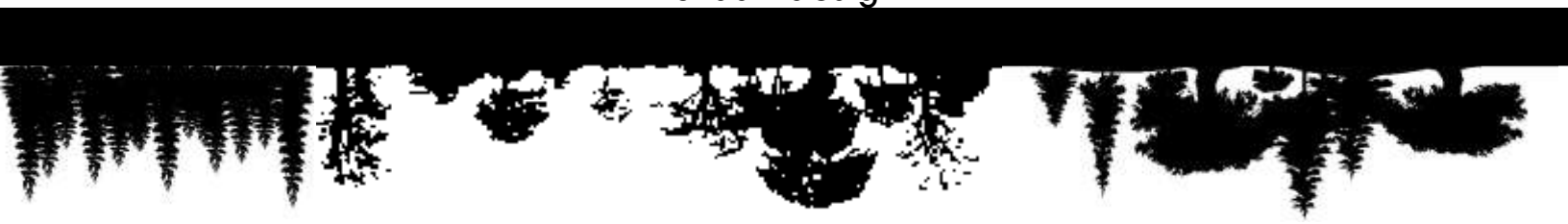
Urban Thermal Comfort

An assessment tool for operationalizing urban thermal comfort in urban policies and urban design



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Thaísa Martins Fernandes Pessanha
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- **Author:**

Thaísa Martins Fernandes Pessanha

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- **Authorities**

1- University of Groningen

Landleven 1, 9747 AD Groningen (Netherlands)

http://www.rug.nl/frw/?lang=en

050 363 3896

2- Witteveen + Bos

K.R. Poststraat 1003, 8441 ER Heerenveen (Netherlands)

http://www.witteveenbos.nl/

051 364 1800

- **Supervisors**

1- Christian Zuidema

2- Jimme Zoete

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ABSTRACT

Thermal comfort refers to the satisfaction with the thermal environment, a concern which has been longstanding explored in Architecture. Even though climate change and urbanization effects have increased the concern with outdoor temperatures – most related to *heat stress* – the attention to how comfortable people feel with urban temperatures is still absent. However, enhancing urban thermal comfort (UTC) contributes to human health, attractiveness and use of public spaces. Studies in Healthy Cities and UTC discuss the lack of a guiding framework for assisting urban planners and designers in creating healthy and thermally comfortable cities. Aimed at translating this fragmented literature, this research proposes an assessment tool of UTC strategies as an analytical framework to assist the design of urban landscapes which cope with the microclimate for mitigating extreme temperatures. By means of a loop-system methodology, the tool was refined by means of testing, assessing and reflection processes. Based on key UTC dimensions, the tool approaches criteria considered relevant in the urban design process, from a policy/abstract to a design/practical approach. Results show that UTC can be operationalized in urban policies and design by means of the assessment tool of UTC strategies. For the city of Groningen, the context in which this tool was validated, this framework can directly inform practitioners about UTC in accordance with climate-adaptation and healthy ageing visions.

Key words: Healthy Cities; urban thermal comfort; microclimate variables; analytical tool; urban design; urban policies.

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1. Introduction

1.1. Thermal comfort: another perspective

A thermally comfortable environment is one in which at least 80% of the occupants are thermally satisfied (Ashrae, A. N. S. I., 2013). The thermal sensation is influenced by microclimate variables and psychological factors (regarding to personal expectations and thermal preferences). In other words, this comfort feeling is defined as a product of one's expectations of the climate and what it actually is (Ashrae, A. N. S. I., 2013).

In Architecture thermal comfort is a priority, with first studies dating from the 1960's. Because the indoor environment is a confined space which contains long-staying environments (such as living and working spaces), it is understandable that thermal comfort has been explored for long within Architecture. However, thinking of current and future environmental changes, in local and global scales, outdoor temperatures are continuously changing. This makes urban thermal comfort an increasing concern in order to maintain the attractiveness and use of public spaces.

Such temperature changes result from processes in different scales. In the local scale, Moonen et al. (2012) emphasizes urbanization and addresses key urban transformations: urban sprawl, urban density, city fabric and blurring boundaries of metropolitan areas. An outcome of this scenario is alterations of outdoor heat balance, a phenomenon called the Urban Heat Island (UHI). This consists of the most climatic manifestation of urbanization (Moonen et al, 2012).

In the individual scale, main effects of the UHI occur on human comfort and health. High air temperatures lead to a "thermal stress", which is capable of causing discomfort, reducing physical and mental performances, as well as behavioural and psychological changes (Moonen et al, 2012). In a broader perspective - the global scale, climate change is capable of aggravating local thermal conditions. One way to mitigate such negative outcomes, according to studies, is allowing urban design to cope with microclimate changes in order to generate urban thermal comfort (UTC).

Another way is to make use of beneficial products of urbanization contributing to UTC. An example is using urban technologies, which are central to smart cities. According to Hollands (2015), smart cities use information and communication technologies (ICTs) for making cities more efficient and for solving shared problems. If smart also refers to improving urban quality, reducing UHI effects – which are shared urban problems - becomes a concern for smart cities to apply urban technologies in smart monitoring, microclimate measurements and management of outdoor conditions.

This discussion shows the direct relationship between urban health and urban thermal comfort. This relationship is also addressed by the Healthy Cities Movement, which aims at healthier cities capable of delivering health benefits for all citizens of varied urban contexts (Rydin et al., 2012). For this reason, healthy cities are one of the grounds of this research. Healthy Cities investigate how physical aspects of cities affect the public health (Duhl & Sanchez, 1999). For instance, (1) the enlarging urban land cover which increases surface waterproofing, (2) more buildings generating more urban heat and (3) longer commute distances contributing to more air pollutants being released (Rydin et al., 2012). However, urban planning and design studies still lack of an understanding how urban environments affect health outcomes, which is considered an urgent priority by the World Health Organization (Rydin et al., 2012). Furthermore, studies in Healthy Cities reveal a lack of an urban design guideline that approaches the urban-comfort-health relationship.

Chen & Ng (2012) illustrated the effect of microclimate on outdoor activities by distinguishing pedestrians from car commutes: pedestrians are directly exposed to the prompt environment, so they instantly feel the changes in the microclimate (e.g. shading, sun, wind), and this determines their satisfaction with and use of public spaces. In addition, the urban design also plays a key role: the configuration and materials used in the urban fabric have direct impact on city temperatures (Rydin et al., 2012).

> *Urban design is the discipline between planning and architecture. It gives three-dimensional physical form to policies described in a comprehensive plan. It focuses on the design of the public realm, which is created by both public spaces and buildings that define them.*
>
> *American Planning Association (2006)*

Urban policies can address and stimulate UTC; however, the actual outdoor thermal comfort relies on the existing landscape configuration. For this reason, this research will have a special attention to urban design, with a dual approach: related urban policies and actual urban design.

Based on this background information, this research will create an analytical framework for assisting the elaboration of UTC strategies in urban policies and urban design.

1.2. Urbanization and the use of public spaces

According to Seto et al. (2010), urbanization consists of changes in four main scopes: land cover, demographics, economic processes and geography. The outcomes of such transformations can be either positive (such as economic growth, income rise and environmental awareness) or negative (such as air pollution and irreversible environmental degradation). The main urbanization changes are perceived in the following aspects (Seto et al., 2010):

- Scale: increasing area, population, economic relevance and environmental impacts of cities.
- Rate: increasing shift of land and population from rural to urban.
- Location: highly active urbanization processes from current developed countries to developing countries in Asia and South America.
- Form of urban settlements: urban sprawl and suburbanization which transformed cities from compact to peri-urban (increase of metropolitan areas).
- Urban functions: increasing specialized labour, which affects directly urban labour force, urban environment and urban lifestyles.

More specific to physical and material changes within cities, Grimmond (2007) discussed the wide atmospheric and surface transformations associated with urban development and functions. In this case, alterations in surface morphology, such as the increase in the quantity of edifications and urban infrastructures, result in changes in wind and water flows, water quality and energy consumption. In addition to the emissions of CO2, pollutants and heat from human activities, different microclimates emerge within urban regions, a scenario which brings up the attention to Urban Heat Island (UHI). The future path of cities and the urban functions that will succeed will be a result of the combination between meteorological conditions, nature of urban environment and human activity (Grimmond, 2007).

Another important aspect consists of material used in urban equipment. Their properties (such as emissivity, conductivity and albedo) are capable of affecting air temperatures due to their large influence on heating and cooling patterns (Grimmond, 2007). The urban warming, which is associated with the heat wave

phenomenon, increases the vulnerability of urban populations and has relevant implications to health, wellbeing and human comfort.

According to Seto et al. (2010), the 21st century consists of the *Century of the City*, since it will delineate new social, economic and environmental patterns for the near and long-term future. In the long-term, for better responding and adjusting to environmental changes, the capacity of cities to adapt to contextual pressures becomes a key element for a sustainable urban development (Seto et al., 2010).

> *Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.*
>
> *(Gupta et al., 2010)*

Such contextual pressures consist of outcomes from urbanization (in local scale) as well as from climate change (in global scale). Some of these aggravating factors are presented in Figure 1, which illustrates this pressure-response relationship in the urban environment and the resulting urban quality.

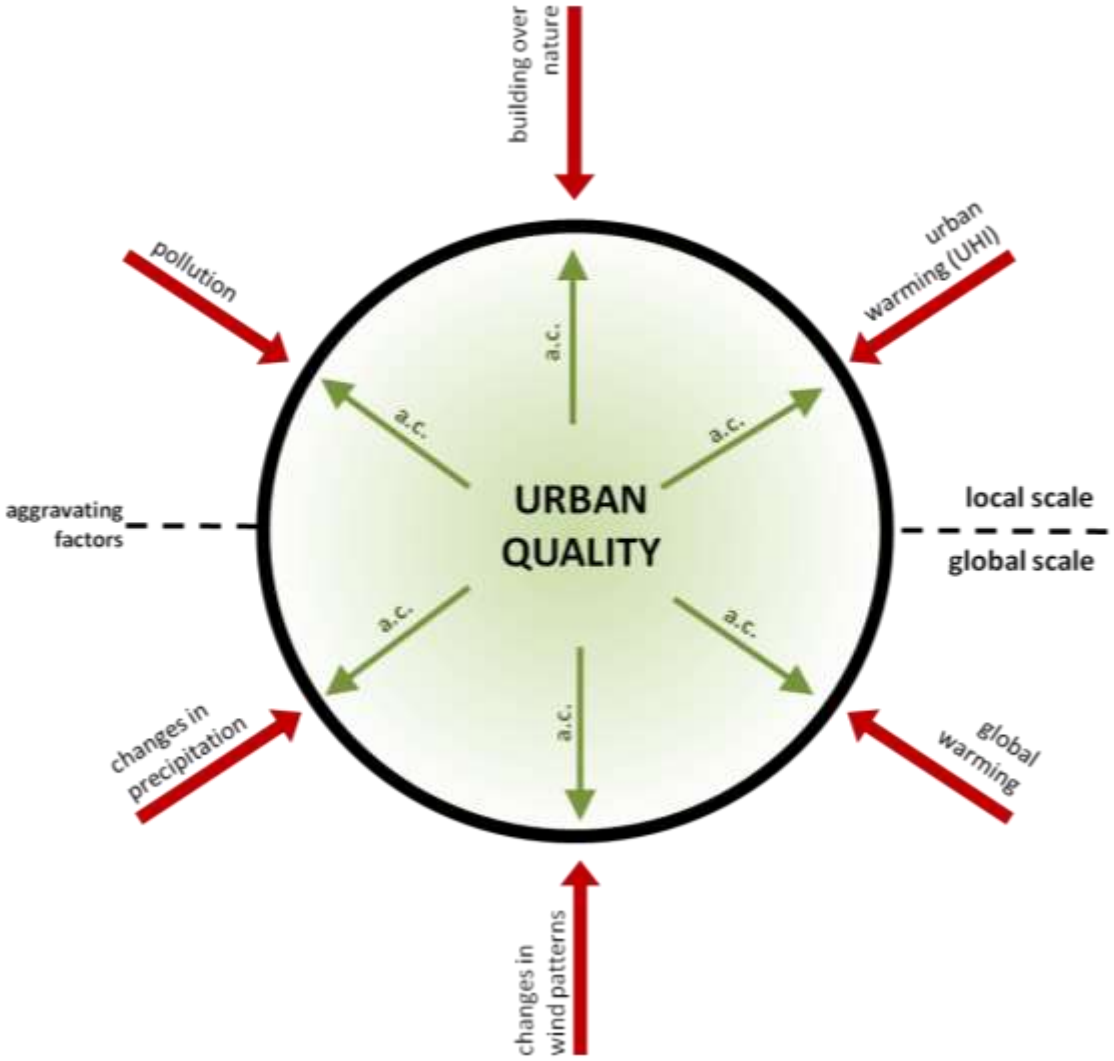


Figure 2- Future urban quality as a result of contextual pressures and system`s adaptive capacity (a.c.) (Author, 2017)

Figure 1 presents instances of internal and external aggravating factors which influence the degree of urban quality. These factors, presented in different scales, are outcomes of human activities related to demographic, environmental and socioeconomic changes. According to Jabareen (2013), such changes increase the vulnerability of urban communities and individuals by affecting their capacity to face and cope with environmental risks and future uncertainties. Therefore, adaptive capacity - a.c. - to such contextual pressures becomes a requirement for cities to make public spaces attractive and promote space use within the city fabric (Nikolopoulou & Lykoudis, 2006).

> *Human health is one part of the larger global ecosystem and is sustained by this system. Damage to the ecosystem will both directly and indirectly damage human health throughout the world.*
>
> *Duhl & Sanchez (1999)*

Duhl & Sanchez` (1999) statement shows the importance of coping with a more stabilized ecosystem in order to avoid harmful risks to urban health. Grimmond (2007) emphasizes that urbanization processes will, inevitably, continue to expand, meaning that urban populations and boundaries will continue to grow in size and number, making cities go through redevelopment and restoration processes. The decisions about how such processes will proceed will affect individuals within different scales (building, neighbourhood, city and region), leading, in a long term, to global implications (Grimmond, 2007). This scenario calls attention to the influence of decision-makers (urban planners, designers and policy-makers) in defining the urban quality.

This research elaborates on the claims from Chen & Ng's (2012) and Lenzholzer (2012) that there is still a lack of urban design guidelines for assessing outdoor thermal comfort. For this reason, the main product of this research is an assessment tool of UTC strategies. The tool is proposed as an analytical tool to assist those involved in the urban design process (decision-makers, urban planners and designers) in creating urban landscapes which contribute with outdoor thermal comfort. The data collection methods will define UTC dimensions, validate the assessment tool and reflect on the research and on the refined tool.

1.3. Relevance of this research

1.3.1. Social relevance

This study focuses on a feature to make places more attractive aside from aesthetics: the thermal comfort. According to Chen & Ng (2012), *a sense of thermal discomfort is likely to affect liveability, people's interest in using public spaces and, therefore, the function of urban spaces*. In a study developed by Lenzholzer (2012), this effect has been formerly perceived by the Dutch, who has associate outdoor thermal discomfort with urban configuration and microclimate conditions.

According to Chen & Ng (2012), it is very important to understand how urban design affects the microclimate, how microclimate affects outdoor thermal comfort and how this last one affects the use of outdoor spaces. Additionally, the Healthy Cities movement emphasized the urgency of urban planning in understanding how urban environments affect health outcomes and providing health improvements. In his aspect, this research aims at supplying such appealing by taking a first step towards developing UTC strategies: understanding and assessing UTC. According to Rydin et al (2012), it is still not clear how to provide potential health benefits that reach all citizens in an urban environment. In this aspect, this research has a social value by developing a framework for assisting the design of more thermally comfortable and healthier cities.

1.3.2. Academic relevance

According to Chen & Ng (2012), outdoor temperature influence pedestrian traffic and outdoor activities, meaning urban activities are highly influenced by UTC. However, literature in UTC is still limited and, according to (Chen & Ng (2012), there is lack of a guiding framework which interprets environmental conditions for assisting the development of urban design strategies. In this aspect, this research translates this fragmented literature into a tool which illustrates the relationship between microclimate and urban design and the resulting effects on outdoor temperatures. This tool can be validated and coherently be applied to practice.

In addition, this research incorporates urban design and microclimate into a tool which can be further used and adapted for studies in resilient cities and revitalization of cities for investigating urban quality. Lastly, based on the scientific discussion on smart cities, this research triggers a new perspective for the use of ICTs in the urban fabric: not only aimed at making urban systems more efficient, but also at promoting outdoor thermal comfort and space use.

1.4. Research questions

Primary research question:

How can urban thermal comfort be operationalized in urban policies and urban design?

Secondary research questions:

A) What characterizes Urban Thermal Comfort?
B) Which dimensions should be taken into account by urban policies and design for promoting urban thermal comfort?
C) Based on urban thermal comfort dimensions, how can an analytical framework be developed to directly inform urban design and urban policies in practice?
D) How does a proposed analytical framework function in practice and what changes can be suggested from its validation?

Figure 2 will be illustrated along this research for pointing out the (sub) chapters in which a research question will be answered. The figure will be an icon inserted beside the chapter name.

Figure 2 - Example of question icon for secondary question "A" (Author, 2017)

1.5. Structure of thesis

The methodological set of this research aims at answering the main research question. As a consequence, secondary questions are answered and the assessment tool is refined into a final product. This purpose defines the selection and the sequence of the methods. Chapter two will provide and the theoretical foundation of this research and, by approaching in-depth literature on UTC and its relevance, it will guide the methodological path. The methods are presented, as following:

A. **Literature review**: this first step will consist of the theoretical basis of this research, which will feed key information to **build up** the tool.
B. **Policy scanning:** for this research, this method has an empirical purpose. By means of scanning urban policies of the city of Groningen, the tool will be **tested**.

C. **Semi-structured interviews:** this step has an **assessment** purpose for this research. By means of semi-structured interviews with urban planners, designers and policy advisors of *Gemeente* Groningen, perceptions and suggestions for the tool will be collected. This will lead to an improved version of the tool.
D. **Focus group:** here a reflection on the research process and product is obtained. Through a session with the *Atelier Stadsbouwmeester* of *Gemeente* Groningen, urban planners, designers and policy advisors will reflect on the improvements to the tool and on the operationalization of UTC in urban policies and urban design (according to the main research question).

This methodology gives form to a loop system, though which a first conceptual model of UTC strategies becomes an assessment tool which is refined according to inputs assembled through the research process (see Figure 3). From a repetitive sequence of feedback and improvements, the methodology sharpens the product of this research until a point in which the contribution from the community of practice is saturated.

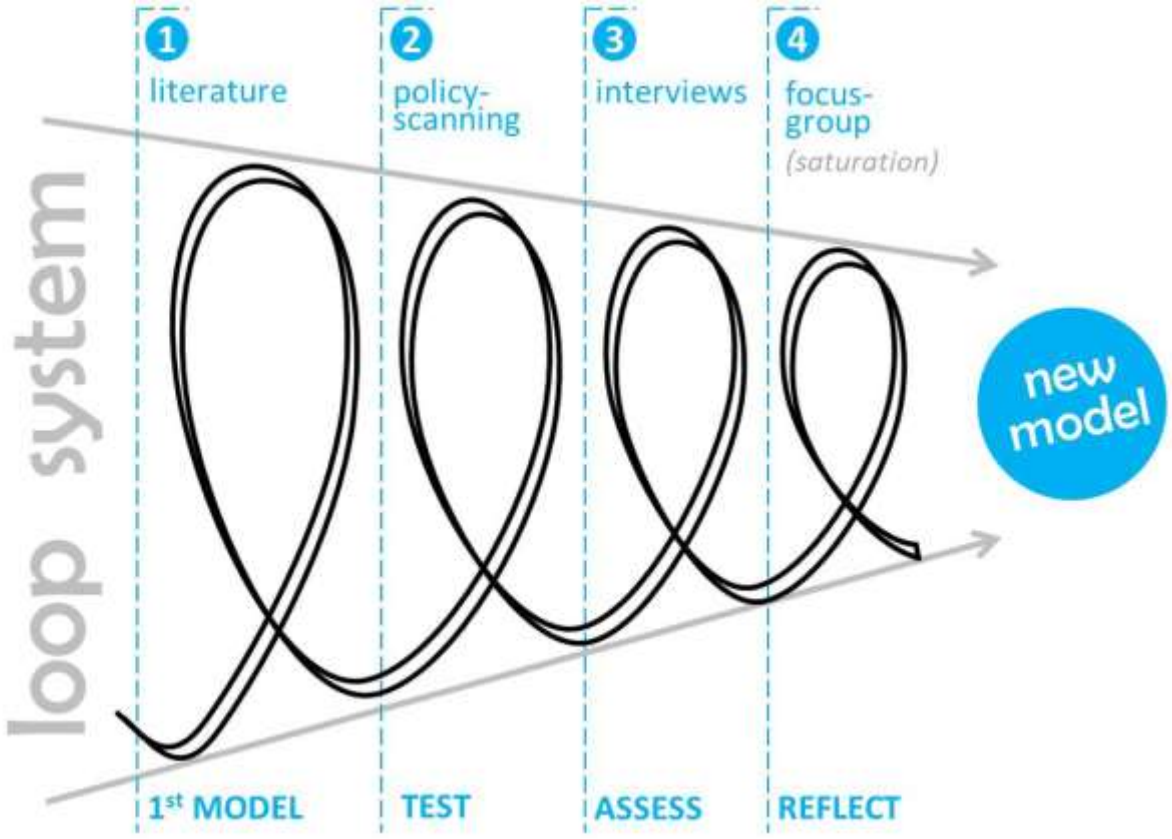


Figure 3 - Research framework (Author, 2017)

2. Theoretical framework

This chapter aims at explaining the reasoning behind this research. First, it is presented the foundation of the idea, where the concept of Healthy cities is introduced. Second, is it suggested the potential of urban technologies to promote outdoor thermal comfort, in which Smart Cities are discussed. In both cases it is enlightened the connection to urban thermal comfort, a concept which is elaborated subsequently. By presenting the longstanding approach to thermal comfort in Architecture, the urban-scale approach is introduced.

Thereafter, a conceptual model is built based on key dimensions for UTC and related criteria – according to literature review. The model is then transformed into an assessment tool which will be improved over the research.

2.1. Healthy Cities

According to Feliziani et al. (2014), the traditional concept of Healthy Cities is mostly related to "health X sickness", which has proven to be an insufficient approach to the varied nature of "health". In 1946, the World Health Organization gave the following definition for "health": *a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*. After this statement, studies have approached "health" in regards also to psychological and social aspects, connecting people with their living environments (Feliziani et al., 2014).

According to Barton & Grant (2013), the effect of the environment on health is an important issue in policy conceptualization and development. However, the relationship between the built environment and urban health is not yet a priority in urban policies and planning practice (Rydin et al., 2012). Overcoming this scenario requires the mutual interaction between society and governance processes, as well as urban planning, policy making and management (Rydin et al., 2012). Implementing green and water features and reducing heat emissions in urban centres are examples of policy measures within urban planning and design that can contribute to improving urban health.

According to Barton & Grant (2013), one of the main themes of the World Health Organization (WHO) is Healthy Urban Planning (HUP). This approach focuses on the determinant aspects of the physical environment and their effect on the quality of urban health. Within the main objectives of the HUP, the promotion of attractive environments with good air quality, healthy lifestyles and the reduction of threatening emissions are aspects directly connected to UTC (Barton & Grant, 2013). Therefore, health and UTC are directly connected, being the later an important condition to the former.

