and spatial planning within municipal organisation. Also, make it part of management and development projects. Can be seen in the development of climate test and climate effect atlas. Moreover, introduce adaptation projects such as greening of schoolyards, facades, roofs, and city disctricts (examples e.g. St. Josephschool and Kasteelplein). These projects should actively engage other stakeholders. Moreover, Breda is involved in regional and national networks on knowledge exchange. City puts great importance on participating in these networks. Breda is involved in City Deal climate network. It sees this network as a place to learn from others, as well as source of experimentation and innovation. Breda is involved in development of compentences and citizen initiatives. Breda also takes great pride in being a leader, together with Dordrecht, in the G32 project group on climate adaptation. The goals of G32 are agenda-setting and knowledge exchange.

So, what policies and action programmes exist on different levels and how well are these coordinated across levels and sectors? These developments and projects discussed above show that within policy documents the action programmes are linked across sectors. This points to internal coordinating of policy across sectors. Across levels, Breda's involvement in networks shows their aim to coordinate policy on a regional and national level.

4.4 – Analysis governance conditions Breda

In this section I will analyse the presence of the governance conditions presented in the analytical framework. Sub-sections each focus on one individual Factor of the seven found in the literature review. At the start of each sub-section a table is given with a reflection on the presence of the factor. In-text, the reason behind the labelling is explained. To finish, an answer to research question eight "*To what extent are the governance conditions identified in the literature present in Breda?*" is given.

4.4.1 – Resources

This Factor is a big player in stimulating the uptake in adaptive measures. Resources has been split into four categories, being technological, financial, human, and situational, see Table 8. Also, the presence of each sub-factor is given in this table.

Table 8 – Presence of the governance conditions for the factor "Resources"

FACTOR: RESOURCES			
Sub-factors	**Description/definition**	**The chance that adaptation measures are undertaken is higher when**	**Presence**
Technological	The technological resources that are available for adaptation High resource and energy efficiency	There are technological resources available for adaptation of historical inner-cities	+/-
Financial	Availability of financial resources to support policy measures and autonomous adaptation, to build the will and capacity to act	Financial resources to support policy measures and autonomous adaptation, and to build the will and capacity to act are available Local authorities increase financial capacity by seeking and establishing support for local adaptation via public private partnerships and local fiscal policies There is enough financial support Adaptation produces economic benefits Stakeholders evaluate the efficacy and incurring costs of adaptation	+/-
Human	Availability of skills, expertise, manpower, local knowledge and experience/competence	Local authorities increase their planning and technical (scientific) capacity Local authorities have enough manpower, with the right knowledge and skills to tackle the issues	Somewhat
Situational	Environmental factors, infrastructure quality and provision Understanding of cultural value	Local priorities are determined Existing urban areas are flexible Users of a cultural space are aware of the impact of adaptation Adaptation measures are context-specific and take into account local environmental factors Adaptation means that critical infrastructure, i.e. the valued heritage, becomes more climate resilient	+/-

Firstly availability of technological solutions for singular buildings, this is a big issue for monument owners. As of yet, they highlight that they are unaware of which technological solutions would be best for them. This is an important issue, as the implementation of a solution can have disastrous effects, as has been shown by the addition of insulation in the Waterstaatskerkje at Begijnhof, see Figure 9 and Figure 10.

Figure 9 - Wood decay in wall plate caused by fungus

Figure 10 - Wood decay in load bearing beams in the roof construction caused by fungus

In addition, heritage specialists at municipal and national authorities and the heritage law are not always conducive to new technologies that require structural changes or may damage the material:

"There are plenty of monuments in the inner city that have single glazed windows that may not be replaced by double glazed windows, because you are not allowed to make changes to the building" (Breda 3)

So even if technological resources are available, the question remains whether application of the solutions will be allowed. This is illustrated by a second example. On the side of the municipality, they are developing a tool 'samen waterproof' (waterproof together) with the Baronie region. Maps and photographs showing information on soil condition and soil characteristics, and information about the urban area are automated. Civilians can enter their postal code on a website and immediately see a list of measures suitable for that address. To test the tool, the postal code of a listed monument in an area susceptible to pluvial flooding was entered. The advice given mostly focussed on changes to the garden in order to create more permeable areas, but also listed two options for the roof: a green roof and a roof pond. As this particular building has been listed due to its architectural value and ensemble value, it is highly unlikely that it will be allowed. This shows that adaptation of single monuments should be tailored to their specific characteristics, and this specific automated service can be used for inspiration on landscape changes, but listed status is not incorporated in the advice.

Regarding heat and creating shadow, the following example illustrates the same tension between conservation and adaptation:

"One of our board members entered a request to attach awnings to his historical monument, but that has been denied. There is a discrepancy between an owner who wants to keep his house cool, and cultural heritage management that stands in between" (Breda 3)

Therefore, yes, technological solutions are available for monuments, but there is a tension between owners' wishes and cultural heritage policy. However, what becomes clear with this issue, is that it is linked to the factors Authority and Access to information.

For adaptation on street and neighbourhood level, this is responsibility lies with municipalities. As Breda is a pilot for the implementation of the new Environment and Planning Act they do try to incorporate other stakeholders within their planning. There are several courses of action they may take. Firstly, technological solutions available for municipalities can be found in water system adaptation, to expand sewerage capacity and to swap old combined systems for sanitary sewerage and storm drains. Moreover, Breda is already planning to improve the capacity of their climate buffers. The Weimeren, Rooskensdonk, and Terheijden storage basins are in place, the Vierde Bergboezem is expected to provide additional flood protection for Breda. On a slightly smaller level, operation 'steenbreek', where impervious tiles are swapped for permeable surfaces, is already something the municipality is involved in. Permeable surfaces do not necessarily have to be grass or other greens, e.g. in parking lots pervious concrete is an option. Moreover, Avans University of Applied Sciences in Breda together with partners have looked at designing biodegradable paving stones made from recycled biowaste. More sustainable pavement options are expected to be developed.
In addition to systems that focus on surface runoff, there are also solutions that have a double (or triple) function. These are creation of places in the urban area that can be inundated or keep water for longer such as bioswales, green spaces and blue spaces. Not only do they hold water, but they also service as mitigations against urban heat stress, and increase people's interaction with the area, improving quality of life. This is something Breda is exploring in its idea of the city as a park, an idea they like to see realised in 2030.

Municipality has financial resources to support policy measures in favour of climate adaptation. However, this does not mean they can do anything they like, it has to have a substantiated effect. Also, most are focussed on water ways and drainage systems.

"We have around seventeen million a year available for work on the sewerage. About three million of that is used on climate adaptive measures. Besides that we spend 300.000 on communication projects, awareness raising, et cetera" (Breda 2)

Therefore, technological resources are available for neighbourhood or street level. However, they are not well available for individual monuments. Therefore, the presence of this sub-factor is labelled +/-.

Second, the Financial sub-factor. What about money for adapting buildings? With regards to energy savings, the municipality wanted to improve the sustainability of their own buildings, but some energy savings and other measures became too expensive. So the

municipality cannot fulfil all their ambitions. In the Memorandum 2018-2022 the ambition to green their buildings is supplemented with an extra €700.000 a year. Moreover, in the Memorandum the coalition has promised to reserve extra €250.000 a year for heritage. What type of heritage or projects will benefit from the extra capital is not specified.

Money is more tight for conservation of monuments, also for building managers. Yes, there are national programmes like SIM, but in order to apply you need to formulate a long-term vision with all the plans and costs of renovation. This plan is usually farmed out as organisations lack knowledge, which is an extra cost but one they are willing to pay as it results in better plans. However, there is no guarantee that you will be granted funding, as there are more applications than reserves. Moreover, maintenance work subsidised via SIM has to be matched with 50% in-house capital. For restoration and renovation, that division is 70%-30%, where sites have to bring 30% to the table. For that 30%, site and building managers depend on other sources:

"That capital we get from four initiatives. We have "Friends of Church of Our Lady", which comprises the population of Breda and environs, around 2.000 people. We have the "Guild", which is made up of retail, and small and medium-sized enterprises. Third, we have the "Fellowship", meant for large companies. On a yearly basis, that means around €100.000 in revenue. Fourthly, we can apply for funding from non-profits, which we can use to match government incentives. But if we do not raise this capital, then the possibility of governmental subsidy is no longer open. Therefore, to encourage people to donate, we explain that for every euro they donate, the government gives us two euros. But it is not easy to raise enough capital. You may have the ambition to implement sustainable measures, but you need money to make it happen" (Breda 1)

Interestingly, including energy mitigation or climate adaptive measures are not stipulated as conditions to conform to. In that regard, government incentives can be said not to encourage sustainable measures yet.

Taking the above into account, financial resources are available for neighbourhood and street level. They are not readily available for individual monuments. Therefore the presence of this sub-factor is labelled +/-.

Thirdly, human capital. When it comes to manpower, the municipality would like more people. There is a lot of enthusiasm, so plenty of projects are conceived, but not enough people to work on them. Scientific capacity to deal with the issues is seen as adequate, however, as climate impact on buildings is hitherto not really considered, it is arguable whether they have technical and planning capacity to deal with that specific issue. When it comes to getting the required knowledge and skills to tackle issues, the municipality refers to the networks they participate in.

Other stakeholders also argue that it is difficult to get enough volunteers involved. This is also true for the various neighbourhood councils:

"We represent 5.000 inhabitants with ten people. But Wijkraad Hoge Vucht, a neighbourhood of 25.000 people, consists of four people. So their work is much harder, as there are less people interested to give advice or be consulted on issues" (Breda 3)

Considering the reflection on the presence of human capital, it can be said that stakeholders have knowledge and skills. Though, they would like more employees and/or volunteers. Therefore this sub-factor is considered to be somewhat present.

Fourthly, situational context, this has to do with the flexibility of a place. As mentioned, the historical town centre of Breda is a designated area, meaning that any type of new construction has to meet certain criteria. In addition, adapting individual monuments is difficult. This is due to the designation system that is in place. Valuations signify the special interest of a place. Additions to a building or restoration should keep these values intact, or even enhance them. This is difficult for the larger monuments. Examples include implementing heating systems in Church of Our Lady and potential projects for Begijnhof.

Pertaining to urban areas, the designated ares themselves are not always flexible. But the municipality tries to stretch the rules some more, for example when it comes to green spaces:

"Pertaining to green facades we are more flexible, we think that removing, say, six paving stone to plant some greens is acceptable, although we always have the locals have a say and we test whether it fits the aesthetic. There is a thin line between conservation and adaptation, but we want to be flexible otherwise the city remains the way it is. So we adopt a made-to-measure approach, where we look at contextual factors" (Breda 2)

Although they also say that local priorities should be determined:

"Greening historic walls is not desirable per se. I thank that it is better to look at other neighbourhoods for installing green walls and green roofs, before applying it in the historical centre" (Breda 4)

This is also true when it comes to solutions for heat stress, like shade sails spanning streets. Both the Wijkraad and the municipality are not enthusiastic by this. Stakeholders in Breda much prefer more green spaces, or additional fountains or other water related measures. Stakeholders in Breda have much love for the centre, and they understand the cultural value, as can be seen e.g. in the development of the 'story of Breda'. Impact of adaptive measures on the context may not always be clear immediately, but the capacity and will to research this is present.

Taking the reflection on the presence of situational resources into account, it can be said that situational resources are available for the various levels. Stakeholders are aware of the impact of adaptive measures and aim to adopt a made-to-measure approach. However, the designated area is not always apt for adaptation. Therefore the presence of this sub-factor is labelled +/-.

4.4.2 – Authority

This is an important factor. It has two indicators, being integration in existing plans and policy, and secondly in presence of political will and mandate, see Table 9. Also, the presence of each sub-factor is given in this table.

Table 9 – Presence of the governance conditions for the factor "Authority"

FACTOR: AUTHORITY			
Sub-factors	**Description/definition**	**The chance that adaptation measures are undertaken is higher when**	**Presence**
Plans & policy instruments	Availability of plans and policy instruments to increase the ability of individuals to act Policy integration and guidance	Plans and policy instruments are in place to increase ability of individuals to act The planning and legal process addresses the potential loss of heritage The adaptation policies address conservation of the historic area There is legal responsibility to adapt/have adaptation planning Policy-makers from various backgrounds are involved in the development of conservation and adaptation strategies for the area	No
Political will & mandate	The political mandate to foster adaptation and raise resources Decentralisation of power, local government has power to implement stricter management measures	Discourse power of local government is high, i.e. local government is able to frame goals for climate protection into policy implementation National or sub-national regional governments empower urban planners by providing institutional support for the development of credible, legitimate and salient science-policy assessment and deliberative-analytic processes National and regional authorities support local authorities by ensuring clarity about jurisdiction, decentralise policy competencies and set out time frames for local action	Somewhat

Firstly regarding available plans and policy instruments. Breda municipality is heavily involved in adaptation, both at the planning stage as at the execution of policy stage. Examples of planning include Markdal, Nieuwe Mark phase 2, water playground at Kasteelplein, and the new bill on water. Pertaining to political will, this is linked to buy in from the top. Breda is blessed to have a very enthusiastic alderman in Paul de Beer, as this stimulates the planning process. Moreover, there is a political pressure to be seen as an adaptation leader. This is reinforced by municipal employees themselves, they care about this issue and put pressure on themselves to deliver sound adaptation planning. However, when it comes to planning adaptation for the historic centre, it is a more tricky business. Heritage itself is hardly addressed in the policy documents on spatial adaptation or the municipal environmental strategy. Even more so, loss of heritage is hardly addressed.

Regarding heritage, the focus lies on telling the story of Breda, in addition to conservation and preservation. With regards to sustainable development, the Heritage vision document focuses on bringing back historic green, blue and red which supports climate adaptation as well strengthening the cultural-historical value of Breda. An example of this is the Nieuwe Mark especially, also as it is a focal point for the Interreg project. Also noteworthy is the following ambition:

"Within the scope of climate change adaptation we will develop a map showing the roofs and gables of listed monuments and buildings with a high cultural-historical value that are appropriate for construction of green facades or roofs, and placement of solar panels" (Vision on heritage, 24)

So currently, heritage covers climate change and adaptation a little bit, but spatial development projects solely look at heritage in 'normal' development projects but not really with climate adaptation in mind. How this will change with the new Environment and Planning Act cannot be predicted. Although, it is likely that the new Act leads to more holistic adaptation planning including provisions for the historic area as the Act covers preservation of heritage and calls for tackling climate change. Although the policy instruments that are currently in place do not always work:

"Our canals are a historical monument, so we are not allowed to indiscriminately develop there. In the past two years, we have moved the mooring for rowing boats from the outside of the canal to the inside of the canal. Because in the end we want to make sure that the inner ring of the canals, the road actually becomes car-free, so that you also have room to walk and for leisure, and perhaps for jogging, and that would be nice to combine with mooring places. So if you look at the protected part of the watercourse, then this here is where we viewed options with regard to berths. In this area here, some peoples' private property borders the municipal terrain next to the canal, and there is where they moor their boats. […] So we agreed with them that they could buy the land next to their property and then use it as place to moor. But as it turned out, we thought that we had mooring places outside of the designated area, but when we applied for the permit it turned out to fit just within. Therefore, our plan had to have been tested beforehand. Well, we did not, so we still have to test it. This means that now we can no longer guarantee these residents that they can moor their boats there. That is quite a disappointment, as we have passed through all the stages of the planning process. We have had stakeholder meetings and made agreements. So to get the door slammed in our faces like that is quite demotivating, as we thought we were very detail-oriented. So that has been an oversight on our part towards the development of the historical environment. Sometimes these things happen, although in this instance we think it is fairly easy to solve, by getting all the stakeholders at the table to form a solution" (Expert 2)

Considering the reflection on the presence of the sub-factor plans and policy instruments, it can be said that current spatial development plans do not incorporate heritage sufficiently. This may change with Nieuwe Mark phase 2. Furthermore, heritage management looks to create linkages to other departments, but protection against climate

change is not addressed satisfactorily. Therefore this sub-factor is considered to be not present.

Regarding the sub-factor political will and mandate, local governments are pushed to plan for their own environs. They are fairly free in their planning, i.e. agenda setting, and executing. There is little national involvement, other than the fact that municipalities are required to execute climate stresstests and develop environmental strategies. However, this changes when heritage is involved, due to the heritage act that is still currently in place. As mentioned, the new Environment Act will influence how this is dealt with but it remains unclear at the moment exactly how. Anyway, to approve plans for monuments, planning permission has to be attained from both Breda municipality and from the NCHA. Changes have to conform to law and values of the site, otherwise the NCHA will throw a spanner in the works:

"Little modification is allowed, but if you do nothing while climate changes a lot, your building will incur damage. Therefore, government supervisors should give way to what the future asks and demands" (Breda 1)

As Breda is a pilot for the implementation of the new Environment and Planning Act they do try to incorporate other stakeholders within their planning, see also sub-factor communication under Leadership.

Are the governance conditions for the sub-factor political will and mandate present? Breda has a certain freedom in agenda-setting. On the other hand, current heritage law is not conducive enough to support modification to buildings. Therefore, this sub-factor is categorised as somewhat present.

4.4.3 – Access to information

Access to information comprises three sub-factors, see Table 10. Also, the presence of each sub-factor is given in this table.

Table 10 – Presence of the governance conditions for the factor "Access to information"

FACTOR: ACCESS TO INFORMATION			
Sub-factors	**Description/definition**	**The chance that adaptation measures are undertaken is higher when**	**Presence**
Futures thinking	Access and use of information such as scenarios of future conditions, in order to inform long-term decision making	Information on future change and concomitant risks for the area are available for all stakeholders The creation of climate science and climate data fits the needs of policy-makers, making it easier for them to use it in their planning Scenarios on future conditions are accessed and used to inform long-term decision-making	Low
Guidance and information	Access to the necessary information, guidance and	There is knowledge exchange between producers of scientific and technical knowledge and potential	Somewhat

	tools to support decision makers. Information transparency and knowledge cohesion	users. Scientific assessment should be tailored to local needs in a deliberative-analytical process Local boundary organisations that have access to regional and local research institutions and engage with other stakeholders are created Local governments get guidance to how information can be used	
Monitoring	Monitoring which provides information to inform how to act and to check progress on targets	Monitoring of the HUL provides information whether action is needed Progress on implementation of adaptive measures is followed to ensure actors can step in to adjust the course of action if necessary	Somewhat

Firstly, the sub-factor futures thinking. Is information on future climate change available for all stakeholders? This is answered with a resounding yes, mostly due to the fact that the Dutch government has this policy of disseminating information about climate change on publicly accessible websites. Information for Breda can be found via CAS or on the climate portal of the Province of North-Brabant. Also, local newspapers pay attention to the changes mentioned in the provincial environmental vision. As shown above, civilians can also make use of the Waterproof together automated tool. Whether civilians make use of these sources cannot be determined though.

Additionally, information on how climate change will impact the built environment, as laid out in chapter 1.2 – Possible impacts on built cultural heritage, is harder to come by. So for city, neighbourhood or street level stakeholders can find effects and risks, while information pertaining to risk posed to individual monuments is more difficult to come by. Of course, heritage organisations such as UNESCO and ICOMOS have information publicly available, but most of it is in English. So while *available* it may not be *accessible* to laypeople.

Does the current creation of climate science and data fit the need of policy-makers? This research would argue that some climate data is not available yet on a local scale, i.e. the resolution is too high. Furthermore, information on certain themes is lacking, like future solar radiation and evaporation in inner cities, which is important e.g. for future thermal stress, and efflorescence and relative humidity respectively.

Concluding, scenarios of future climate conditions are available and accessed. Information on impact on historic built environment is available to a certain degree but not accessed (or inaccessible to the general public). Therefore, the presence of this sub-factor is considered low.

Second, guidance and information: do site managers and other heritage stakeholders have access to necessary information and have guidance and tools to support their decisions? Regarding dissemination, the local government says:

"We occasionally organise workshops around themes like this, where we look at an issue from different angles. However, sharing of that knowledge could be organised more centrally by the municipality" (Breda 4)

On the topic of information, heritage managers themselves point out the following:

"That expertise [on impacts from climate change] is not something we have in-house, so we try to get it from other places. Especially dampness in walls seems interesting to keep a close eye on. Similarly, there are many cases where you have to check if you have your information complete" (Breda 5)

Regarding local boundary organisations that have access to the necessary information, guidance and tools, this is actually strongly linked to the presence of networks, and makes more sense to be discussed there.

Pertaining to guidance on how information can be used, government themselves have the knowledge, or are working to create it. However, they want to make climate information available to other stakeholders and guide them into using it properly:

"That prioritisation was already there. We have not yet discussed a stress test, but we have a stress test at the provincial level, and we are now furthering our knowledge at the neighbourhood level and at the local level. We have put out a tender for that. Also, we want to make it available at a climate portal, so not only to exchange that knowledge with other regions, but also to make it available to residents and companies because we want tackle the issue together." (Expert 2)

Concluding, access to the necessary information, guidance and tools to support decision-makers is present. There is knowledge exchange between producers of scientific and technical knowledge and potential users. Scientific assessment should be tailored to local needs in a deliberative-analytical process, but currently creation of climate science and data does not fit needs. Therefore, this sub-factor is categorised as somewhat present.

Lastly, the municipality is looking at a form of monitoring which provides information about how to act and to check progress:

"Within the framework of maintenance and upkeep we will inspect the state of monuments, but we are not of mind to introduce a baseline and measure changes accordingly. That would be too time-consuming and too costly" (Breda 4)

So when it comes to monitoring, Breda is working towards this. Maybe individual stakeholders can be encouraged to participate. Based on this, monitoring is labelled as somewhat present.

4.4.4 – Learning capacity

This includes institutional memory, heritage as a learning resource, single loop learning and double loop learning, see

Table 11. Moreover, the table shows the presence of the governance conditions.

Table 11 – Presence of governance conditions for the factor "Learning Capacity"

FACTOR: LEARNING CAPACITY			
Sub-factors	**Description/definition**	**The chance that adaptation measures are undertaken is higher when**	**Presence**
Institutional memory	Memories and knowledge which transcends the individual Learning is central: reinforce relationships between actors	Knowledge creation involves many stakeholders from different backgrounds Memories and knowledge which transcends the individual is present and used	Yes
Heritage as a learning resource	Tapping into what can be learnt from heritage itself	It is acknowledged that the longevity of the building/area has been proven and thus warrants future protection as continued use is likely due to design and construction, materiality, use, and planning Knowledge of how to use traditional materials is passed on to future generations Heritage is used as a learning resource e.g. knowledge on what type of environmental protections have been since long been in place	Yes
Single loop learning	Ability to learn from past experiences and improve routines	Actors learn from their own past experience: self-reflection Actors learn from others: learning on a horizontal level in partnerships	Yes
Double loop learning	Learning which questions values, assumptions and policies Normative processes are at work, social and environmental knowledge can be based on values	There is public or political support or pressure in favour of adaptation measures Urban planners have a holistic understanding of the social and cultural value of a city district Adaptation of the area is sensitive of the relational structure of buildings in historical districts Knowledge on the (traditional) materials used informs protection of natural resources to repair incurred damage to ensure conservation Stakeholders use their experience to question values, assumptions, and current policies	+/-

Institutional memory relates to memories and knowledge which transcends the individual. In this case this is present within the historic make-up of the city, i.e. street planning. Also defensive waterline the Zuiderwaterlinie, the *Turfschip* trick, the weekly street market that has taken place on the market square for hundreds of years. The Begijnhof that is the eldest, still inhabited Begijnhof in the Netherlands. These are all areas that uphold Breda's unique character. Places that should be safeguarded. Breda is aware of the importance of these places, as shown in the storylines approach they have developed. Main point is to link heritage to tourism and economic benefits, but safeguarding the resource for future generations is also incorporated. Also, the public is encouraged to participate.

Reflecting on the sub-factor institutional memory, the aim is to learn from the story of Breda. This storylines approach transcends the individual. Additionally, incorporating local knowledge within municipal planning and preservation is principal. For this reason, this sub-factor is categorised as present.

Heritage as a learning resource is something that is pressed by the NCHA, e.g. in the push to use knowledge about historical canals and waterways to inform climate stresstest and adaptive practices. This is not something that municipality Breda is involved in. However, this may change with the WaVe project.

To what extent do stakeholders acknowledge that the longevity of the building/area has been proven and thus warrants future protection as continued use is likely due to design and construction, materiality, use, and planning? The following quotes make it clear that stakeholders are very aware of this:

"We argue that heritage is sustainable due to the fact that it has been around for so long. Demolishing buildings and replacing them with new developments would release much more CO_2 than renovation" (Breda 4)

And:

"For sustainable heritage management you have to look at the use of materials. Original building materials are often natural products, locally produced. They last a long time and can be recycled or upcycled" (Breda 4)

Moreover*:*

"We have the issue that there are few stonemasons capable of handling the work at Church of Our Lady. Only around three or four. We work in close collaboration with 'Monument' from Belgium, as they still have enough skilled workers and places for students. They still have students who aspire to become stonemasons, and masters who can educate them. With 'Monumentenhuis Brabant' we are looking into the possibilities of getting those students here. Although ideally, we would have enough experts in the Netherlands" (Breda 1)

Lastly:

"[slowly it is becoming more acceptable to consider biobased insulation in monuments] as you are working on the inside. Insulating material can be hidden behind stucco. You know there is biobased material fixed in that wall, but look-wise it does not matter if it is a natural or less environmentally friendly insulation product. [conservation authorities] prefer the use of a natural product, in the spirit of the monument. That type of construction material was in use 200 years ago as well, so pick that" (Breda 5)

Based on this discussion of heritage as a learning resource, it becomes clear that people in Breda stress the need to learn from the materials used in construction. They highlight that this can inform sustainable development, i.e. climate adaptation. Unfortunately, a slight

issue is not being able to pass on knowledge, as skilled workers have to be resourced from abroad. Hence, this governance condition is deemed present.

Single loop learning means whether participants have learned from past experience. With this regard, climate adaptation projects related to heritage have not taken place yet. Projects that have been undertaken focused on insulation projects. For example, Begijnhof learned from implementing insulation in the Waterstaatskerkje. Organisations depend on their partners in these kinds of energy mitigation or adaptation projects for knowledge and experience, so in that sense there is a form of single loop learning. However, when asked whether any of their partners are aware of climate impacts on their monument and have undertaken action, the interviewees could not recall at that point in time if one of their partners were aware or had taken action. They do no note that:

"When renovating a monument, often the line of reasoning is to use the same material as the original building material. However, new insights on damage cause and effect relationships may result in permission to deviate from the original material and instead use something which looks similar" (Breda 5)

This sub-factor of single loop learning is related to the sub-factors communication and networks. However, in this instance it can be said that stakeholders learn from their own experience as well as from others. For that reason, this sub-factor is labelled present.

Double loop learning refers to knowledge about values. In the Heritage vision policy document, this is an important topic. This is also linked to national policy by the NCHA, see heritage as a learning resource. Breda is looking at *waardedrijvers* (drivers of value) when it comes to their heritage. They aim to make smart combinations of these drivers of value, which can help with protection but also in city marketing, i.e. cover social, cultural, and economic domains. Connecting drivers of value and climate adaptation is not done sufficiently, yet.

With regard to the other components of double-loop learning, it can be said that normative processes are at work, where there is pressure to adapt by including more green and blue in the city. Urban planners have maps at their disposal showing the cultural-historical value of the built environment and of trees. As mentioned in section 4.3.2 Authority, current spatial development plans do not incorporate heritage sufficiently. So 'adaptation of the area is sensitive of the relational structure of buildings in historical districts' is not really applied. As said, maybe it will change with the Nieuwe Mark phase 2 and Interreg project. The next point, on keeping natural materials available for conservation, this is not addressed in municipal policy. However, this may more be a task for national or provincial governments. Lastly, stakeholders do use their experience and understanding of cultural-historical values to question other values, assumptions and current policies:

"Under the flag of climate adaptation, a lot can be achieved with greening urban areas. Though, the inner city in the middle ages was not excessively green either. There were dirt roads which aided drainage, contrarily to the paved surfaces we have nowadays. But I am not swayed by the added benefits of more fountains in the inner city for climate

cooling. Other departments are convinced, so we will have discussions about it. Additionally, the impervious surfaces in the inner city cause an increase in heat, which cannot escape. But it is not possible to green the entire inner city. Another solution is placing sail shields against the heat, but [from a cultural-historical point of view] I am not convinced that that is a good idea either" (Breda 4)

Based on the above deliberation on the sub-factor double loop learning, the following aspects emerge. Normative arguments between conservation of heritage and impact of adaptive measures on heritage are expected to happen more often. This in turn will support urban planners' holistic understanding of the social and cultural value of a city district. Second, adaptation is not yet sensitive of the relational structure of buildings in historical districts. Furthermore, knowledge on materials is not used for protection of natural capital. Considering all this, this sub-factor is categorised as +/-.

4.4.5 – Cognitive factors

Cognitive factors were defined as uncertainty, perceived capacity, and individual risk, see Table 12. This table shows the presence of the governance conditions for this Factor.

Table 12 – Presence of governance conditions for the factor "Cognitive factors"

FACTOR: COGNITIVE FACTORS			
Sub-factors	**Description/definition**	**The chance that adaptation measures are undertaken is higher when**	**Presence**
Individual risk appraisal	Individual assessments of the probability and severity of potential risks Local sense of urgency	Civic engagement with and understanding of the issues is high Problem has salience: urgency	Somewhat
Perceived adaptive capacity	Individual perceptions of the efficacy and costs of adaptation Change actors' perceptions of reasons to act, to show that change is possible, and to counter resistance by individuals or groups of actors: undermine the legitimacy of their behaviour or stance	Individual views of effectiveness and costs of adaptation are addressed	Yes
Approach to uncertainty	Openness to the uncertainties around climate change and adaptation Problem recognition	Problem recognition is high Stakeholders are open to uncertainty about future climate change	Yes

Firstly, the presence of sub-factor of individual risk appraisal is looked at. This is linked to knowledge about probability of certain events, and severity in impact. Moreover, a sense of urgency is part of the risk appraisal. Bearing this in mind, there are differences between the stakeholders in how they asses the risk. Risk assessment has been carried out by the local government, and various policy documents make not of the impact that climate

change will have on the city. Especially the potential of flooding caused by heavy rainfall and increased heat stress are acknowledged. However, the policies focus mostly on effects on people. How building material is impacted is not addressed. Interviewees also point out that this is something they have not considered yet. They understand the environmental drivers behind damage to building material,

"We are definitely aware of the fact that limestone weathers due to environmental factors, especially the combination of sun, rain, and frost. This erosion results in cracks, at the moment that water enters the limestone through these cracks and you have frost, the water expands and more cracks are the result" (Breda 1)

But how climate change is going to affect that is something new:

"We are aware that temperature and rainfall have an impact [on hour historic environment] […] It is interesting to look at what the future may bring. This is something that we have not considered yet" (Breda 4)

Therefore the potential risks of climate change is something that they want to gain more knowledge on.

However, not all actors have a clear understanding of the risks of climate change. They understand that more extreme weather is expected for the future. However, what this means for their individual buildings and surrounding urban area is often unclear. This lack of clarity about potential impact is also linked to perceived capacity, in the sense that it hampers peoples' understanding for reasons to act:

"Within our organisation we do not have someone who focuses purely on environmental issues. We do expect to have someone, especially when push comes to shove. But concerning climate and the environment, deliberation is still superficial, we do not go in-depth yet. I do believe we will in the future" (*Breda 3)*

And:

"I think it is very stimulating to look at precipitation, as it is an attention-grabbing example. Many people have experienced the impact of heavy rainfall. Maybe not every building has been affected. However, informing owners about risk and what actions they can take themselves is an excellent chance to get climate adaptation recognised" (Breda 5)

Concluding, climate change is seen as an issue for the city. However, awareness of impact on built heritage is low. This low awareness obstructs action. Therefore, the sub-factor individual risk appraisal is considered to be somewhat present.

Secondly, perceived capacity. This factor pertains to ideas stakeholders hold about potential efficacy and costs of climate adaptation measures, and reasons to act. Here, ideas differ. For municipality Breda, they have a clear understanding of potential efficacy and costs. They refer to offering civilians a certain level of service. They argue they are

changing from governing based on obligation to governing for a result. Here they argue that not every measure is cost-effective.

"It is not our intention [that our sewer system can handle any type of event]. In our urban water plan we have guidance on what we must do, and what we do not have to do. Our policies and measuring systems are aimed at achieving a desired effect. Previously, we used to be able to handle a rainfall event that is statistically plausible to fall once every two years. For us it is understandable that such an event can happen two days in a row, but for others it is more difficult to grasp. But we can still say that it is an extreme event, however, with climate change it will fall more often. In our old measuring system, we would have to comply with a T=2 event, but we were unsatisfied with how that was measured. So now we consider nuisance and hindrance. Nuisance is annoying, but acceptable for an hour or two. Once it becomes hindrance, when water enters houses or floods streets or tunnels for long periods of time, then we as municipality have duty of care. In such cases we want to look for and implement a solution that is cost-effective, no matter if it is a T=10 or T=100 event. However, if the solution is not cost-effective, then we have to explain our reasoning and what we will do instead to compensate for the hindrance. However, measuring hindrance is difficult, it is something we are not busying ourselves with yet. First we want to look at defining nuisance and hindrance, and find ways to deal with it" (Breda 2)

When it comes to reasons to act and efficacy and cost, the municipality focuses on connecting various sectors:

"Retrofitting historic green, blue, and red spaces [built environment, red], like for example with the construction of the Nieuwe Mark, not only adds to climate adaptation, but also strengthens the historic character of Breda" (Erfgoedvisie, 21)

Getting rid of impervious surfaces and increasing percentage of green space within the urban area is seen as no-regret measures. These measures not only positively affect the cultural-historical value of the city, but also peoples' impression of the quality of their environment in terms of aesthetics. Moreover, it has positive impacts on air quality, besides functioning as means to keep UHI in check. To change actors' perceptions of reasons to act and to show that change is possible, the municipality educates inhabitants about the kind of actions they can undertake:

"We organised all kinds of activities in the communication week that we just had, the 'week of our water'. This included VR experiences, recording climate videos at the climate summit for the youth we organised, countless guest lectures, and more. In this way we end up trying to get all those possible action strategies that exist out there, to increase resources and commitment" (Expert 2)

For this second sub-factor, the focus lies mainly on cost-effective measures. Actors try to link benefits, and look for no-regret measures. Hence, the sub-factor perceived adaptive capacity is considered present.

Thirdly, approach to uncertainty pertains to the actors' questions about the future. Concerning Breda, most interviewees signal that they are uncertain about what the future will hold for their monuments; how future conditions may impact the material. Actors volunteer that they are uncertain whether the historic centre is susceptible to effects of climate change:

"We do not have flooding events that often. However, it is interesting to look at what may happen in the future. This is something we have not considered yet" (Breda 4)

Also consider Figure 11. The photo was photoshopped to give an impression of what climate change may mean for the urban environment. The photo fits the common response to sea-level rise and increase in mean temperature in Breda (as well as elsewhere), which is the idea of 'Breda at sea'. Even though this is a relatively jestingly approach to the climate change problem, it shows that people are interacting with the issue, and realise that how exactly the future will look is still fairly uncertain.

Figure 11 - Is this how the surroundings of the Marquant appartment building may look in the future due to climate change? (Breda 3)

However, Breda stakeholders do recognise that climate change could become a future problem for the city. In various policy documents (UPK, Impuls Spatial Adaptation), Breda municipality makes clear that it is important to have clear definitions around climate

change and adaptation. There is a difference between climate adaptation and climate proofing. Moreover, as alluded to above, there is a difference between minor inconvenience and major impacts caused by consequences of climate change.

Nonetheless, recognising the need for climate adaptation for the city is not the same as acknowledging the problem it poses for the historic centre. Maybe this can be amended by the use of stresstests. To take away some of the uncertainties surrounding how Breda will be impacted by climate change, Breda municipality focuses on stresstests.

"We have a stresstest on provincial level, and we are now looking at using this test to get in-depth information on city and neighbourhood level" (Breda 2)

Taking the reflection on the presence of approach to uncertainty into account, it can be said problem recognition is present. Stakeholders acknowledge uncertainty about future conditions. Moreover, they can be informed by stresstests. Therefore, this sub-factor is categorised as present.

4.4.6 – Leadership

As mentioned, leadership can be looked at with help of five indicators, see Table 13. Moreover, this table shows the presence of the governance factors for the Factor "Leadership".

Table 13 - Governance conditions for the factor "Leadership"

FACTOR: LEADERSHIP			
Sub-factor	**Description/definition**	**Chance that adaptation measures are undertaken is higher when**	**Presence**
Buy in from the top	Commitment to adaptation at a senior level within organisation Integrate adaptation and mitigation in organisation and in existing plans, legal responsibility and ownership	Responsibility and competence lie with a powerful actor Senior level of organisation commits to adaptation	Yes
Motivators/ champions	Existence of individuals who are motivated and enthusiastic, who act as a catalyst for action	There are individuals (at local authority or from civil society) who inspire others	Yes
Creation of a vision	Long term visions which include adaptation at strategic level, but also short-term operational planning Give practical strategies and measures to conform to principles. Set out expectations arising from regulation and the potential benefits and establish a route to achieving outcomes	Local authorities determine long and short-term goals A pathway to achieving the vision is established	Yes
Holistic management approach	Incorporation of a systems thinking approach; managing	Policy integration is high between sectors The co-benefits to adaptation are considered	Yes

	system as a whole rather than in parts Anchor policy across all sectors		
Communication	Good internal and external communication Clear task-division	There is a clear task-division at the management level of local authorities When there is clear communication with external partners of local authorities	Somewhat

Firstly, buy in from the top. This is very clearly present in Breda, as validated by the support of alderman Paul de Beer and other members of the local council for climate adaptation. Moreover, Breda likes to be seen as a leader in climate adaptation. Therefore, they put resources into expanding their knowledge:

"As one of the top ten largest cities in the Netherlands, our aim is to be a leader in climate adaptation" (Breda 2)

Regarding other stakeholders in Breda, it is a little harder to determine the level at which leadership is incorporated. The interviewees are very interested in climate adaptation. However, since this is a fairly new topic of interest for them, there has not really been a drive to act. This also impacts the other four factors. Stakeholders involved in the management of individual buildings have as of yet not developed plans to incorporate climate adaptation. Contrarily, most have been aware of the national government's push for energy transition, and have been planning to accommodate for this accordingly. However, most are not eager to be a leader in this regard. They want more knowledge regarding the changes needed before they decide to have work done. Additionally, financial capacity plays a role, as has been discussed in 4.3.1.

Pertaining to the sub-factor buy in from the top, this is clearly present in Breda. There are an enthusiastic alderman and municipality who want to tackle climate change and adaptation. The other stakeholders are also interested in climate change and adaptation, but for them it is not a priority yet, energy transition is. However, because people in higher government functions in Breda are enthusiastic, and the others show interest, this sub-factor is regarded as present.

When it comes to motivators and champions, the municipality acknowledges that it is important to celebrate milestones. An example is the successful kids climate conference (Kidsklimaatexperience), organised for over 1100 children.

"When a project like that is successful, it is important to acknowledge that. It helps that our alderman [Paul de Beer] is proud of that achievement. The kids climate conference is nominated for an award, Missing chapter, which is a foundation of which Princess Laurentien is a patron. That nomination is great. This way the project gets more recognition, gets in the news, and that is a nice reward for working overtime" (Breda 2)

Being vocal about successful projects also helps spread the word, and may inspire others to take action. Taking this and the above into account, the sub-factor motivators/champions

is present in Breda. The enthusiastic man and the fact that achievements are celebrated by management, plus that they get in the media, help spur on uptake of adaptive measures. Thirdly, it is important that a vision is created and that pathways to achieve those goals are outlined. When it comes to adaptation of the historic centre, the main focus is on water and heritage. An example here is the Nieuwe Mark phase 2 development project and the Markdal project. Nieuwe Mark phase 2 aims to extend the current river Mark, and is a follow-up project.

"This plan has been presented to the council. When the Nieuwe Mark phase 2 will be extended, this will bring back the historic watercourse" (Breda 2)

For this project, the city has also entered the WaVe (WAter-linked heritage Valorization by developing an Ecosystemic approach) Interreg project as lead partner. This is a partnership with Ravenna, Alicante, Aarhus and the Ister Granum region, and research institutions from TU Delft and Certimac. The project aims to look at heritage and water within cities, and how that historic area can be developed. For Breda the interest lies in the following:

"Concerning the development of the Harbour area in the inner-city. How do you deal with the historical monuments in the area. Also, what are the old water systems and watercourses, how was water integrated within the city, and is this useful pertaining to water nuisance" (Breda 4)

The Nieuwe Mark phase 2, the Markdal, but also other water-related developments are mostly still in the planning phase. These are all long-term visions, and are developed by looking at different sectors. That fact means it is closely related to the sub-factor holistic management approach. Other stakeholders, like the Wijkraad are asked to get involved, and they themselves actively seek out participation too.

Regarding the creation of a vision, Breda is currently busy developing long-term planning. In this plans, they want to outline pathways to achieve goals. Therefore, the third sub-factor creation of a vision is present in Breda.

Pertaining to the fourth sub-factor, the holistic management approach, policy integration is high. In the planning stage, departments look to combine sectors and developments for co-benefits. Concerning the Nieuwe Mark, the sectors heritage, economics, and climate adaptation are combined. Moreover, Breda sees chances to combine more plans. For example, when energy mitigation projects are being carried out, this can be done in tandem with climate adaptation. Also, the long-term vision on water development is connected to the programmes of civil engineering, urban green spaces management, water boards et cetera. Climate adaptation measures are guided by projections for extreme waterlogging, droughts, or heat stress. In this way, Breda municipality anticipates the implementation of the Environment and Planning Act.

Pertaining to the other actors, they also try to combine sectors. In renovation plans, they aim to integrate conservation of the building with adapting it to the needs of current, and future, use. One reason for doing this, is because renovation planning takes a long-

term view, and once you start you want to do it right immediately. A holistic management approach increases the chance that the correct choices are made for the renovation work or adaptive reuse of the building.

Are the governance conditions for the sub-factor holistic management approach present? Breda aims to integrate the policy on all levels and all sectors of their governance (see also 4.3). in addition, heritage managers usually have a holistic approach, as it helps in decision-making regarding renovation, and by extension adaptation. Therefore, this sub-factor is categorised as present.

Fifthly, (internal) communication, and to what extent is this condition present in Breda? For municipality Breda it seems that there is plenty of internal coordination within the spatial development department. People from various sectors work together on planning. An example is the development of the new Vision on heritage:

"During the writing process of the policy document we have been in touch with other departments, especially when our policies touched upon issues that they had to deal with. In these instances we asked their opinions and visions. Is it true what we say and what we want?" (Breda 4)

Also, when it comes to climate adaptation projects, the designers are forced to develop constructions that fit in with the current architectural language of the city. Before implementation, the planned projects are tested by the heritage department to see if it fits the use and function of the area. However, sometimes collaboration between the department responsible for climate adaptation and the department in charge of heritage leaves something to be desired: see also the mooring places for boats example in 4.3.2 Authority.

Moreover, the interviewees from the different disciplines expect to have discussions in the future about climate adaptation in the historic urban area, especially when it comes to greening of roofs and placement of fountains in the designated area.

On the other side, the aim of the Wijkraad Valkenberg/Centrum is to communicate what is going on in the city centre. They already communicate with citizens, municipality, retail and horeca about a variety of topics. Including events, policing etc. they have a total of eighteen topics, and for each topic they have a volunteer who looks at that topic in depth. This volunteer communicates to the other members of the Wijkraad about updates, consecutively, the Wijkraad disseminates this knowledge. This can happen via their website, or through hearings. Their aim is to include climate change and adaptation to this list. Mostly because they have noticed that topics linked to environmental factors and sustainability have gained traction amongst the inhabitants of Centrum and Valkenberg.

As part of the Environment and Planning Act, municipalities are required to inform and include citizens about and in the planning process. The municipality aims to do so through a Triple Helix outlook; to develop spatial planning with citizens, companies and other public authorities. There are several examples where the various stakeholders meet.

Additionally, when it comes to energy mitigations and monuments, the stakeholders would like more communication with the municipality. They like some confirmations on what will not be possible due to infrastructural boundaries that Breda is not planning on

addressing, or due to provisions on placement of double or triple glazing. Once they are certain some adaptive options are not possible, they can look for alternatives.

Considering the above, the sub-factor communication is somewhat present. Municipality of Breda tries to incorporate citizens and other partners. However, other partners feel communication is something that can be improved, both on their part as well as on the side of the municipality.

4.4.7 – Multi-level governance

Factor 7, multi-level governance, comprises collaborative action and involvement in networks, see Table 14. In addition, this table shows the presence of the governance conditions for this factor.

Table 14 – Presence of governance conditions for the factor "Multi-level governance"

FACTOR: MULTI-LEVEL GOVERNANCE			
Sub-factor	**Description/definition**	**The chance that adaptation measures are undertaken is higher when**	**Presence**
Collaborative action	Urban governance involves relations between levels of state (local, provincial, and national) Shared problem ownership External coordination	The local authority has strong relations between levels of state The local authority has strong horizontal relationships: cooperation between government and society and ensures that the issue stays on the agenda Implementation of policy is done in tandem with stakeholders	Yes
Creation of networks	New network spheres of authority, create agenda for action, release resources within networks, controlling actors within networks through sanctions to overcome resistance and conflict, and alter established relationships between actors to change incentive structures Shared problem ownership International lobbying	Authority is shared between actors in new network spheres Networks set agenda for action, release resources within, control actors to overcome resistance and conflict, and increase idea of shared ownership of the problem Public problem ownership has been established, civic engagement can increase chances of implementation of devised policies Users and producers of climate data and climate science form collaborative partnerships	Yes

For municipality Breda: there is collaborative action in the sense that at times departments work together. This can sometimes be for financial reasons, to pull resources together to enable more work to be done. Or, to get a more holistic view. Because of the pending implementation of the Environment and Planning Act they expect to have to work together more closely in the future. In addition, as mentioned Breda likes to keep its role as a leader of climate adaptation. In this role, they aim to disseminate their knowledge to smaller municipalities within the region, who have less capacity.

For individual stakeholders, collaborative action is not yet on their agenda. The Wijkraad could be seen as a form of collaborative action, as a bottom-up civilian initiative to achieve collaborative action. However, here, the Wijkraad is seen as a singular entity. They highlight that they are in touch with other Wijkraden in Breda. The board member of the Wijkraad Stadshart Valkenberg notes that not all other Wijkraden in Breda have similar involvement of inhabitants (not enough human capital, see also 4.3.1 resources). As mentioned in the previous section on the sub-factor communication, the other stakeholders aim to increase their communication with the municipality. Embroidering on, they want to collaborate more often and more closely with the municipality because they think knowing of Breda's plans for the inner city in an early state will benefit them.

In this regard, when it comes to collaborative action public authorities in Breda collaborate often with other regions. When it comes to collaboration between inhabitants, other stakeholders, and the municipality, the aim is to collaborate more often to shape spatial development. There are examples where collaborative action has led to implementation of adaptive projects, see the adaptation developments discussed in chapter 4.2.3. Therefore, this sub-factor is considered to be present.