This relationship is perceived in the framework created by Barton & Grant (2013) for illustrating the key elements of health and wellbeing in cities (Figure 4).

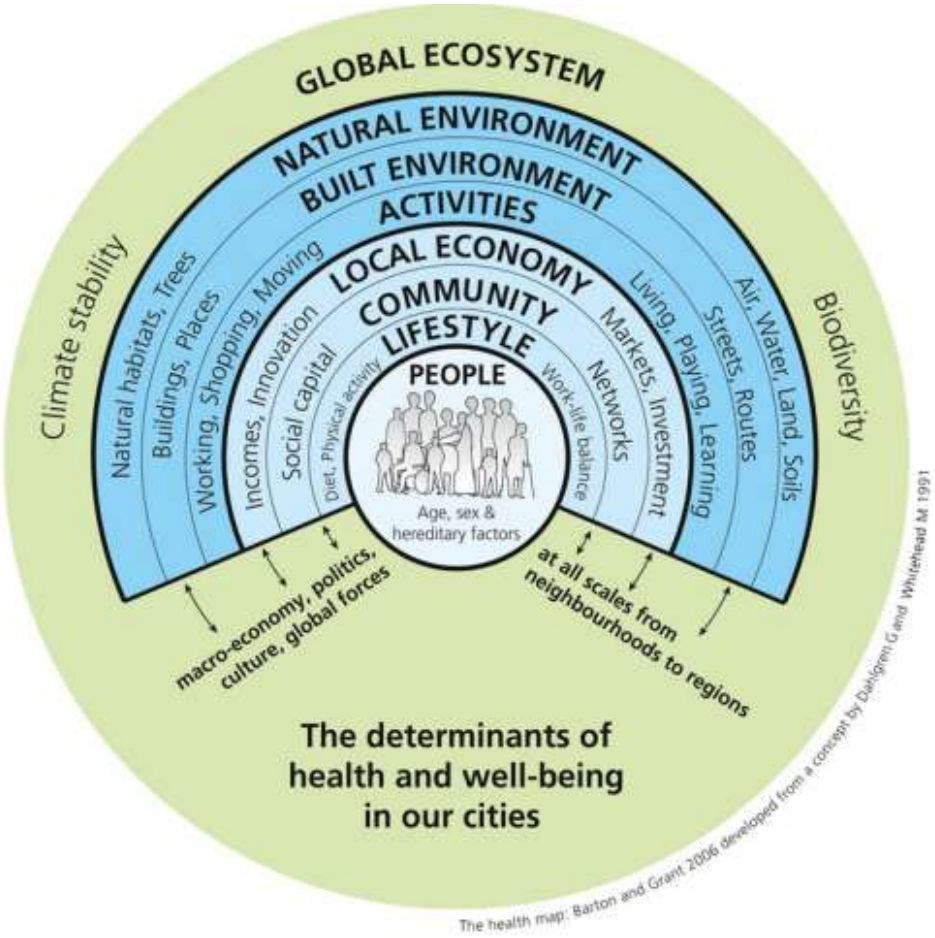


Figure 4 - A settlement-health map showing the broad nature of human-activity impacts on health and wellbeing (Barton & Grant, 2013)

Figure 4 shows the interactions between human activities and space throughout built and natural environments. In the local scale, the outcomes of human activities interfere in the natural environment, affecting the microclimate and, subsequently, UTC and urban health. Therefore, it is perceived that urban ecosystems are also capable of interfering in regional and global ecosystems through time. This illustrates a cause-effect relationship chain in which UTC and urban health are affected by man-made environmental changes in both short and long periods of time.

The outcomes of ecosystem changes are mostly felt on the local scale, which comprises the living environment. Densification and expansion of the urban fabric, outcomes of rapid urbanization, lead to the Urban Heat Island effect (UHI). According to Moonen et al., 2012, the UHI *is the most obvious climatic manifestation of urbanization*. The phenomenon is capable of causing intense urban discomfort by heat, affecting human health by means of a thermal stress (Taleghani el al., 2015). This scenario highlights the importance of accounting the microclimate for promoting more thermally comfortable and healthier cities.

2.1.1. Microclimate and outdoor space use

The quality and image of cities is determined by many factors amongst which a city's public spaces play a major role. Well-designed public spaces with a high sojourn quality attract people and contribute to the liveability of inner cities. The sojourn quality of urban public spaces depends on various aspects amongst which thermal comfort has been identified as important. Public spaces which do not offer thermal comfort tend to be underused or even avoided.

(Lanzholzer, 2012)

Microclimate is discussed in literature as a determinant of UTC. According to Moonen et al. (2012), it is a clear fact that urbanization and global warming are phenomena which enhance the Urban Heat Island (UHI). A consequence of this is the increase of energy demand for city maintenance, as well as of human exposure to discomfort and health-related problems (Moonen et al., 2012). For instance, excess heat has caused great number of deaths in the past: in 2003, heat waves killed 35000 people in Europe and 1900 in India, (Harlan et al., 2006).

Reflecting on how to assess the nature of urban warming, Moonen et al. (2012) suggests a multi-scale approach to the phenomenon and related factors to urban temperatures:

Globe: climate and climate change
Region: topography
City: urban heat island
Neighbourhood: urban morphology
Individual building: technical installations

It is perceived, therefore, that UTC is an outcome of heat exchanges throughout the different scales. In this aspect, it is important to define in what urban design scale UTC is properly assessed and managed? To what scale (within the ones presented by Moonen et al., 2012) is the assessment tool of UTC strategies better suitable for? For defining so, it is important to find out which of the scales comprise a more tenuous microclimate variation. In the study from Steeneveld et al. (2016), parameters of human thermal comfort and air quality were combined for the elaboration of an index for assessing urban climates. In the research process, it was verified that atmospheric variables vary substantially between neighbourhoods, being influenced by land-use, human activity and urban design. Thus, it is believed that the assessment of UTC dimensions is more coherent for a neighbourhood scale.

Another important aspect is: what is considered comfortable? Comfort ranges vary according to the climate (e.g. 21°C in the Netherlands is very pleasant, but in Rio de Janeiro pedestrians would wear scarfs). According to Ashrae (A. N. S. I., 2013), thermal comfort is mainly influenced by air temperature and humidity. For this reason, this research proposed UTC to focus on comfort ranges (scientifically defined) of air temperature and humidity, so urban design interventions would contribute for reaching these ranges throughout the year. An example is provided in Figure 5:

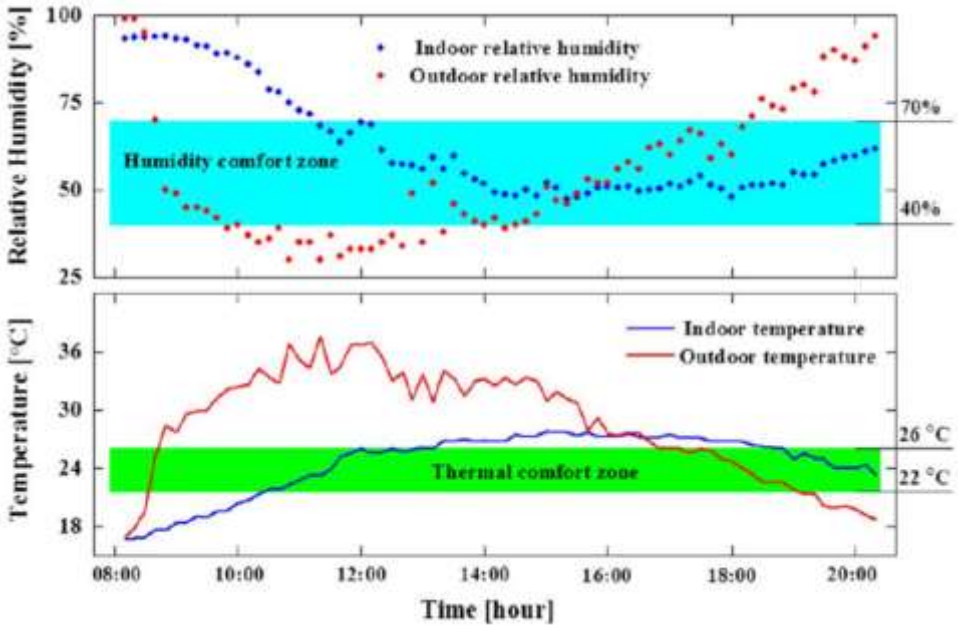


Figure 5 – Temperature and humidity annual performances and comfort zones for South Korea (Source: Kim et al., 2015)

Thinking of this aggravating scenario of urban warming discussed by Moonen et al. (2012), how can contemporary cities avoid becoming unattractive and depreciated? How can urbanization contour this scenario towards healthier and more comfortable public spaces? Resources for alleviating this downside path can be harvested from positive attributes of urbanization processes (as mentioned in sub-chapter 1.2). One of such attributes consists of innovative and technological developments of Smart Cities, which are perceived as great opportunities for assisting the monitoring and maintenance of UTC.

2.1.2. Smart cities

In a few words, Smart city is an urban vision which aims at solving urbanization problems with the assistance of information communication technologies (ICTs) (Hollands, 2015). According to Kitchin (2014), there are two understandings which define a city as "smart": first, cities increasingly consisting of "everyware", meaning the disseminating computing of digital devices throughout the urban fabric; second, a city driven by a knowledge economy, meaning a city from which economy and governance are led by creativity, innovation and entrepreneurship.

Based on these concepts of "smartness", Hollands (2015) suggests another perspective: outdoor technologies collaborating for solving shared problems and for providing more pleasant cities. Nonetheless, Smart Cities do not have yet an approach to urban thermal comfort, although they have a great potential for promoting and monitoring outdoor conditions in urban environments. According to Seto et al. (2010), a positive side of urbanization is that agglomerations are technologically equipped for providing more sustainable solutions for softening negative urbanization effects. According to the author, this is possible by means of the flows of ideas and innovations that contribute to economic growth and healthier urban developments. It is perceived, therefore, the potential of smart cities in contributing to heartier urban environments and to UTC.

2.2. Thermal comfort: a preceding approach

In the field of Architecture, thermal comfort is a longstanding topic of research. This can be attributed to the fact that people spend, in general, more than 90% of their lives inside buildings (Evans & McCoy, 1998).

However, in urban planning and design, outdoor thermal comfort is not a topic properly explored. Consisting of delimited and controlled spaces designed for assuring occupants` health and comfort (Saberi et al., 2006), indoor environments are studied, monitored and simulated more easily than outdoor environments.

> *Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation.*
>
> *(Ashrae, A. N. S. I., 2013)*

In general terms, thermal comfort is achieved when there is a balance between the heat produced by one`s body and the heat lost to the environment (Lin et al., 2011). The non-stability of this balance leads to a thermal discomfort from heat or cold, referred to as "thermal stress" (Lamberts, 2016). From the adaptive perspective, this thermal discomfort stimulates individuals to seek mechanisms for achieving the thermal balance, such as clothing or electrical equipment (e.g. heater or air conditioning) (Lamberts, 2016). The later, according to Manzano-Agugliaro et al. (2015), entails intense energy consumption, represented by 60% to 70% of the energy consumed in non-industrial buildings. To avoid aggravating this situation, architectural solutions aim at creating zero energy strategies for generating thermally comfortable indoor environments. These are referred to as **bioclimatic strategies**, which aim at three main factors: sustainability, human health/wellbeing and energy (Manzano-Agugliaro et al., 2015).

In this case, bioclimatology refers to *the study of climate in relation to living organisms and especially to human health* (OED, 2017). According to Manzano-Agugliaro et al. (2015), the predominant climate variables are solar radiation, temperature, humidity and wind. Similarly, because indoor temperatures vary according to outdoor thermal conditions, bioclimatic strategies consider the following thermal comfort variables: radiant temperature, air temperature, humidity and airflows (Taleghani et al., 2015). These four variables are also approached by the main thermal indexes, such as the Psychological Equivalent Temperature (PET). When the four thermal comfort variables provide together an indoor thermal balance, a "comfort zone" is achieved.

> *The comfort zone [...] exhibits the ideal conditions for the human body. Statistically speaking, this zone is comfortable for 80% of the population. It represents the area in which the human body, with light clothing and little activity, does not require energetic expenditures to remain comfortable. This zone is bound by temperature values between 21 ℃ and 26 ℃ and relative humidity values between 20% and 70%. No strategies need to be implemented in this zone.*
>
> *(Manzano-Agugliaro et al., 2015).*

When outside the comfort zone, the bioclimatic strategies used can be either passive (when the approach is the building envelope – the "skin" of the building) or active (when external energy sources are used). Some examples of passive strategies used for heating are presented in Figure 6:

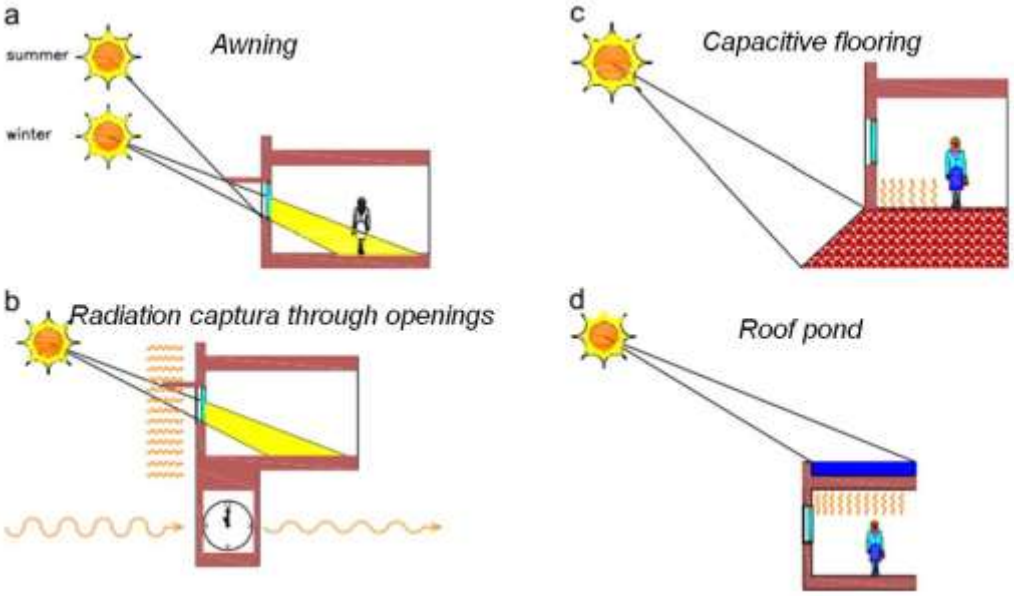


Figure 6 - Samples of bioclimatic strategies for passive solar heating (Manzano-Agugliaro et al., 2015).

Introducing the Architectural approach of thermal comfort to this research is important for triggering the thinking of how to transplant this concern to urban spaces. Even though outdoor spaces are more difficultly manipulated, this sub-chapter provides an overview of basic requirements to be taken into account for implementing UTC in urban policies and urban design. Likewise, the discussion of bioclimatic strategies provides an understanding of how to manipulate a certain environment for promoting thermal comfort. Therefore, bioclimatic strategies are an inspiration for proposing UTC strategies.

2.3. Urban thermal comfort strategies: towards a guiding framework A

This sub-chapter elaborates on what characterizes UTC (research question "A"). According to Eliasson et al. (2007), the great aim of architecture and urban design is to create "comfortable" living environments. Zacharias et al. (2001) complements this statement by emphasizing that this sense of comfort requires urban design to understand how humans respond to microclimate conditions. In this aspect, Chen & Ng (2012) and Lenzholzer (2012) emphasized the current lack of a framework to guide urban planners and designers in this understanding towards creating thermally comfortable urban spaces.

The creation of such guiding tool requires the operationalization of UTC. According to the Oxford English Dictionary, "operationalization" consists of *operationalize + action*, in which "operationalize" means to *express or define (something) in terms of the operations used to determine or prove it* (OED, 2017). For this reason, the main product of this research will be an assessment tool of UTC strategies, which will "turn UTC into practice". The tool will function as an analytical framework which will suggest key aspects in urban policies and urban design for promoting UTC.

Since the tool concerns to UTC strategies, it is first required to understand what characterizes urban thermal comfort. Based on the literature previously discussed, UTC can be defined as (Figure 7):

A **thermal balance** of the human body in outdoor environments. Such balance consists of an equilibrium between the heat produced and the heat lost by an individual outdoors, influenced by microclimate variables and urban design aspects. Thermally comfortable outdoor spaces are those in which the urban design interprets and copes with microclimate variables for providing an urban landscape with more comfortable temperatures.

(Author, 2017)

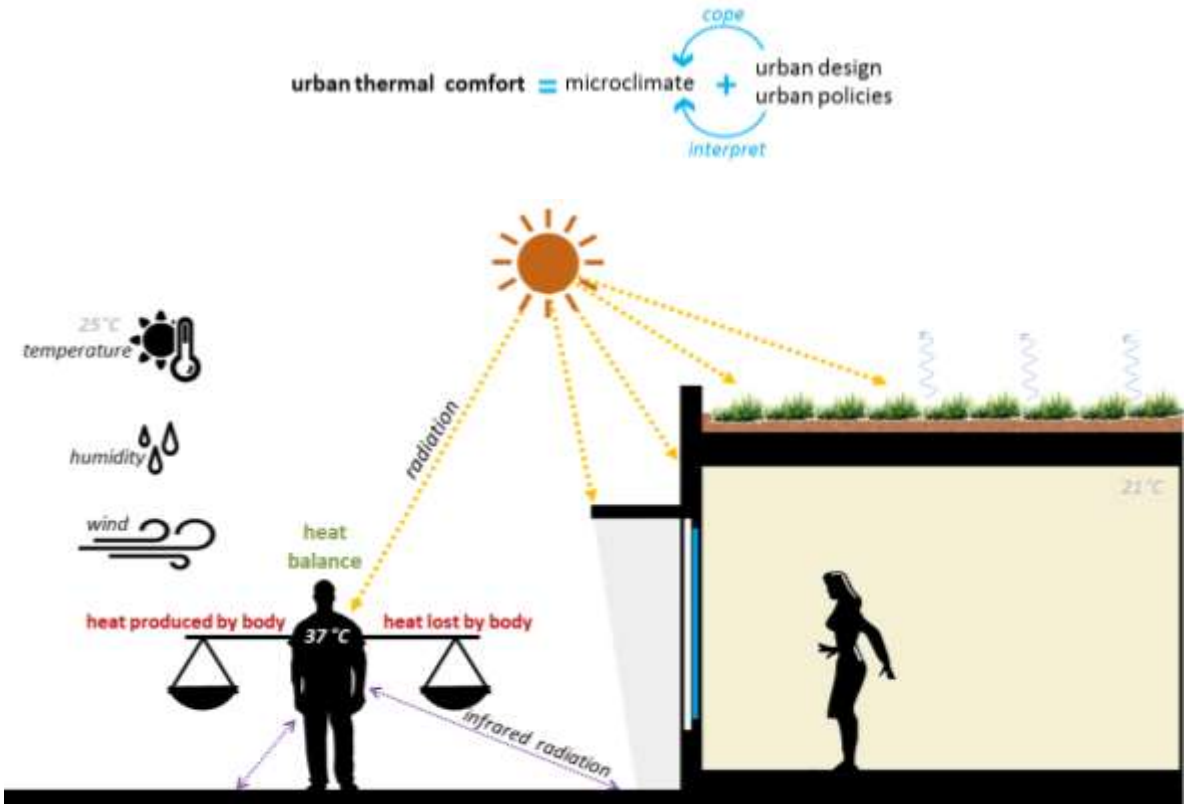


Figure 7 - Illustration of thermal comfort in the urban and in the indoor space (Author, 2017)

From the conceptualization, it is perceived the difference between thermal comfort in the urban environment and in the built environment. In the last case, as previously discussed in sub-chapter 2.2, Architecture makes use of bioclimatic strategies for promoting UTC (e.g.: green roof and shading devices for cooling - see figure 6). This illustrates the capability of individuals to use mechanisms for achieving, themselves, an indoor thermal balance. Because outdoor thermal conditions are largely out of one`s control, achieving outdoor temperatures within comfortable ranges is extremely difficult. For this reason, what applies in this situation is creating urban landscapes which cope with the microclimate for alleviating extreme temperatures, here proposed by means of UTC strategies (further explained in chapter 2.4).

Because UTC takes form in the outdoor environment, the promotion of UTC in public spaces requires the definition of policy ambitions and strategies. For this reason the assessment tool will contemplate both urban design and policies. Land-use policies and the physical landscape should be able to incorporate UTC in public spaces of varied activities through seasonal and over time temperature changes. By doing such, urban health is enhanced and public spaces become more attractive for people to experience and to use.

The next chapter will build up the conceptual model and subsequent assessment tool of UTC strategies. First, the dimensions for developing UTC strategies will be presented. Subsequently, their corresponding criteria will be defined.

2.4. Research dimensions: a literature review B

This sub-chapter will introduce key dimensions for promoting UTC (answering research question "B"). Extracted from the literature review, these dimensions are perceived as necessary features for the development of an assessment tool of UTC strategies with a urban design and policy approach. They will be elaborated in accordance to the guiding questions of qualitative analysis (Berg, 2004): "what?", "who?", "why?", "how?" and "when?". The "why?" establishes the general purpose of the research; the "what?" and "how?" help define the issues and problems; "who?", "where?" and "when?" focus on specific events or actors related to the issues and problems (Berg, 2004).

For this research, the purpose ("why?") was previously discussed in the introduction, with the claim for a guiding framework to assist urban planning and design towards UTC. The answer to the other questions will be reflected on the dimensions (Figure 8), which will structure the assessment tool.

Figure 8 - The dimensions accounted for developing urban thermal comfort strategies (Author, 2017)

- **Design**: what is UTC and what is the relationship between urban design and microclimate?
- **Inclusion**: who is involved in the inclusion of UTC in urban policies and design and how does this inclusion proceed?
- **Implementation**: How is UTC implemented in urban policies and urban design? What (legal) mechanisms are used in this implementation?
- **Adaptability**: how is urban design and policies managed over time for continuously providing UTC?

Figure 8 illustrates the interconnections between the dimensions of UTC strategies. Within each dimension, different actions can be taken in order to promote UTC. Such actions will be structured as criteria, which are suggestions for urban policies and design to take into account for promoting UTC. Even though the *design* and *adaptability* dimensions refer directly to urban design practice, all dimensions and criteria of the tool are to be considered also in urban policies.

The discussed literature has emphasized that urban planning and design lack of understanding microclimate conditions. For this reason, the tool suggests that an interpretation of the microclimate is performed before actions are taken within each criterion. With this *microclimate-sensitive* perspective, regular urban design strategies become actual UTC strategies. The dimensions and respective criteria will be illustrated, therefore, as Figure 9:

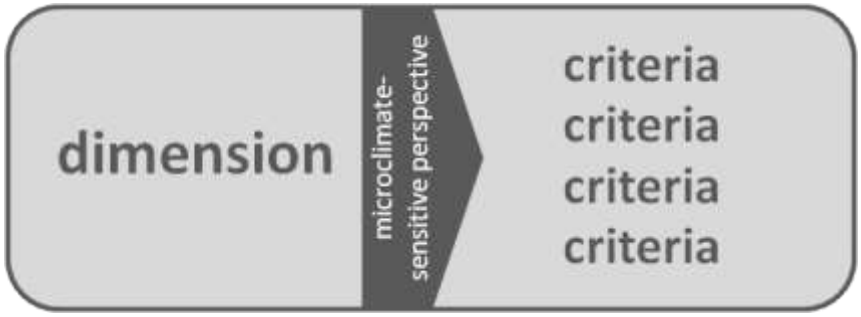


Figure 9 - Scheme of dimensions and criteria which will structure the assessment tool (Author, 2017)

The upcoming sub-chapters will deepen the discussion in each dimension and their corresponding criteria, which will, all together, structure the assessment tool.