Creation of networks

Pertaining to the municipality they partake in a variety of networks on various scales:

"I will discuss the most important ones. Our alderman [Paul de Beer] is on the VNG water committee. Also, he is involved nationwide in the DPRA [Delta Plan Ruimtelijke Adaptatie, delta plan spatial adaptation], he is regionally involved in the DPRA for DPRA South. Then we have cooperative partnerships in the waste water chain, for which he is administratively active in the four regions in West Brabant and administratively active in the Baronie region. Breda is officially part of DPRA South, we are included in the Delta Plan for dekzand, *deposit of sands and clays, and we are part of the water quality track. I am a driving force behind West-Brabant cooperation in the waste water chain and regional cooperation. Additionally, I am part of the national working group for cooperation in the waste water chain. Then two other valuable networks are living garden and G32" (Expert 2)*

Besides these regional and national links, Breda also participates in international networks. Examples here are the Interreg 2seas Cool Towns initiative and the Interreg WaVe initiative. The former is a research initiative which focuses on heat stress within medium sized towns. The other is a new research initiative on valorisation of water related heritage. This is a new project in which Breda is lead partner. Pertaining to WaVe, the specificities of the research have yet to be specified, however, the aim is to look at heritage in areas with lots of water, and how to develop such areas with respect to this built heritage. It could be interesting to also look at this issue through a climate change and adaptation lens, in order to ensure such regeneration is future proof. Other networks include:

"Then we have Cool Towns, we have a Twin city agreement with Leeds [England], we have a cooperation with [...] and Zwolle, we cooperate internationally with our sister

city Yangzhou and the province of Jiangsu in China, also in the field of water. Then we have some activities in France, currently a colleague is there for a project associated with Cool Towns, and there are still a few more. Occasionally I forget which ones we participate in, the ones I just listed are networks were we are not passive participants but actively contribute" (Expert 2)

Regarding the representatives for monuments, they are part of national networks formed around that specific type of monument. They use these networks to exchange knowledge about technological advancements, and to gain ideas of how others have made changes, and how they were able to get permission from the NCHA and their local government:

"For example, take this project for greening canal houses in Amsterdam. It looked at what is possible, and what is allowed. It was a kind of pioneering project. Making the ring of canals in Amsterdam more sustainable was the theme. How can you minimise energy use. But with that project, I did not hear them say a word on climate adaptation" (Breda 5)

And:

"A tailor-made approach is required to carefully develop heritage. Development therefore takes place in dialogue with the parties involved. Preferably as early as possible in the process. From the start we want to focus on what is indeed possible. In this way, processes run smoother and faster. In deliberative dialogue we try to clarify how we want to deal with ethical issues concerning heritage in Breda" (Vision on Heritage, 23)

Bearing in mind the above, is the sub-factor creation of networks present in Breda? Pertaining to the city, the municipality participates in a lot of networks, on various levels, being regionally, nationally, and internationally. They get to engage with a lot of information this way and play an active role in knowledge creation and dissemination. Site and building managers also participate in networks tailored to their building type. This is also helpful for them, as this provides a podium for learning from others, as well as an opportunity to participate in workshops. However, focusing solely on their own building type may result in oversight of impacts or adaptive measures that would be useful to them but that they do not come into touch with due to the narrow scope of the network. However, because all stakeholders are very active, this sub-factor is present.

4.4.8 – Are these conditions present in Breda?

Based on the analysis, question eight can now be answered *"To what extent are the governance conditions identified in the literature present in Breda?"*. For each of the seven Factors, it was determined to what extent the sub-conditions were present. This resulted in a total appraisal of the presence of each Factor. This evaluation of governance conditions is presented in Table 15.

Table 15 - Presence of the governance conditions for each of the seven factors

FACTOR	Sub-factor	PRESENT	TOTAL
Resources	Technological	+/-	
	Financial	+/-	
	Human	Somewhat	
	Situational	+/-	
Total			**+/-**
Authority	Plans & policy instruments	No	
	Political will & mandate	Somewhat	
Total			**Somewhat**
Access to information	Futures thinking	Low	
	Guidance and information	Somewhat	
	Monitoring	Somewhat	
Total			**Somewhat**
Learning capacity	Institutional memory	Yes	
	Heritage as a learning resource	Yes	
	Single loop learning	Yes	
	Double loop learning	+/-	
Total			**Yes**
Cognitive factors	Individual risk appraisal	Somewhat	
	Perceived adaptive capacity	Yes	
	Approach to uncertainty	Yes	
Total			**Yes**
Leadership	Buy in from the top	Yes	
	Motivators/champions	Yes	
	Creation of a vision	Yes	
	Holistic management approach	Yes	
	Communication	Somewhat	
Total			**Yes**
Multi-level governance	Collaborative action	Yes	
	Creation of networks	Yes	
Total			**Yes**

4.5 – Conclusion

This chapter has answered questions three, four, and five. For question three it has discussed potential climate change for Breda. Moreover, it has shown what local areas are threatened, and how the heritage situated in these areas are at risk. Furthermore, it has looked at examples of how built cultural heritage in Breda's inner city can be adapted. This can be at neighbourhood or street level, or at individual building level. Not all the tools given by the municipality are currently useful for monument owners/managers.

For question four, the policy-documents, developments and projects discussed show that within policy-documents the action programmes are linked across sectors. This indicates that the municipality is coordinating policy internally. Across levels, Breda's involvement in networks shows their aim to coordinate policy on a regional and national level.

Pertaining to question five, sections 4.3.1 – 4.3.7 each looked at the presence of one Factor. Section 4.3.8 gives a total evaluation for each Factor. What stands out from this analysis? Looking at the appraisals of the seven Factors, it shows that Breda is strong in some aspects, namely *learning capacity*, *cognitive factors*, *leadership* and *multi-level governance*. This strength in these factors is mainly due to the fact heritage is highly valued by all stakeholders. They see benefits to safeguarding it, not just because of aesthetic reasons, but also for economic, educative, and social benefits. Enthusiasm for

heritage management and adaptation to climate change means that governance conditions for these Factors are present somewhere in the organisation. However, when it comes to fully integrating the sectors, those are still plans for the future, e.g. the WaVe project.

When it comes to *resources*, the presence of governance factors is mixed, as it depends on whether you assess the municipality or other heritage stakeholders. The Factor *resources* is chiefly in need of improving governance conditions for the sub-factors financial and technological. Making the situational context more conducive towards climate adaptation is difficult, as this relies on making the area more flexible: linked to *authority* sub-factor plans and policy instruments, as it needs changes in heritage laws. In the same vein, it depends on assessors of heritage planning to apply the rules a little more loosely. Reinterpreting those rules is something the municipality is willing to look at, focusing more on the change that is possible, that has co-benefits.

Looking at the Factor *authority*, what is noticeable is that there are no suitable policy instruments available to increase ability of individuals to act. Also, loss of heritage is not addressed in plans. The municipality should addressed heritage in official document on spatial adaptation or the municipal environmental strategy. Plus, as mentioned, the planning evaluators could be a little looser in applying the rule that changes have to conform to law and values of the site.

Lastly, considering *access to information*, it is clear that the science-policy interface needs to be addressed. Together with *authority*, this Factor is the least present. An explanation for this is that the governance conditions for this Factor relate to the science-policy interface: is there enough data available on climate change impacts on heritage, is this accessible to end-users, is there communication or co-creation of knowledge between producers and users, and is the environment monitored, plus are policy outcomes evaluated. The knowledge gap identified by this paper already alluded to this, that the fields of climate change adaptation and heritage management in the Netherlands are not integrated well enough yet. An additional factor that hampers integration, is the lack of climate data useful for futures thinking. These should be developed in a deliberative-analytical process. Then, regarding guidance and information, local boundary organisation can play a role in disseminating this information. For other stakeholders it should be clear who these organisations are and what they can help with. Finally, monitoring that informs how to act, i.e. what action is necessary, and to check progress is needed. Breda is planning to have some form of heritage monitoring, looking at the state of the urban heritage, in this process climate impacts should be incorporated. The next point of evaluating implementation is also important, especially considering the Kasteelplein example.

The assessment framework for adaptation in historic cities enabled a structured review of adaptation in Breda. The next chapter will discusses whether this assessment framework is generalizable First, it looks at the limitations of the method. Second, it answers question six, what do experts think of governance conditions.

Chapter 5 – Discussion

5.1 – Introduction

Chapter four has tested the governance conditions found in the literature in a case study. It found that Breda scores well for some factors and is not as strong in others. In this chapter, the generalizability of the assessment framework is discussed. Are the conditions universally applicable? That is what this discussion tries to answer. It determines the motivating conditions and barriers to adaptation determined by the interviewed experts and expert grey literature. Next, the limitations of the research method are discussed.

5.2 – Limitations of the research method

The often unique character of heritage and of inner cities make it seem like policy outcomes or content are not transferable from one place to another. With that being said, this research has focused on finding general characteristics that support uptake of climate adaptation policy in cities with a historical centre. This framework was tested using a case study. This section on limitations focuses firstly on limitations for the case study. Regarding the use of a case study method, Vogel & Henstra (2015, 110) state that "much of policy analysis to date has been in the form of individual case studies, which are instructive, but generally do not lend themselves to comparison and knowledge cumulation"

Regarding the case study method, there are some limitations towards generalisation. An inherent aspect of case study result is that by focusing on one case, the external validity is low. This study has tried to make up for it by employing a cross case method, where the use of the framework was tested in a single city and by including expert knowledge on the topic. However, it should be noted that the sample of interviewees is small. Moreover, the background of the interviewees also impacts on the knowledge they were able to share regarding stimulating governance conditions. Furthermore, the sample could be improved by including people from water boards, research institutions, or even project management, engineering and consultancy firms. This would result in a more holistic sample, making generalisations on what governance conditions are needed more robust.

Another limitation for this study is the use of qualitative methods. With qualitative research method like semi-structured interviews, you can get a different answer depending on who you are talking to. Moreover, it is possible that interviewees give answers that they think you want to hear (Brinkman, 2014). In addition, even though similar questions were asked each interviewee (see the interview guides in Appendix D), the interviews were guided by the level of expertise and affinity the interviewees had with the topic. This meant that some interviews focussed more on one Factor, e.g. learning capacity, than another. This impacts on the breadth and depth of information available on the Factors. To counter this, a triangulation of methods was used, where insights from the interviewees was compared to information gained in desk-research (see also Chapter 3).

Moreover, what could also have been a factor in the interviews was the newness of this topic. This could account for the fact that most interviewees stress the need for awareness, knowledge, and access and guidance for information. Moreover, it limits the research in the sense that not all interviewees have had hands-on experience with climate

adaptation yet. In the same vein, the researcher chose to ask the interviewees about their knowledge of successful climate adaptation projects regarding heritage. To get more insight into what could be considered 'successful adaptation', the researcher could have asked the interviewees to reflect on some examples of adaptation in HUL, and what makes the adaptive measures successful or unsuccessful in their opinion.

Secondly, there are also limitations towards the methods used to sub-questions two and three of research question three. These questions focusing on what areas are being threatened and what monuments in these areas are vulnerable, respectively. The present study looked at climate information maps. This was partly inspired by the project Noah's Ark and the use of the Climate Vulnerability Index (CVI) applied to WH properties. The CVI is a fairly new developed tool by Scott Hero and Jon Day at James Cook University (Australia), and Adam Markham of the Union of Concerned Scientists (USA), however, it has already been picked up by ICOMOS, IUCN and is supported by UNESCO (Climate Vulnerability Index, n.d.; ICOMOS, 2019) . The method is described as follows:

"*The CVI is (i) a rapid assessment tool consistently applicable to all types of WH properties (natural, cultural and mixed) that (ii) assesses both OUV Vulnerability (physical) and Community Vulnerability (economic, social and cultural) for individual WH properties. The CVI is (iii) a systematic and comprehensive approach that balances scientific robustness and credibility with a level of practicality, which enables it to be undertaken in a multi-day workshop of diverse stakeholders, and (iv) whose transparent process can be repeated to assess trends*" (Climate Vulnerability Index, n.d.)

Figure 12 - Climate Vulnerability Index shows the steps.

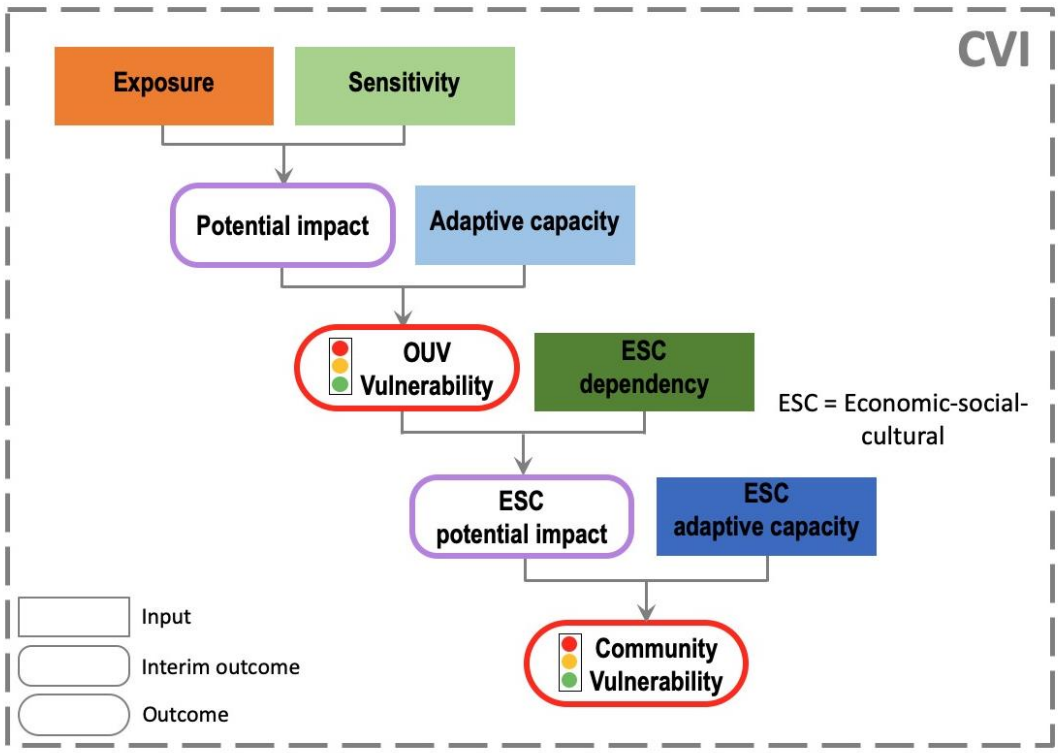

Figure 12 - Climate Vulnerability Index

The OUV Vulnerability is assessed by looking at the values that are threatened by climate change. The three main climate drivers for a specific site are included in this assessment. For Community vulnerability, the economic, social, and cultural dependency of a community on that specific world heritage site is compared to the adaptive capacity of the community. This structure makes the CVI a useful tool to assess climate vulnerability at heritage sites, but there are two reasons why it has not been employed within this study. Firstly, the author was unaware of the CVI until the first study using the method for a cultural site was released in June this year, which is the case study on Orkney (Day et al., 2019). The use of the method requires a workshop with diverse stakeholders to assess OUV Vulnerability, but organising this was no longer possible because of the limited time frame. Secondly, despite being a rapid assessment tool, the CVI requires a lot of work (Day et al., 2019), which again was not possible due to the time frame. However, for future assessments of the climate vulnerability at historic town centres the method could be very suitable.

Another limitation is the use of climate projection maps. Most of them are actually too crude, i.e. their resolution is too large, to be useful on a small, local scale. High resolution maps would make it easier to spot which areas will be pressurised due to a specific environmental factor. Also, for sea level rise more information is needed (Kovota et al, 2019). Site managers and other stakeholders need reliable information on sea-level rise to manage cultural heritage. This cannot easily be derived from climate models as there are too many variables involved that cannot be reliably estimated. This is made more difficult by the fact that variables are interdependent. Despite this, it is clear that climate models need to be tailored to needs of the heritage community. A positive example is Climate for Culture, where climate modelling was coupled with building simulation, resulting in calculation of future indoor climates and energy demands (Kovota et al., 2019). This makes it possible to develop mitigation strategies.

Moreover, this study has not employed maps on plumbing system or the BAG registration showing building years, but instead used the cultural-historical value maps that were available for the area. Using these other maps might also indicate potential bottlenecks. Another aspect of these maps is that they show a single scenario. To get a fuller picture of the range of possible scenarios, a multi-model and multi-pathway combination is required.

5.3 – Expert discussion

As mentioned under limitations, an inherent flaw in case study research is low external validity. By including expert interviews this study tried to amend that caveat, so that the framework can be used to analyse adaptive capacity in other cities with a historical inner centre. The Expert discussion aims to answer guiding research question six:

- What do experts think about governance conditions for successful adaptation in historic centres?

Which conditions are refuted or confirmed, and which need more refinement? Based on the Expert interviews and desk-research on grey literature, the following elements became

clear: Experts really hone in on the necessity of awareness of the issue. Awareness is discussed in 5.2.1. A further aspect that became clear is that the governance conditions do not fit the current subdivision in Factors. This section has adjusted for the experts' views. The other Factors are knowledge, resources, authority, and multi-level governance.

5.3.1 – Awareness

According to the experts interviewed, awareness is an important factor in successful adaptation. People often know about climate change, but many are not aware of the impact it has on monuments. Because of this they are often not yet planning for it. Awareness should be present as a precondition before adaptive measure are considered. Need for awareness becomes clear from the following quotes:

"*If you were to ask me if I have ever met someone who told me that 'climate impacts on monuments is something we have to consider more' or 'what should we do about [climate impact on monuments]', then no. But if you mean sustainability, or energy transition, then yes. Those topics come up more and more, also for monument owners" (Expert 1)*

"*I do not know any examples of a stakeholder actively planning for climate change and concomitant impact on the historic built environment. I do know the current agenda, also set by Brussels: to look at the city of the future. In those cities, built heritage is present. Cities slowly start to consider the potential consequences of climate change. […] But if you ask me, do I see that for single monuments, then based on my expertise I have to say that I do not see that yet" (Expert 1)*

Also, the experts link awareness to the need of knowledge on the topic.

"*I have not really thought about that climate change can lead to damage for historic building materials. It is something that requires more knowledge. And a different approach, but awareness is the most important" (Expert 5)*

Additionally, awareness on climate impact on natural urban heritage, i.e. listed trees, should be raised:

"*You have to change the way you think. Climate change and groundwater-levels, peak discharge and slow drainage can affect native trees. Moreover, introduction of new diseases can play a role. How are we going to deal with that? Those domestic trees, it took 50-100 years before they reached this height. Will be plant new trees, and if so, which species? We do not know yet. More knowledge is required, in addition to an awareness that climate is going to change, and knowledge on how it is going to change" (Expert 5)*

However, awareness of the issue is increasing:

"*Currently, we are very busy with the energy transition, which is a top priority for the Province and they put a lot of effort in it. Climate adaptation is considered more reluctantly. Though, it will definitely become a priority" (Expert 4)*

Also, the Experts incorporate individual risk appraisal as a factor impacting on awareness:

We are now looking at whether [future waterlogging] poses a problem [for the Zuiderwaterlinie]. As part of the heritage deals, we are looking at what the problem is, whether there is a climate adaptation problem around the Zuiderwaterlinie. I think that is mainly about flooding, but we do not yet know exactly. […] We are having a risk analysis made, the tender has been put out. That should give a lot of clarity" (Expert 3)

From the interviews and desk-research it becomes clear that awareness and political will are linked. Awareness of risk increases the political will to address the issue. Once something is seen as an issue, it becomes a problem that needs solving. Once it is a problem, it is set on the agenda.

"*Because of climate change, the political awareness on the need for climate adaptation has grown" (Expert 5)*

5.3.2 – Knowledge

Under the term knowledge, the experts construe: a) knowledge of climate change, b) knowledge on climate change impact on monuments and sites, c) knowledge on potential solutions. They also regard skills to implement solutions as part of knowledge. Moreover, knowledge availability is linked to this. Also, the governance conditions for the Factor access to information are framed as knowledge governance conditions.

Firstly, knowledge of climate change can be linked to the theme of energy mitigation and energy transition. This is something that has traction at the moment. Experts see opportunities to link these issues to climate adaptation.

Second, as mentioned in 5.2.1., climate change impact on monument and sites is something the Experts wish would get more recognition. It should be researched more thoroughly and holistically. Experts would like more information regarding this topic. Although some have knowledge on the issue that they aim to incorporate in their policies:

"*The biggest impact of climate change on 's-Hertogenbosch' heritage is related to fluctuations of groundwater-levels, as the city is built in marshland. In 's-Hertogenbosch mostly shallow foundations were used, therefore volumetric loss of peat (through oxidation) directly impacts built heritage. Up until now, this has resulted in cracks in few monumental buildings, and in the future can cause further subsidence. More broadly speaking, climate impact on monuments also affects municipal archaeology" (Expert 5)*

Thirdly, knowledge on potential solutions is important as Experts think that solutions are available, however, they remain mostly unknown due to limited dissemination. Experts consider highlight that knowledge of potential solutions changes actors' perceived adaptive capacity. If actors know that there are solutions that are available and cost-effective or have co-benefits, this can increase their reasons to act.

Regarding technical solutions, the innovation field and the heritage field do not always speak the same language. This makes it difficult to match solutions to problems. Experts argue it is important to look at what you can learn from the past, e.g. what can historical watercourses and maps tell us about historical adaptation. Can we use this for future adaptive measures? This is a theme that heritage managers are familiar with. They have affinities with cultural-historical value. To look at what heritage can teach us about adaptation is just another way to make the past come alive, while also justifying conservation.

"*'s-Hertogenbosch has been using cultural-historical information as a learning resource for almost twenty years. After the floods of the city and environs in 1995 the choice was made, inspired by heritage, to bring back old watercourses for better urban water management. This has been done as part of a European project, Water In Historic City Centres, where the city was a leading partner of the project" (Expert 5)*

Knowledge on solutions generated by historical-waterways is being disseminated more often:

"*A lot of the knowledge that we have generated are being disseminated via brochures and workshops and similar channels to cities. They are also included in the newest version of the Delta Plan, which incorporates the folder and handbook. Slowly, not everybody goes at the same pace, cities are turning towards using it. Then, engineers will also go along with it, though it also depends on how you steer it. That is when you end up at the political situation in municipalities. There, you see that our knowledge is being used more and more, like the folders and the Jacob van Deventer atlas, the city atlas. At the moment you show [how to use this knowledge] people will use it more" (Expert 2).*

Another knowledge aspect that Experts considered valuable is the development of skills. It is difficult to access knowledge about implementation of adaptive measures. Experts argue that policy implementation should also be studied and knowledge on what works and what not should be distributed. Moreover, there are not enough contractors who have knowledge on how to use certain materials:

"*Knowledge creation is very important. What happens in knowledge creation though, is that too little attention is being paid to execution. A positive point of projects like 'stroomversnelling' is that they consider implementation and create knowledge on that topic. But to get the knowledge developed in Groningen to Brabant, that is a tough job. Really, what you should do is execute local projects with local contractors to pass on knowledge on implementation" (Expert 3)*

Best practice examples are useful, but making these accessible is a challenge. What Kampen did by putting a video of their planning process of climate adaptation in the historical city on YouTube video is very smart, maybe other organisations can follow this example. Nevertheless, policy-makers on adaptation should keep in mind their own locale and context. Nevertheless, best practice examples can inspire other projects:

"*You have to consider how you are going to implement solutions in your context, and whether they fit [the cultural-historical values]. That is why I am in favour of realising local projects. This way, people can go visit and see it in real-life" (Expert 3)*

Best practice examples are also discussed in KEER (2018). Figure 13 shows some ideas on how to use the canal system in the city of Utrecht to support climate adaptation. Ideas include the use of green space to ensure a cooler local climate, to make develop squares with fountains and other water elements to provide cooling spaces. Also the geographical characteristics of the centre are to be used. Higher places should be developed to hold water for usage in drier periods, whereas low-lying places should be equipped collect water, use it or drain off. In addition to the Utrecht case study, the KEER publication has more inspiring examples. However, the negative aspect is that most projects are still in their infancy, are just ideas and not yet real-world applications. So the success of policy outcomes cannot be measured yet.

Figure 13 - Potential interventions that can transform the canal to a climate-adaptive driver for the inner city in Utrecht (KEER, 2018, 24)

In addition to these specific examples, there are also possible adaptation options developed for cities that share certain soil characteristics. An example are the *Gidsmodellen* (Guiding models) by Natuurlijke Alliantie, comprising of a collective consisting of public authorities and research organisations. Gidsmodellen are theoretical models for climate adaptation based on landscape characteristics. They give information on sustainable development of the spatial situation. Breda is situated on what is called *dekzand*, a specific type of deposit consisting of sands and clays. Potential adaptive measures for a city situated on *dekzand* can be seen in Figure 14.

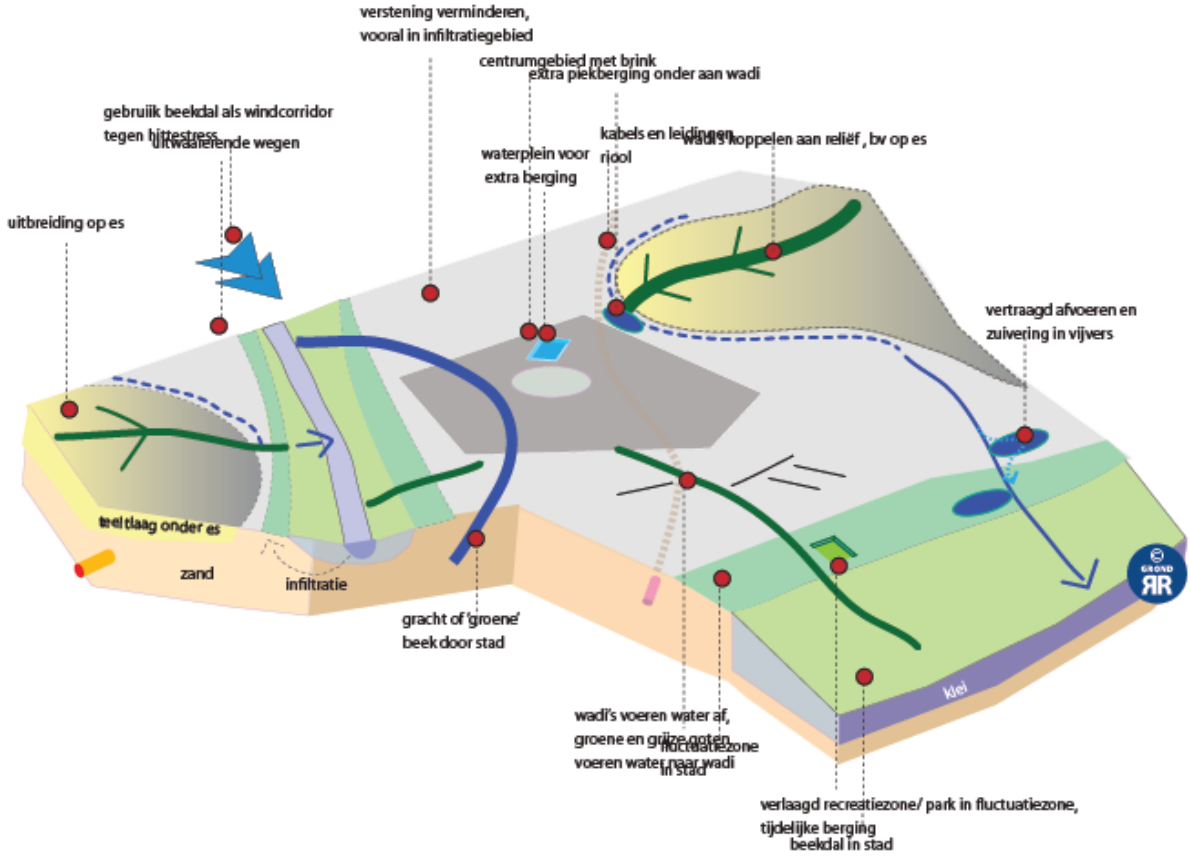

Figure 14 - Guiding model 'Dekzand / city' (GrondRR, 2016)

Then there are some other solutions that focus on adaptation of our streets. Examples are given in Kluck and colleagues (2017) study to neighbourhood types and climate adaptation. The study presents several examples of climate-proof renovation options for some characteristic typologies of residential streets. They looked at four options for renovation, and conducted a cost-benefit analysis for each option. Regarding the building characteristics of the city-centre of Breda, it fits into the description of 'stedelijk bouwblok' (urban building block). Therefore, the following could be interesting for renovation:

Figure 15 - Traditional renovation (Kluck et al., 2017, 27)

With traditional renovation of a street, water is expected to enter buildings during a precipitation event of 40mm an hour, see Figure 15. Sewerage systems are not prepared for extreme rainfall events, and water cannot be collected at street level. Figure 16 shows the comparison between traditional and option 1, which is to lower street level by 10cm. this option is the comparable in price to traditional, while the options which offer infiltration are more expensive, although these offer other benefits like control of groundwater levels. Option 1's costs are similar to traditional, but result in less damage due to waterlogging.

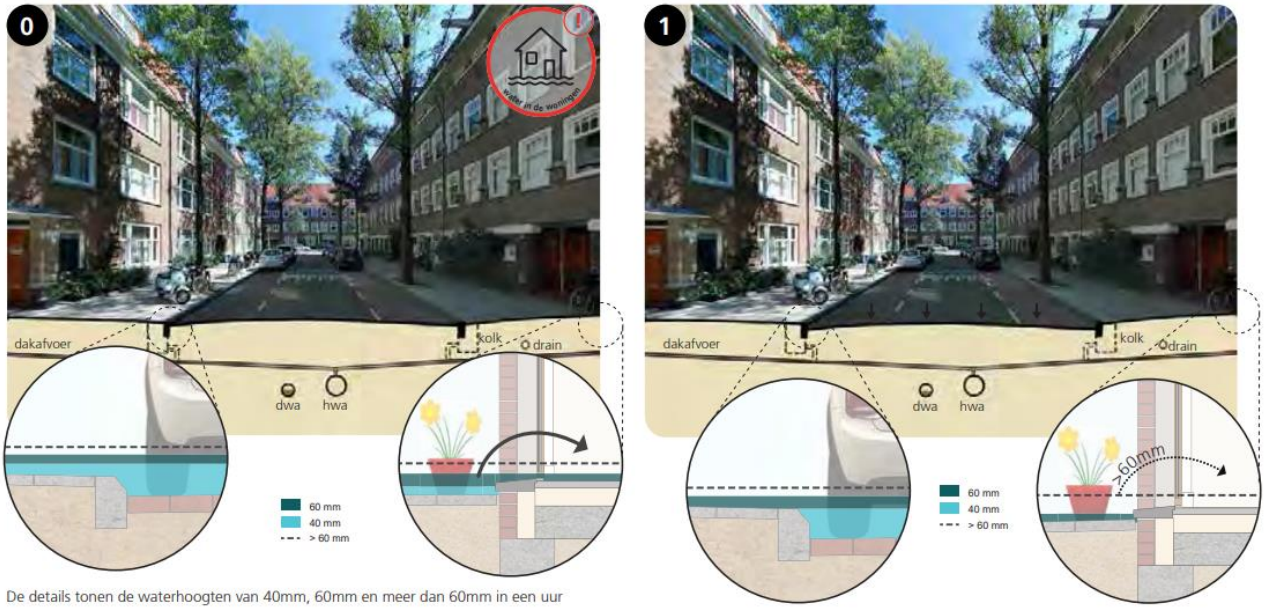

Figure 16 - Comparison traditional renovation option 0 and collection at street level option 1 (Kluck et al., 2017, 28)

Last, the experts consider access to information as part of the knowledge factor. Access to information consists of three sub-factors, being futures thinking, guidance and information, and monitoring.

Regarding futures thinking, the experts link this to awareness. They highlight that the chance that adaptive measures will be undertaken is higher when policy-makers have access to accurate climate change projections. This they can then use to get a visual of what is needed in the future, and they can plan accordingly.

Regarding guidance and information, the following was said on adaptive reuse:

"*What is very important is that in the case of adaptive reuse or renovation, you inform the owner early on about what is possible. Which increases sustainability. You have to start with that. In fact, what you need to do is ensure that you help them make choices for the procurement process. You do that in the predictive phase. That means in any case that the contractor, the builder, or the process supervisor, is aware of the possibilities. And you have to provide instruments that installers can employ to calculate benefits of sustainable development of a heritage complex" (Expert 3)*

The experts acknowledge that there are various research institutions that provide useful information. Examples are NCHA and STOWA. Also research commissioned by other municipalities or water boards is accessible to them. Moreover, they see opportunities to make knowledge more cohesive by incorporating knowledge on natural heritage.

Third, monitoring, this condition has been confirmed by the experts. They do make some additional notes, especially when it comes to implementation. They point out that not only do we have to transform our thinking about the issue, also our behaviour must change:

"*We once did a project called 'Proeftuin voor verduurzaming', to make the built environment more sustainable. It turned out that in the planning process sustainability is taken into account, but that it does not happen during implementation. So that has to do with behaviour"* (*Expert 3)*

This is also linked to the issue of awareness raised by the experts. People have to be aware of solutions or other materials they can use before they can change their behaviour. Therefore, monitoring policy implementation can help change behaviour. However, where does monitoring fit Factor-wise? On the one hand part of monitoring comes before planning, where it is linked to awareness: continuously monitoring the state of buildings provides information on how the monument is affected. Then there is monitoring during implementation, to see if our behaviour is changing: push people to work with new materials, check whether the actions that are being undertaken lead to achievement of goals. Thirdly, there is monitoring that comes after the implementation phase. Here, check the policy outcome: is the solution successful, also in the long-term?

5.3.3 - Resources

When it comes to resources, the experts mainly refer to three aspects: 1) the skills to implement technological solutions, and human capital; 2) financial resources and 3) the environmental context.

Firstly, the skills to implement technical solutions is centred on. As mentioned above, the actors regard knowledge of solutions as an essential 'knowledge' factor, and not as a resource factor. Instead, they see the skills to implement the solutions as a resource factor. This way it is more related to the sub-factor human of the Factor Resources. This condition is confirmed by the experts. Availability of skills, expertise, manpower, local knowledge and experience are all needed in adaptation planning, as has also been discussed above. However, they mainly stress the number of human capital available for the work. They argue that too few people are available:

"*Everyone would like extra colleagues to get all the work done. For now, we have to make use with the people and means that we got. The reality is that energy transition is seen at the moment as a more pressing issue, partly caused by the national context" (Expert 4)*

And:

"*A problem for heritage management is that municipalities often have too little capacity for heritage. This has also been ascertained by the Council for Culture, I myself noticed it in research towards heritage in areas with population decline. Knowledge there is very fragile. There are small municipalities where a policy-maker only has one afternoon a week to do everything heritage-related. In such instances more collaboration between municipalities would be preferable. The Province aims to address this issue by establishing support organisations. However, it is something we have to be wary of" (Expert 3)*

In this way, the skills to implement solutions are also related to the sub-factor guidance and information, in the sense that technological solutions are a tool to support decision-makers. However, it could also be grouped with perceived adaptive capacity, as knowledge on solutions can show actors that change is possible and thus change their perception on adaptation.

Secondly, the financial capacity is seen as an important resource factor. Financial capacity is important, and the Experts and literature cite the need to combine heritage with other factors as this enhances the chance to get subsidies or governmental financial assistance. It is important to link cultural-heritage values to other functions and qualities, as this will bundle financial budgets while also keeping total costs down:

"*At the moment heritage is being used, you have less maintenance costs, because sluices and pumping-engines are paid for from the water management budget as they play a part in water management, while at the same time they are being preserved. In that sense it is a lot easier to make changes then, as you can say, bearing in mind conservation, that you are adapting it to historical use and current times. That is fairly easy to get done. Especially with the public, because you can show them that their local heritage is put to good use" (Expert 2)*

Thirdly, the situational sub-factor has also been confirmed by the experts. It is necessary to have clear what the cultural-historical values of the environment are. Moreover, the spatial characteristics of the environment play a role in problem recognition.

People look for cool spaces because of the increase in temperature. Due to the historical development of the inner city we have a lot of small alleyways that provide shade. Although, an area with a large percentage of impervious surface warms up and releases this heat at night" (Expert 5)

They point out that heritage is often seen as 'difficult' and holds back development. However, they argue that in such instances, the positive qualities of the historic environment should be stressed. For example:

"*Something we come upon often is that cultural-historic factors are seen as barrier. So we try to counter that by pointing out inspiring qualities, and that some heritage still functions and can be made useful" (Expert 2)*

Adaptive measures are seen as ways to improve urban environmental factors and quality of infrastructure. A good example is the redevelopment of 's-Hertogenbosch:

"*The redevelopment of the defensive works, as established in "Den Bosch Versterkt" (1999), has resulted in the return of the old defensive works in the city scape. This return has been accompanied by the additions of parks and the placement of systems to deal with excess rainfall. Development like this leads to a reduction of UHI, although the large presence of impervious surfaces in the city still lead to a higher urban temperature than out of town" (Expert 5)*

Furthermore, the experts are looking at opportunities to use the landscape for adaptive measures:

"What we are looking at in the context of climate adaptation within the Water line are the possibilities that exist for water storage. For drought, but also for precipitation. We have inundation areas. We need space for water in the city, we need water for heat stress in the city. All things that can easily be combined with the Water line. In this sense we focus more on how you can use the area for climate adaptation" (Expert 4)

5.3.4 – Authority

Pertaining to, authority, Experts discuss planning, policy instruments, and political will and mandate. When it comes to planning, the experts discuss legal responsibility, integration, involving stakeholders, and holistic management. Regarding legal responsibility and integration, the new need for environmental strategies on a local, provincial, and national level ensure that climate change adaptation and conservation of heritage have to be included in policy. This requirement for more integrated vision on spatial development blurs the lines between sectoral responsibilities.

Additionally, the experts stress that for successful adaptation, heritage and climate adaptation have to be considered together. Conservation has to be integrated in adaption planning and vice versa. Moreover, benefits of heritage should be linked to other sectors. Ergo, there is a need for holistic management. However, the experts do stress that heritage managers need clarity when it comes to policy, as their planning is often long-term, and renovations done now should be sufficient for at least the next 15-20 years.

"*The legislation has decreed that by 2022, municipalities have determined what they will do per district, so you can anticipate that. But these plans do not have to be realised until 2030. So that means that you have a period of ten years where you are in an uncertain situation. So the question then is, should monuments be at the beginning or at the end. If you put them at the forefront of adaptation you may make investments that turn out wrong. Thus, what is important is that you look at when you will renovate and restore the building. That is the moment you decide what to do with the building" (Expert 3)*

Second, policy instruments. The new heritage deal in theory increases capacity to act, be it on executing renovation work, to forming partnerships, or generate knowledge on heritage. However, most important is monitoring, see also 5.2.1.

Third, political will and mandate. With regard to shifting mandates, the experts note that decentralisation gives municipality the means for agenda-setting and addressing aspects they consider necessary. However, they also note that shifting authority can lead to problems in the Factor Resources, while also increasing the need for collaborative partnerships:

"*The effect of decentralisation is that municipalities suddenly have to do a lot of extra work for which they lack capacity. Then you notice that collaborative programmes like City Deals play an important role. So those are things we set our sights on" (Expert 2)*

Another aspect of political will and mandate is the presence of buy in from the top and motivating actors. Experts comprise these conditions under political will because buy in from the top and motivating actors influence the level of political ambition. In this sense, OCW and NCHA can be seen as examples of buy in from the top and motivators. Buy in from the top as they are actors with responsibility and competence. Moreover they comprise senior level of organisation. Buy in from the top is exemplified for example in the heritage deals but also in national and provincial environmental strategies. Motivator of adaptation for example is demonstrated by NCHA's championing of using information of historical water courses for adaptation planning.

5.3.5 – Multi-level governance

According to the Experts, this Factor consists of the sub-factors collaborative action and networks.

Collaboration on vertical and horizontal levels is important. When it comes to water management of drainage and waterways, cooperation with the local water boards is very essential. More cooperation is also stressed by the new Environment and Planning Act, and in the new national environmental strategy .The Experts are aware the national government is stressing collaborative action. They are looking into ways to cooperate more with others.

"*In any case, what the municipality can and must do is to collaborate with the water board on all ideas pertaining to water and climate adaptation. Water boards are not always good at working together. But through water boards and their knowledge centre, STOWA - moreover we collaborate with them, we released a booklet on urban development 'cities and their subsurface' with information about where you can do something with water, how you can do something with water, what has been the natural situation. So in this way tools are developed that can end up at municipalities. Then you also see that slowly trickle down in information provision via VNG and the like. If you look at climate adaptation on the VNG website you will get a link to the large engineering firms. There are not that many, besides, they also have to look at our brochures and guides, and the STOWA, and things like that" (Expert 2)*

Moreover, the importance of collaboration becomes clear from the following quotes.

"*For climate adaptation, the water board is looking for a new position within the collaborative partnership, whereby the focus shifts from the (traditional) rural and agricultural environment to both the rural area and the urban environment. The water boards see problems arising there, also for water management, but have no formal position to contribute to the solutions" (Expert 5)*

"*As the Province, we developed plans and funded adaptive re-use plans for large heritage complexes. The advantage of this is that as a government you are forced to think along with the entrepreneur, and the municipality, and often also citizens, to come to a new position. When you talk about governance in this sense, you get a completely different playing field than when you only give a subsidy. We deploy project leaders to guide those processes, and we deploy knowledge. We have set up a knowledge programme for this" (Expert 3)*

An example of partnership in real-life:

"*We did a pilot on climate adaptation at large estates. People from the water board, people from heritage, from green management, and the owners were involved. By walking around together we got a much better picture of the problem. Together we came up with new solutions, without the site visit we would not have succeeded in that" (Expert 3)*

The above shows that collaboration becomes very important. The benefits are acknowledged by experts and the national government. The fact that is stressed as a policy instrument may lead to institutions and local governments to being more open towards others' ideas and solutions, and working together on adaptive measures. This increases the chance that successful adaptive measures are undertaken.

The experts see networks as places to generate knowledge, and where actors generate and share knowledge. Therefore these are very important. It is especially useful to participate in international networks:

"What strikes me is that what is happening internationally, is being spread very slowly among national governments, and from there trickles down to the provinces. I have learned that what you read and learn on an international scale often appears on the national agendas a few years later" (Expert 1)

Other actors also point out that international networks are places were useful knowledge is generated through EU supported projects, for example the Interreg projects. Networks are also useful for bringing together budgets for research. Moreover, the international agenda influences the national agenda, in the sense that e.g. OCW starts to pay attention on a national level to issues that have been raised on international agenda, or because they have noticed one of their counterparts doing so. So lobbying on an international level can result in an issue being put on the national agenda.

5.3.6 – Governance conditions according to experts

The abovementioned discussion of governance conditions has shown that most governance conditions are universally applicable. There really was only one condition that was refuted, which was the need for clear a task division. The reason this was refuted is related to the pending implementation of the new Environment Act, which stresses holistic management and cooperation. According to the Experts, tasks should not be divided according to sectors, but instead should be tackled together.

5.4 – Generalizability of framework

Given the limitations regarding case study method, mainly low external validity, this study has aimed to address that by including a discussion of expert insight on governance conditions. Also, desk-research on grey literature was used to distil governance conditions in practice. Based on the expert discussion, it becomes clear that the governance conditions for successful adaptation in historical inner cities are universally applicable. There are certain limits though, which have been discussed in 5.2. Nevertheless, the expert discussion also shows that the assessment framework gives a good structure to research the governance conditions. However, based on the expert interviews, the division of factors and sub-factors has been adjusted. This also confirms what has been found in Breda, namely that more awareness is needed.

Chapter 6 – Conclusion

6.1 – Introduction

This final chapter ends the paper with some concluding remarks. The main objective of this research is to address the knowledge gap identified, namely what governance conditions are required for successful adaptation to climate change in historic cities in the Netherlands. An assessment framework has been proposed which is applied to the empirical case of Breda and supplemented with information by the Expert analysis. The seven factors found were studied through a triangulation of methods for data collection. Studying policy-documents gained insight in the prevalence of the factors in these formal and objective documents. Supplementing this with in-depth understanding from the interviews made it possible to get a better understanding of the governance conditions necessary.

Firstly, the paper refers back to the research objective. Here, the main research question *"What governance conditions are required for successful adaptation to climate change in historic cities in the Netherlands?"* is answered. Second, the theoretical and practical contribution of this research are considered. Lastly, some recommendations for further research are given. The main objective of this research is to address the knowledge gap identified, namely what governance conditions are required for successful adaptation to climate change in historic cities in the Netherlands. An assessment framework has been proposed which is applied to the empirical case of Breda and supplemented with information by the Expert analysis. The seven factors found were studied through a triangulation of methods for data collection. Studying policy-documents gained insight in the prevalence of the factors in these formal and objective documents. Supplementing this with in-depth understanding from the interviews made it possible to get a better understanding of the governance conditions necessary.

However, the first issue that should be touched upon is: what is "successful" adaptation. As mentioned in 4.3, the literature discussed did not clearly define what is meant with the term "successful". What do you need for successful adaptation? According to Vandergert and colleagues (2015, 5-6), institutional entrepreneurs are important for successful adaptive governance. They argue that networks of actors and institutions within social-ecological systems are often complex, and institutional entrepreneurs are able to make connections between various actors. The role of institutional entrepreneurs is linked to awareness and knowledge: spotting windows of opportunity and institutionalising innovation as well as enabling dissemination of knowledge, plus stimulating innovation and partnerships.

Vandergert et al. (2015) give indications on what we need, however, that is still not an answer to what success entails. Adger, Arnell and Tompkins (2005) determine when you can call adaptive measures successful. They argue that

"the success of an adaptation strategy or adaptation decision depends on how that action meets the objectives of adaptation, and how it affects the ability of others to meet their adaptation goals. Crucially, an action that is successful for one individual, organisation or level of government may not be classed as successful by another. Success therefore depends on scale of implementation and the criteria used to evaluate it at each scale" (Adger, Arnell & Tompkins, 2005).

Moreover, effectiveness, efficiency, equity and legitimacy are all elements important in judging success, however their importance varies over time. Next to this, they note that there is a temporal factor at play when it comes to determining success. Something that is perceived successful in the short-term may turn out to be unfavourable in the long run. To conclude, the authors state that successful adaptation is adaptation that "that balances effectiveness, efficiency and equity through decision-making structures that promote learning and are perceived to be legitimate is an ideal from which much adaptation inevitably diverges" (Adger, Arnell & Tompkins, 2005, 83). Therefore, the following conditions underline successful adaptation: using windows of opportunity, using innovation and knowledge, collaborate in partnerships, setting up goals for climate adaptation that have to be met together with stakeholders, and during the implementation phase monitor whether action is being taken to fulfil those ambitions.

6.2 – Required governance conditions

The central research question is:

What governance conditions are required for successful adaptation to climate change in historic cities in the Netherlands?

The assessment framework based on conditions found in a literature review have been tested in Breda and with experts. The results from Breda show that the framework gave a good structure to analyse adaptation governance in a single city. Based on the experts insights, some adjustments regarding division in factors and sub-factors have been made. The conditions found to be important there are compared to the assessment framework as used for the case study. This results in the following assessment framework:

Table 16 – Revised assessment framework: governance conditions needed for successful adaptation in historic city centres

FACTOR	Sub-factor	Governance conditions needed for successful adaptation
Awareness	Awareness of climate change	Awareness of climate change leads to political will to address the issue
	Monitoring state of buildings: Awareness of climate change impact on monuments and sites	Awareness of climate change impact on monuments and sites leads to political will to address the issue
Knowledge	Futures thinking	Policy-makers should have access to local projections of climate change. Knowing what areas will be impacted and how increases chance that action is undertaken

		Knowing what monuments will be impacted and how increases chance that action is undertaken
		Local projections match the needs of end-users
	Guidance and information	Stakeholders are guided in how to use climate projections
		Information should be available and accessible
		Information is holistic
	Potential solutions	For technical solutions, have the innovation field and the heritage field speak the same language. This makes it easier to match solutions to problems.
		Knowledge of potential technical solutions addresses perceived adaptive capacity: increases the chance that adaptive measures are implemented
		Local Best practice examples should be made accessible
	Heritage as a learning resource	Knowledge of workings of historical water systems increases chance that adaptive measures are mindful of heritage values
		It is acknowledged that the longevity of the building/area has been proven and thus warrants future protection as continued use is likely due to design and construction, materiality, use, and planning
		Knowledge of how to use traditional materials is passed on to future generations
	Single loop learning	Actors learn from their own past experience: self-reflection Actors learn from others: learning from best practices or from partnerships
	Double loop learning	Learning which questions values, assumptions and policies: stakeholders use their experience to question values, assumptions, and current policies regarding heritage and adaptation
Resources	Skills to implement technical solutions	Availability of skilled workers increases the chance that adaptive measures are successful
		Push people to work with 'new' materials
	Human capital	Local government should have enough people with necessary expertise available to tackle the work, i.e. have satisfactory planning and technical capacity
	Financial	Show co-benefits of adapting heritage: increases budget or subsidy opportunities
		Use heritage: adapting it to historical use and current times. If it still functions getting budget is easier
	Situational	Spatial characteristics of the HUL inform problem recognition. This includes interplay between heritage and modern development
		Stress quality of the HUL for other sectors
		Use the characteristics and values of the HUL to inspire adaptive measures
		Be flexible: look at what is possible without damaging cultural-historical values of HUL
Authority	Planning & Policy	Have legal responsibility to adapt/have adaptation planning: local, provincial, national environmental strategies
		Integrate conservation of heritage in adaptation planning

		Involve policy-makers and stakeholders from various backgrounds in the development of conservation and adaptation strategies for the area from the start
		Create a vision with long-term goals
		Address potential loss of heritage
	Policy instruments	Ensure policy instruments are mindful of specific needs of HUL
		Make use of heritage deals
		Monitor implementation: see if our behaviour is changing Check whether the actions that are being undertaken lead to achievement of goals
		Monitor policy outcome: is the solution successful, also in the long-term
	Political will and mandate	Make use of local agenda-setting power
		Buy in from the top: responsibility and competence lie with a powerful actor. Senior level of organisation commits to adaptation
		There are local motivators/champions who push for adaptation
Multi-level governance	Collaborative action	Vertical: seek cooperation with province or national bodies
		Horizontal: seek cooperation with other cities, water boards
		Create partnerships with local actors
	Networks	Capacity to generate knowledge in networks is higher. Participating in networks increases chance of knowing about or developing suitable adaptive measures
		Networks have agenda-setting powers. This can be used for lobbying purposes

To conclude, this study has shown that some conditions are more essential than others. Awareness, knowledge, and access and guidance for information and their governance conditions are highlighted as the most important factors influencing successful climate adaptation in historic centres. In particular, awareness is very important; it can even be considered as a pre-condition for adaptation. Especially, more awareness regarding the fact that climate change will impact monuments and sites is necessary. Next, this awareness should be included in local site management plans, as well as in the various municipal, provincial, and national environmental strategies.