2.4.1. Dimensions of UTC strategies: design

> *Wind, sun, and humidity also interact with air temperature such that the felt temperature may vary considerably, as will the comfort level of people experiencing those conditions.*
>
> *(Zacharias et al., 2001)*

The discussed literature has presented four key microclimate variables: solar radiation, temperature, humidity and wind (Manzano-Agugliaro et al., 2015). Zacharias et al. (2001) also discussed the importance of understanding how these variables combine in sensations of outdoor thermal comfort. In addition, Lin (2009) emphasized that thermal comfort patterns vary according to different climates. This means that the temperature ranges of thermal comfort in colder and warmer climates are different, due to the distinct average year temperatures. For instance, the Dutch may feel very comfortable outdoors when it is 18 degrees; however, Brazilians from the Northeast region may feel a thermal stress by cold with such temperature. This reflects the different effects from microclimate variables in different contexts. While Dutch pedestrians have a negative perception about wind as great intensifier of cold temperatures (Lenzholzer, 2012), in Northeast Brazil the situation is reverse: wind alleviates the sensation of warmer temperatures.

For this reason, the development of urban design strategies requires understanding that urban design aspects in different microclimate contexts have different effects on UTC. This situation is not only perceived in places of distinct geographic locations, but also within the same microclimate, due to seasonal changes. Following the Dutch case, wind buffering (with use of trees, for instance) may soften wind speeds in open areas and contribute to UTC during the winter; however, during the summer, wind may have a reverse effect, enhancing UTC.

Hence, the criteria within the *design* dimension will be flexible for taking into account the adverse effects of urban design on UTC, so the resulting assessment tool is suitable for different climates. The criteria of this dimension will be based on the literature presented in Table 1, which analysed UTC in distinct climates (hot and cold / arid and humid).

Table 1 – Scientific articles selected for defining the criteria of the *design* dimension

Authors	Title	Case studies	Climate
ShashuaBar et al. (2011)	The influence of trees and grass on outdoor thermal comfort in a hot-arid environment	Be'er Sheva (Israel)	hot
Johansson (2006)	Influence of urban geometry on outdoor thermal comfort in a hot dry climate: a study in Fez, Morocco	Fez (Morocco)	hot
Lenzholzer, (2012)	Research and design for thermal comfort in Dutch urban squares	Den Haag, Eindhoven, Groningen (Netherlands)	cold
Thorsson et al. (2011)	Potential changes in outdoor thermal comfort conditions in Gothenburg, Sweden due to climate change: the influence of urban geometry	Gothenburg (Sweden)	cold

The literature has mostly performed intense quantitative and technical analyses on UTC. Lenzholzer (2012), however, despite having collected quantitative data, also performed a clear qualitative reflection on microclimate characteristics: citizen perception of microclimate, citizen perception of outdoor thermal comfort and possible urban design strategies capable of improving the UTC. For this reason, the findings of Lenzholzer (2012) will be taken as a benchmark (Table 2) and will be complemented by insights from the other articles presented in Table 1(more details in Appendix 7.1).

Table 2 – Urban design aspects and their effects in Lenzholzer (2012)

	Thermal comfort in Dutch urban squares			
	Urban design aspects	**Effects on microclimate**	**General UTC sensation**	**Urban design suggestions**
A	Very open areas	Windswept	Discomfort	Use **spatial objects for wind buffering** (wind screen, vegetation, larger urban furniture, artistic sculptures); create **urban sheterbelts** as microclimate transition zones (between buildings and outdoors)
B	Open foot areas of high buildings	Wind downwash effects	Discomfort	Adding awnings or **wind buffering** devices; keep public away from these areas
C	Entrances of street canyons	Strong wind effects	Discomfort	Avoiding long-standing functions in these areas
D	Passages	Strong wind from varied directions	Discomfort	Avoiding long-standing functions in these areas
E	Semi-enclosed areas	Acceptable shading and wind speeds	Comfort	Create more **semi-enclosed areas as alternative wind-protected spots** (with trees, walls, wind screen...); proper solar orientation of such areas for ideal sun exposition
F	Open foot areas of lower buildings	Acceptable wind speeds	Comfort	Use **well oriented areas** for long-standing functions
A'	Wide squares	*(associated with psychological perception)*	Discomfort	Urban designers adopt the ratio Height/Width (**H**/**W**) of 0.25 for designing squares
B'	Open squares	*(associated with psychological*	Discomfort	**Equipping space** with vegetation, special furniture, wind screens, fountains and other elements; **allowing**

		perception)		**microclimate for various needs**
C'	Urban layout with "cold" materials	*(associated with psychological perception)*	Discomfort	Use materials with warm colour tones (less conductivity and lower albedo)

According to Lenzholzer (2012), there are two main microclimate variables of which effects on UTC can be mediated by urban design: solar radiation (related to sun/shading) and wind. This argument is clearly reflected in the findings presented in Table 2. According to the author, wind is the microclimate variable which most influences the thermal discomfort by cold in colder climates. By contrast, Johanson (2006) and Thorsson (2012) pointed out solar radiation as the microclimate variable which most influences thermal discomfort by heat in warmer climates.

In a cold climate, Lenzholzer (2012) proposed urban design strategies for overcoming thermal discomfort by cold which, in summary, consist of diverse types of wind buffering. These are supposed to be strategically located for providing proper shading during warmer seasons. In this aspect, the author analyses the physical aspects within urban design which affect directly outdoor temperatures (on Table 2, from A to F) and which affect specifically people`s sensation of outdoor temperatures (from A' to C'). This infers that the sensation of UTC is not simply assessed by quantitative measurements of microclimate variables, but also by assessing citizen perception of outdoor environments.

From the urban design aspects presented by Lenzholzer (2012), the first criterion is defined: **urban geometry**. The author` study showed the influence of open, wide, narrowed and semi-enclosed areas in contributing to thermal comfort or discomfort. Urban geometry is also approached by Johanson (2006), who analyses the configuration of street canyons[1]. According to the author, *the ratio between the height of buildings (H) and the distance between them (W) influences the amount of both incoming and outgoing radiation and also affects wind speeds*. In other words, the taller buildings are along a street canyon, the more wind is canalised and the more shading is generated throughout the canyon surfaces. Accordingly, the reverse occurs in shallow canyons (Figure 10). Thorsson et al. (2011) also points out that the more open urban areas are, the higher amplitudes of radiant temperature are obtained. This criteria, therefore, affects mostly shading and wind speeds.

[1] According to Vardoulakis et al. (2003), there are three main classifications of street canyons: shallow canyon (Height/Width ~= 1 with no major openings on the canyon walls; avenue canyon (H/W < 0.5); deep canyon (H/W ~= 2).

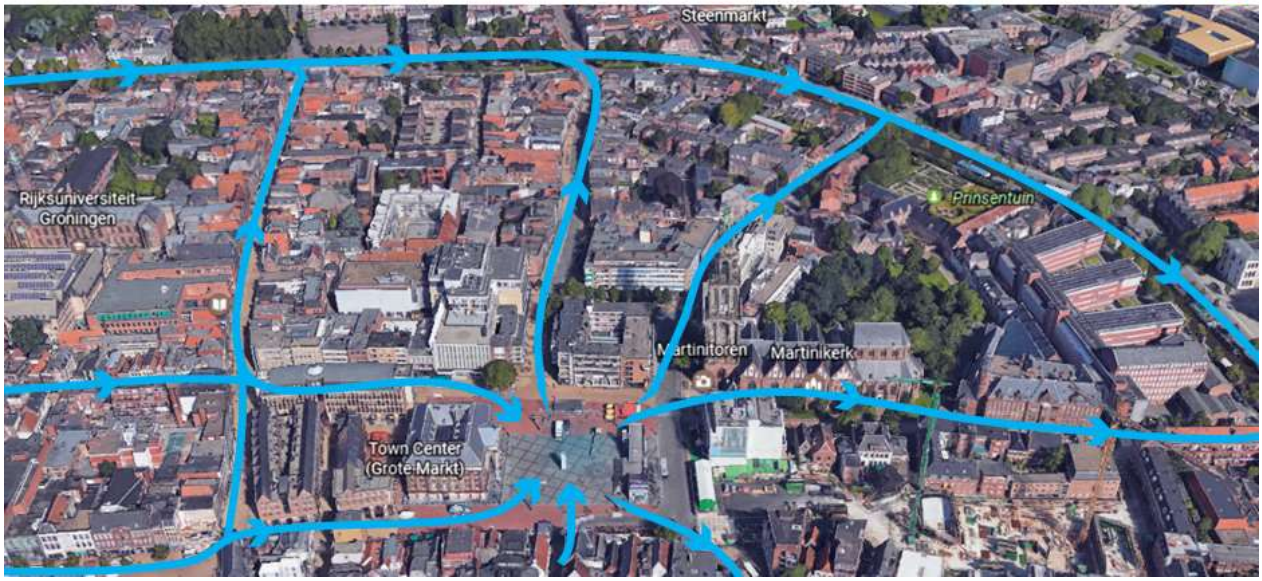


Figure 10 - Effect of urban geometry in wind speeds (predominant Southeast) during winter in the inner city of Groningen. Shallow street canyons (without spacing between buildings) receive high speed wind from canals and canalize towards the *Grote Markt*, where varied wind directions converge. In a very cold and cloudy day, this square is likely to be uncomfortable and disused. (Source: Google Earth, adapted)

The literature of Table 1 has discussed that variations in urban geometry within a single neighbourhood (and microclimate) entail different degrees of UTC. This means that people walking by a wooded sidewalk along a shallow street canyon and others standing in the middle of an open square, at the same time of the day, can have different UTC sensations. Similarly, the literature proposed punctual urban design solutions for improving UTC in each small-scale scenario. Such strategies played with the urban furniture, which consists of natural or material elements for shading or wind buffering purposes, allocated on the ground or vertically attached as urban shelters (figures 11 and 12). Perceived that urban design is more effective in promoting UTC if focused on each landscape configuration (Lenzholzer, 2012), **micro-scale geometry** is the second criterion of the *design* dimension.

Figure 11 - Grote Markt (in the inner city of Groningen): an open, wide square, with lack of greenery, shading or wind buffers, retaining much heat in the summer and feeling colder in cold-cloudy days (Source: online)

Figure 12 - The Grote Markt with trees strategically located for buffering wind during the winter and providing shading during the summer (not many design interventions proposed due to the heritage building in the middle of the square) (Source: Author)

The third criterion consists of **built surface materials.** The different properties of materials used on floors, urban furniture and facades influence differently the dissipation or retention of solar radiation (Johanson,

2006) (Figures 13 -17). Another perspective is also the influence of surface materials on people`s thermal sensation by means of visual aspects (such as warm and cold colours, as discussed by Lenzholzer (2012).

Figure 13 - The Damsterplein in Groningen: an open and completely paved square with scarce shading and unattractive colours. This area is likely to retain much heat in hot days and feel colder in cold days (Source: Author)

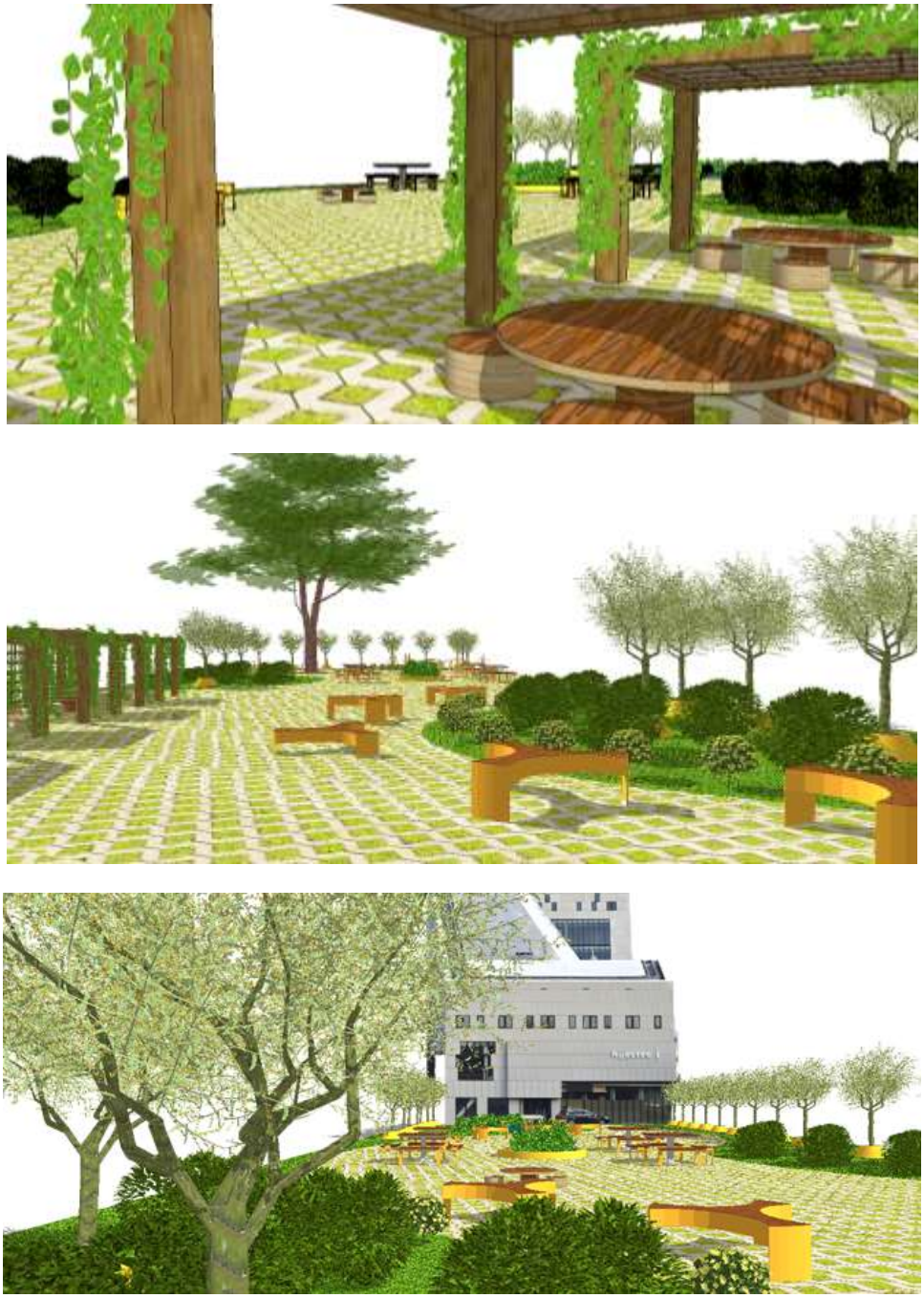


Figure 14-17 - An alternative to Damsterplein: permeable ground, warm colours in landscape, leisure equipment, more greenery (also with portable trees due to the parking garage underneath); a more thermally and aesthetically attractive square (Source: Author)

In the case of natural surfaces, ShashuaBar et al. (2011) discuss the contribution of ground vegetation for mitigating extreme temperatures. According to the authors, green is more efficient in providing thermal comfort when it is combined with a water source. This can be from simple irrigation until the use of ponds, fountains, water canals (among other alternatives), as long as evapotranspiration is promoted for humidity to mediate extreme urban air temperatures. In addition, heat exchange in ground surface is a relevant aspect. In very hot days, the underground is cooler, and vice versa (ShashuaBar et al., 2011). This is why greenery is also interesting for colder seasons. Based on this argument, **green (+blue)** is the fourth criterion within the *design* dimension.

By means of the *design* dimension, the assessment tool will verify if the respective criteria (presented in Figure 18) are perceived in urban design and considered in urban policies:

Figure 18 - The criteria within the *design* dimension for UTC strategies (Author, 2017)

2.4.2. Dimensions of UTC strategies: inclusion

In the assessment tool, the *inclusion* dimension will verify how UTC can be included in urban policies and urban design. This inclusion concerns to key institutions involved in the promotion of UTC which, in turn, take actions for UCT strategies to be incorporated in urban policies and design.

According to Chen & Ng (2012), urban planning is more effective when it analyses the connection between microclimate conditions and human sensations, in both spatial and temporal terms. This implies an assessment of people`s microclimate perceptions, thermal feelings and behaviours in outdoor environments over time, by means of interviews and observations (Cheng & Ng, 2012). Based on this citizen approach, two criteria are perceived as relevant in the *inclusion* dimension: **citizen assessment** and **space use assessment**. The first criteria relates to a citizen feedback on UTC, in which citizens make personal evaluations of microclimate variables in distinct locations. This can be done by means of local interviews (as suggested by Chen & NG, 2012), online questionnaires or even by creative mechanisms. The last one, for instance, could be websites or mobile apps of easy access by citizens, capable of supporting municipalities in assessing UTC within neighbourhoods. This example illustrates the potential role of smart technologies in enhancing UTC.

Space use assessment, the second criterion, refers to studying the occurrence of urban activities in public spaces in different temperatures. In other words, it relates outdoor temperatures with human behaviour. This could be done, for instance, with heat maps in hands: in critical spots, observing space use – or even according to age groups.

Another important aspect in this dimension is that the inclusion of UTC in urban policies and design requires institutions with either political or economic power to take initiatives. Such institutions are likely to be non-citizen organizations which have an interest in the cause. In the discussion about healthy cities, Rydin et al (2012) emphasized the importance of local government in taking initiative for strategy development. The author suggested local governments to develop health information systems, incorporating methods to promote urban health in urban policy and planning documents, as well as creating procedures to evaluate the strategies implemented. The connection between UTC and urban health previously discussed allows the translation of Rydin et al (2012) suggestion into the third criterion: **governmental action**.

However, public institutions are not the only ones capable of taking such initiative. When discussing adaptive spatial planning for climate change, Van Buuren et al. (2013) summarizes spatial planning as a sum of regulations and private investment. According to the author, two scenarios are expected: one in which the government takes first actions and another in which the private sector takes initiative. In this last case, when there is no spontaneous action taken, the public sector is capable of influencing the private by means of subsidies and political instruments (such as changes in land-use plan). Hence, Van Buuren et al.

(2013) emphasizes that both public and private institutions share responsibilities in promoting policy changes. Perceived both public and private institutions as pioneers in UTC initiatives, the fourth criterion is **market involvement.**

Nonetheless, the preceding literature has addressed the lack of approach to human thermal comfort in urban planning - theory - and in urban design - practice. According to Jabareen (2013), urban spatial transformations require the production, trade and diffusion of knowledge. Without proper knowledge about the microclimate and its mutual relationship with urban design, UTC strategies cannot be successful. In practice, this supply can derive from individual studies (such as this research), universities and/or expertise organizations. Hence, **knowledge base** is the fifth criterion in this dimension.

By means of the *inclusion* dimension, the assessment tool will verify if the respective criteria (presented in Figure 19) are perceived in urban policies and design:

Figure 19 - The criteria within the *inclusion* dimension for UTC strategies (Author, 2017)

2.4.3. Dimensions of UTC strategies: implementation

The *implementation* dimension, in general, will approach the process of implementing UTC in practice. In other words, it will assess if the means through which UTC can be implemented are perceived in urban policies and urban design. In addition, it will assess if the implementation of UCT is already explicit in the existing urban design.

In the previous sub-chapter, the relevance of governmental action in taking initiatives for promoting UTC was introduced. In this aspect, Carmona et al (2014) argues that *generating a vision* is a key factor for a positive change in urban design. Such visions are translated in policy plans, programmes and projects which are capable of providing a direction for actions in urban design to be taken. Perceived the importance of such actions in steering UTC strategies, **UTC visions** will be the first criterion of the *implementation* dimension.

The actual implementation of UTC in urban design requires that UTC is incorporated in **urban design parameters**, which consist of the second criterion. Such parameters are design guidelines which shape the urban landscape. These are related, for instance, to land use, permeability rates, distribution of green (also in roofs), occupation rates, proportions of buildings and streets, among other parameters. According to Carmona et al (2014), urban design plays a role in injecting quality in cities by means of creating urban landscapes capable of bringing public benefits.

Another aspect is that the promotion of UTC in public spaces is influenced by urban design in both public and private areas. Imagine, for instance, a housing neighbourhood in which all dwellings contain terrains 100% paved. For an individual passing on a sidewalk of this neighbourhood, what is the difference in the temperature if compared to a scenario in which all dwellings have a minimum green area? Even though public urban design may distribute trees along the sidewalks, the paved terrains have an impact on the

radiation emitted by the ground surface and, subsequently, the air temperature. This example illustrates the influence of the set of landscapes on UTC as a whole. Based on this observation, how can urban design parameters be enforced within public and private areas (when applicable)?

According to Carmona (2014), a variety of regulatory instruments must be agreed on for the realization of urban design projects (either public or private). Such instruments are defined by the author as *negotiating consents,* which consist, for instance, of public proposals and building consents. These consist of **regulations for public spaces** and **regulations for private developments**, the third and fourth criteria in this dimension. In this case, the two criteria are separated because legal mechanisms are applied to public and private areas differently.

Another criterion is based on the resources necessary for implementing UTC, which can require new actors and new institutions[2]. Carmona (2014) indicates the combinations of public and private funding as necessary for the development of urban design projects. In other words, financial resources from private or public actors. Another important resource relates to expertise in the field of UTC. In this case, Restemeyer et al. (2015) presents *intellectual capital* as *knowledge resources,* which consist of expert knowledge and technical systems. Such resources may involve other actors in the process, such as universities, planning and ICT organizations. Based on this discussion, the fifth criteria of the implementation dimension is **institutional resources**.

The last criterion regards to how explicit is the provision of UTC in the existing urban design. After all, UTC is not provided only by means of written policies; it must also be incorporated in the actual landscape. For this reason, **actual implementation** is the sixth criterion of this dimension.

Thus, by means of the *implementation* dimension, the assessment tool will verify if the respective criteria (presented in Figure 20) are explicit in the implementation process of UTC in urban policies and urban design:

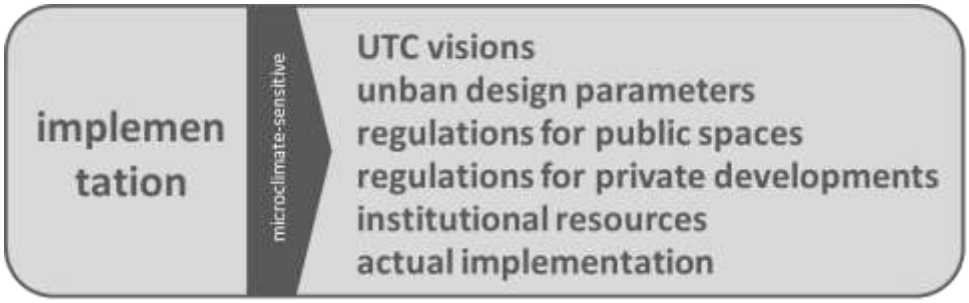


Figure 20 - The criteria within the *implementation* dimension for UTC strategies (Author, 2017)

2.4.4. Dimensions of UTC strategies: adaptability

> *Urban design projects are rarely subjected to post-occupancy review in the way that buildings are, and almost never is a systematic view taken across the entire process of creating or recreating places. This plays into a key critique of urban design, that its obsession with finished product marginalizes its understanding as an on-going long-term process intertwined with social and political mechanisms.*
>
> *(Carmona, 2014)*

[2] According to Gupta et al. (2010), institutions are *systems of rules, decision-making procedures, and programs that give rise to social practices, assign roles to the participants in these practices, and guide interactions among the occupants of the relevant roles.*

When discussing urban design processes, Carmona (2014) emphasized the issue of urban design approached as a finite process. This fact, however, contradicts with the instability of environmental changes and urban dynamics over time. Bringing this issue to an UTC perspective, the management of UTC within urban policies and urban design through time becomes a concern. Eliasson et al. (2007) discussed the seasonal microclimate variations during the year, emphasizing the importance of urban design in considering such temperature changes for turning public spaces "climatically" attractive during all the year. In a long term, as previously discussed, two potential phenomena can alter microclimate variables: urbanization, which changes space and promotes an endogenous change in the microclimate; and climate change, which can entail exogenous changes in the microclimate (Eliasson et al., 2007). Based on these observations, how can an analytical tool assess UTC strategies that are effective over time?

In this topic, Nikolopoulou & Lykoudis (2006) reflected on the relationship between microclimate changes and citizens` outdoor behaviour. According to the authors, an urban landscape which adapts to environmental circumstances over time is capable of enhancing the use and experience of open spaces within the city fabric. This illustrates the role of adaptive urban spaces.

Accordingly, the *adaptability* dimension of the assessment will verify if certain aspects are incorporated in urban design and considered in urban policies for contributing to UTC over time. Gupta et al. (2010), presented adaptive capacity as *the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences*. In addition, Jabareen (2013) discussed the importance of improving the adaptive capacity of institutions in order to adapt and cope with environmental changes over time. According to the author, this can be promoted by increasing knowledge, establishing new institutions, providing resources, enhancing good governance and local participation – which have an abstract approach. In practice, urban design can be flexible for softening extreme temperatures according to the situation. This discussion translates into the first criterion in this dimension: **flexible design**.

By means of creating and experimenting new policy measures and urban interventions, a learning-by-doing is promoted and UTC is likely to improve over time. Similarly, Rydin et al. (2012) points out *experimentation and trial-and-error* as key aspects for the promotion of healthier cities. Based on this empirical perspective, **trial-and-error** becomes the second criterion within the *adaptability* dimension.

However, this learning-by-doing will not succeed if continuous monitoring and evaluation is not performed. The influence of microclimate on UTC (discussed in sub-chapter 2.1.1) suggests that these measures are applied to both microclimate variables and UTC sensations. The first can be done, for instance, by precise measurements performed by ICT. The second, as discussed in the *inclusion* dimension, can be performed by citizen assessment. Thus, **monitoring and evaluation** is the third criterion of this dimension.

In sum, the *adaptability* dimension relates to over time management of urban design and policies (the "when?" question). In a long-term, it is perceived that adaptive UTC strategies are capable of contributing to the adaptive capacity of cities, adding value to urban resilience. By means of the *adaptability* dimension, the assessment tool will verify if the respective criteria (presented in Figure 21) are perceived in over time actions and management within urban policies and urban design:

Figure 21 - The criteria within the *adaptability* dimension for UTC strategies (Author, 2017)

2.5. UTC strategies: the assessment tool

Based on the UTC dimensions and criteria just defined, this sub-chapter will develop an analytical framework for directly informing urban design and urban policies in practice (answering research question "C"). The proposal of an assessment tool as main product of this research is rooted in two main claims from the studied literature:

- Healthy Cities: need of a conceptual framework which supports planning practice for the development of healthier urban environments (Rydin et al., 2012).
- UTC studies: need of an urban design guideline which understands microclimate for designing urban landscapes (Lenzholzer, 2012); lack of an assessment framework which relates climatic conditions to people`s outdoor behaviour (Chen & Ng, 2012.

Hence, this research aimed at creating framework with a clear language, simple geometry and easy interpretation. Figure 22 illustrates an outline of the framework structure, which reflects the assessment process. First, the criteria will be assessed, which will conclude on the approach to UTC in the dimensions. The assessment should always take into account the time and space use (related to spatial activities, as a contextual background, for interpreting the assessment tool. For this reason, *time* and *space use* are included in the tool.

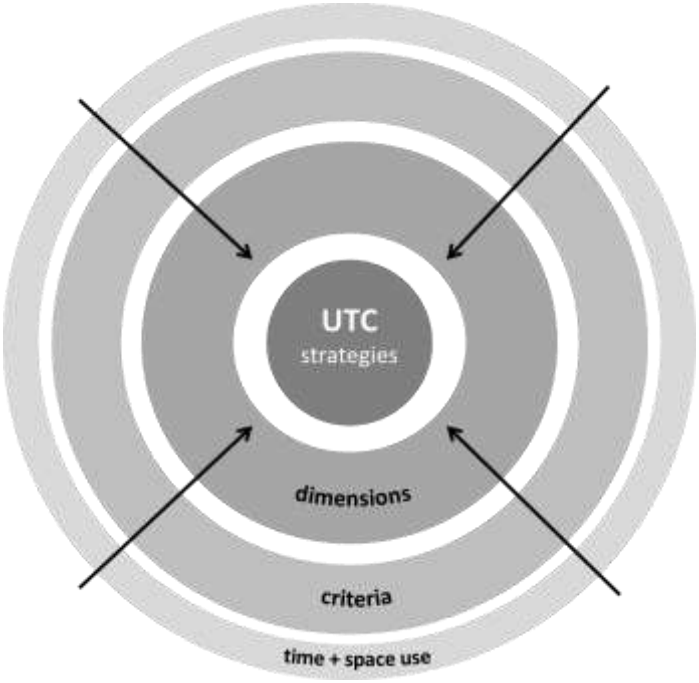


Figure 22 - Order of assessment (Author, 2017)

The gradual process of defining dimensions and criteria for UTC strategies provided a foundation for elaborating the structure of the assessment tool. First, content assemble of dimensions and criteria gives form to a conceptual model, illustrated in Figure 23.

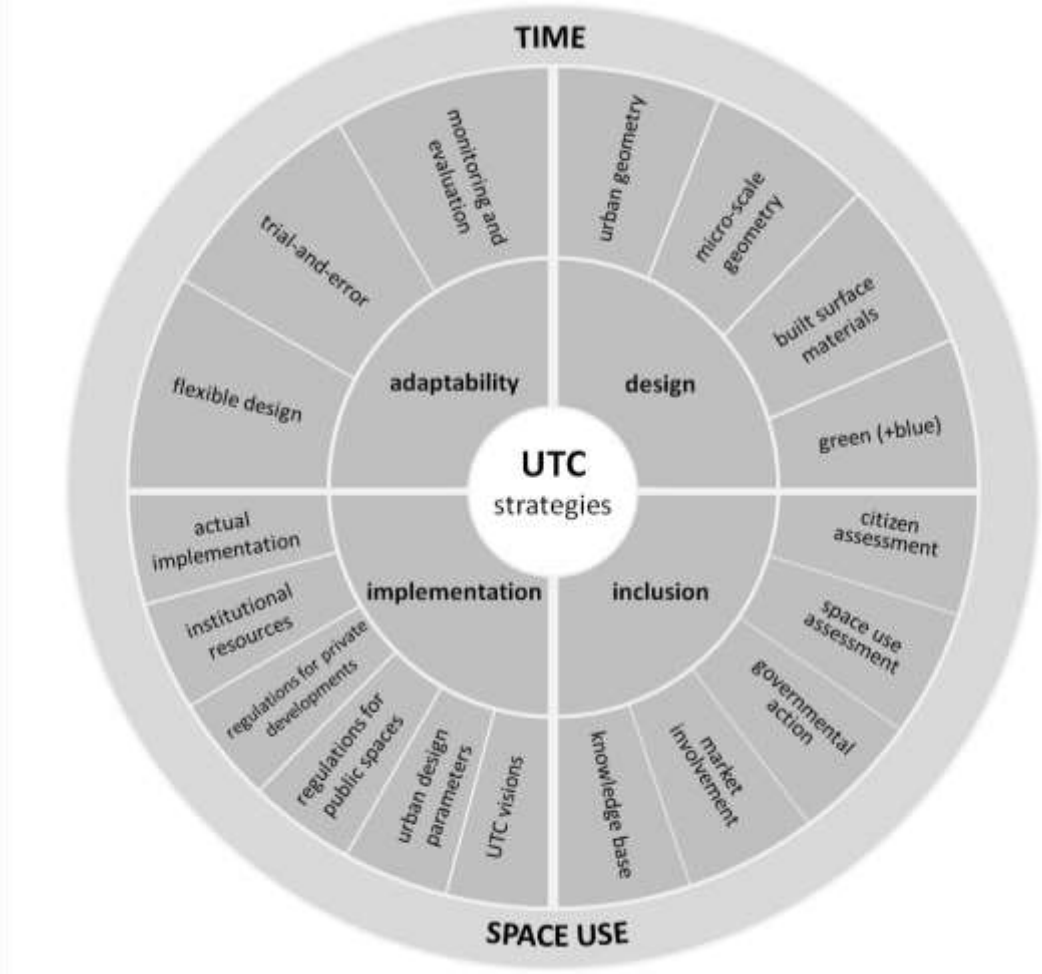
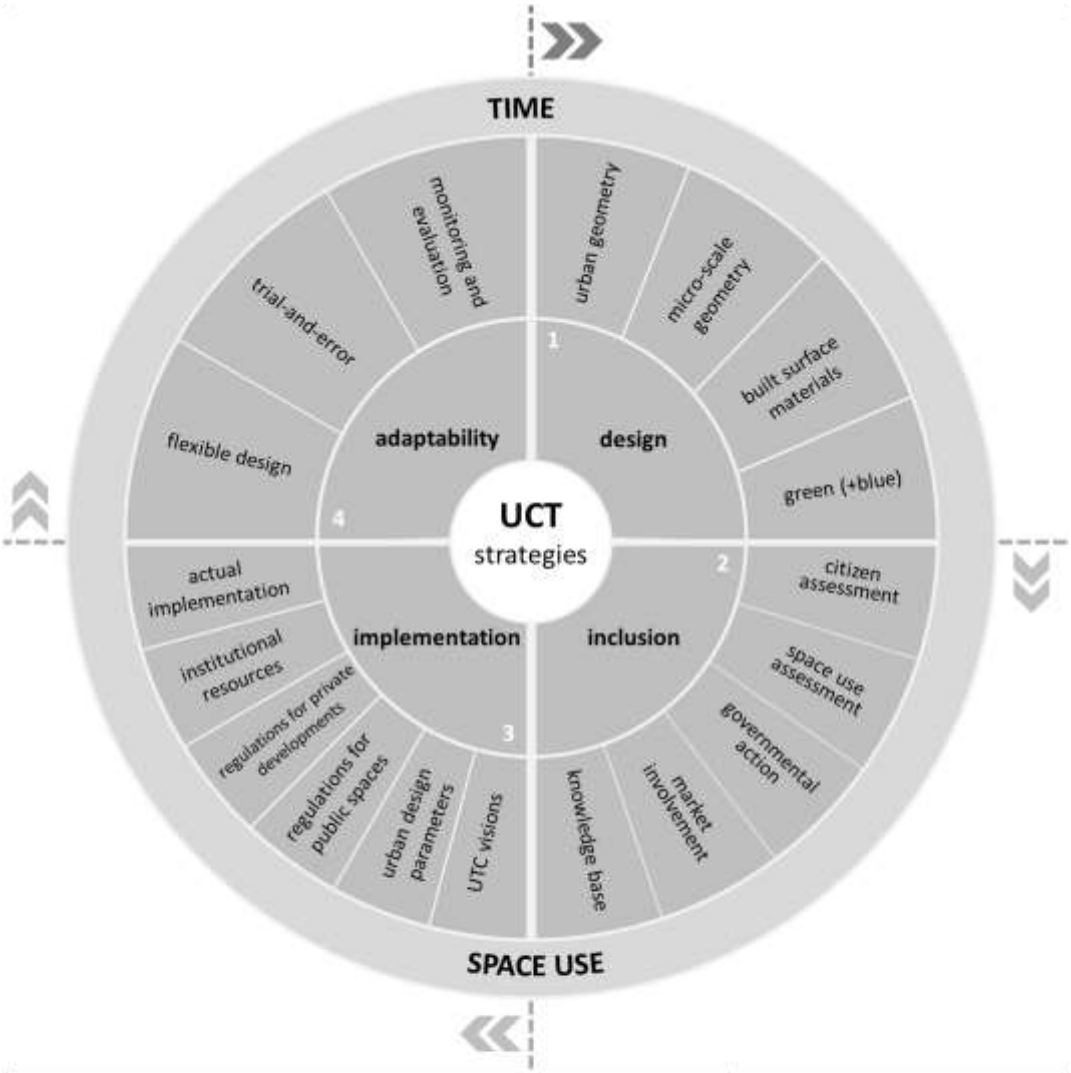


Figure 23 - The "conceptual model" of UTC strategies (Author, 2017)

In the model, the dimensions and criteria discussed in sub-chapter 2.1 are presented in a way that the criteria are grouped and connected to the corresponding dimension. This framework proposes that all criteria of the model are considered together, without a specific sequence, since all dimensions are interrelated. In such a way, it stimulates that actions taken in urban policies and design in a present moment take into account the *over time* factor (*adaptability* dimension).

At this point of the research, it is suitable to reflect on this first product in accordance with the practical contribution of this research. Chapter 2 has exalted that the UTC literature is currently fragmented due to limited UTC studies (e.g. most studies focused on hot climates – *heat stress*) and the lack of a guiding framework for assisting planners and designers in creating thermally comfortable cities. For filling in this fragmentation and enhancing the contribution of this research, it is perceived the convenience – and potential – of turning the conceptual model into an assessment tool which can be applied in any location (notwithstanding the climate it is inserted). This tool is for professionals involved in the urban design process (urban planners, designers and decision makers) to collectively use, so decisions are made through a consensus. This feature aggregates a practical contribution by allowing such professionals to analyse the existing approach to UTC and where actions can still be taken. For this reason, the **conceptual model is transformed into an assessment tool**, illustrated in Figure 24.



a	b	c
Occurrence *(outer wheel)*	**Score** *(outer wheel)*	**Aggregated scores for dimensions** *(inner wheel)*
Existing: overarching and explicit	4	3.50 – 4.00
Existing: limited and explicit OR overarching and implicit	3	2.50 – 3.49
Existing: limited and implicit	2	1.50 – 2.49
On development	1	0.50 – 1.49
Non-existent	0	0.01 – 0.49

Figure 24 – Assessment tool of UTC strategies (Author, 2017)

For optimizing an analytical process, it is proposed a sequence of analysis for the assessment tool (however, for taking actions the criteria should still be all considered at the same time). Because the *design* dimension approaches the relationship between urban design and microclimate - providing a basis for understanding UTC, the assessment will follow a clockwise direction from this dimension. The sequence is illustrated with the numbers from 1 to 4 and the peripheral grey arrows. Subsequently, the *inclusion* dimension will assess how UTC is included in urban policies and design; the *implementation* dimension will assess the mechanisms through which UTC is implemented in urban policies and design; the *adaptability* dimension will assess how urban design and policies adjust and cope with temperature changes over time for maintaining UTC. In this cycle, according to environmental changes in a long term, UTC strategies may need to change, leading to new interpretations of the microclimate. Consequently, the *design* dimension is

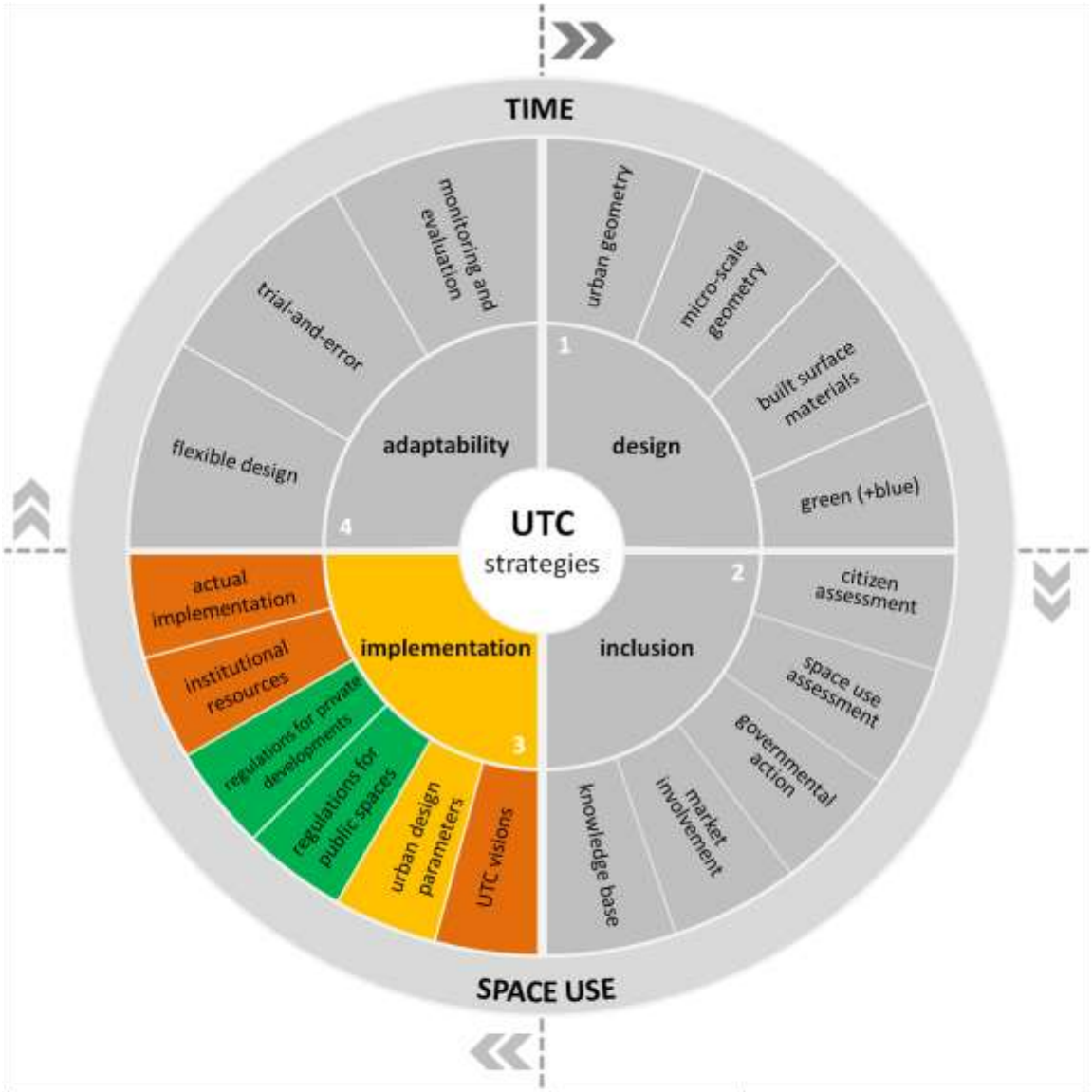
reassessed, and so are the other dimensions. In sum, it is proposed that UTC is assessed over time as an on-going cycle.

The tool assesses first the criteria and, subsequently, the dimensions. The process is performed according to the table illustrated in figure 24. First, the ***occurrence*** of the criteria is assessed (first column ***a***), based on the existence and approach of the criteria in urban policies and design, as well as on the explicitness of UTC. A criterion is: **existent** if perceived in urban policies and design as related to UTC in any degree; **overarching** if criterion is perceived integrally in urban policies and design; **limited** if criterion is perceived partially in urban policies and design; **explicit** if it clearly refers to UTC; **implicit** if it does not refer to UTC, but has influence on it; **on-development** if perceived as related to UTC but still being elaborated in urban policies and design; **non-existent** if discussed but absolutely not related to UTC or if not discussed in urban policies and design.

The occurrences are combined and each combination corresponds to a signalizing colour, which will fill in the criteria. For assessing the dimensions, each combination / colour receives an implicit score (column ***b***). The sum of scores of each dimension's criteria, divided by the n° of criteria, will define the colour of the dimensions according to column ***c***. In such a way, assumptions can be elaborated for both criteria and dimensions. This method of assessment is inspired on the *Adaptive Capacity Wheel* developed by Gupta et al. (2010). With a similar geometry, approaching dimensions and corresponding criteria, the authors made use of signalizing colours for assessing the data collected. According to Gupta et al. (2010), for an assessment framework, traffic-light system is the most useful way to communicate scored data. Even though a scoring system with values are used in the assessment process, the aim of this tool is to **signalize** UTC initiatives (taken and to be taken) for practitioners. For this reason, the traffic light colour system was selected for this tool in order to clearly and more directly inform about features which deserve more or less attention in UTC strategies.

It is believed that any initiatives in UTC are already a positive step. For this reason, the assessment will not approach negative scores. The lowest score (referred to the non-existing occurrence) will consist of "0", so subsequent occurrences will have a "+1", reaching "4" for the highest score.

Figure 25 provides as example of how the assessment will succeed. In the *implementation* dimension, which has 6 criteria, the sum of scores equals *13*, which divided by 6 equals *2.17*. This numbers is between 1.50 and 2.49, inferring a yellow colour to the dimension. When all dimensions are filled in with a colour, the illustrative assessment of the tool is concluded. In other words, the core of the framework (*UTC strategies)* will not receive a colour. This is because it is believed that, according to the context, certain criteria may be essential for promoting UTC or not. For instance, depending on the political regime, market involvement may be non-existent, but UTC can still be implemented by strong governmental actions. Therefore, a conclusion will be taken for each dimension, but no "label" will be given to the general approach to UTC strategies.



a	b	c
Occurrence *(outer wheel)*	**Score** *(outer wheel)*	**Aggregated scores for dimensions** *(inner wheel)*
Existing: overarching and explicit	4	3.50 – 4.00
Existing: limited and explicit OR overarching and implicit	3	2.50 – 3.49
Existing: limited and implicit	2	1.50 – 2.49
On development	1	0.50 – 1.49
Non-existent	0	0.01 – 0.49

Figure 25 – Example of filled in assessment tool (Author, 2017)

Before starting with chapter 3, it is important to reflect no the methodological process. At this point, the tool is a first version of an analytical framework developed for assisting planning practice. With such aim, the proposed tool will be improved, over this research, for better assisting the community of practice and, in such a way, fulfilling a fragment in the UTC literature. This choice suggests that the research diverges from the usual methodological path towards a tool-oriented process, as illustrated in Figure 26.