Second, knowledge creation is very important. This study has found that besides awareness of the fact that climate change is impacting HUL, more knowledge is needed on how Dutch heritage is affected. Especially local projections are needed. For this, a collaboration between end-users of scientific knowledge and the generators of knowledge is necessary. Moreover, this information should be provided in a way that is accessible to laypeople. Regarding knowledge on potential technical solutions, more knowledge is needed on solutions for materials. These options should be generated in test projects. On street and building level, local best practice examples should be available. This way, people have easy access to examples which can inspire them to take action. What is very important regarding *successful* adaptation is the fact that heritage should be used as a learning resource. Knowledge of workings of historical water systems increases chance that adaptive measures are mindful of heritage values while also making use of the

characteristics and OUV of HUL. Additionally, regarding buildings and sites, their longevity has been proven and thus warrants future protection as continued use is likely due to design and construction, materiality, use, and lay-out. However, for this we need to ensure that we pass on knowledge of historical architecture and traditional materials. Moreover, stakeholders should use their experiences to question values, assumptions, and current policies regarding heritage and adaptation. This ensures longevity of conservation as well as solutions that are successful, because they will have more legitimacy. This way, adaptation is mindful of the historical context.

Third, regarding resources, skills, human capital, financial capital, and an understanding of the context are all important. Regarding skills, we need skilled workers who can undertake highly specialised renovation work. Moreover, we need to push contractors to work with 'new' materials so they can develop their skills. People are reluctant to use material that they are unfamiliar with, due to a lack of training on how to implement this. This should be addressed. The more familiar contractors are, and the higher the chances that they use preferred material in their projects. Pertaining to human capital, government organisations should have enough people with necessary expertise in place, especially with the new Environment and Spatial Planning Act just around the corner. Also an important Resource sub-factor is financial capacity. To increase financial capacity stakeholders should show the co-benefits for adapting heritage for other sectors, e.g. tourism or health. In addition, using heritage means getting budget for maintenance and/or renovation is easier. Last, regarding the situational context of the inner city, this is closely related to the knowledge sub-factor heritage as a learning resource. However, here, the interplay with modern development is stressed. Also, the quality of HUL that impacts on other sectors is important. Heritage itself is used to inspire adaptation to the area as a whole, not just the listed monuments. Moreover, regarding modern development in the designated area more flexibility in applying regulation is required.

Fourth, pertaining to authority, planning and policy, policy instruments, and political will and mandate are important sub-factors. Planners should have a more holistic view of the spatial characteristics and values of the historic urban landscape. In the planning process, all stakeholders should be involved from the start. Moreover, the vision itself should be long-term, and address potential loss of heritage for certain places. Regarding policy instruments, the most important governance condition is to monitor implementation. Checking whether the decisions and actions actually lead to achieving the goals set out in the planning process is for successful adaptation. However, what will really drive uptake of adaptation are buy in from the top and motivators. Having the senior level of organisation commit to adaptation and/or local stakeholders who champion adaptation can enthuse and inspire others to take action. It can cause a snowball effect.

Last, multi-level governance is also beneficial for successful adaptation in historic city centres. Collaborative action with other stakeholders combines skills, human capital and financial resources, as well as knowledge of potential solutions. Moreover, integration with other levels of government ensures a more holistic view, and thus adaptation measures that are more effective, efficient, and legitimate. Another excellent way to generate knowledge is participation in networks. Networks usually form around specific themes, so they can provide a depth of information regarding a specific topic, e.g. adaptation of religious heritage. Moreover, networks have agenda-setting powers, which can be used for lobbying purposes.

6.3 – Recommendations

The following recommendations on conditions for adaptation of the historic urban landscape are given. Municipalities can increase the chance that adaptive measures are undertaken by taking the following steps:

First, for individual monuments, the ball is in the owner's court. The initiative to undertake action has to come from them. The owner, or site manager, can be the municipality themselves, or other stakeholders. Other stakeholders sometimes lack access to knowledge, so municipality can help address that. The municipality can kickstart action by:

1. Risk mapping: find areas that are at risk of climate change and determine which monuments are in that area
2. Determining for each climate change driver what the impact will be on the monuments in that area
3. Disseminating this knowledge to stakeholders: spread awareness
4. Determining together with public and private stakeholders what solutions are available, and what are the most favourable. This is context-specific: requires knowledge on the cultural-historical values and requires technological knowledge about the solutions plus the skills to implement it.
5. Formulating plans + arranging funding/subsidies. Get permission. Keep in mind that people who are involved in the development of the plan are not allowed to be in the review committee
6. Implementation
7. Monitoring policy outcome: does the implemented solution work? Are stakeholders satisfied with the solution? What could be improved about the process?

Second, for street and neighbourhood level, municipalities should take a leading role as they are responsible for public urban areas. Municipalities can increase the chance that adaptive measures are undertaken by:

1. Keeping cultural-historical value map up-to-date. Continually incorporate new insights into HUL in cultural-historical value assessments and maps
2. Risk mapping: find areas that are at risk of climate change and determine which monuments are in that area
3. Determining for each climate change driver what the impact will be on the monuments in that area
4. Looking for information and guidance in the networks they participate in for potential adaptive solutions. Is enough knowledge available? Are skills present? If not, engage in partnership to create knowledge (e.g. Interreg project, City Deal)
5. Looking for local knowledge about the area: incorporate citizen knowledge, incorporate heritage as a learning resource
6. Starting planning process by including public and private stakeholders from the beginning. Determine short-term and long-term goals for the area and include other governmental sectors (e.g. health, education, tourism) for a holistic vision that bears in mind the cultural-historic value of the area
7. Formulating plans + arrange funding/subsidies and necessary permits
8. Implementation

9. Monitor implementation phase: do the actions that are being undertaken drive towards meeting goals? How are set-backs managed?
10. Monitoring policy outcome: does the implemented solution work? Are stakeholders satisfied with the solution? What could be improved about the policy process?

6.4 – Further research

Future research could focus on evaluating applied adaptation policy, i.e. the outcomes, in a few years' time. Climate change adaptation in historic town centres will be a better understood concept, and thus comparing policy by scoring with evaluative criteria will be a possibility. Moreover, more knowledge regarding successful adaptive measures is needed. For this, a clear definition for *successful* should be established.

Then there are certain topics that are on the fringes of this study, being accountability, inter-generational justice and equity. These are topics studied within the field of climate adaptation and in the field of heritage research. It could be interesting to combine these strands of academic research.

Moreover, as multiple interviewees indicated, there can sometimes be a "language barrier" between disciplines. This underscores the need for a dialogue between the research communities involved in climate change projections and users of these climate information in the cultural heritage sector. This will help translate current knowledge in a language that is understood by both, and make clear what types of climate knowledge are currently lacking and necessitate further exploration. This will help realise practicable information which can stimulate adaptation and precautionary measures to protect not only built heritage, but also natural or intangible heritage.

With regard to using CVI to assess risk at historic urban landscapes, future research into governance conditions could study this by carrying out participatory action research. In participatory action research, the researcher actively engages in the study and is not just present as an observer (Winter, 1987). Action research aims to address the problem at hand while furthering the goals of social science simultaneously. In addition, while the system is studied, the research collaborates with the stakeholders within the case to change the undesirable situation into a desirable situation. In CVI, the OUV Vulnerability and Community Vulnerability are both researched by organising workshops for all stakeholders. These could be led by the researcher. In that way, you can study the system (governance conditions needed for climate adaptation in HUL), discuss with the local population what the most desirable outcome is (engage in co-learning), analyse the causal mechanisms that lead to that desirable outcome, and if necessary steer towards them. Therefore, the study would address the problem at hand, i.e. climate risk at a heritage site, while also studying the system, generating knowledge on necessary governance conditions.

This study also delved into the large variety of possible impacts of climate change on built cultural heritage. One of the effects mentioned in this study is creep (see 1.2.4) caused by daily fluctuations in relative humidity. Anzani, Garavaglia and Bindi (2009) explain creep as follows: "if a vertical constant load is applied to a masonry specimen, an increase in the vertical and horizontal deformation takes place, which is commonly subdivided into three

phases: the so-called primary, secondary and tertiary creep [...] [whereby tertiary creep is] characterized by strain developing at increasing rate and ending with the specimen failure". Creep is accompanied by visible cracks in towers, vaults, and pillars (Sánchez-Beitia, Luengas-Carreño & Crespo de Antonio, 2017). Creep can be caused by wetting and drying cycles as mentioned by D'Ayala and Artem (2016), but also by redistribution of stresses in time caused by drying shrinkage and drying creep (Ferretti & Bažant, 2006). There are numerous studies on masonry and brick failure due to creep, however, this study did not find any that looked at climate change and potential impact on creep. This could also be influenced by the fact that there are ongoing structural integrity conservation projects that fail to look at creep (Sánchez-Beitia, Luengas-Carreño & Crespo de Antonio, 2017), meaning it is already an ugly duckling in structural integrity and building failure research. However, this could be an interesting topic for further exploration, also with regard to expected increase in UHI and additional heat stress in building walls in the future caused by solar radiation.

Additionally, more research should be done on the impact of temperature on built cultural heritage, especially bearing in mind the UHI effect. This is definitely a theme that is understudied at the moment. There are studies in building failure that look at influence of temperature, especially medieval stone towers, but they do not link these to future climate change and thus to potential failure of other buildings.

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Appendix A – Climate change in the Netherlands in-depth

A.1 – Temperature and precipitation

Firstly, regarding temperature it is important to make a distinction between variances in higher and lower temperatures. The four KNMI'14 scenarios show that average temperature will rise in the future. Mean temperature in the Netherlands will rise faster than globally, especially in coastal areas. This rise in temperature is caused by a combination of the rise in air temperature both above land and sea, and an increase in water temperature (KNMI, 2014, KNMI, 2015). Cold days and periods of frost are projected to decrease in the Netherlands (KNMI, 2014; EEA, 2017). On the other hand, periods of consecutive hot days, i.e. number of heatwaves, will increase (KNMI, 2015). Warmer temperatures mean milder winters, changes to climate zones, higher temperature of surface water, and more frequent extremes, e.g. more heat stress and summer smog (NAS, 2016; EEA, 2017). Heat stress is exacerbated by atmospheric pollution (which includes high levels of ozone and summer smog), warmer summers and an increase in frequency of continuous warm periods, which worsens air pollution (NAS, 2016).

Concerning precipitation, the number of precipitation events will increase (EEA, 2017). Currently, intensity of such events is already higher compared to last century, and this is projected to rise in the future (KNMI, 2014, KNMI, 2015). The KNMI'14 projections expect an increase in the frequency and intensity of extreme rainfall in all four scenarios, and in all four seasons of the year (KNMI, 2014, KNMI, 2015). Increase in peak precipitation means an increased risk of flooding leading to increased incidence of interior mould and mildew (NAS, 2016). Additionally, the length of continuous wet periods is expected to increase (KNMI, 2014, KNMI, 2015). An increase in wetter periods leads to e.g. soil compaction, and increased risk of flooding in primary and regional waters (NAS, 2016). Moreover, increased precipitation leads to increased river discharge, which becomes less predictable across seasons (EEA, 2017). Additionally, more intense precipitation events are expected to lead to higher probability in frequency and intensity of winter and spring river flooding, and urban floods (EEA, 2017). Higher river flow effects increased erosion along upper reaches and increased sedimentation elsewhere, increased peak discharges and flood risk in primary waterways, and more frequent flooding in area outside dykes (NAS, 2016). Furthermore, it leads to increased groundwater drainage from higher sandy areas, in turn worsening risk of damp in homes. Lastly, it leads to higher atmospheric humidity (NAS, 2016)

A.2 – Sea-level rise

Because the Netherlands is a very low-lying country with large areas that lie below sea-level, a large percentage is vulnerable to flooding (KNMI, 2015, NAS, 2016). The parts of the Netherlands at risk of flooding will increase in accordance with sea-level rise. The risk and scale of flooding will increase because of sea-level rise, especially when combined with changes in storm intensity and storm surges (EEA, 2017). Sea-level rise accounts for higher water levels, which mean more frequent flooding in area outside dykes, combined with a higher risk of flooding overall (NAS, 2016). Moreover, it means salinisation of river estuaries and of groundwater in coastal areas (NAS, 2016).

A.3 – Extreme wind

Not only the strength of the storms is important, but also the wind direction. Van den Hurk, Siegmund, and Klein Tank (KNMI, 2014) conclude that the most recent climate models suggest no changes in the wind climate in the next century, regarding mean wind conditions, low wind conditions, and extreme wind speeds. However, climate models do identify an increase in extreme wind from westerly directions, i.e. from the North Sea. In contrast, northerly winds over the North Sea cause the highest sea surges along the Dutch coast (KNMI, 2015). The number of days with southerly to westerly wind directions, which is the prevailing wind direction, will increase in the GH and WH scenarios in winter, and decrease in the GL and WL scenarios. Moreover, EEA (2017) expects stronger storm surges for North Sea countries, and therefore a higher risk of severe winter storms and possibly also autumn storms.

A.4 – Relative humidity, solar radiation, evaporation and drought

Ruosteenoja and Räisänen (2013) point out that changes in relative humidity and solar radiation have several practical implications. They note that these variables influence surface energy balance, and therefore impact actual and potential evaporation. Evaporation impacts soil water balance. Regarding changes to relative humidity in the Netherlands, this is expected to decrease overall (NAS, 2016), but especially in summer months (Ruosteenoja & Räisänen, 2013). NAS (2016) points out that a reduced atmospheric humidity meaning an increase in particulate matter.

Pertaining to solar radiation, KNMI (2014) identifies an increase between 1981 and 2013. KNMI'14 scenarios associate this with a more transparent atmosphere following the successful abatement of air pollution (KNMI, 2015). Ruosteenoja and Räisänen (2013) show that the solar radiation in the Netherlands in the 21st century is expected to increase in spring, summer and autumn, and stay the same in winter months, when compared to the period 1971-2000. Moreover, KNMI'14 scenarios expect an increase in solar radiation under cloudy suggestions, which they ascribe to lessening of air pollutions. Therefore, solar radiation is expected to increase in the next century (KNMI, 2015).

As mentioned above, relative humidity and solar radiation influence evaporation. KNMI (2015) add that higher temperatures are also a driver for increased evaporation. Potential evaporation refers to the amount of evaporation that would occur if sufficient water is available in the soil (KNMI, 2014). In KNMI'14 storylines the potential evaporation increases linearly with solar radiation. In addition, the potential evaporation increases by about 2% per degree of temperature rise (KNMI, 2015). The NAS projects that higher levels of evaporation lead to increased salinisation of groundwater in coastal areas. Moreover, they project increased subsidence in peat areas, meaning higher risk of damage to, and higher maintenance costs for, infrastructure and the built environment, as well as being a threat to cultural heritage (NAS, 2016). Regarding the fourth variable, droughts will increase in frequency and intensity, especially in summer (EEA, 2017). Dutch summers are likely to be drier (KNMI, 2015) which increases changes of periods of drought in the Netherlands, where drought is defined as "a shortage of rainfall of an order that may

be expected to occur only once in ten years (NAS, 2016, 8). Droughts are expected to be between 5% and 25% more prevalent by 2050 than in the period 1981 to 2010 (NAS, 2016).

A.5 – Extreme weather

EEA (2017) point out that extreme weather and climate events are driven by global climate change and are more likely to occur in the future. Weather extremes such as heatwaves, heavy rainfall and hailstorms will become more frequent and will cause even greater damage and personal injury than in the past (NAS, 2016). More events will also mean higher associated costs., e.g. in June 2016, hail and rainstorms in the southern Netherlands caused damage totalling over 700 million euros (NAS, 2016). The KNMI'14 scenarios ascribe this rise in hailstorms to the presence of water vapour. More water vapour implies more heat released from condensation. This process leads to more movement in clouds, which in turn means more hail and lightning, as well as hailstones with a larger diameter (KNMI, 2015). KNMI'14 (2015) projections expect that for each degree of warming the number of lightning strokes increases by about 10-15%. Moreover, the number of lightning strikes and winds capable of causing damage or personal injury is also expected to rise accordingly (NAS, 2016). Regarding visibility and fog, visibility is expected to increase in this century. This is associated with a reduction in hours of fog per year for all four scenarios (KNMI, 2014, KNMI, 2015).

Appendix B – Climate change impacts on built cultural heritage in-depth

B.1 – Temperature and precipitation

Figure 17 - Waterlogging at Paleis het Loo (RCE, 2009)

Pertaining to colder periods, periods of frost are projected to show a slight decrease. Therefore it can be expected that there will be less freeze-thaw and less wet-frost cycles in the future. During a period of frost, water particles embedded in wall cavities will freeze and expand, thereby shattering the porous material (Proudfoot, 2011; Sabbioni, Brimblecombe & Cassar, 2012). Additionally such freeze-thaw and wet-frost cycles damage soil structure which in turn can damage archaeology (Sabbioni, Brimblecombe & Cassar (2012). Another consequence of frost cycles is decay of clay containing materials, e.g. sandstone. In this process, wetting induces the swelling of clayey binder, which expands when frozen. This leads to deterioration. Over time, clay containing materials disintegrate completely. Process is an interplay of increased precipitation and frost. The number of absolute events is expected to rise in north Netherlands but to decrease in south Netherlands. This is due to the fact that periods of consecutive precipitation and intense downpours are expected to rise in winter, in combination with higher chances of frost in north Netherlands when compared to south Netherlands, where chances of frost are lower. However, since more precipitation means more water retained in clay, the damage caused by this process is expected to be much higher than it currently is.

Regarding higher temperatures, weakening of building facades due to thermal stress is expected to increase (UNESCO, 2007a). Ortiz and colleagues (2014) note that increased temperatures affect texture and surface of granite, brick, marble and limestone. Regarding texture, thermal stress causes chipping off of pieces (also known as spalling) and efflorescence. Efflorescence due to temperature has three consequences, being cracking, fragmentation, and fracturing of the texture. The surface is altered by fracturing and cracking due to thermal stress. Both textural and surface decay lead to loss of material (Ortiz et al., 2014). As mentioned, NAS expects the Urban Heat Island effect to increase, which can have an impact on temperature stress in urban areas.

Changes in precipitation are expected to have a large impact on built heritage. Water damage comes in various forms. Regarding the scenarios for the Netherlands, increase in intense downpours, i.e. more days when precipitation exceeds 20 mm, results in overloading of roofs, gutters, hoppers and downpipes. Moreover, intense downpours are a threat to architecture constructed of unfried materials, e.g. wattle and daub, adobe or cob (Sabbioni, Brimblecombe & Cassar, 2012). However, these building materials are mostly used in farms, which are not really present in historic city centres. Therefore this effect may be ignored in this study. Intense downpours and days with consecutive precipitation also temporarily increase the moisture levels in building material. Additonally, as Cassar and Pender (2005) mention, historic drainage systems may not be equipped for dealing with heavy rain as they are too small for the expected volume. However replacement of rainwater drainage systems in historic buildings is tricky, because it could mean that architectural features have to be altered, which requires planning permission, but also this may alter grounds for designation i.e. could change the intrinsic value of the property. Alterations may also damage integrity and authenticity of the structure.

Regarding the consequences of intense downpours, severe rainfall can cause ground subsidence, which in turn leads to the decay of stonework (Sabbioni et al., 2006). Moreover, events with consecutive precipitation for five days or more are expected to rise. Such long rainy periods result in accelerated deterioration of organic as well as inorganic materials due to 1) changes in water volume in the material, 2) increased risk of biological attack (see also below), 3) frost damage if the event coincides with a period of freezing weather (see also abovementioned freeze-thaw and wet-frost cycles), and 4) triggering of natural disasters by amount of precipitation, such as floods (see below) and landslides (ground heaves) (Sabbioni, Brimblecombe & Cassar, 2012). Extreme variations between precipitation patterns, thus in the moisture levels of the walls, can cause three processes to happen in masonry works, being salt crystallisation, erosion caused by water flow, and biodegradation (Sabbioni et al., 2006, UNESCO, 2007b, UNESCO, 2006). Firstly, salt crystallisation is an indirect biological consequence of water damage, as water acts as a medium for migration of salts (Van Hees & Lubelli, 2012; Sabbioni, Brimblecombe & Cassar, 2012). It works in tandem with relative humidity, where a combination of the presence of water and lower relative humidity increases the potential for salt crystallisation. These salts involved are mainly sodium chloride, and hydrated salts like magnesium sulphate and sodium sulphate. Pertaining to the latter salts, these exert a higher pore pressure and therefore are a bigger threat (Sabbioni, Brimblecombe & Cassar, 2012). Salt crystallisation mainly attacks Gothic architecture in soft porous stone (Sabbioni, Brimblecombe & Cassar, 2012), where its effects include efflorescence on the

surface (Van Hees & Lubelli, 2012) and delamination (if the rock is layered) or exfoliation (if the rock is non-layered) depending on the kind of material (De Clerq & Hendrikx, 2012). Based on the available climate data in 2012, Sabbioni, Brimblecombe and Cassar (2012) project an increase in salt crystallisation frequency from fifteen to 20 events a year to over 45 events a year in the latter quarter of this century. This increase implies that salt crystallisation is a process that should be monitored closely.

Erosion caused by water flow is the second process developed by variations in the moisture levels of walls. There are multiple factors that increase occurrences of this process. One being flooding (see below), the other being wind-driven rain (English Heritage, 2008, D'Ayala & Aktas, 2016). Wind-driven rain is "rain that is given a horizontal velocity component [and therefore is being] driven into vertical surfaces that otherwise would be sheltered from vertical rain" (Sabbioni, Brimblecombe & Cassar, 2012, 14). Wind-driven rain has several consequences. It may be a cause of surface erosion, such as erosion, soiling, and discoloration and secondly facilitate moisture penetration and biodeterioration (Erkal, D'Ayala, & Sequeira, 2012; D'Ayala & Aktas, 2016). This results in changes in water level of the material, for which the effects have been described above, but since this process is a combination of water and wind, it also results in powdering of the material (Sabbioni et al., 2006). An increase in this process is expected in the Netherlands, but mostly in coastal areas (Sabbioni, Brimblecombe & Cassar, 2012).

The third process to happen in masonry works as a consequence of extreme variations between precipitation patterns is biodegradation. This pertains to the biological growth of plants as well as microbiological organisms (Julien, Stanisforth, & Bullock, 2011, Ortiz et al., 2014). Although, biodegradation is to a lesser degree also influenced by temperature. Regarding vegetation, i.e. biomass, the feedback loop is increase in precipitation equals increase in biomass, but increase in temperature equals decrease in biomass. Biomass accumulation on monuments result in aesthetic changes to the surface and stone deterioration (UNESCO, 2007b; ICOMOS, 2009; Ortiz et al., 2014) and in decay of outdoor wooden structures (Sabbioni, Brimblecombe & Cassar, 2012). However, regarding stone deterioration, plants can sometimes act as a protector instead of as a contributor to destruction (Wood, 2008). Climate induced decay of outdoor wooden structure by fungal growth is expected to decline in the Netherlands, because of increased periods of drought. Drier conditions are associated with lower risk for biodegradation (Sabbioni, Brimblecombe & Cassar, 2012). Pertaining to organism growth, this is also driven by a combination of temperature and precipitation. Regarding precipitation, the feedback loop is an increase in precipitation leads to an increase in richness of lichen species, and a decrease in precipitation leads to a decrease in richness. For temperature, an increase in temperature equals a decrease in the richness of lichen species, whereas a decrease in temperature leads to an increase in richness (Sabbioni, Brimblecombe & Cassar, 2012). Combining these two feedback loops with the projected climate changes leads to the following projections. Regarding precipitation, the number and intensity of precipitation events is expected to increase, leading to a theoretical increase in richness of lichen species. Concerning temperature, average temperature in Netherlands is expected to increase, leading to a decrease in the richness of lichen species. However, Sabbioni, Brimblecombe and Cassar note that the projected richness in lichen species for the Netherlands is expected to decrease. Therefore it can be assumed that the influence of temperature outweighs that of precipitation. However, it is not only the surface that can be

damaged by vegetation and organism growth, sometimes deeper layers are affected (Sabbioni et al., 2006) or the mortar (Hees & Lubelli, 2012; Randazzo et al., 2015). Also, as Heathcote, Fluck, and Wiggins (2017) point out, a changing climate can lead to the introduction of other pests and diseases. These can damage healthy timber, both natural heritage as in trees, and timber used in buildings. Especially species-specific timber loss may be problematic, if changing conditions mean that fewer timber critical for repair and maintenance of buildings is available.