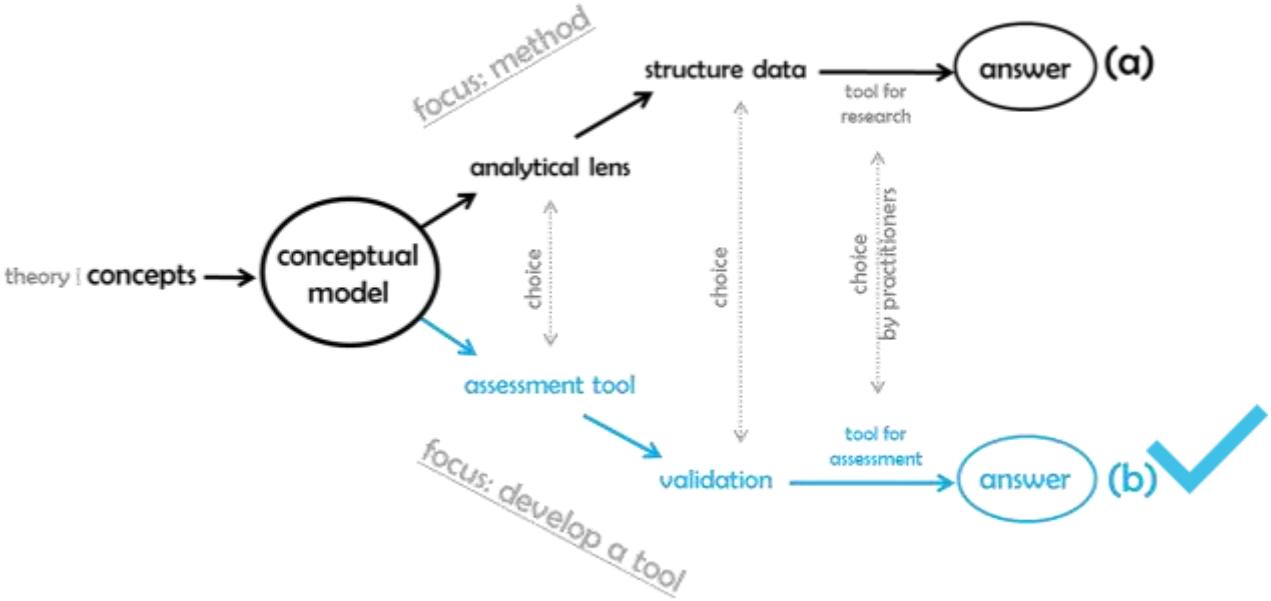


Figure 26 – Research path **(b)** (Author, 2017)

Figure 26 illustrates the typical research path **(a)** and the path taken by this research **(b)**. The difference between the two is the means chosen for answering the research question. In path **(a)** the theoretical study gives form to a conceptual model which will structure the research by means of steering the analytical lens of the researcher, influencing the methodology and structuring the data. This research, however, takes a different path (**b**), with a focus not on a method but on developing an analytical tool. The first version of the framework created is the conceptual model, which is transformed into an assessment tool. Subsequently, the data collection empirically generates an evaluation and reflection on the tool by the community of practice, which consists of urban planners, designers and policy advisors. This, in turn, leads to alterations and validation of the analytical tool, of which the utility in practice is be verified. The path taken by this research will be in-depth discussed in chapter 3.

3. Methodology

Four data-collection methods build up this research towards answering the research question. First, a **literature review** was performed, as presented in sub-chapter 2.4. This method was selected for translating the fragmented UTC literature into a tool to be empirically tested, attributing to it an important role. Because the literature review originated the product to be refined through this research, its result is the assessment tool, already presented in sub-chapter 2.5. For this reason, from this moment on, the methods and results will focus on the subsequent methods of this research.

The second method will consist of a **policy scanning**, which will be performed with the purpose of testing and validating the assessment tool. Third, **semi-structured interviews** will be developed for complementing the validation of the tool by means of an in-depth assessment. Fourth, a **focus group** will be organized for reflecting on the research process and, consequently, on the improved assessment tool.

The four data collection methods, which will be further discussed in sub-chapter 3.2, define the path taken by this research (illustrated in Figure 26) towards answering the research question. The context for developing this research is the city of Groningen, which will be zoomed in (to a neighbourhood scale) for testing the model and zoomed out (to a city scale) for collecting data towards refining the model.

3.1. Tool validation: context

As previously illustrated in the research path presented in sub-chapter 2.5, this research will not be based on methods framed around a case-study. In fact, it will focus on developing and refining the assessment tool of UTC strategies.

Thus, the data collection process will take place in the city of Groningen, approaching practitioners involved in urban policies and design of the municipality. The city of Groningen is, therefore, the context for the tool validation. Because the assessment tool is applicable to a neighbourhood scale, the city will be narrowed down to Binnenstad-Noord especially for testing the tool.

The Netherlands is inserted in a cold climate with frequent cold winds (Taleghani et al., 2015). Located in the North region of the country, the city of Groningen is a compact city with approximately 202,451 inhabitants. Throughout the different urban landscapes, varied microclimates are encountered. The inner city, enclosed by the inner canals, consists of two neighbourhoods: Binnenstad-Noord (marked in Figure 27) and Binnenstad-Zuid. The first, to be covered in the policy scanning, contains an area of 0.47km^2 and has 4380 residents (CBS, 2017).

Figure 27 – Map of inner city of Groningen; emphasis to Binnenstad-Noord (RUG, 2016; adapted)

Four main reasons drove the selection of this context. The first consists of accessibility: the city of Groningen is close to the locations in which most part of the research is carried: Rijksuniversiteit Groningen (Groningen - NL) and Witteveen+Bos (Heerenveen - NL). Second is the availability of data, which facilitates the data collection. Groningen has a great amount of urban planning and design data, which were promptly provided by the planning department. The third reason is the possibility to assess initiatives towards UTC related to urban technologies. This is because Groningen consists of a smart city of medium size (European Smart Cities, 2014).

The fourth reason is the engagement of the municipality in researches related to the topic. The city has developed – and is developing – projects in liveability, healthy ageing, urban heat (including heat maps) and climate adaptability. In special, *The Next City* project aims at thinking of how to deal with and adjust to future changes in the city (from land area increase, population growth, urbanization effects and climate change) and still promoting urban quality by 2030 (Gemeente Groningen, 2017). Urban planners involved in this project have shown great interest in this research. According to them, incorporating UTC to one of the concerns of *The Next City* project is capable of helping achieve a healthier and more attractive city. This also plays a role in city marketing, aiming at the *Next City* as a "comfortable" city for people to experience and to use. Hence, it is perceived a mutual contribution from the city of Groningen as the context approached in the methods of this research: it contributes to the research with great support and information, as well as its results can add value to future urban interventions in the city.

3.2. Data collection

The beginning of this chapter introduced four data collection methods which contribute for answering the research question. The first method, *literature review*, was already performed in sub-chapter 2.4, which

gave form to the first assessment tool developed. This chapter will, therefore, elaborate on the other three methods: policy scanning, semi-structured interviews and focus-group.

3.2.1. Policy scanning

In order to properly validate the tool, a first step is correlating its content with actual municipal policies and practices. By directly interviewing practitioners, such analysis could be performed. However, the degree of detail for the assessment might also require the respondents to verify policy documents, which brings up the suitability of first making a policy scanning in the tool-validation process. In addition, if interviews would be first performed, they would require more time than the availability of the respondents approached.

According to Amanatidou et al. (2012), there are two types of scanning: exploratory and issue-centered. The first one consists of gathering potential issues from varied elements by means of processing varied sources. Differently, the issue-centered type focuses on processing key documents which provide parts of information about potential issues. These, in turn, will be confirmed or denied by the process (Amanatidou et al., 2012). Because the assessment tool will approach one issue (UTC) explored in different policy documents, this research will perform an issue-centered policy-scanning.

As previously discussed, this method will test the assessment tool for the neighbourhood Binnenstad-Noord. This will be done by means of three steps:
(**1**) **Gathering policies**: such documents are related to outdoor temperatures and urban design of the city of Groningen. The request for the documents was made, in person, to the department of planning of the municipality, which promptly replied. Nine documents were gathered (see Table 3):

Table 3 – Documents for policy scanning

Document type	Document name
Project	The Next City
Agenda	Uitvoeringsagenda 2017 *(Implementation agenda 2017)*
Programme	Groningen klimaatbestendig *(Groningen climate-proof)*
	Groningen Energizes *(Groningen Energizes)*
Vision	Healthy Ageing Visie *(Healthy Ageing vision)*
	Watervisie Groningen *(Water vision Groningen)*
	Woonvisie Groningen *(Residential vision Groningen)*
	Bomenstructuurvisie Groningen *(Tree infrastructure vision Groningen)*
	Groenstructuurevisie voor Groningen *(Green structure vision for Groningen)*

(2) Scanning documents: this step will be manually performed. For such, all policies will be grouped in one file in order to optimize the process. Based on the criteria of the assessment tool, related key words will be defined (in Dutch language, according to the documents) for steering how to find criteria-related topics in the documents. Appendix 7.2 presents the structure of the policy scanning: key words, related topics, instances of each key word in the documents and the scoring for each criteria and dimension (according to occurrence of criteria). Such scoring is presented in Appendix 7.2 with the respective colours (defined according to assessment explanation in sub-chapter 2.5), to be used in step (3).

(3) Filling in scores: after the criteria are identified in step 2, the outcome scoring will be transferred to the assessment tool of UTC strategies, where the colours will be filled in.

This method allows directly evaluation of the content and structure of the assessment tool of UTC strategies.

In other words, it allows assessing the clarity of the content for being searched in policy documents and if the scoring for assessing the criteria are sufficiently distinguishable throughout real policies.

3.2.2. Semi-structured interviews

The aim of this method is to complement the validation of the assessment tool of this research. The interviews will obtain the perception of the tool from the community of practice. According to Gill et al. (2008), there are three types of interviews: structured, an inflexible interview with pre-determined questionnaires; unstructured, an interview performed with little or no organization and that does not reflect any preconceived theories or ideas; semi-structured, a flexible interview which allows space for extensions of answers and additional questions. Because this research aims at assembling varied perceptions of the tool, the approach of semi-structures interviews are the most suitable. Such interviews are flexible enough for allowing a natural conversation floe and discovery of information that is important to the respondent but that has not previously been proposed by or thought of the researcher (O'Leary, 2010).
Hence, five semi-structured interviews will be performed with urban designers, planners and policy advisors from the municipality of Groningen. Besides the in-depth approach required, the limited number of local practitioners who have profound experience with urban design processes make semi-structured interviews a method more suitable than surveys.

The structure of the interviews will consist of four parts (see script of interviews in Appendix 8.4), according to the desired information:
(1) Goal: objective reflection on tools used for urban design.
(2) Goal: reflecting on UTC in practice.
(3) Goal: reflecting on the tool.
(4) Goal: preparation for focus group (no questions to be made; only explanation of model assessment and policy scanning results).
The sequence of questions will be elaborated as providing a continuity and spontaneity to the conversation, connecting the topics and slightly steering the respondent to answer the information of interest.
The *design* dimension, which has a more in-depth and technical approach, can be unclear to some respondents. For this reason, during the explanation of the assessment tool, questions will be supported by illustrations, as presented in sub-chapter 2.4.1. The results of the interviews will be analysed by means of the software ATLAS ti. After the analysis, the suggestions received will be incorporated in a new version of the assessment tool, to be reflected on the focus group.

3.2.3. Focus group

The reason for this method consists of achieving a collective decision from the community of practice on this research. This is a more effective procedure if compared to individual interviews, as the discussion held will lead to final conclusions on the whether the tool is recognizable and useful in practice. In addition, a focus group meets the research's need of a productive and effective way for reflecting on the changes incorporated from the semi-structured interviews.

According to Marshall & Rossman (2014), focus groups can vary from 4 to 12 people, selected because they share important aspects for the specific study. The interviewer/facilitator should create a stimulating environment, asking focused questions that encourage the participants to discuss and express their personal opinions. In addition, an assistant is important for taking notes and recording participants' main reactions, freeing the interviewer to interact with the group (Marshall & Rossman, 2014). For this reason, the research developer will be the interviewer (Thaísa Pessanha) and the assistant will be Jimme Zoete, the thesis supervisor at Witteveen+Bos. For facilitating further data analysis, the focus-group session will be recorded.

The group will consist of ten people, including the respondents from the semi-structured interviews and additional traffic and design experts, which all consist of the *Atelier Stadsbouwmeester* (from *Gemeente* Groningen). Even though some participants are not the target group, performing the focus group in this atelier will be a great opportunity (see focus group structure in appendix 8.6). In order to all participants of the focus group to have a previous understanding of the tool, a presentation will be delivered to the Atelier one week before the focus group is performed.

A result of this method will be, therefore, a debate between practitioners which will build up a conclusion on the operationalization of UTC by means of the assessment tool developed in this research.

3.3. Data analysis

The policy scanning will be manually performed, so the policies will be analysed with assistance of the *Full Reader Search,* a search tool from Adobe Acrobat Reader. This simple tool provides a good assistance for finding words and occurrences in PDF-format files.

The semi-structured interviews will be manually transcribed and the transcripts were analysed with assistance of ATLAS ti. This software facilitates analysis of long-text data by means of a coding system which relates to the topic of interest (in this case, according to interview questions). By allowing making groups of codes, the topics within the text are easily accessed and analysis is facilitated (ATLAS ti, online).

Because the focus group had only four questions (followed by the explanation of improved assessment model), the analysis was manually performed. Notes from the assistant and records also supported.

3.4. Ethical issues

Before recording or reporting the data analyses, the respondents of the semi-structured interviews and the focus-group will be handed an *acceptance letter* (Appendix 8.3). In this letter they will declare if they would like their identity and functions to be mentioned, so data analysis will reveal their identity in accordance. For the focus group, a similar letter will be provided (Appendix 8.5) explaining purpose of focus group, ground rules and asking accordance with participants.

4. Results D MAIN

This chapter will present the results of the policy scanning, semi-structured interviews and focus group.

4.1. Policy scanning

This method allowed assessing the practicality of cross-referencing the tool content with policy documents. As a detailed process (due to amount of criteria to be assessed and the amount of documents acquired), a long time was demanded for a proper scanning to all suitable key words for each criterion. The content of the assessment tool was distinguishable enough for being identified in policy documents. However, it was perceived that criteria approaching similar actions (e.g. monitoring and evaluation and citizen assessment; UTC visions and governmental action) had a similar analysis and less varied information collected in the documents. Despite the extended analysis, this method proved to be very productive: the scoring categories were easily applied to the criteria and, subsequently, to the dimensions.

The results of policy scanning were achieved as following: policies were scanned according to key words (Appendix 7.3); findings were translated in the occurrence of the criteria (according to Figure 14); colours were assigned to criteria and dimensions according to explanation in sub-chapter 2.2. For better organizing the detailed findings of this method, the results (brief findings and signalizing colour) will be presented in groups, according to the dimension. More details are presented in Appendix 8.2.

- **Design:**
  - **Urban geometry**: policies (especially the *Groningen klimaatbestending*) acknowledge the influence of urban geometry in city temperatures and stimulate urban interventions based on this. However, the urban geometry mentioned was limited, referring mostly to wide streets and open squares. Despite the deep discussion on urban heat, UTC was not mentioned. Overall: **existent, limited, implicit.**
  - **Micro-scale geometry**: policies (especially *Groningen klimaatbestending* and *Bomenstructuurvisie Groningen*) stimulate urban problems to be studied in object levels and acknowledge the need of micro-scale design solutions. Urban equipment is approaches, but it is limited to trees, for shading and wind buffering. Despite the deep discussion on urban heat, UTC was not mentioned. Overall: **existent, limited, implicit.**
  - **Built surface materials**: policies (specially the *Groningen klimaatbestending*) discussed the influence of material properties (on buildings and ground) on the accumulation of heat in cities. Permeability and material colour (inferring albedo, radiation emissivity) ad relationship of built surfaces with green+blue were broadly mentioned. Despite the deep discussion on urban heat, UTC was not mentioned. Overall: **existent, overarching, implicit.**
  - **Green (+blue):** all policies scanned discussed the green+blue network, its capability to enable climate-adaptive cities, its effects on city temperatures and health benefits. Despite the deep discussion on urban heat, UTC was not mentioned. Overall: **existent, overarching, implicit.**
- **Inclusion:**
  - **Citizen assessment**: policies acknowledge that citizen participation in urban design is still limited. Direct citizen assessment of UTC-related topics (such as heat stress) is fomented, but still being elaborated in policies. Thermal discomfort by cold or UTC are not mentioned. Overall: **on development.**

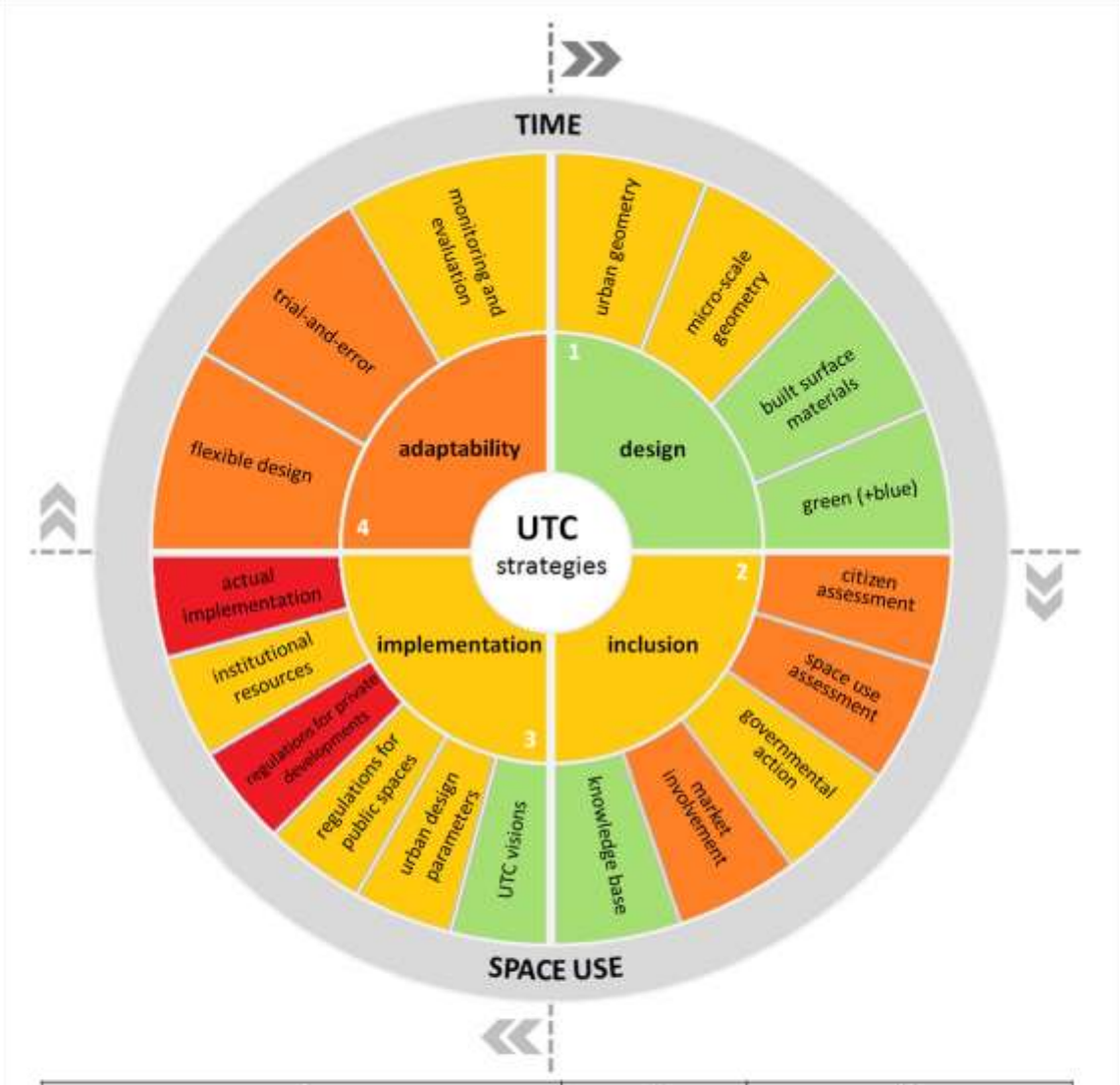
- **Space use assessment**: The *Groningen klimaatbestending* has mentioned the performance of field observations (of people`s outdoor behaviour) in the inner city, for a research about heat stress. Even though such assessment is stimulated for elaborating urban solutions, this criterion was not enforced in the policies. In addition, UTC was not mentioned. Overall: **on development.**
- **Governmental action**: even though UTC is clearly implicit, the municipality much stimulates and invests in researches in and climate-proof city and urban health. It is promoting great awareness, trying to enhance citizen support. According to policies, subsidies exist, however, focused only on greenery. UTC was not mentioned. Overall: **existent, limited, implicit.**
- **Market involvement**: this is mostly perceived as sponsorship to researches related to UTC (*Groningen klimaatbestending*). Policies mention that private investments in urban developments are decreasing, despite some market involvement in urban greenery which is stimulated by policies. Overall: **on development.**
- **Knowledge base**: Policies show the abundance of researches already performed in the city regarding urban temperatures, climate adaptability and urban health. More researches are also fomented, and the municipality has partnership with strong expertise institutions. However, UTC is not acknowledged or mentioned. Overall: **existent, overarching, implicit.**

- **Implementation**:
  - **UTC vision**: The visions for the city broadly and clearly stimulate actions towards greener and healthier city, climate-adaptive city and healthy ageing, which directly or indirectly influence UTC. However, UTC is not mentioned. Overall: **existent, overarching, implicit.**
  - **Urban design parameters**: policies show urban design parameters that influence urban temperatures. However, these are limited to design of streets, trees and greenery. In addition, UTC is not mentioned. Overall: **existent, limited, implicit.**
  - **Regulations for public developments**: these are perceived mostly referring to greenery and distribution of trees along main streets. UTC is not mentioned. Overall: **existent, limited, implicit.**
  - **Regulations for private developments:** even though land use plan and permits exist, none referred to specific requirements of permeability, greenery or facade materials (among other UTC-related aspects) for private developments. UTC is not mentioned. Overall: **non-existent.**
  - **Institutional resources:** from the policies it is perceived the abundance and availability of expertise; engagement is being enhanced and financial resources are limited. UTC is not mentioned. Overall: **existent, limited, implicit.**
  - **Actual implementation**: no actual implementation of UTC-related strategies (approaching outdoor temperatures) is perceived. There are ambitions for reducing "heat stress", but these are addressed in policies as goals or expected results. UTC is not mentioned. Overall: **non-existent.**

- Adaptability:
  - **Flexible design**: the policies (especially *Groningen klimaatbestending*) acknowledge the need of adaptation in living environments, multi-use and flexibility in urban design. However, this is not perceived as translated to urban regulations yet. UTC is also not mentioned. Overall: **on development.**

- **Trial-and-error:** the policies refer to urban interventions as urban experiments towards a healthy and climate-proof city, however, as a goal or procedure to follow. UTC is also not mentioned. Overall: **on development.**
- **Monitoring and evaluation**: policies infer that annual measurements of air temperatures and greenery are performed. Climate stress tests were once developed, but it lacks of assessing thermal stress by cold. There is a lack of citizen assessment and, even though devices are used, no special technologies are mentioned. Assessment of housing quality (related to healthy ageing) and healthy neighbourhoods are motivated, but there is no indication of monitoring or evaluation of UTC itself. Overall: **existent, limited, implicit.**

The validation performed by the policy scanning is translated to the assessment tool as presented in Figure 29:



a	b	c
Occurrence *(outer wheel)*	**Score** *(outer wheel)*	**Aggregated scores for dimensions** *(inner wheel)*
Existing: overarching and explicit	4	3.50 – 4.00
Existing: limited and explicit OR overarching and implicit	3	2.50 – 3.49
Existing: limited and implicit	2	1.50 – 2.49
On development	1	0.50 – 1.49
Non-existent	0	0.01 – 0.49

Figure 29– Policy scanning performed for the neighbourhood Binnenstad-Noord (Author, 2017)

This method was performed for filling in the assessment tool of UTC strategies, a first step for validating it.

Results show that UTC is not yet a concern and, therefore, not explicit in any urban policies from the city of Groningen. For this reason, so dark-green colour was identified. The light-green colour obtained reflects the recent concern from the city of Groningen with *heat stress* and climate change, which is addressed in a few policies. In the municipality, discussions on these two issues are being held, but actions and incorporation of the criteria in policies is still limited, reflecting on the yellow colour. Because the concern with outdoor temperatures is in a development process, orange colour is also identified, as well as the red colour for criteria which are absolutely not yet existent in local policies. An over time factor is also

perceived as influential in the assessment: being current urban policies and design measures in outdoor temperatures limited, over time measures are likely not yet performed, which led to an orange colour in the adaptability dimension.

For this research, this method provided benefits and difficulties. One of the benefits relates to the case-study: the abundant documents were promptly provided and with digital availability, which catalysed the process. Second, the policy scanning made use of concrete evidence of legitimate policy documents. Consequently, a third benefit consists of a research source (policies in PDF format) which was longstanding available for exploring and revising the findings. Fourth, this method allowed obtaining separate data sources with concentrated information on specific criteria, making it easier to find where each criterion was addressed. Difficulties of this research consisted, first, of the high instance of some key words, which made the analysis more extensive. Second, the language: even though Dutch is a familiar language for the researcher (but not yet fluent), for criteria with very frequent key words the level of difficulty was increased. Third, the subjectivity of some topics discussed in policies slowed down the process of scoring the criteria.

Perceived the amount and relevance of the benefits in the face of difficulties, the policy scanning was perceived as a helpful method for a research to first test its pilot tool. In addition, this method provided great learning of the local urban policies for the researcher, facilitating understanding and arguments for the following research methods.

For the research question, the use of this method suggests that UTC can be operationalized in urban policies and urban design by means of the assessment tool of UTC strategies. Such assumption is to be ratified further in the methodology.

4.2. Semi-structured interviews

The interviews were structured in four parts (previously discussed in sub-chapter 3.2.2):

(1) Goal: objective reflection on tools used for urban design.
(2) Goal: reflecting on UTC in practice.
(3) Goal: reflecting on the tool.
(4) Goal: preparation for focus group.
For better organizing the results, a summary of the findings will be structured according to each part in Table 4:

Table 4 – Summary of semi-structured interviews

Sections	Topic of question	Summary of answers
(intro)	function of respondents	(1) director of urban planning, (1) program manager in liveable and sustainable cities, (1) policy advisor in green policies, (2) urban designers
Part 1 *tools used for urban design*	Urban design tools used by the Gemeente	**Conceptual / theoretical:** *Leidraad:* steering urban interventions according to the landscape profile for better suiting the activities for pedestrians Placemaking: concept for urban design according to specific situations; each street, corner or square are not the same. With this tool, the focus is zoomed in, an analysis is done on space use and the best combination of design strategies which suit better the users and activities is elaborated *The city in eye level* (book): overview of "the ground floor architecture"; about what pedestrians see and feel; about the urban activities and

		interactions in the ground floor Compact city: closeness in the city; citizens with close access to basic facilities and to work (until 5km and accessible by bicycle). It has cultural, economic, social and environmental factors. It relates to liveability, entrepreneurship, safety, mobility and social values (Jane Jacobs as inspiration) Study of morphology and use of public space (case-dependent): analysis of what is already there. **Policy tools**: *Omgevingsvisie*: environmental vision for the city Healthy ageing visie Groenvisie Economic, housing and infrastructure programs of the city Urban design rules (Handboek Openbaarruimte) Land use plans Zoning plan **Technical / practical**: <u>Reference projects</u> Handboek Openbaarruimte: technicalities for designing public spaces (dimensions, materials…) *Brandvak*: details for planting trees Water models (for flooding) GIS models Heat maps *Zeroway atlas*: "Dutch bible" for traffic (Groningen also has its own traffic rules) *Program for the street* (traffic design rules based on local designers knowledge)
	Current urban challenges to which a new tool would be useful	Climate change: a tool for identifying the problem; for helping assess the impact on city (rain water, heat stress); for helping know how to reduce problems; for giving long-term views; for raising awareness Combining the new (needed) infrastructure with the soft network of cyclists and pedestrians, the greenery going out the city, nature and existing ecology Integrating urban functions again (which were separated in modernist times) for making a durable city Explaining why a design proposal is the best option (to politicians, citizens): a tool for assisting understanding
Part 2 *UTC in practice*	Priorities in urban design	Age friendly; safe; comfortable; aesthetics; flexibility; mobility; efficient energy use; keeping the city compact; "having to build"; integrating functions; wealth and wellbeing; stimulating economic benefits
	Scales to which urban design is proposed	micro (street level) - meso (neighbourhood level) - macro (city level)
	Concern to outdoor temperatures	None; new / recent (since 2016); still not a great concern People don't acknowledge temperatures are changing also in the Netherlands; temperature can't be changed, but urban design can adapt to it; still need of awareness within professionals involves in urban design and within citizens; need of a sense of urgency for concern to emerge; lack of

		knowledge of relationship between urban design and climate and impact on urban temperatures People are used to the cold (when it is very cold) No concern with cold stress
	Concern to UTC	None; still in starting phase; slowly emerging;
Part 3 *the assessment tool*	Understanding of assessment tool Positive comments	Yes Tool is logical; good for analysis; steers actions with assessment colours ("it is like a compass"); good because it doesn't matter where you use it; it contains everything "this is a picture I can show my colleagues" "we can make much more out of it"
	Opinion of dimensions and criteria	Dimensions are clear; design dimension is very clear - also its examples
	How could the tool be helpful to current visions for Groningen	It can help translating ambitions into practice in urban design / climate-adaptive related measures It points out things that the municipality is missing at the moment This way of looking at UTC can help identify ideal urban design parameters; it can be an input to how the municipality proceeds with urban design It is a nice agenda and also a check list
	Suggestions Improvement comments	**Structure of framework**: The sequence of dimensions for analysis: make similar to the *beleidscyclus*, which starts with policy → design → building / engineering → maintaining (and the cycle continues). Therefore, the policy-related dimensions (*inclusion* and *implementation*) could first, followed by *design* and *adaptability* Include the framework in a larger structure: a framework of liveable cities, in which UTC is introduced, and then show tool of UTC strategies Elaborate the tool more **Functioning of framework**: Present the context of liveable cities beforehand and then deepen into UTC - and the tool **Criteria of framework**: Make regulations for public spaces and private developments as one criterion only Illustrate with examples, of different locations, of criteria in thesis – during text, so the tool doesn't look generic but specific to UTC Show detailed criteria; what is right and what is wrong in each of them, in practice. Add reference projects (if there is any), as good and bad examples within each criteria Include awareness and sense of urgency. **Additional comments**: for practical use there could be a guideline, a manual, to be used anytime by professionals of practice; very complex for a citizen to understand, or even politicians, people need to have previous knowledge to understand

This method was performed for assessing and validating the assessment tool of UTC strategies. The semi-structured interviews have shown that the municipality does have a variety of theoretical, policy and practical tools for guiding the urban design in the city of Groningen. However, no tool assists both urban policies and urban design.

According to most of respondents, the main challenge - to which a new tool would be useful - is climate change. It is perceived that the assessment tool of UTC strategies fits in two of the mentioned desired tools for assisting urban design in dealing with this challenge: *a tool for helping assess the impact of climate change on a city* (e.g.: heat stress and space use) *and for helping know how to reduce problems* (e.g.: what best urban design strategies would help mitigate extreme temperatures).

One of the priorities of the city mentioned in interviews referred to promoting comfort (in general terms). According to all respondents, the elaboration of urban design has attention to all spatial scales (from macro / city level to micro / street level). This is a positive aspect perceived the punctual urban design solutions proposed by this research for promoting UTC.

The concern with outdoor temperatures is predominantly new. Policy visions approaching a climate-adaptive city and healthy ageing refer to *heat stress* as a concern. City programs, such as *The Next City,* establish goals for a climate-adaptive city, also addressing *heat stress*. However, no action in urban design and planning practice is already realised. According to most of respondents, the concern to very cold temperatures is inexistent, as well as to UTC.

The content (criteria and dimensions), function and structure of the tool were clear for all respondents. Figures 30 and 31illustrate the suggestions received for further improvement of the tool.

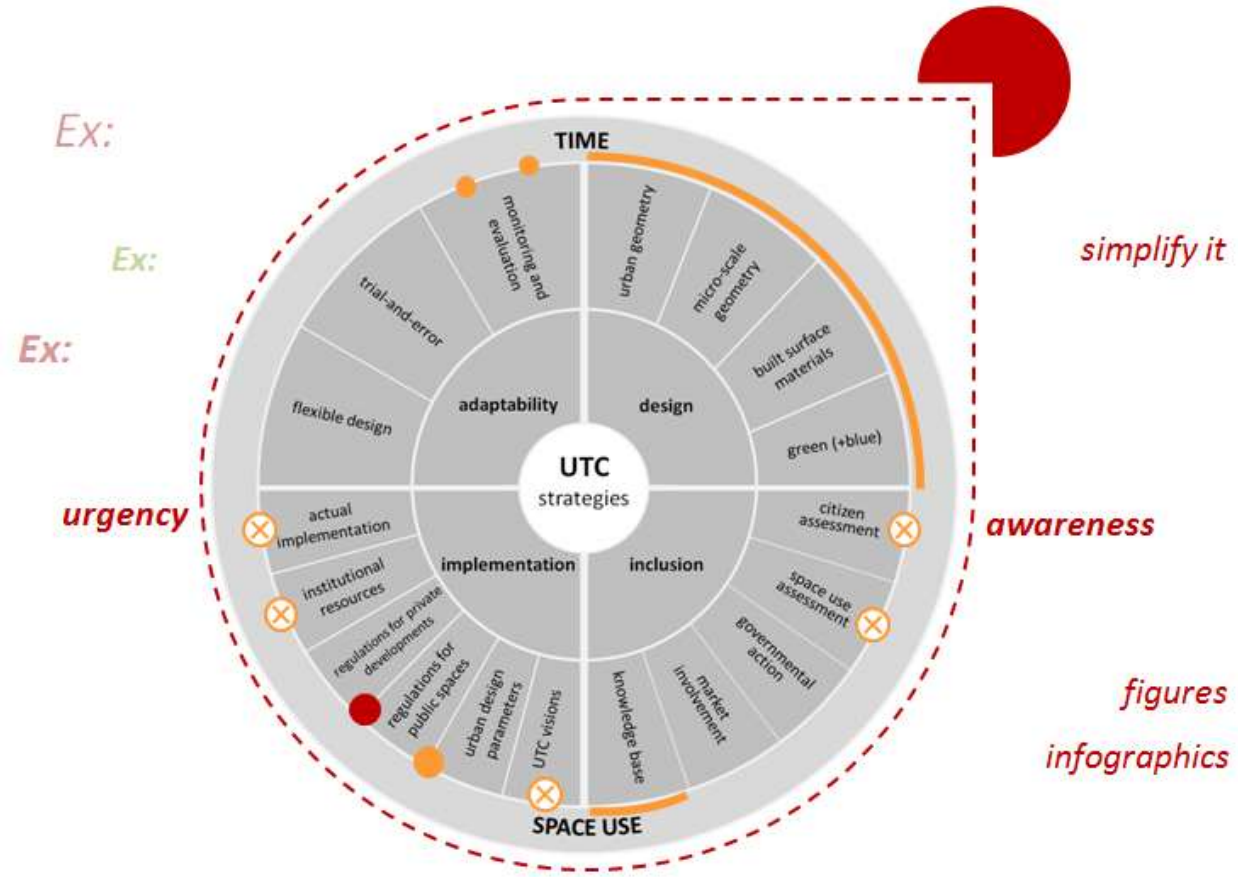
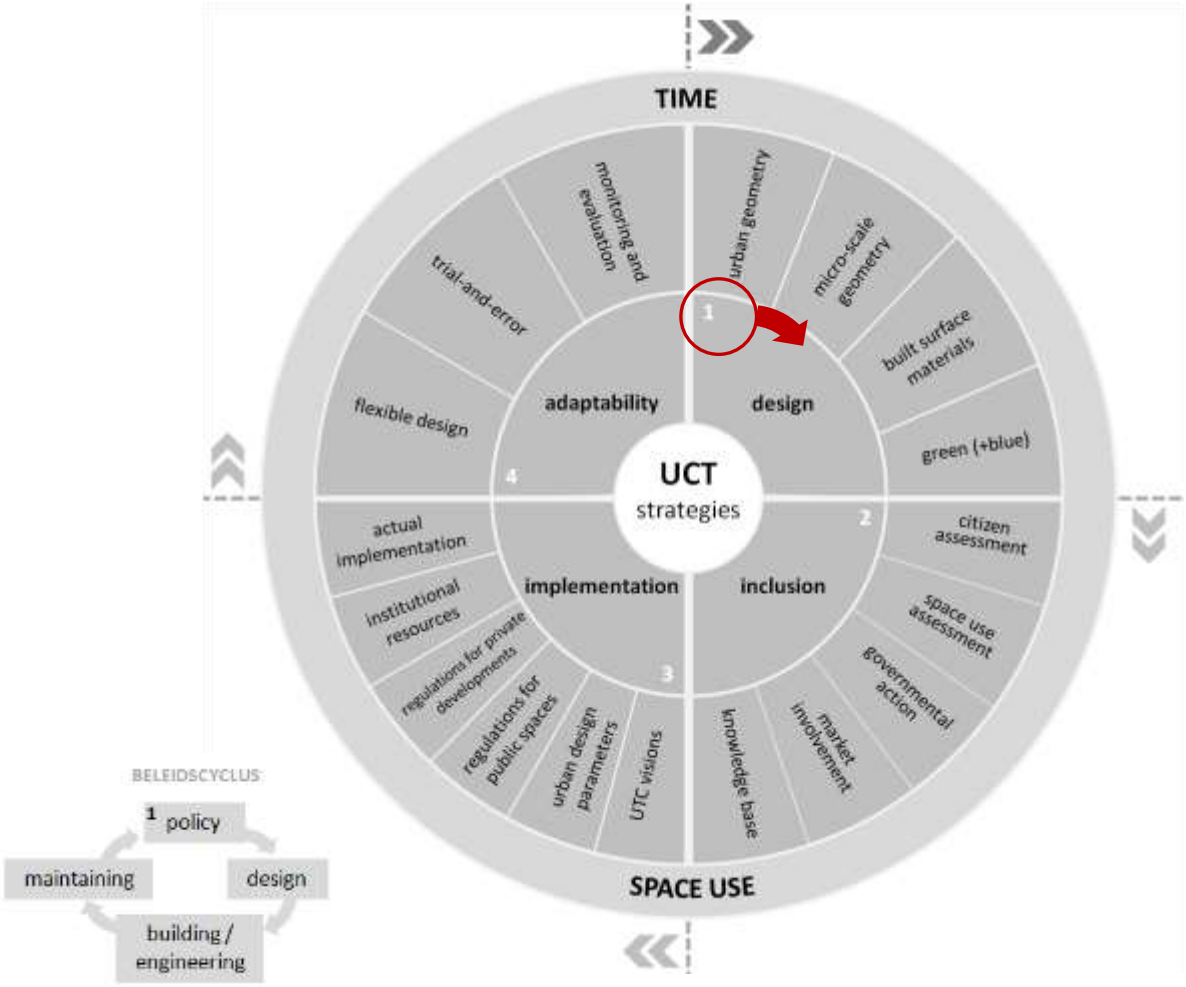


Figure 30 – Changes from semi-structured interviews suggested to assessment tool (Author, 2017)

In Figure 30, the remarks in red point out the suggestions from the respondents: including the assessment tool of UTC strategies in a framework of liveable cities; simplifying model; combining regulations of public and private spaces; adding figures and infographics for a better content understanding from the visual; giving good and bad examples for illustrating criteria. Additional changes are pointed out in orange: easing the nomenclature of criteria in the design dimension and of the knowledge base criterion; separating *monitoring microclimate variables* from *UTC evaluation* (which consist of *citizen assessment* and *space use assessment*); annulling *citizen assessment* and *space use assessment* for avoiding content repetition; cancelling UTC visions (which are part of governmental actions); "transforming" institutional resources (into - existing - knowledge and - new - financial incentives); incorporating urban design parameters into a more suitable criteria, which will also cover *regulations for public spaces;* cancelling *actual implementation*. The last change was an outcome from the policy scanning method. Because *actual implementation* regards to the perspective of assessment - policy or practice, a policy scanning is incapable of judging this criterion

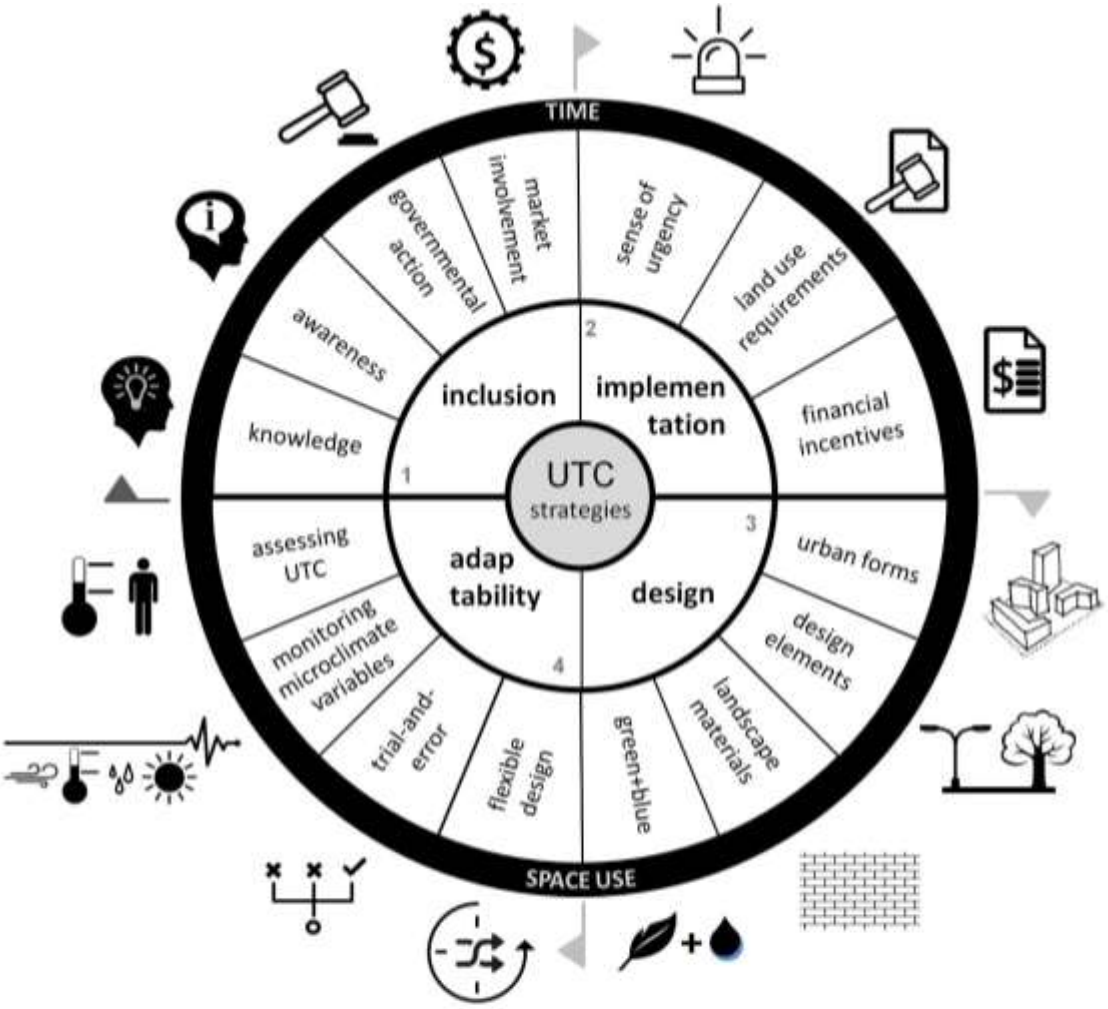


a	b	c
Occurrence *(outer wheel)*	**Score** *(outer wheel)*	**Aggregated scores for dimensions** *(inner wheel)*
Existing: overarching and explicit	4	3.50 – 4.00
Existing: limited and explicit OR overarching and implicit	3	2.50 – 3.49
Existing: limited and implicit	2	1.50 – 2.49
On development	1	0.50 – 1.49
Non-existent	0	0.01 – 0.49

Figure 31– Changes from semi-structured interviews suggested to sequence of assessment tool (Author, 2017)

Figure 31 emphasizes the suggestion regarding changing the sequence of analysis. In red it is pointed out the start point for assessment, suggested by the first version of the tool. In accordance to the Beleidscyclus, one respondent suggested that the assessment starts with the abstract approach (policies), followed by the practical approach (designing, building and maintaining over time).

All the suggestions were studied and, according to its suitability to the purpose of this research, they were incorporated into a new version of the assessment tool (illustrated in figure 32).