These changes in precipitation patterns not only lead to changes in the microclimate of monuments' building materials, but also to changes in the microclimate of the objects they contain. Since most historic building materials are permeable, changes in the moisture content of walls happen quickly, which as mentioned kickstart other processes such as salt crystallisation which result in damage of the appearance of exterior and sometimes interior walls, but also in damp issues (Wood, 2004; Wood, 2008).

Flooding is not mentioned as an independent variable in the KNMI'14 scenarios, but falls under precipitation or sea-level rise. Most materials used in historic buildings are not able to withstand prolonged immersion of water. Consequently, it is inevitable that water will damage the historic fabric (Brimblecombe, Grossi, & Harris, 2006; Taylor et al., 2007). During a flooding event, the flow of water erodes flooring and walls. In addition, the water will leave behind rubble and mud, and cause physical alteration and staining of wooden floorboards (Brimblecombe, Grossi & Harris, 2006; Sabbioni et al., 2006). Moreover, flooding causes ground heave of the direct environment of buildings. This has a destructive effect on the sturdiness of exterior walls, i.e. unstable foundation leads to unstable buildings (Brimblecombe, Grossi & Harris, 2006; English Heritage, 2008). Another after effect of flooding includes a difficult choice regarding the drying method to be employed. In order to save interesting features, a time-intensive drying method can be used, however the downside to this is that such methods may not be cost-effective. On the other hand, a drying method which is faster reduces disruption and hence may diminish accompanying costs, but can result in definitive loss of instrinsic value (Taylor et al., 2007; ICOMOS 2009).

B.2 – Sea level rise

Regarding sea level rise, a 2012 study by the European Environment Agency (EEA) delved into the potential impact of a rising sea level on three areas of interest, being the physical environment, social impact, and cultural impact. Figure 18 shows the combined potential impacts of changes in inundation heights of rivers, sea level rise, a potential 100 year coastal storm surge event and changes in flash flood potential on these three aspects. The physical environment includes settlements, major roads, railways, airports, harbours, thermal power stations and refineries. Social impact is understood to include the impact on population, including migration. The third area of interest, that of damage to culture, concerns the potential effects of climate change on registered World Heritage sites and museums (EEA, 2012).

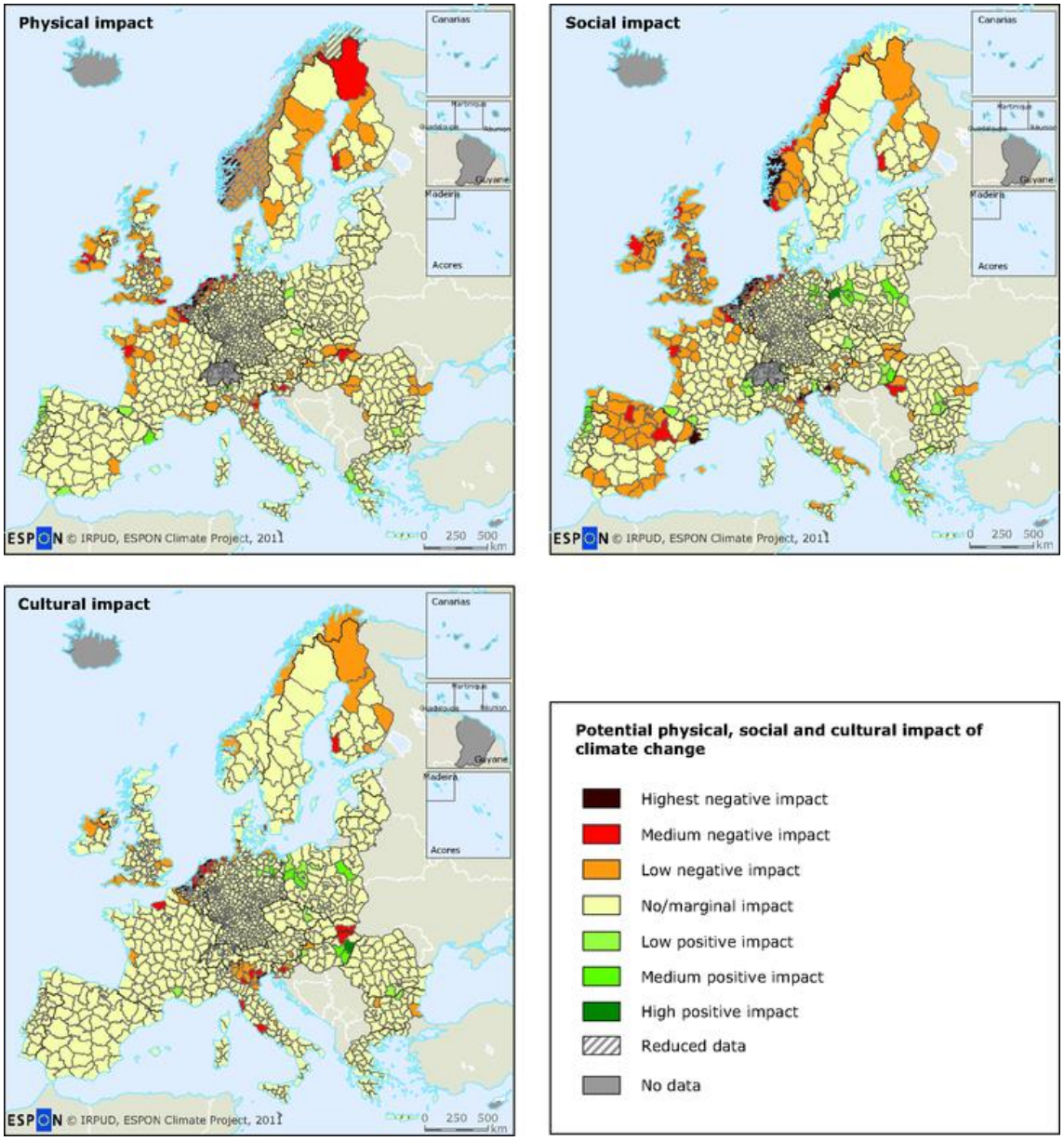

Figure 18 - Sea-level rise and potential physical, social, and cultural impact

Sea-level rise mostly affects heritage in coastal areas (Marzeion, & Levermann, 2014). Especially coastal areas in Netherlands, see figure 18. The figure shows lots of medium negative impact, and some areas which are suspect to highest negative impact of sea-level rise. Sea-level rise mostly results in physical damage from water like flooding, see above.

B.3 – Extreme wind

Extreme wind has similar consequences as mentioned under wind-driven rain in section 1.2.1. An increase in both wind-force and number of storminess events amplify erosion of building material, as well as the foundation on which the building is constructed (UNESCO, 2007a). As the KNMI'14 projections assume more westerly winds, since air currents in coastal areas are likely to contain various types of salts, the combined effect of storminess and salt-rich winds enhance salt crystallisation (see section 1.2.1) and thus the

formation of crypto-florescence and efflorescence (Hees & Lubelli, 2012). Moreover, wind alters the surface of outer walls due to erosion and sanding (Ortiz et al., 2014).

B.4 – Relative humidity, solar radiation, evaporation and drought

Regarding relative humidity, the projected higher humidity levels for winter, in conjunction with higher precipitation levels, keep buildings wet for longer periods (Ruosteenoja & Räisänen, 2013). In a case study, D'Ayala and Aktem (2016) found that cycles where relative humidity fluctuates between wetting and drying are mostly daily and two-daily phenomena especially for spring and autumn. This lead to cyclic expansion and contraction of bricks and mortars, hence weakening in the long term. Other consequences resulting from cyclic wetting-drying impact are in changes in pore structure, and stress values that trespass limits causing damage by creep and fatigue (Anzani, Garavaglia, & Bindi, 2009; D'Ayala & Aktem, 2016). Cyclic expansion and contraction caused by fluctuations in relative humidity also exacerbate the risk for moisture damages, like salt crystallisation, erosion, and biodegradation (see above). Another risk posed by relative humidity increase is that of climate induced decay of indoor wooden objects (Sabbioni, Brimblecombe & Cassar, 2012) or other heritage assets (Kovota et al., 2019) due to humidity shocks.

Second, what is the potential impact of an increase in solar radiation for heritage buildings? The human body is damaged by two components of solar radiation, being UVA and UVB radiation. An increase in solar radiation means that humans can spend less time in the sun before getting burned. In the same vein, buildings also experience "sunburn". An example of this is the process of thermoclastism, which entails microcracking and exfoliation of stone materials, caused by repeated thermally induced expansion and contraction of surface mineral grains (Sabbioni, Brimblecombe & Cassar, 2012). This is a response to temperature fluctuations at the material surface caused by solar radiation, which leads to increased internal tension. This is particularly damaging to buildings constructed with marble and calcite materials, as thermoclastism causes these materials expand on a vertical axis but contract in the horizontal axis. As a result, the material will crack. The KNMI models and Ruosteenoja and Räisänen (2013) project an increase in solar radiation. Sabbioni, Brimblecombe and Cassar (2012) assume an increase from zero events a year to around fifteen events a year for the south of the Netherlands, caused by this increase in solar radiation. In other words, thermoclastism has not been a problem as of yet, but definitely needs attention in the future.

The effects of evaporation and drought are closely related to temperature increases. Especially in summer periods, where evaporation and periods of drought are more prevalent, moisture content in sandstone and brick walls is expected to decrease (Sabbioni, Brimblecombe & Cassar, 2012). As a consequence, buildings are more likely to be affected by thermal stress (Sabbioni, Brimblecombe & Cassar, 2012; Ortiz et al., 2014).

B.5 – Extreme weather

Includes hail and thunderstorms, and limited visibility (due to fog). These climate events do not really impact architectural heritage. Hail and thunderstorms are included in precipitation impacts, freeze-thaw and wet-frost cycles. However, it should be noted that thunderstorms are expected to be more heavy in the future. This is accompanied by more

lightning. This increases the chance of lightning strike in buildings. A devastating effect of this is when thunderbolts cause fire. Therefore, it is important that site managers check their smoke detectors regularly, add sprinkler systems, and include the fire department in their risk planning In addition, projected increase in size of hailstones means that potential damage to roofs, windows, and chimneys is higher. Fog only impacts visibility i.e. aesthetics, but hours of fog are expected to decline over the next century so this is not really a problem.

Appendix C – List of interviewees

BREDA

Table 17 - Interviewees Breda

In-text reference	*Institution*	*Position*	*Date*
Breda 1	Stichting Grote Kerk of Lieve Vrouwe Kerk	Member Board Stichting Grote Kerk of Lieve Vrouwe Kerk and Member Restoration and Conservation Committee	16-05-2019
Breda 2	Breda Municipality	Manager Urban Water	27-05-2019
Breda 3	Wijkraad Stadshart Valkenberg	Board Member	29-05-2019
Breda 4	Breda Municipality	Policy advisor Heritage	21-06-2019
Breda 5	Stichting Begrijnhof Breda	Members Board Stichting Begijnhof Breda (2 interviewees)	26-06-2019

EXPERTS

Table 18 - Interviewees Experts

In-text reference	*Institution*	*Position*	*Date*
Expert 1	erfgoed.nu	Owner	14-06-2019
Expert 2	Netherlands Cultural Heritage Agency	Researcher Spatial analysis	03-07-2019
Expert 3	North-Brabant Province	Policy advisor Heritage	09-07-2019
Expert 4	Utrecht Province	Senior advisor Linie Expert Team and Project Leader Nieuwe Hollandse Waterlinie (2 interviewees)	23-07-2019
Expert 5	's-Hertogenbosch Municipality	Programme manager Climate adaptation and water (and colleagues) – questions answered via e-mail	24-07-2019

Appendix D – Interview guide

First the questions that guided the semi-structured interviews with Breda interviewees

What policies and action programmes exist on different levels and how well are these coordinated across levels and sectors? (question 4)

- What can you tell me about Breda policy and programmes and the potential consequences for your work

<u>On Authority</u>

- Is there political pressure or ambition for heritage conservation
- Is there political pressure or ambition for climate change adaptation
- How is heritage currently integrated within policy programmes (also question 4)
    - Transparent? Who is responsible for policy planning?
    - Who is responsible for policy implementation?
    - Is there communication between various sectors (internal coordination)
    - Is there communication between monument owners and municipality (external coordination: involvement stakeholders, shared responsibility, partnerships?)
- What are the current strategies to conserve heritage? Monitoring

On <u>Access to information</u>

- Aware of the NAS? Aware of the scenarios discussed in the NAS?
    - Hotter
    - Wetter
    - Drier
    - Sea-level rise
- Do you know whether this impacts the cultural heritage you work with? Risk assessment
- What is the reason it is seen as a problem / not an issue

<u>Question how can this built cultural heritage be adapted – success?</u>

- Do you know of specific examples where climate adaptive measures have been undertaken in/near/around a heritage site/designated area?
- In what way was heritage incorporated within
    - Policy process
    - Policy implementation
- What is the reason the project was carried out? Who was the driving force
- What is the reason it is a successful project
- What lessons have been learned

<u>Resources:</u>

- Human capital: skills and education. What skills and knowledge do you have in-house. What knowledge is needed (access to information). Theoretical vs. Practice

- Financial: does Breda have enough money to carry out policy. Are there enough opportunities to get subsidised. Is the law around subsidies sufficient
- Situational: how flexible is the Breda designated area

Multi-level governance:

- Knowledge exchange between networks
    - What kind of knowledge
    - Enough
    - Relevance? What is missing
    - Accessible
    - Availability, does this match the needs of end users?
- What is the role of knowledge networks in the future
    - Similar
    - New themes/specific types of monument / specific environmental driver
    - Scale? Local, international

Second, interview questions that guided the semi-structured interviews with the Experts

On Awareness & monitoring

- What is the level of awareness on climate change and its impact on the historic built environment?
- Do you notice any effects of climate impact on buildings (freeze-thaw cycles, water damage, efflorescence, cracks caused by thermal stress, etc.)
- Do you have a specific example?

On cognitive factors

- As about policy documents and what this means for perceived risk
- Are there reasons to act
- Are you familiar with future projections of climate change

Learning capacity

- What can heritage teach us about the past
- What can heritage teach us about climate adaptation
- What are the values associated with heritage
- What do you learn from other's experience

On multi-level governance

- Do you collaborate with others
- On what level: vertical or horizontal
- What kind of help/support do you expect from these partners
- What kind of help/support offers your organisation

On information on technological solutions (resources) and law (authority)

- is the current available information from governmental sources sufficient?
- How is this information available
- Does this match the users' need for information (guidance and information)
- What is the role of knowledge networks in the future (multi-level governance)

Access to information

- Aware of the NAS? Aware of the scenarios discussed in the NAS?
- Do you know whether this impacts the cultural heritage you work with?
-

Questions on policy documents relevant for that expert. In general touch upon:

- What is the reason that adaptation to climate change is mentioned in the policies
- What is the reason that heritage is/ is not incorporated in climate adaptation policy
- Are there plans to include adaptation policy / to include heritage within adaptation policy

Question on situational context (resources)

- The policy document mentions sustainable development and adding more green spaces. How is this matched to conservation of the cultural-historical landscape?
- Policy mentions adding solar panels/green roofs/green walls/green facades. How is this matched to conservation of the cultural-historical landscape

Regarding resources: human and financial

- Sufficient in-house skils?

- Sufficient people to tackle the work?
- Sufficient subsidy/budget/financial capital?

Question how can this built cultural heritage be adapted – success?

- Do you know of specific examples where climate adaptive measures have been undertaken in/near/around a heritage site/designated area?
- In what way was heritage incorporated within
    - Policy process
    - Policy implementation

Appendix E – Maps

This appendix contains a table listing the climate maps that were consulted, and the figures that were created by superimposing climate projection maps onto the cultural-historical value map of Breda.

Table 19 - Maps consulted

Name map (Dutch name in bold, translation between brackets)	**Source**	**Information about the map**
Cultuurhistorische Waardekaart 2010 (Cultural-historical Value map, CHW), **2016 revision.**	Provided by Province of North-Brabant	This map shows all types of built and archaeological heritage for the Province of North-Brabant.
Cultuurhistorische Waardekaart Breda (Cultural-historical value map Breda)	Breda Municipality	This map shows the cultural and historical value of all buildings and sites within the Breda municipal area.
Stedelijk hitte-eiland effect (UHI) in Nederland (Urban Heat Island (UHI) effect in Netherlands)	Provided by RIVM, Atlas Natuurlijk Kapitaal (Atlas Natural Capital, ANK).	The map is made using the UrbClim model that employs median year temperatures, so it does not take into account extremely hot summer days or nights. The UHI is the summer mean temperature difference between urban and rural areas.
Verkoelend effect van groen en blauw (Cooling effect of green and blue)	Provided by RIVM, ANK	This map shows the current cooling effect of green (natural capital) and blue (water) in urban areas in °C). This is calculated by detracting the decrease in actual UHI from the maximum UHI. UHI takes into account cooling effect from large scale green and blue around a location, such as parks and lakes, and local scale green and blue such as trees.
Jaarlijkse neerslag – huidig (Annual precipitation – current situation).	Provided by Climate Adaptation Services (CAS)	This map shows the average annual precipitation in mm over a period of 30 years. Current situation is based on the 1981-2010 period.
Jaarlijkse neerslag – 2050 (Annual precipitation – 2050)	Provided by CAS	This map shows the average annual precipitation in mm for the situation in 2050, based on the KNMI'14 WH-scenario. This scenario has the highest expectations of the four KNMI'14 scenarios.
Waterdiepte bij intense neerslag – 1:100 jaar (Depth of water during a severe precipitation event – 1:100 years)	Provided by CAS, developed by Deltares	This map indicates the maximum depth of water following a short and intense precipitation event. The model is based on a precipitation event with 70 mm of water in 2 hours. In the current climate, this has a chance of happening once every 100 years.
Waterdiepte bij intense neerslag – 1:1.000 jaar (depth of water during a severe precipitation event – 1.1.000 years)	Provided by CAS, developed by Deltares	This map indicates the maximum depth of water following a short and intense precipitation event. The model is based on a precipitation event with 140 mm of water in 2

		hours. In the current climate, this has a chance of happening once every 1.000 years.
Dagen met 25 mm neerslag – huidig (Days with 25 mm precipitation – current situation)	Provided by CAS	This map shows the average number of days a year that have a precipitation event of 25 mm or more, over a period of 30 years. Current situation is based on the 1981-2010 period.
Dagen met 25 mm neerslag – 2050 WH (Days with 25 mm precipitation – 2050 WH)	Provided by CAS	This map shows the average number of days a year that have a precipitation event of 25 mm or more, over a period of 30 years, for the situation in 2050, based on the KNMI'14 WH-scenario. This scenario projects the most number of days with minimum 25 mm, together with WL-scenario, of the four KNMI'14 scenarios.
Dagen met 15 mm neerslag – huidig (Days with 15 mm precipitation – current situation)	Provided by CAS	This map shows the average number of days a year that have a precipitation event of 15 mm or more, over a period of 30 years. Current situation is based on the 1981-2010 period.
Dagen met 15 mm neerslag – 2050 WH (Days with 15 mm precipitation – 2050 WH)	Provided by CAS	This map shows the average number of days a year that have a precipitation event of 15 mm or more, over a period of 30 years, for the situation in 2050, based on the KNMI'14 WH-scenario. This scenario projects the most number of days with minimum 15 mm, together with WL-scenario, of the four KNMI'14 scenarios.
Neerslag winterkwartaal – huidig (Precipitation in winter – current situation)	Provided by CAS	This map shows the average precipitation in mm in the winter months over a period of 30 years. Current situation is based on the 1981-2010 period.
Neerslag winterkwartaal – 2050 WH (Precipitation in winter – 2050 WH)	Provided by CAS	This map shows the average precipitation in mm in the winter months for the situation in 2050, based on the KNMI'14 WH-scenario. This scenario projects has the highest projection for precipitation in winter months, together with WL-scenario, of the four KNMI'14 scenarios.
Bodemdaling (Soil subsidence)	Provided by CAS, developed by Deltares, WEnR and TNO	Subsidence is caused by shrinkages, oxidation, and compressing of soil, which leads to a decrease in volume. The map shows which parts of the Netherlands may experience soil subsidence due to low groundwater level and gas extraction, but not salt extraction, extraction of other minerals and geological subsidence. The expectations are based on current climate conditions.
Aantal tropische dagen (Max ≥ 30 °C) – huidig (Number of tropical days (max ≥ 30 °C) – current situation	Provided by CAS, KNMI	This map shows the number of tropical days (max ≥ 30 °C) over a period of 30 years. Current situation is based on the 1981-2010 period.
Aantal tropische dagen (Max ≥ 30 °C) – 2050 WH (Number of tropical days (max ≥ 30 °C) – 2050 WH	Provided by CAS, KNMI	This map shows the number of tropical days (max ≥ 30 °C) for the situation in 2050, based on the KNMI'14 WH-scenario. This scenario projects has the highest projection

		for number of tropical days a year of the four KNMI'14 scenarios.
Aantal zomerse dagen (Max ≥ 25 °C) – huidig (Number of summer days (max ≥ 25 °C) – current situation	Provided by CAS, KNMI	This map shows the number of summer days (max ≥ 25 °C) over a period of 30 years. Current situation is based on the 1981-2010 period.
Aantal zomerse dagen (Max ≥ 25 °C) – 2050 WH (Number of summer days (max ≥ 25 °C) – 2050 WH	Provided by CAS, KNMI	This map shows the number of summer days (max ≥ 25 °C) for the situation in 2050, based on the KNMI'14 WH-scenario. This scenario projects has the highest projection for number of tropical days a year of the four KNMI'14 scenarios.
Aantal warme dagen (Max ≥ 20 °C) – huidig (Number of warm days (max ≥ 20 °C) – current situation	Provided by CAS, KNMI	This map shows the number of warm days (max ≥ 20 °C) over a period of 30 years. Current situation is based on the 1981-2010 period.
Aantal warme dagen (Max ≥ 20 °C) – 2050 WH (Number of warm days (max ≥ 20 °C) – 2050 WH	Provided by CAS, KNMI	This map shows the number of warm days (max ≥ 20 °C) for the situation in 2050, based on the KNMI'14 WH-scenario. This scenario projects has the highest projection for number of warm days a year of the four KNMI'14 scenarios.
Aantal vorstdagen (Max < 0 °C) – huidig (Number of cold days (Max < 0 °C) – current situation	Provided by CAS, KNMI	This map shows the number of cold days (max < 0 °C) over a period of 30 years. Current situation is based on the 1981-2010 period.
Aantal vorstdagen (Max < 0 °C) – 2050 WH (Number of cold days (Max < 0 °C) – 2050 WH	Provided by CAS, KNMI	This map shows the number of cold days (max < 0 °C) for the situation in 2050, based on the KNMI'14 WH-scenario. This scenario projects the lowest projection for number of cold days a year of the four KNMI'14 scenarios.
Jaarlijkse referentieverdamping – huidig (Annual evaporation – current situation)	Provided by CAS	Evaporation is mainly determined by radiation and temperature. This map shows average evaporation in mm a year, over a period of 30 years. Current situation is based on the 1981-2010 period.
Jaarlijkse referentieverdamping – 2050 WH (Annual evaporation – 2050 WH)	Provided by CAS	Evaporation is mainly determined by radiation and temperature. This map shows average evaporation in mm a year, over a period of 30 years for the situation in 2050, based on the KNMI'14 WH-scenario. This scenario projects the highest average evaporation in mm a year of the four KNMI'14 scenarios.
Potentieel maximaal neerslagtekort (gemiddelde) huidig (Potential maximum precipitation deficit (average) current situation)	Provided by CAS	Potential maximum precipitation deficit indicates dry conditions. It is based on the difference between evaporation and precipitation during april-september. An increase in precipitation deficit usually leads to a decrease of water availability of ground and surface water. This map shows average potential maximum precipitation deficit. Current situation is based on the 1981-2010 period.