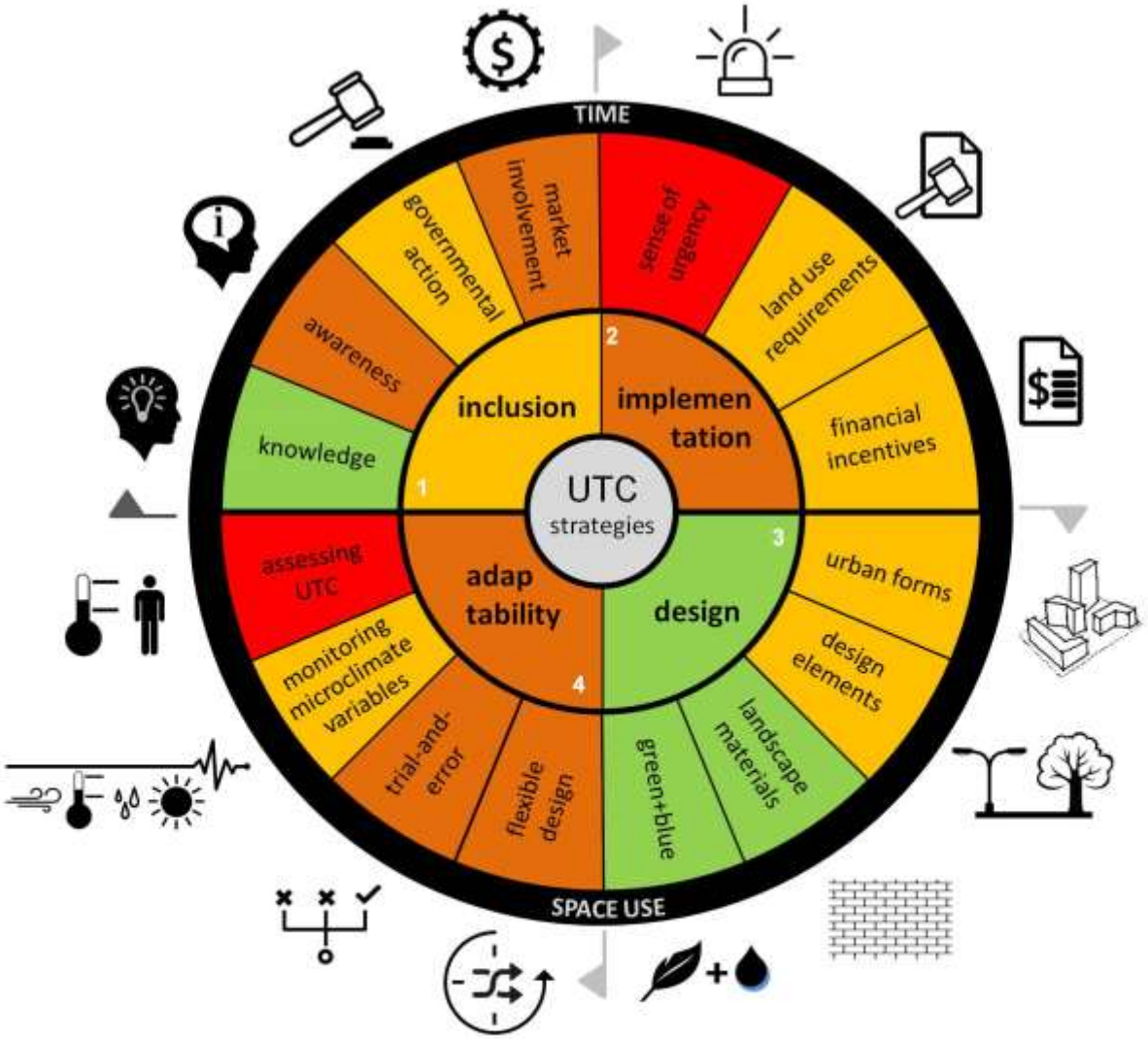


a	b	c
Occurrence *(outer wheel)*	**Score** *(outer wheel)*	**Aggregated scores for dimensions** *(inner wheel)*
Existing: overarching and explicit	4	3.50 – 4.00
Existing: limited and explicit OR overarching and implicit	3	2.50 – 3.49
Existing: limited and implicit	2	1.50 – 2.49
On development	1	0.50 – 1.49
Non-existing	0	0.01 – 0.49

Figure 32– New assessment tool (Author, 2017)

Figure 32 incorporates the changes retrieved in the semi-structured interviews on a new assessment tool. The assessment now begins in the *inclusion* dimension, continuing clockwise. Some criteria were assembled, others excluded and others incorporated (as previously discussed in detail), having now - all of them - infographics for illustrating the content referred to. For a visual harmony and contrast of the text with the infographics, the tool changed from grey-scale to black and white. With this new configuration, the new assessment tool has an upper **abstract** section (*inclusion* and *implementation* dimensions) and a lower **practical** section (*design* and *adaptability* dimensions). Even though the word *implementation* resembles practical matters, its criteria now refer to abstract aspects which trigger the implementation of UTC strategies.

Because a new assessment tool was created, policy scanning results were adapted and are illustrated in Figure 33:



a	b	c
Occurrence *(outer wheel)*	**Score** *(outer wheel)*	**Aggregated scores for dimensions** *(inner wheel)*
Existing: overarching and explicit	4	3.50 – 4.00
Existing: limited and explicit OR overarching and implicit	3	2.50 – 3.49
Existing: limited and implicit	2	1.50 – 2.49
On development	1	0.50 – 1.49
Non-existent	0	0.01 – 0.49

Figure 33 – New policy scanning result (Author, 2017)

The new policy scanning result is x due to the condensed content (refined criteria) assessed. This refined tool proved to be more effective by properly synthetizing the criteria – of compared to the first version of the tool. I such a way, the tool becomes more objectively informative. If reflecting on the policy scanning process, the issue of repeated key words previously identified is alleviated.

Because knowledge and sense of urgency are two new criteria, the structure of their scanning in the policies is presented in the last part of Appendix 8.2 (with key words, related topics, instances of key words, scoring and colour definition).

Throughout the interviews it was perceived the priorities of the city of Groningen towards urban design, which turn around Groningen as a liveable city. It was clear, therefore, the appreciation of the practitioners interviewed in having the assessment tool as a useful framework if it would be inserted in the context of liveable cities. Based on these priorities and on reported tools currently used for the urban design of the city, an assessment tool for the context of the city of Groningen is later developed by means of incorporating the existing framework "what makes a great place to live", which addresses outdoor comfort. Perceived as relevant by the respondents, this new figure is also provided with illustrations of the practical criteria of the model, assisting the comprehension and use in practice. The contextualized tool for the city of Groningen consists, thus, of four interrelated parts:

This context is an adaptation of the model *what makes a great place?* from the *Project for Public Spaces*. This project approaches the concept of *placemaking*, in which liveability is promoted in a city with a focus on the street level and is implemented with community involvement. Within the key aspects for making a great place, comfort is emphasized. Within the varied types of comfort (e.g. visual and acoustic), the thermal comfort is zoomed in. At this point, Part 2 is connected.

In this part, the assessment tool of UTC strategies is introduced. In addition, there is a side in-depth elaboration of the abstract and practical sections of the assessment tool. Due to the higher degree of technicality, the practical section is elaborated in more detail and illustrated as a sequential process. First, extreme real scenarios are presented: *cold* and *heat stress*. Second, aggravating aspects from the microclimate and urban design are emphasized. Third, *design* criteria of influence in each scenario are referred to. Fourth, the desired effect from UTC strategies is emphasized (in case of cold stress, because no passive strategy is able to generate heat in the outdoor space, "alleviating sense of cold" is the desired effect). Lastly, Part 3 is introduced.

In this part, UTC strategies are developed according to accumulative knowledge. The similar colours in strategy names of both situations correlate strategies which can similarly soften extreme temperatures in both *heat* and *cold stresses*. This reflects the importance of flexibility in urban design. *Adaptability* criteria are, subsequently, incorporated as methods for realizing the strategies in the urban landscape. An outcome of this process, ideally, is UTC, which is then connected to the context of liveable cities.

In this part, good and bad examples within each design criterion are provided for city, block, street and building scales (for reflecting on financial incentives - subsidies and permits). The *adaptability* criteria are illustrated with creative and effective examples from different countries.

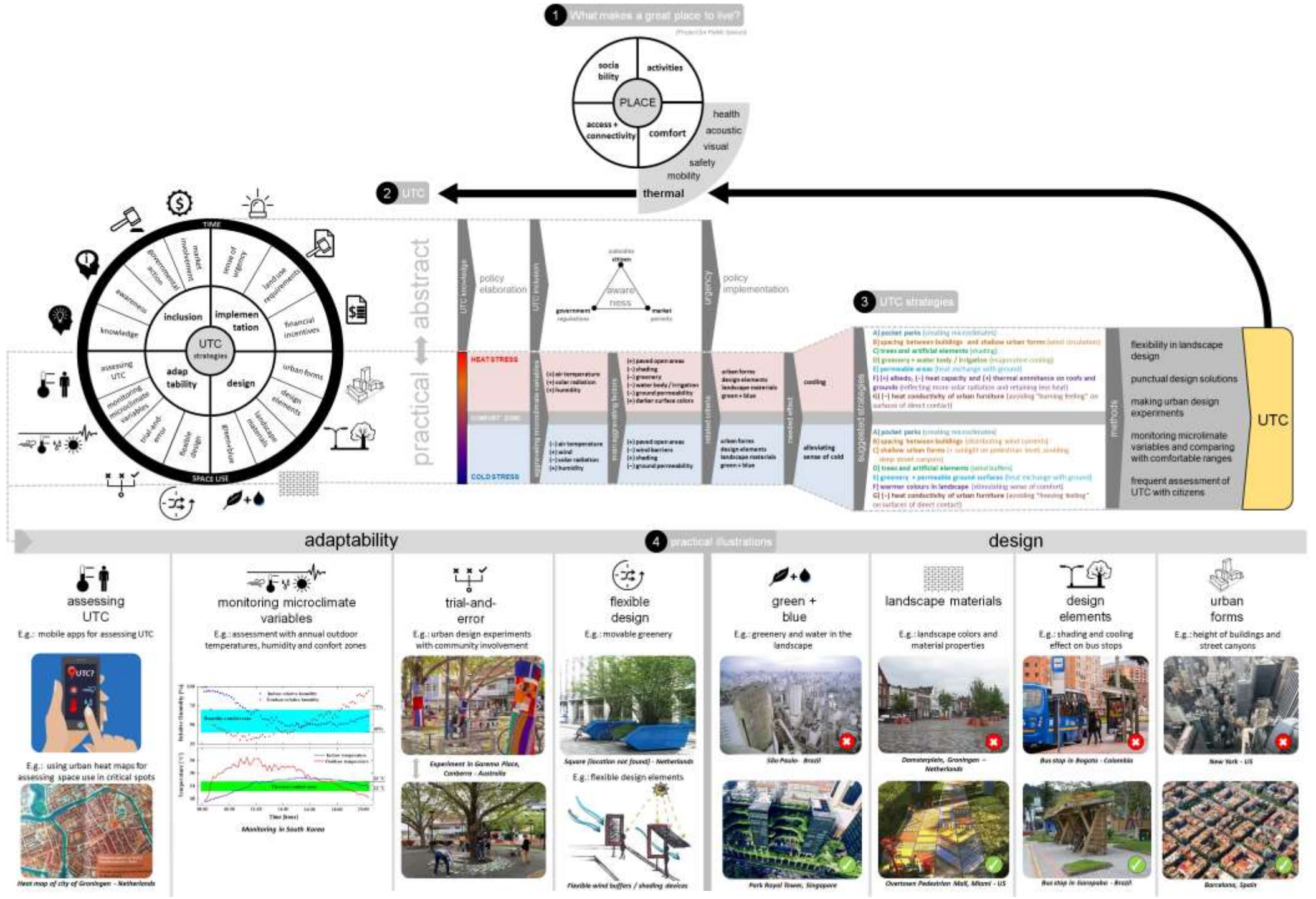


Figure 34– Contextualized assessment tool for the city of Groningen (Author, 2017)

The contextualized assessment tool illustrated in Figure 34 consists of a framework applicable to the city of Groningen. Creating this new figure proved how the assessment tool might be given added value if positioned in a wider practical urban policy context. If the methods were performed in another city, this figure would likely have a different form and additional content. For this reason, Figure 34 is not a result which will help answer the research question. Instead, it is a product of the semi-structured interviews which is aimed at assisting the city of Groningen in practice.

For the research, the semi-structured interviews cautiously refined the first version of tool proposed, leading to a more objective and clearer tool for assessment. Because this research required a few amount of quality interviews (5 successfully performed), this method was very efficient in content and timewise.

4.3. Focus group

The focus group was developed for reflecting on the research process and, consequently, on the improvements made no the assessment tool. The session started with presenting the overall changes made in the first tool and. After, in order to avoid an extensive session, a few key questions were performed. Similar to the semi-structured interviews, for better organizing the results, the findings of the focus group are assembled in Table 5 according to the question.

Table 5 – Summary of focus group

Question	Summary of answers
What is your opinion about the new assessment tool?	Tool is overarching; interesting the zooming in and out in the criteria; interesting how new tool is elaborated fits UTC in making comfortable cities; the tool provides a guideline for more than just UTC, which is not a bad thing.
What would you suggest for the new tool?	Should consensus be inserted between awareness and governmental action? Personal and cultural opinions can matter in UTC? Can it be inserted in the tool? If you score the practical - lower - part of the tool, do you still need to improve the abstract - above - part? What about the economic and social value of UTC? (e.g.: how does it relate to traffic design)
What do you think about the new policy scanning result?	It is based on policies, so the assessment of the implemented urban design would have different colours; Agreed that inner core (referring to the approach to UTC strategies in general) is not filed in, because climate adaptability changes over time, it is growing, it is constantly evolving.
Do you think UTC can be operationalized in urban policies and urban design by means of this assessment tool??	YES

In general, the focus group had a very good acceptance to the new assessment tool. In addition, the members were satisfied with the contextualized tool created from the processed suggestions for the case of Groningen. This session obtained additional suggestions from the respondents. However, at this moment of the research, it was perceived that the data collection was saturated: their further suggestions to the tool were either not practical or either too detailed into one specific field of design (e.g. traffic), which is inconvenient for the purpose of this research.

The first suggestion consisted of adding *consensus* as a new criterion for the *inclusion* dimension. However, it is believed that *consensus* is part of the *awareness* process, as well as - to a certain degree - a governmental responsibility, meaning it is also part of *governmental action*. For this reason, this suggestion was not incorporated: if the assessment tool would comprehensively approach communicative methods of planning processes, it would lose practicality.

The second suggestion consisted of including personal and cultural opinions for the definition of thermal comfort in the tool. Nonetheless, because this research aims at a simplistic and objective tool, the envisioned thermal comfort remains focused on comfortable ranges scientifically proved (and not on personal temperature preferences). In practice, UTC strategies should be framed according to comfortable ranges of microclimate variables for the specific climate. Thus, this suggestion was not incorporated.

The third suggestion was a reflection on the functioning of the tool: scoring well in the practical part may not need taking actions to "look green" in the abstract part of the tool. In this case, it is perceived the tendency of the abstract dimensions of the tool as a pre-requisite of the practical dimensions. In other words, it is unlikely that a neighbourhood which scores well in the practical dimensions does not have awareness, governmental action, knowledge or sense of urgency in what regards to UTC. If it would be the case of existing landscapes which are ideally thermally comfortable, taking actions towards "greening" the abstract part of the tool provides an institutional structure for implementing UTC in further urban developments. Hence, this suggestion was reflected on but no changes were incorporated in the tool.

The forth suggestion consisted on showing economic and social values of UTC in the tool. This was also not incorporated due to the higher degree of detail, which would compromise the practicality of the tool and deviate it from its original purpose. In further adaptations of the tool – towards specific design functions – this suggestion can be incorporated.

The contributions of the focus group can be here discussed for the city of Groningen and for this research. In the first case, this method raised UTC as the theme of an in-depth discussion in the niche of urban planning and design of the city of Groningen. This means a "seed was planted": UTC can be now raised in new visions and plans for the city of Groningen and even be considered as an urban design priority in a near future (for the *Next City*). In addition, the knowledge of UTC for the practitioners was enhanced by the reflections in specific fields (e.g. traffic and landscape design), triggering them to think of the added value of UTC in public spaces.

For this research, this method was an effective way for reflecting on the research development and for providing a productive closure for answering the research question. By the end of the session, **all focus group members agreed that UTC can be operationalized in urban policies and urban design by means of the refined assessment tool of UTC strategies**.

5. Conclusion

This research was inspired in the longstanding concern with thermal comfort in architecture, bringing the topic to a larger scale: the urban landscape. By deepening into key dimensions of UTC and in criteria for elaborating UTC strategies, this research developed a guiding framework for the community of practice within urban planning and design. After results were obtained, the conclusion will be here presented according to the structure of this research.

5.1. Research theory

The theoretical framework explored in this research provided an extensive content input. Based on the theory collected, a lack in the UTC literature was identified and the purpose of this research was consolidated. Translating the fragmented UTC literature originated the main research product: the assessment tool of UTC strategies. Along with this purpose, this research was guided by the goal of the Healthy Cities movement, which is reflected on the contributions of the generated tool for the society: enhancing urban quality, space use and human health. In addition, the studies in microclimate, UTC and smart cities provided the necessary input for defining the UTC dimensions and criteria. In such a way, the selected theories consisted not only of an initial source, but also of a continuously approached content which was materialized by means of the assessment tool of UTC strategies.

The empirical character of the methodology, aimed at refining an assessment tool, also provides a reflection on the theory approached. The literature initially presented connected UTC with *healthy cities* and *urban quality*. A linkage between these theories was built up through the changes performed in the tool for attending the community of practice. In the contextualized version, UTC was additionally connected to liveability and wellbeing. This reflects the importance of UTC in enhancing urban health, recognized in planning theory and practice.

Changes performed in the tool also turned the start point of analysis towards urban policies (abstract part of the model: *inclusion* and *implementation* dimensions). In the theoretical background, Carmona et al. (2014) has emphasized that policy visions are essential for positive changes in urban design, as well as for creating urban landscapes which adapt to environmental changes over time. Such role of urban policies in guiding urban design was acknowledged by practitioners and sustained in the refined tool. This, in turn, consequently reflects the urban design perspective of the city of Groningen.

Based on the context in which the tool was validated, the alterations performed in the tool slightly diverged from the core theory of this research. On one hand, the deletions contributed positively to achieving a clear and objective framework, still aligned with the theory. On the other hand, the additions incorporated aspects which were not yet approached by the theory (e.g. sense of urgency and awareness). Even though such additions are not addressed or directly connected to the research theory, the last does not contradict with or prevent them from being added-value inputs. In general, the theory involved was enough for providing content and guideline for the choices made through the research.

5.2. Research questions and methodology

The research questions were formulated in a way that, by answering the secondary questions - in the order they were proposed, the main question was gradually answered. This strategy realized by means of aligning the sequence of questions with the methodology for building up the final answer for this research.

First, the in-depth *literature review* defined the UTC dimensions and criteria which built up the assessment tool. This tool was a first proposal of an analytical framework which can directly inform urban design and policies in practice. The validation of the assessment tool by means of the policy scanning and semi-structures interviews, as well as the discussion performed in the focus group, allowed to tool to be empirically improved towards a refined version. Such methods proved to be efficient content and timewise. This is due to the sufficient amount of practitioners approached, who were very much qualified for the input required.

If compared to other research methods (such as questionnaires), the one selected for this research successfully attended to the required input for answering the research question. Due to the engagement with the *Gemeente Groningen* and in *The Next City* project, as well as the strong local support to this research, the context of tool validation was limited to the city of Groningen. If more time were available (for both the research and in the agenda of the respondent profile required), the interviews and the focus group could be performed with practitioners from distinct cities. This could certainly add value to the refined tool by means of a varied source of the community of practice.

5.3. Research process

This research took place in the city of Groningen, which led the refined assessment tool of UTC strategies to becoming a reflection of the urban design priorities for this context. If validated in a different city, this framework could probably have suffered different changes. For Groningen, the alterations involved the criteria, functioning and visual of the tool; for another location, changes could reach the dimensions and even the model figure, if drastic changes in content and the functioning were perceived as relevant (e.g. disconnecting dimensions and obtaining a different shape). For an analytical process, however, the tool created in this research is sufficient and efficient.

Over the methodology, research questions were answered and the path towards a refined assessment tool of UTC strategies was designed. Such path, illustrated in Figure 26, has effectively led this research to achieving the aim at creating a tool for assessment to be used by urban planning and design practitioners. Because this process diverges from usual research paths, the methodological choices consisted of delicate acts, in which further consequences had to be though in advance. Perceived this complexity, the research supervisors played a great role in providing assistance. In addition, the *Gemeente* Groningen contributed - timewise and contentwise - over the methodological process.

In a scientific research perspective, the set of methods strategized (according to the research framework in Figure 3) has proven to be effective for a context in which plenty of policies are available. As previously mentioned, in practice this tool is to be assessed directly by means of a discussion between key practitioners involved in urban policies and urban design, who are fully aware of existent policies and the actual urban design. For a context in which policies are scarce, even though there are no policy documents, it is expected existent parameters or urban design frameworks for guiding actions. This can be, therefore, identified and explored by means of interviewing practitioners who are active in the urban design process.

5.4. Contribution to urban design and planning practice

In planning practice, this research provides an assessment which indicates actions in urban policies and design to be performed along a continuous learning process. An outcome of this process consists of enhancing livability and wellbeing. The added value of this research, however, is not limited to the context to which the assessment tool was applied to (the city of Groningen). The assessment tool created was an

analytical framework approved by practitioners in urban design and planning practice, which can be applied to any location, regardless of the climate.

This tool also adds value to consultancy services related to urban planning and design. In this case, the assessment tool becomes a mechanism of clinical analysis and diagnosis of UTC for the existing outdoor space. For clients such as municipalities, the tool has a dual function: it provides policy advice (for visions, agendas and other initiatives), as well as it steers urban design interventions for promoting UTC. Such consultancy needs to be further elaborated by experts of the company which holds the assessment tool. This process is to be performed based on further knowledge about the *design* and *adaptability* dimensions of this research.

For the city of Groningen, it is perceived a contribution for the current visions of the city of Groningen, which are also reinforced by *The Next City* project. In the *Groningen Klimaatbestendig* - a vision for a climate-proof city, the assessment tool of this research can assist in the elaboration of urban design interventions in the build area of the city. For new districts and urban developments, the tool assists with the proposal of landscapes which cope with the microclimate for continuously promoting UTC.

Thus, the main contributions of this research to urban design and planning practice are:

- An analytical framework for assisting municipalities in promoting healthier and resilient cities by means of prioritizing UTC in urban policies and urban design.
- A legitimate tool for consultancy companies to provide policy and landscape advices towards UTC, urban quality and resilience.

6. Recommendations and further research

The interviews and the focus group of this research suggested the improvement of the assessment tool of UTC strategies into specific fields within urban design (such as traffic design). Because such suggestions were not practical for the framework proposed, the first recommendation is an adaptation of the tool to other urban design related fields. These could vary according to the experience and ambitions of the respective practitioners, such as traffic-mobility, recreation and landscape architecture. A result of such adaptations could be, for instance, obtained similarly to the contextualized assessment tool developed for the city of Groningen (Figure 34), however with different frameworks and figures.

A second recommendation consists of a further research testing the assessment tool in a different climate context. This second validation of the tool can be developed by means of similar or different methods. Independent of the results (changes suggested for structure and content of the tool), this action will certainly conclude on the flexibility of the framework, firstly assumed to be overarching.

A third recommendation was obtained at Witteveen+Bos. It consists of incorporating UTC strategies to the ASVV (*aanbevelingen voor verkeersvoorzieningen binnen de gebouwde kom*), according to the suitability. In sum, the ASVV consists of a Dutch guideline for traffic infrastructure in public areas, which approaches mostly infrastructure design technicalities. The suggestion consisted of adapting the AVSS with UTC aspects, such as the criteria within the *design* dimension. Adding greenery, using infrastructure materials which retain less heat and avoiding deep street canyons according to width of streets are examples of inputs that could make the Dutch traffic infrastructure contribute to UTC.

A fourth recommendation consists of exploring ICTs for assisting the promotion of UTC. As discussed in this research, ICT can be not only used for monitoring and evaluation purposes, as usual, but also in creative urban devices for interacting with performances of wind and solar radiation (microclimate variables most influenced by the physical landscape). Such devices could be, for instance, flexible and automatic wind buffers and shading devices.

The fifth recommendation concerns to UTC strategies. This research aimed at operationalizing UTC in urban policies and urban design (according to the research question), which was realized with the assessment tool of UTC strategies. As mentioned in sub-chapter 2.1.1., UTC strategies should be focused on scientifically proven comfortable ranges of temperature, which varies according to the climate. A further research could consist of developing actual strategies by making use of the tool, with assistance of weather data and site analysis (of existing urban design). This could be done for the city of Groningen with a focus on a local neighbourhood. The annual weather data can be easily obtained in weather websites. However, Appendix 8.7 shows weather analysis generated with the software *Climate Consultant* for the city of Groningen (more detail of simulation process in the appendix). The software – of free access – generates graphs with annual performances of the microclimate variables, including the *comfort zone* (which refers to the temperature range of thermal comfort). It shows, therefore, the degree of thermal discomfort (if any) for any time of the year. Such results are commonly used in Architecture for assisting the provision of thermal comfort indoors, as it provides bioclimatic strategies. Thus, such information can be used for developing UTC strategies, softening *cold* or *heat stress* according to the context.