Potentieel maximaal neerslagtekort (gemiddelde) 2050 WH (Potential maximum precipitation deficit (average) 2050 WH)	Provided by CAS	Potential maximum precipitation deficit indicates dry conditions. It is based on the difference between evaporation and precipitation during april-september. An increase in precipitation deficit usually leads to a decrease of water availability of ground and surface water. This map shows average potential maximum precipitation deficit for the situation in 2050, based on the KNMI'14 WH-scenario. This scenario has the highest projections for average precipitation deficit of the four KNMI'14 scenarios.
Ontwikkeling kans op grondwateroverlast – 2050 WH (Potential development of nuisance caused by groundwater levels – 2050 WH)	Provided by CAS, Deltares	This map shows the potential development for nuisance caused by increase in groundwater levels in 2050, taking into account climate change, and changes in water and land use, for the KNMI'14 WH scenario.

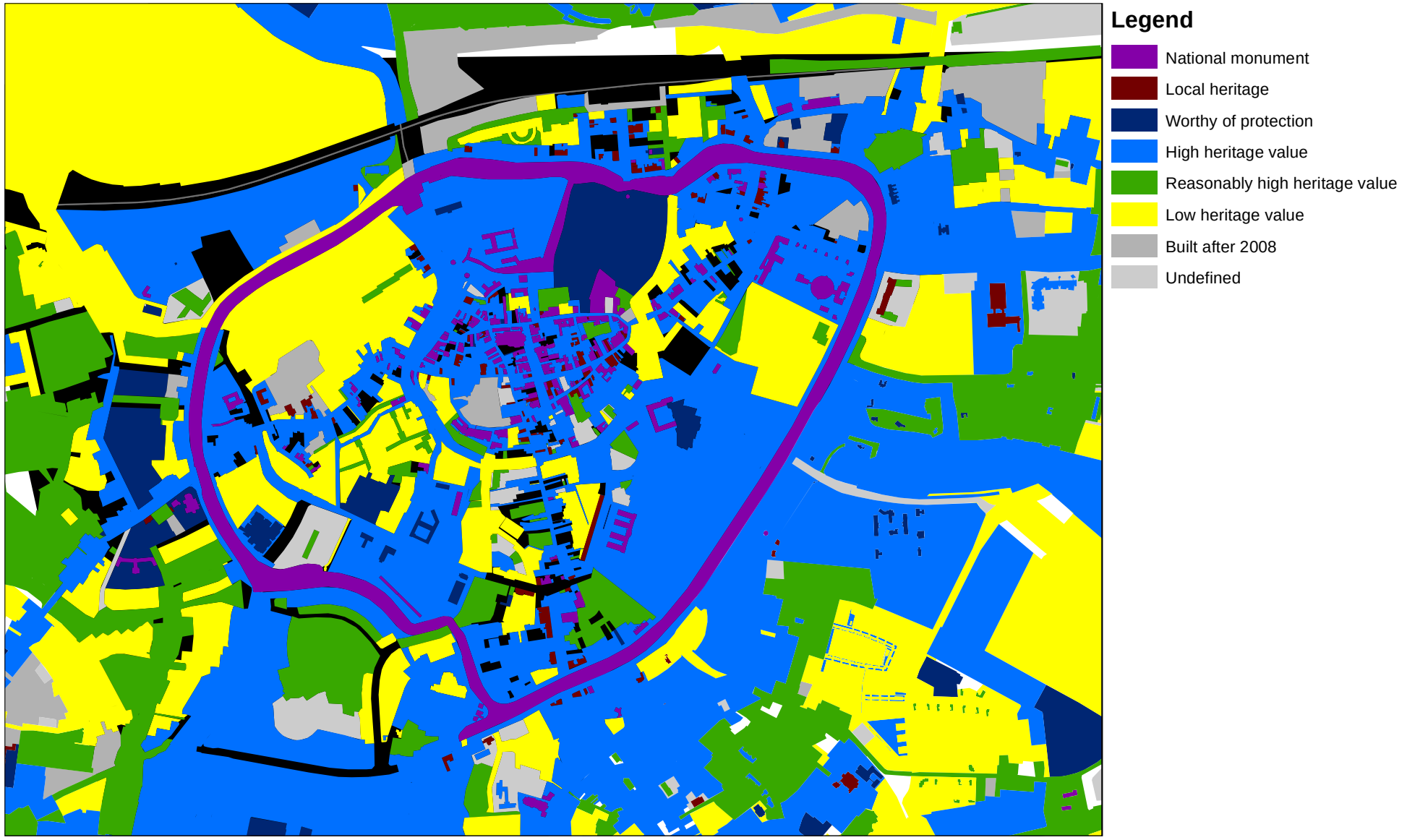

Figure 19 - Cultural-historical value map, zoomed in on city-centre (Source: Breda Municipality)

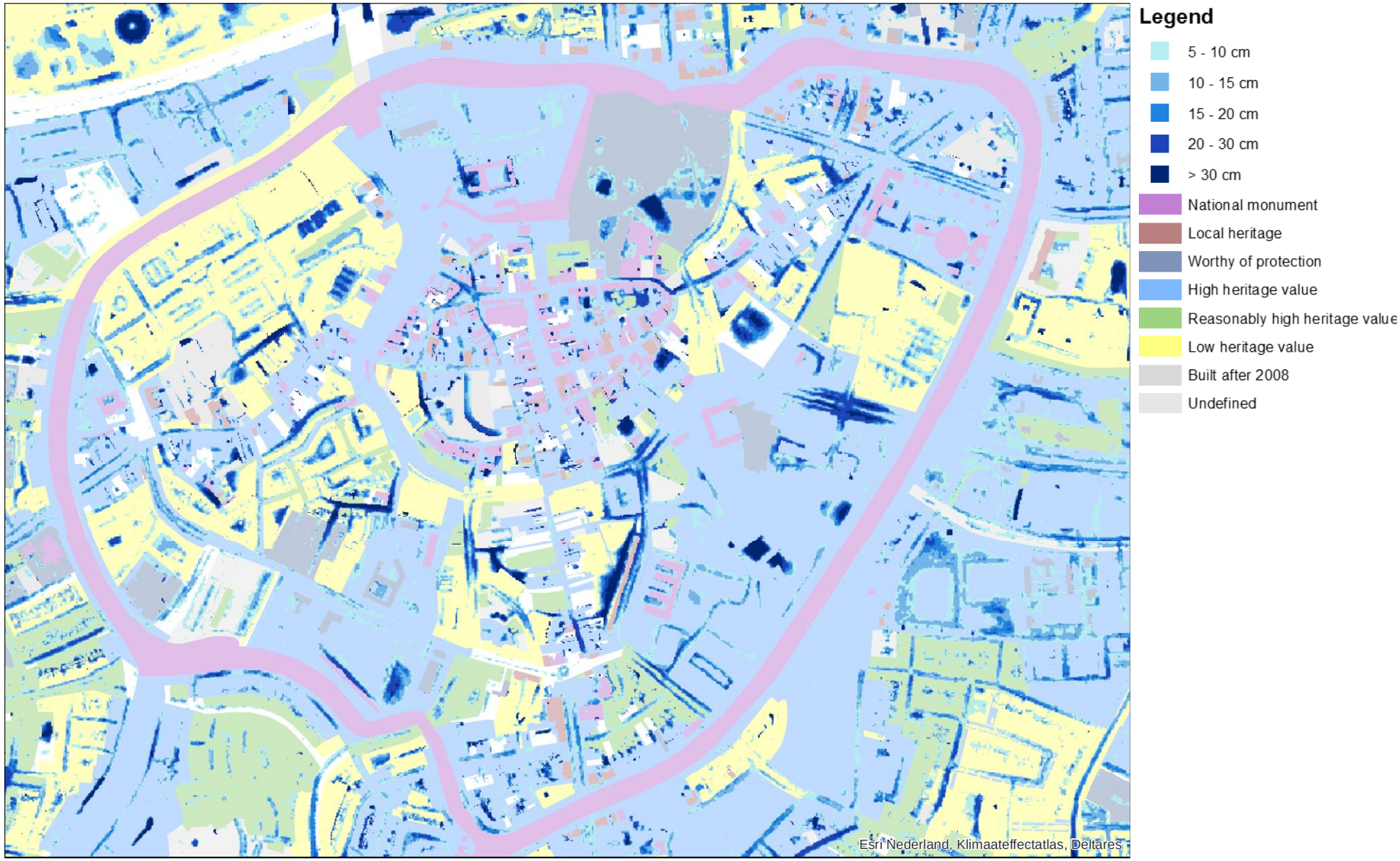

Figure 20 - Depth of water in cm during a severe precipitation event T= 1:100 years superimposed on Breda cultural-historic value map (1:9.000)

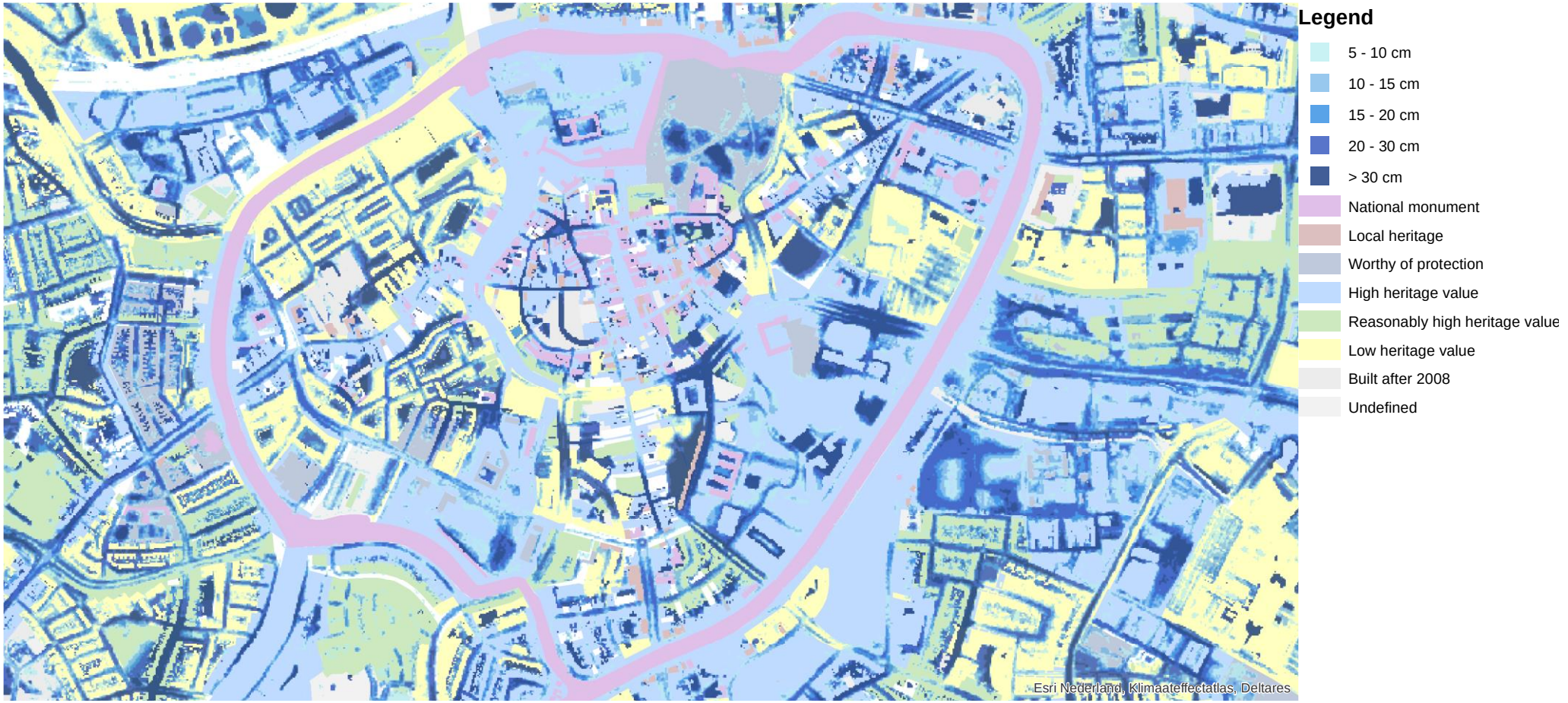

Figure 21 - Depth of water during a severe precipitation event 1:1.000 years superimposed on Breda cultural-historic value map (1:10.000)

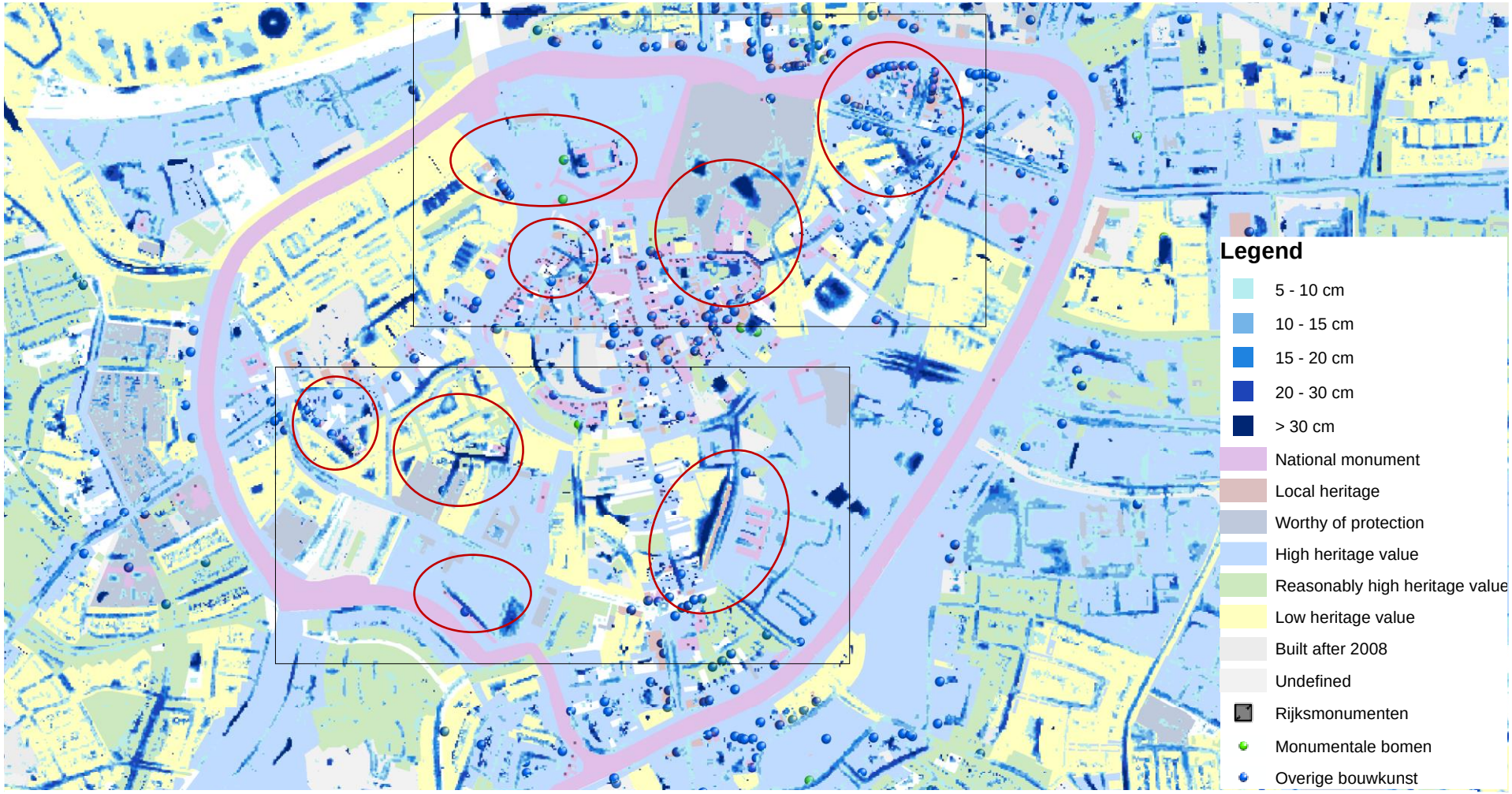

Figure 22 - Figure 18 again but signifying areas of interest (red circles) (Northern black rectangle zoomed in figure 21, Southern black rectangle zoomed in figure 22) the tiny purple squares and lilac colours are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1:10.500)

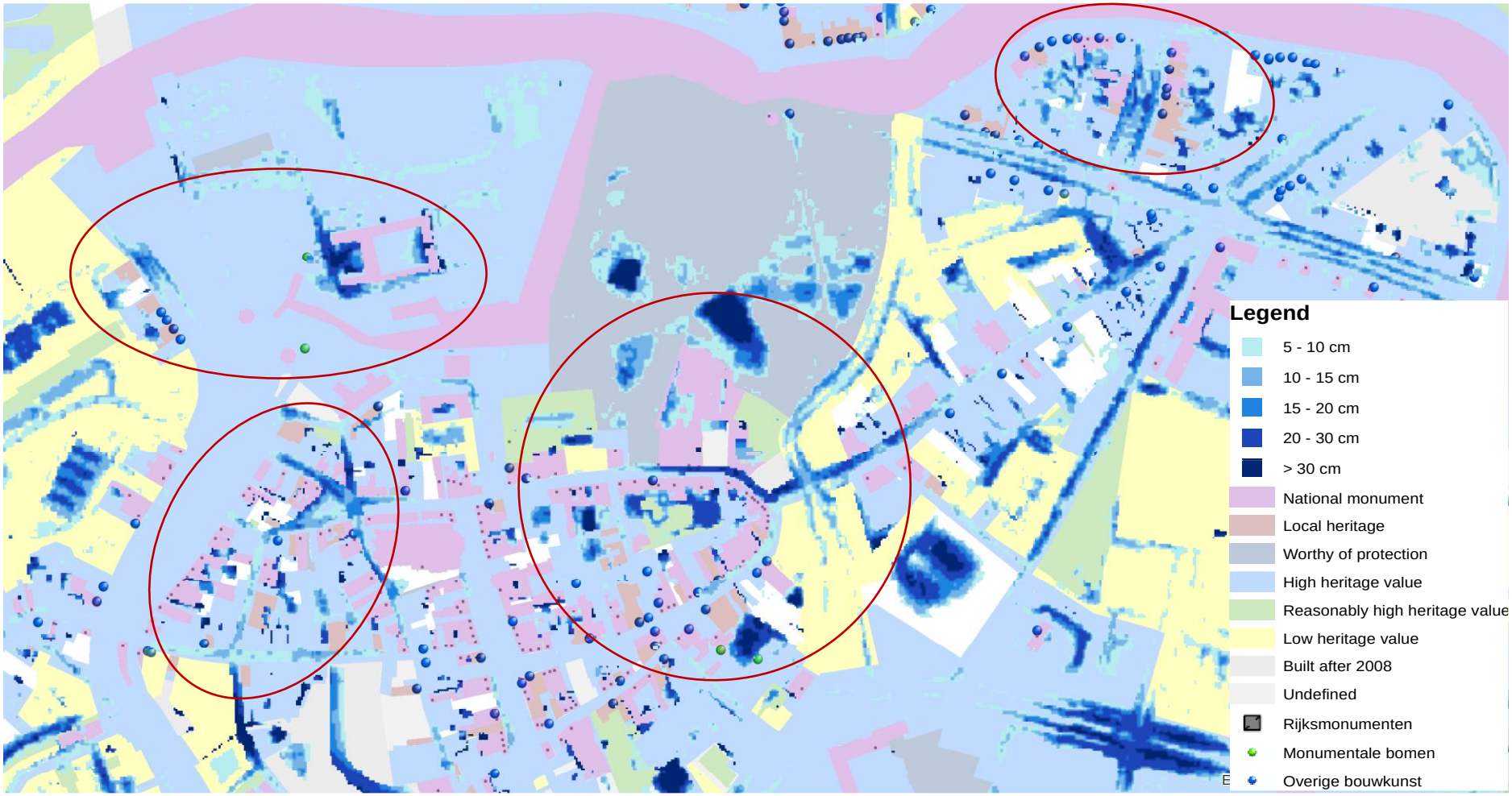

Figure 23 - Depth of water in cm for precipitation event T =1:100 superimposed on Breda cultural-historical value map signifying areas of interest (red circles) (Northern rectangle) the tiny purple squares and lilac colours are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1:4.500)

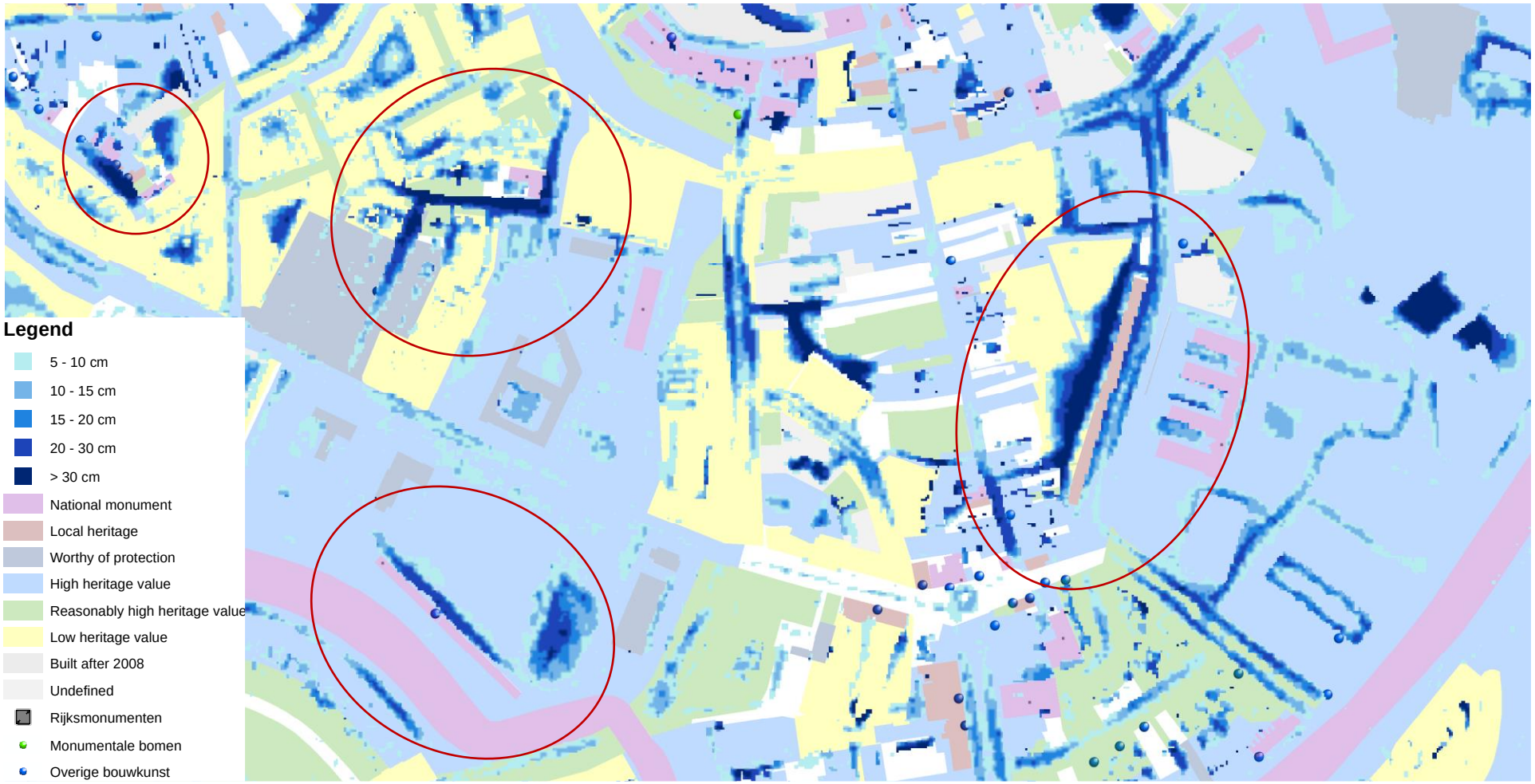

Figure 24 - Depth of water in cm for precipitation event T = 1:100 superimposed on Breda cultural-historical value map signifying areas of interest (red circles) (Southern rectangle) the tiny purple squares and lilac colours are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1:4.000)

Figure 25 - Annual evaporation current situation superimposed onto cultural-historical value map Breda municipality

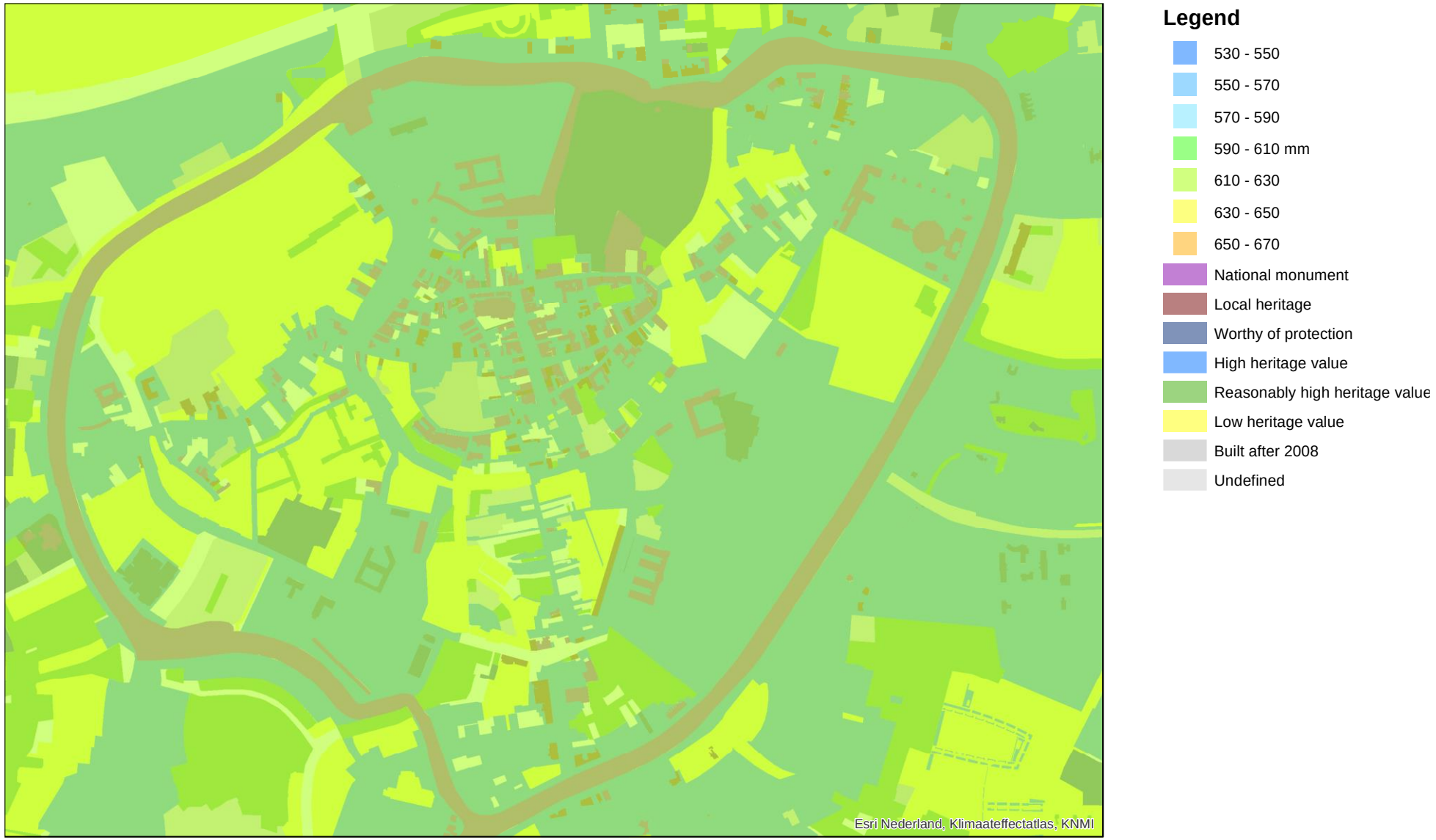

Figure 26 – Annual evaporation 2050 WH superimposed on cultural-historical value map Breda municipality

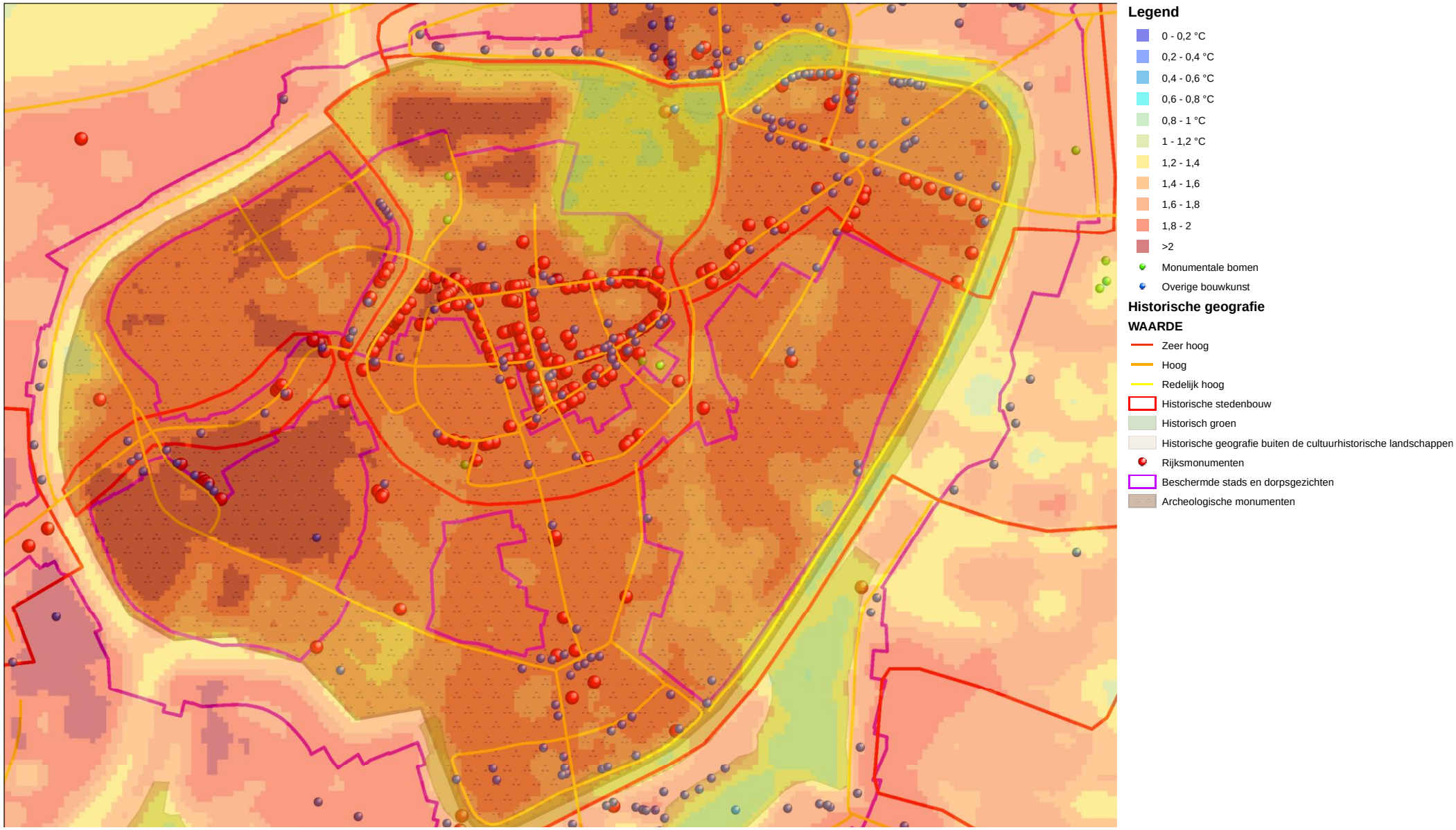

Figure 27 - Urban Heat Island effect superimposed on CHW North-Brabant

Figure 28 - Urban heat island effect superimposed on Breda cultural-historical value map showing same areas as figure 21 (Northern rectangle) the tiny purple squares are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1:4.5000)

Figure 29 - Urban heat island superimposed on Breda cultural-historic value map (Southern rectangle) the tiny purple squares are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1:4.000)

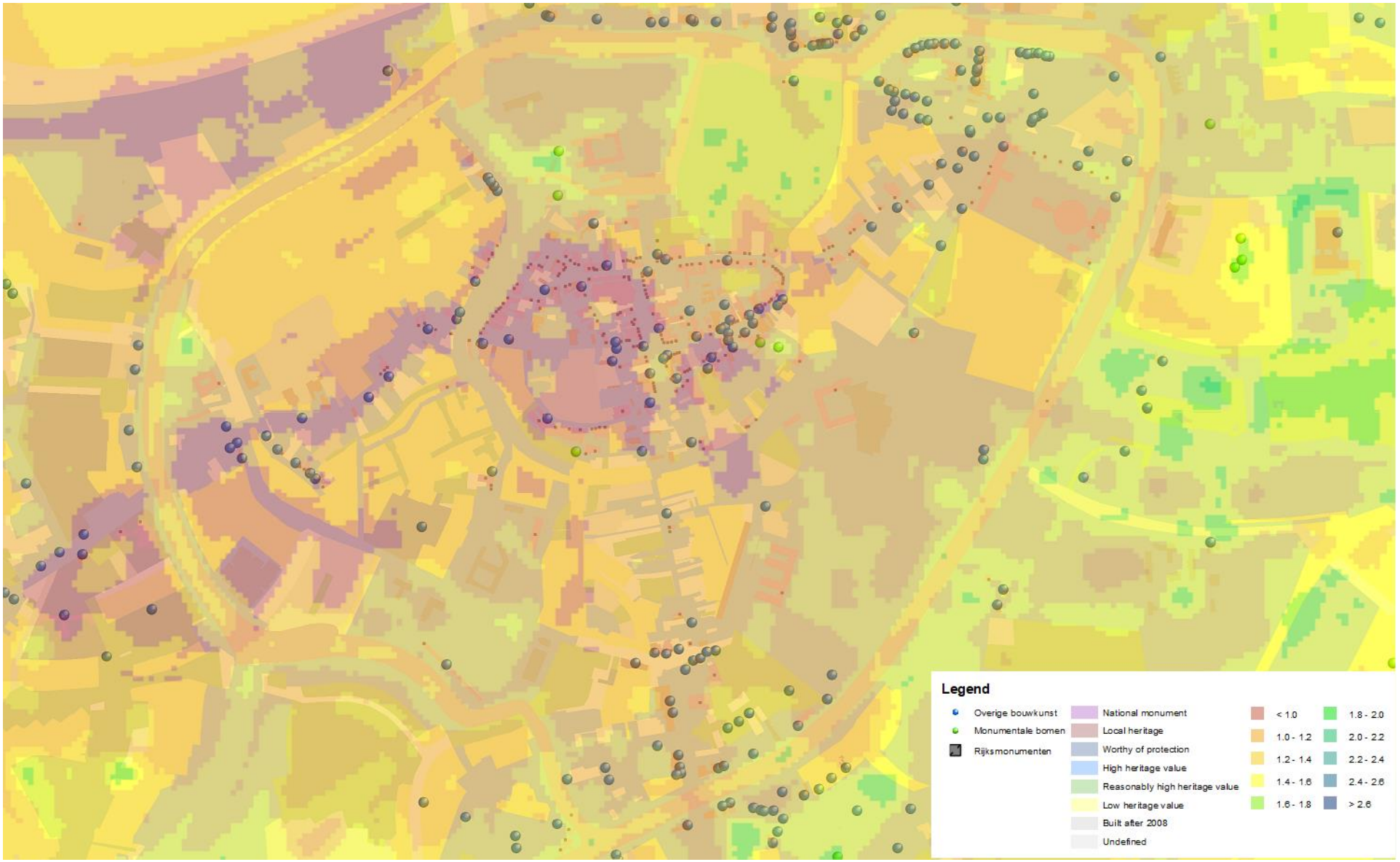

Figure 30 - Cooling effect of green and blue superimposed on Breda cultural value map. The tiny purple squares are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1:10.000)

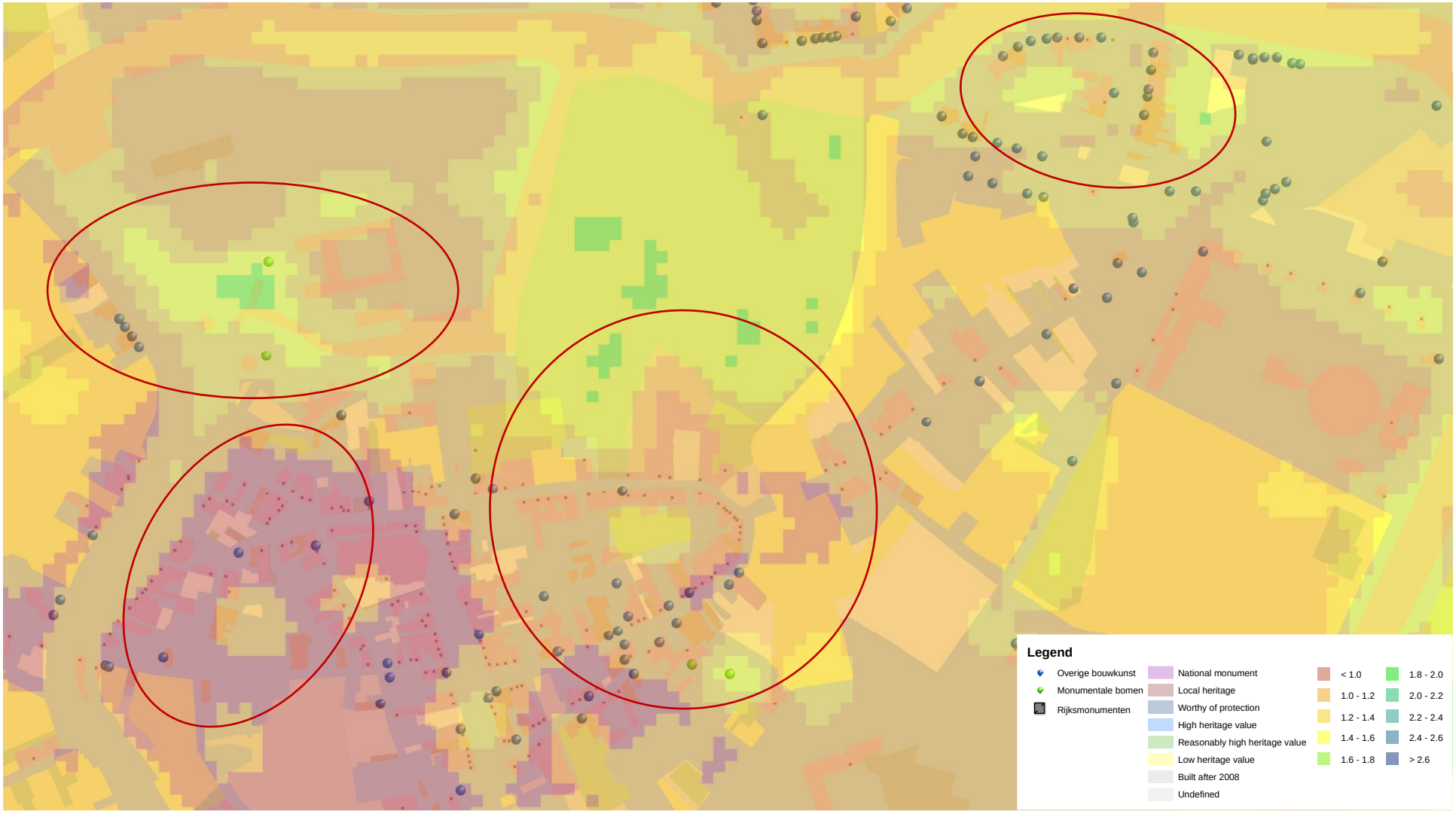

Figure 31 - Cooling effect of green and blue superimposed on Breda cultural-historical value map (Northern rectangle) The tiny purple squares are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1:4.5000)

Figure 32 - Cooling effect of green and blue superimposed on Breda cultural-historical value map (Southern rectangle) the tiny purple squares are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1: 4.000)

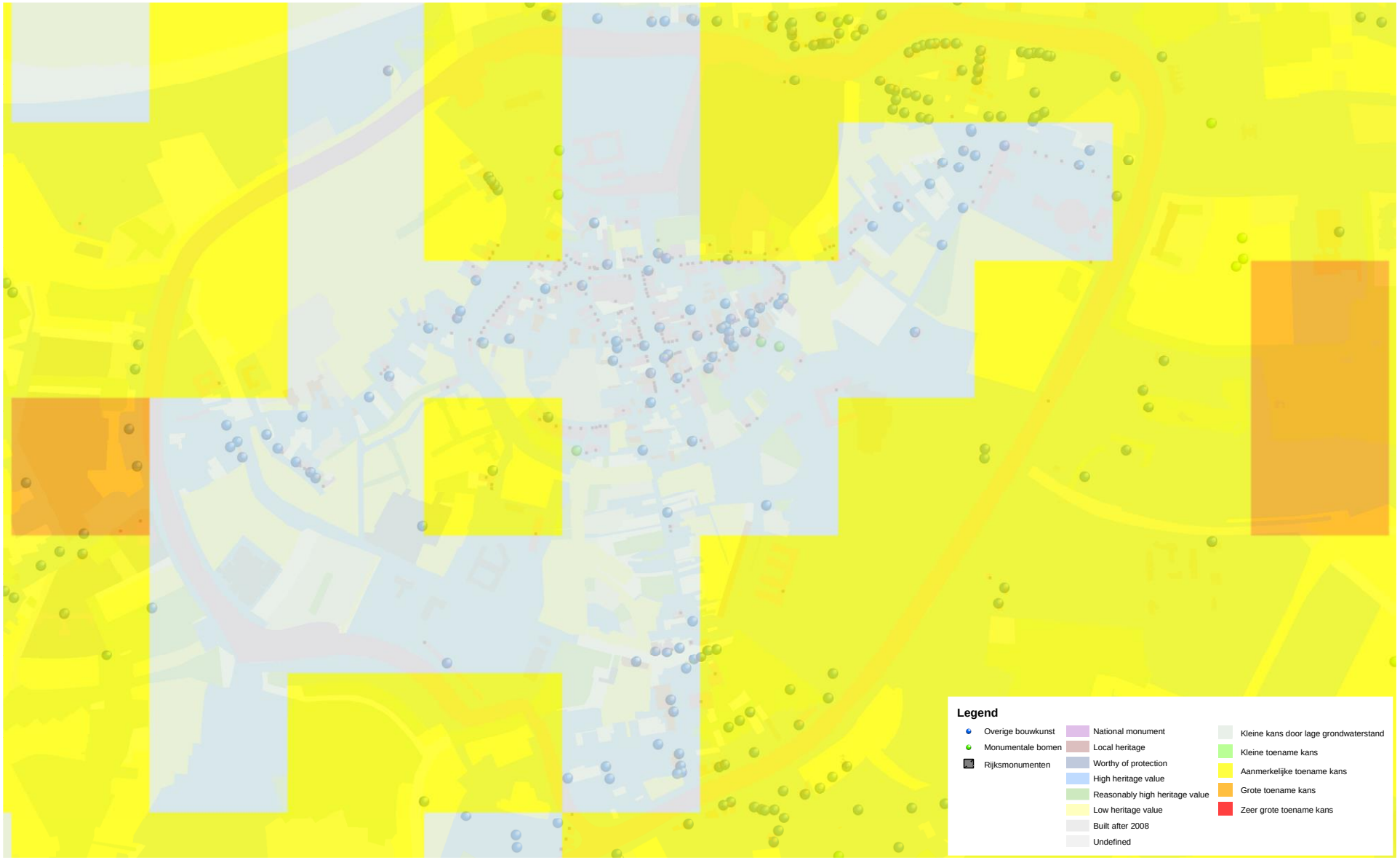

Figure 33 - Potential groundwater nuisance in 2050WH superimposed on CHW Breda.. The tiny purple squares are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1:10.000)

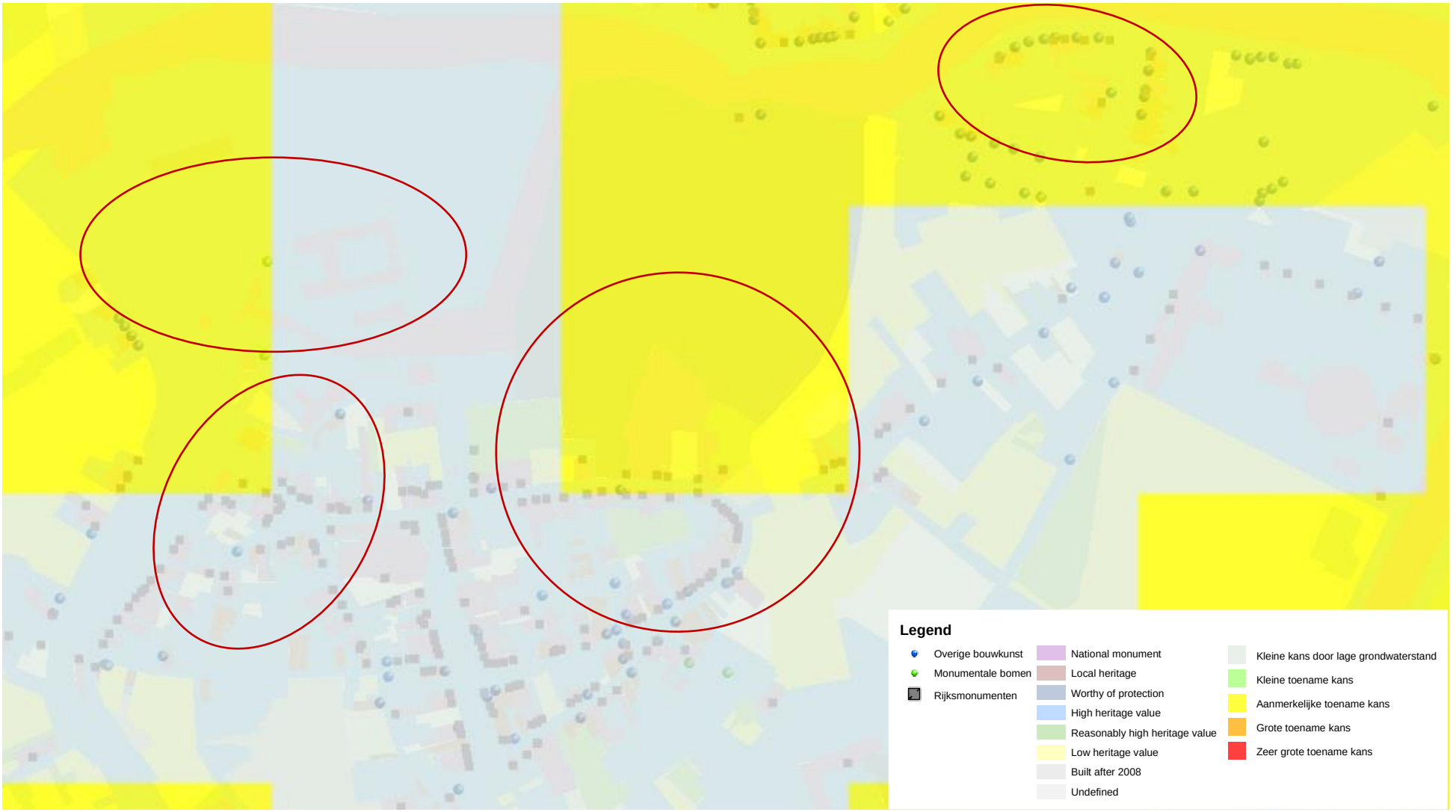

Figure 34 - Potential groundwater nuisance in 2050 WH superimposed on Breda cultural-historic value map (Northern rectangle) the tiny purple squares are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1:4.500)

Figure 35tangle) the tiny purple squares are nationally listed monuments, the green dots are monumental trees, and the blue dots are municipal listed buildings (1:4.000)