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8. Appendixes

8.1. Complementary literature for criteria in design dimension

Urban design patterns and their effects: ShashuaBar et al. (2011)

	Urban design pattern	Effects on microclimate	General UTC sensation	Urban design suggestions
A	Open spaces with pavement	Higher radiation emission by ground surface, higher irradiative surface temperature	Discomfort (warm)	Make use of **vegetation with irrigation** (or other water resources) in order to have an efficient evapotranspiration effect (combined with proper shading)
B	Semi enclosed, exposed area with pavement	Higher radiation emission by ground surface, higher irradiative surface temperature	Discomfort (warm)	
C	Semi enclosed, exposed area with grass	Higher radiation emission by ground surface and higher irradiative surface temperature (however, lower than in A and B); lower albedo (sunlight on grass); evaporative cooling on air; slightly convective heat removal	Discomfort (warm)	
D	Semi enclosed area with material shelter and pavement	Lower incidence of solar radiation; low convective heat loss	Discomfort (warm)	
E	Semi enclosed area with natural shelter (trees) and pavement	Lower incidence of solar radiation; low convective heat loss; evapotranspiration	Discomfort (warm)	
F	Semi enclosed area with material shelter and grass	Lower incidence of solar radiation; more solar radiation absorbed; evaporative cooling on air; lower emissions of solar radiation	Comfort	
G	Semi enclosed area with natural shelter (trees) and grass.	Lower convective heat loss; evapotranspiration; evaporative cooling on air; smaller temperature peaks	Comfort	

Urban design patterns and their effects: Johanson (2006)

	Urban design pattern	Effects on microclimate	General UTC sensation	Urban design suggestions
A	Deep street canyons	Summer: daytime cool-islands (due to more shaded surfaces of buildings); wind with lower speeds and more stable; lower mean radiant temperature. Winter: lower air temperatures (due to more shading); less sun radiation access	Summer: comfort Winter: discomfort	Avoid disperse urban forms; Adopt a **climate-sensitive urban design**. For hot climates: combine **urban forms** with deep canyons and a few wider streets (or open spaces) as solar spots during the winter. Such open areas should have trees or shading devices for **solar protection** during the summer. **Surface materials**: make use of lower albedos for pavements and facade
B	Shallow street canyons	Summer: higher mean radiant temperatures; lack of shading options. Winter: more shading options (changes sun trajectory); pleasant wind.	Summer: discomfort Winter: comfort	

Urban design patterns and their effects: Thorsson et al. (2011)

	Urban design pattern	Effects on microclimate	General UTC sensation	Urban design suggestions
A	Large square	Higher yearly temperature amplitudes; higher air temperatures in summer; lower temperatures in winter; higher incidence of solar radiation as well as emissivity; more spatial variations of mean radiant temperature within short distances	Discomfort	Use **urban geometry** to **mitigate daytime thermal stress**
B	Small courtyard	Warmer than open areas; more build up areas reduce the amplitude of mean radiant temperature	Discomfort	
C	North-South oriented street canyon			
D	East-West oriented street-canyons			

8.2. List of words for policy scanning

Policy scanning		
Type of policy	**Encountered documents**	**Subject**
Project	The Next City	How the city can deal with future changes (e.g. increase of population and land area, climate change, UHI) and still promote urban quality
Agenda	Uitvoeringsagenda 2017 *(Implementation agenda 2017)*	Promoting healthy urban development by means of a cooperation between political programmes and related research
Programme	Groningen klimaatbestendig *(Groningen climate-proof)*	Urban warming and city adjustment to climate change; "climate-proof Groningen"
	Groningen Energizes *(Groningen Energizes)*	Exploring renewable energy; studying how Groningen can make use of geothermal and residual heat for the achievement of a Smart Energy City (target)
Vision	Healthy Ageing Visie *(Healthy Ageing vision)*	Enhancement of healthy cities activities, contributing to healthier citizens in a healthy city
	Watervisie Groningen *(Water vision Groningen)*	Spatial-economic perspective of water use in the city; how the public space nearby water be improved in order to have quality water for living, recreation and sailing
	Woonvisie Groningen *(Residential vision Groningen)*	The future of living in Groningen; youth housing; living comfort; housing affordability, quality, sustainability, safety and accessibility (among others)
	Bomenstructuurvisie Groningen *(Tree infrastructure vision for Groningen)*	Green city and healthy trees for improving liveability; enlarging tree structure, planting them in proper locations and letting them grow old
	Groenstructuurevisie voor Groningen	Quality, quantity and meaning of green in the city;

	(Green structure vision for Groningen)	functions of green areas for environment and urban quality

General topics		
Key words[3]	**Related topics (to UTC)**	**Instances[4]**
Binnenstad	Climate-proof, urban heat, green in the city, more trees planted in the inner city, water canals, functions in the inner city, lack of shading in the Binnenstad and more heat in open squares and wide streets, greenery and shading in Martinikerkhof	167
Klimaat *(Climate)*	Climate-change, climate-proof city, climate adaptation, influence of urban design on climate	132
Microklimaat *(Microclimate)*	(microclimate referred to as "climate")	0
Comfort *(Comfort)*	Comfortable housing	7
Temperatuur *(Temperature)*	Urban warming, UHI, influence of green in urban temperatures	4
Wind *(Wind)*	Wind circulation in city, trees as shelter for wind	10
Bestraling *(Radiation)*	-	0
Vochtigheid *(Humidity)*	-	0
Overall perception: In general, aims in policies involving to heat stress and climate adaptation (related, to a certain degree, to UTC) are perceived for all the city of Groningen. However, it is limited, as the focus remain on high temperatures, having no connection to UTC by cold. In addition, despite the approach to urban warming, UHI and climate change, UTC is still implicit, as outdoor thermal comfort is not mentioned in any document.		
Dimension: design		
I. Criterion: urban geometry		
Key words	**Related topics (to UTC)**	**Instances**
Geometrie *(Geometry)*	-	0
Hoog/Hoogte *(High/Height)*	Wáter levels, increase of greenery in city, climate change and high urban temperatures	122
Breed/Breedte *(Wide/Width)*	Larger green areas and urban quality, large open spaces, urbanization and city expansion, larger number of trees along main roads and avenues	36
Plein *(Square)*	Urban heat analyses, attractive public spaces, open squares as warmer places, square functions, trees in squares	133

[3] Certain words – when applicable – were also searched in the plural form and other grammar variations (e.g. *deze acties zijn **lokaal**, dit zijn **lokale** acties; **observatie** van de straat, het **observeren** van de straat*).
[4] In all policies scanned; also count words which contain the key words (not necessarily mentioned in *related topics*).

Gebouw *(Building)*	Sustainable buildings (energy efficiency), influence of building materials outdoors	59
Straat *(Street)*	Street profile, urban heat, street vegetation, wide streets as warmer places	343
Open *(Open)*	Open air, open squares as warmer places, open landscapes	243
Gesloten *(Closed)*	Closed gardening, city centre enclosed by water	27
Canyon *(Canyon)*	-	0
Passage *(Passage)*	(not related)	3
Stoep *(Sidewalk)*	Sidewalks with trees and greenery	4
Estimated scoring: existent, limited, implicit		
II. Criterion: micro-scale geometry		
Key words	**Related topics (to UTC)**	**Instances**
Design *(Design)*	Sustainable and Smart design, design for a healthy city, design for a living climate, wellbeing, attractive urban design	11
Meubilair *(Furniture)*	-	0
Uitrusting *(Equipment)*	-	0
Bomen *(Trees)*	Trees in public spaces, dimensions and spacing between trees, contribution to climate-adaptive and healthier city, general functions and properties of trees	638
Lokaal *(Local)*	New local opportunities for housing by water, local recreating with water, local involvement in city programs towards a healthier city	
Lay-out *(Layout)*	-	0
Configuratie *(Configuration)*	-	0
Schuilplaats *(Shelter)*	-	0
Buffer *(Buffer)*	Ground vegetation buffering rain water	5
Schaduw *(Shade)*	UHI, cooling effect from the shading (from trees)	12
Oplossing *(Solution)*	Lack of attention to climate-adaptive solutions, location-specific solutions, solutions for public spaces by the water, integrative solutions for achieving urban health goals, cost-effective solutions	10
Schaal *(Scale)*	Water system in district level, green+blue connection in city scale, urban structure and green solutions designed for small	10

	scale, understanding problems in city and object level	
Estimated scoring: existent, limited, implicit		
III. Criterion: built surface materials		

Key words	Related topics (to UTC)	Instances
Oppervlak *(Surface)*	Surface water, built surfaces and urban temperature increase, cooling effect from greenery	13
Materiaal *(Material)*	Used material in buildings and urban landscape (related to urban heat)	4
Verdieping *(Floor)*	-	0
Grond *(Ground)*	Underground water and distribution of green, permeable ground (permeable concretes), rainwater gardens, relationship between land and Canals	88
Facade *(Facade)*	Grants for who makes use of green facade	1
Muur *(Wall)*	Green walls for "filtering" air pollution	4
Kleur *(Colour)*	Light-colour asphalt emitting light from vehicles (less light necessary along roads; reduction of UHI), green colour making public spaces more attractive	15
Eigenschappen *(Properties)*	Properties of trees	1
Emissie *(Emissivity)*	-	0
Albedo *(Albedo)*	-	0
Estimated scoring: existent, overarching, implicit		
IV. Criterion: green (+blue)		
Key words	**Related topics (to UTC)**	**Instances**
Groen *(Green)*	Green+blue network generating more pleasant (aesthetic value) and healthier spaces, greenery encouraging outdoor activities, greenery for water drainage, distribution of vegetation, cooling and evaporation functions, tree shading, recreation, groundwater, urban biodiversity	787
Blauw *(Blue)*	Green+blue network for regulating extreme temperatures, integrative planning (water and spatial planning), blue functions, sustainable cities	52
Gras *(Grass)*	Ground water feeding, ideal combination of trees with grass	18
Bomen *(Trees)*	Weather and wind shelter, greenery in public spaces, shading, urban design composition, healthy city, liveability, wellbeing, urban biodiversity	638
Vegetatie *(Vegetation)*	Meadowns of Canals	1
Grachten *(Canals)*	Urban design composition	3
Water *(Water)*	Green+blue network, water-nature conservation, liveability, leisure, sustainable urban design, water availability, rain	786

	water and groundwater feeding, cooling effect, balance between too much and too little water	
Irrigatie *(Irrigation)*	-	0
Park *(Park)*	Greenery, leisure, social and ecological functions, liveability, wellbeing, attractive public spaces	665
Estimated scoring: existent, overarching, implicit		
Dimension: inclusion		
V. Criterion: citizen assessment		
Key words	**Related topics (to UTC)**	**Instances**
Mensen *(People)*	Attractive spaces stimulating social interaction, active citizenship, citizen participation and cooperation in urban projects, awareness and inspiring people to contribute to a climate-adaptive Groningen, wellbeing, public space and people behaviour, liveability	75
Perceptie *(Perception)*	-	0
Mening *(Opinion)*	People's opinion on current housing and neighbourhood quality and what they wish for the future	2
Gevoel *(Feeling)*	Sensitive areas for heat, green make people feel better and safer	13
Beoordeling *(Assessment)*	Still little room for citizen participation in urban design	2
Interview *(Interview)*	Proposed assessment of health outcomes in cities	1
Vragen *(Questions)*	Healthy ageing research, climate-proof city research, permits for living and building on water	39
Samenwerking *(Cooperation)*	Cooperation between various stakeholders for improving liveability and housing and promoting a climate-proof city	2
Technologie *(Technology)*	Smart homes, health technology (for housing), contribution of knowledge institutions	3
Estimated scoring: on development		
VI. Criterion: space use assessment		
Key words	**Related topics (to UTC)**	**Instances**
Ruimte *(Space)*	Space for collaboration between different stakeholders in city developments, functions of public spaces, climate-proof public spaces, space for pedestrians, cyclists and green, space for trees and water	322
Gebruik *(Use)*	Multiple space use, use of green spaces, water use, knowledge use for urban projects, space use as one of the	169

	criteria for climate-adaptation	
Observatie *(Observation)*	-	0
Gedrag *(Behaviour)*	Adapting public spaces, space use and public behaviour, impact of healthy neighbourhoods on a healthy behaviour	27
Aantrekkelijk *(Attractive)*	Attractive public spaces, attractive green, attractive city, attractive living climate, greenery distribution	50
Activiteiten *(Activities)*	Healthy places enhancing social activities, green space activities, communication between stakeholders, activities enhancing urban health	22
Technologie *(Technology)*	Smart homes, health technology (for housing), contribution of knowledge institutions	3
Beoordeling *(Assessment)*	Still little room for citizen participation in urban design	2
Estimated scoring: on development		
VII. Criterion: governmental action		
Key words	**Related topics (to UTC)**	**Instances**
Regering *(Government)*	Government stimulating and expecting public participation, reduction of government funding for developments, government role in housing development	2
Actie *(Action)*	Actions for housing, water management and towards healthier cities	91
Gemeente *(Municipality)*	Commitment in improving urban quality, subsidizing and promoting collaboration between different stakeholders for urban projects, promotion of healthy living environment	293
Initiatief *(Initiative)*	Active citizenship, urban recreation, active movement, healthy buildings, healthy city, healthy ageing, climate-proof city, greenery and tree distribution, water management, sustainable housing and neighbourhoods	15
Aansporing *(Incentive)*	-	0
Inclusie *(Inclusion)*	(not related)	12
Meenemen *(Include / carry along)*	Stakeholder consultation to cliamte-adaptive city, collaboration of expertise institutions to urban plans	5
Plan *(Plan)*	Integratove urban planning, plans for improving urban quality, accessibility of plans to stakeholders	522
Programma *(Program)*	Programs towards a healthier city, greener and climate-adaptive city, healthier neighbourhoods, sustainability programs	132
Beleid *(Policy)*	Visions, programs, projects and plans of policies studied, changing policies	168

Subsidie *(Subsidy)*	Investments in sustainability related projects, subsidies for green roofs, grants for who develops green roofs or façade, subsidies from varied levels of government	13
Estimated scoring: existent, limited, implicit		
VIII. Criterion: market involvement		
Key words	**Related topics (to UTC)**	**Instances**
Markt *(Market)*	Water market prices, scarce housing market	51
Aansporing *(Incentive)*	-	0
Initiatief *(Initiative)*	(not related)	15
Investering *(Investment)*	Partnerships in climate-proof city researches, partnerships for cost-effective greenery developments, budgets for urban renewal, long-term private investment in housing, municipality depends on private investors and housing corporations for crating housing	34
Privaat *(Private)*	Joining partners for urban health related projects, private initiatives on water related developments	9
Instelling *(Institution)*	Collaboration between knowledge, government, citizens and private institutions for greener and healthier city	69
Kapitaal *(capital)*	-	0
Estimated scoring: on development		
IX. Criterion: knowledge base		
Key words	**Related topics (to UTC)**	**Instances**
Kennis *(knowledge)*	Knowledge network (stakeholders), expanding knowledge from regional to international level, research from knowledge institutions for contributing with urban health, healthy ageing, climate adaptation, liveability	91
Expertise *(Expertise)*	Active expertise institutions	5
Wetenschappelijk *(Scientific)*	Researches on liveability, healthy city, healthy ageing, climate adaptive city,	15
Onderzoek *(Research)*	Research about heat stress in different levels (regional, national, international), researches on liveability, healthy city, healthy ageing, climate adaptive city	107
Organizatie *(Organization)*	-	0
Estimated scoring: explicit, overarching, implicit		
Dimension: implementation		

X. Criterion: **UTC vision**		
Key words	**Related topics (to UTC)**	**Instances**
Visie *(Vision)*	Greenery, trees, healthy city, healthy ageing, water, housing, infrastructure, future city	263
Begeleiding *(Guidance)*	EU Directives (EU Water Framework, EU Birds and Habitats Directives) as foundation for national and local initiatives (in urban health, the G6: *Actief Burgerschap, Bereikbaar Groen, Actief Ontspannen, Actief Verplaatsen, Gezond Bouwen en Gezonde Voeding*), plans, preparation, visions for guiding projects towards climate adaptive city and healthy city	5
Doel *(Goal)*	Working together for: achieving and maintaining healthy and safe physical living environment, promoting quality of life, mitigating high temperatures	108
Estimated scoring: Existing, overarching, implicit		
XI. Criterion: **urban design parameters**		
Key words	**Related topics (to UTC)**	**Instances**
Ontwerp *(Design)*	Design of climate-adaptive city (long-term approach), distribution of green, streets and trees	67
Parameters *(Parameters)*	-	0
Benodigheden *(Requisites)*	For public spaces: ground and underground space for trees	9
Profiel *(Profile)*	For public spaces: trees, street designs with green and blue	10
Distributie *(Distribution)*	-	0
Landgebruik *(Land use)*	-	0
Richtlijn *(Guideline)*	Guideline for greenery and tree design, future guideline for a healthy city	44
Estimated scoring: existent, limited, implicit		
XII. Criterion: **regulations for public spaces**		
Key words	**Related topics (to UTC)**	**Instances**
Regulatie *(Regulation)*	Space for recreation, water use	1
Publiek *(Public)*	Public health, leisure in city, public use of spaces nearby water	9
Eis *(Requirement)*	Planting trees, quality requirements for housing, EU requirements, land use, living with water / on water	47
Vereiste *(Requisite)*	Increase of quality standards in urban developments	3

Main findings for criterion: existent, limited, implicit		
XIII. Criterion: regulations for private developments		
Key words	**Related topics (to UTC)**	**Instances**
Privaat *(Private)*	(not related)	9
Ontwikkeling *(Development)*	Land use plan	194
Eis *(Requirement)*	Quality requirements for housing, land use, living with water / on water	47
Vereiste *(Requisite)*	Increase of quality standards in urban developments	3
Onderhandeling *(Negotiation)*	-	0
Toestaan *(Permit)*	Permits (public law instruments)	3
Toestemming *(Consent)*	(Not related)	5
Estimated scoring: non-existent		
XIV. Criterion: institutional resources		
Key words	**Related topics (to UTC)**	**Instances**
Instelling *(Institution)*	Collaboration between knowledge, government, citizens and private institutions for greener and healthier city	69
Middelen *(Resources)*	Financial (housing), knowledge and engagement (climate-adaptive and healthy city), efficient use of resources, management of green structures, sustainable green management	24
Kapitaal *(Capital)*	-	0
Investering *(Investment)*	Collaboration between knowledge, governmental investments, citizens and private institutions for greener and healthier city	69
Expertise *(Expertise)*	Active expertise institutions, knowledge input in projects	5
Kennins *(Knowledge)*	Knowledge network, research from knowledge institutions for contributing with urban health and healthy ageing, climate adaptation,, liveability	91
Technologie *(Technology)*	Technologies as contribution of knowledge institutions (most technologies referred to Smart Housing - indoor benefits)	3
Estimated scoring: existent, limited, implicit		
XV. Criterion: actual implementation		

Key words	Related topics (to UTC)	Instances
Uitvoeren *(Implement)*	In policies, referred mostly in future tense (greenery has already started to be implemented), implementation and management costs as one of the criteria for climate-adaptation	125
Realiteit *(Reality)*	-	0
Gebouwd *(Built)*	Housing, parks, greenery, trees (built quality mentioned for the future)	17
Bestaand *(Existent)*	Greenery, existing urban qualities (parks, water courses…) saturated housing infrastructure	99
Estimated scoring: non-exixtent		
Dimension: adaptability		
XVI. Criterion: flexible design		
Key words	**Related topics (to UTC)**	**Instances**
Flexibele *(Flexible)*	Multiple space use in green spaces, flexible types of dwellings, flexible urban spaces, multifunctionality as one of the criteria for climate-adaptation	3
Ontwerp *(Design)*	Design of climate-adaptive city (long-term approach), distribution of green, streets and trees	67
Beleid *(Policies)*	Visions, programs, projects and plans of policies studied, changing policies	168
Instellingen *(Institutions)*	Collaboration between knowledge, government, citizens and private institutions for greener and healthier city	69
Aanpassen *(Adapt / Adjust)*	Need of adaptation of living environment to social, environmental and climate changes	15
Tijd *(Time)*	Initiatives for healthy city and healthy ageing will take time to show results, providing cooling in time for climate change effects, green structure needs time to generate cooling effect	107
Toekomst *(Future)*	Future climate, urban interventions, housing quality, relationship between city and water	45
Creatief *(Creative)*	Fianncing creative initiatives, still little experience with cerative measures for climate adaptation	10
Estimated scoring: on development		
XVII. Criterion: trial-and-error		
Key words	**Related topics (to UTC)**	**Instances**

Vallen en opstaan *(Trial-and-error)*	-	0
Interventie *(Intervention)*	Using housing to "sink" the urban heat, interventions for reducing health differences among citizens	2
Experiment *(Experiment)*	Communities of practice for making experimental fields towards healthier lifestyles, experimenting different architecture and energy sources, experiments with permeable concrete on ground surfaces	10
Leren *(Learn)*	Healthy ageing vision and related measures are a learning process which takes time, knowledge in healthy city and healthy ageing is being stimulated, experimental learning from long-term process, learning-by-doing stimulated in climate adaptive researches	49
Proberen *(Try)*	Attempt to promote flexibility in land developments, trying to stimulate citizen engagement	6
Tijd *(Time)*	Initiatives for healthy city and healthy ageing will take time to show results, providing cooling in time for climate change effects, green structure needs time to generate cooling effect, not much is known about long-term performance of climate-adaptive measures	107
Estimated scoring: on development		
XVIII. Criterion: monitoring and evaluation		
Key words	**Related topics (to UTC)**	**Instances**
Monitor *(Monitor)*	monitoring and studying local effects of climate change, housing conditions, health impacts on measures towards a healthy city, ecological management in green areas, need of greenery conditions through time	19
Schatten *(Evaluate)*	Deployment of city structures	1
Inwoner *(Citizen)*	Participation, awareness, space use, liveability, wellbeing, energy consumption, housing quality	66
Technologie *(Technology)*	Smart homes, health technology (for housing), contribution of knowledge institutions	3
Beoordeling *(Assessment)*	Still little room for citizen participation in urban design	2
Meten *(Measure)*	Health outcomes are hard to measure, collaboration with knowledge institutions for measuring it	7
Estimated scoring: existent, limited, implicit		

After the semi-structured interviews, two new criteria were proposed for new version of the assessment tool:

Criterion: **awareness** *(in: inclusion)*		
Key words	**Related topics (to UTC)**	**Instances**
Bewust *(Aware / awareness)*	Greenery for quality of living environments, living with water, healthy ageing aspects, residential situations and liveability	7
Informatie *(Information)*	heat tress, water pollution, water uses, water infrastructure, liveability	11
Verloving *(Engagement)*	-	0
Estimated scoring: on development		
Criterion: **sense of urgency** *(in: implementation)*		
Key words	**Related topics (to UTC)**	**Instances**
Urgentie *(Urgency)*	Cooperation for healthier urban development	1
Estimated scoring: non-existent		

8.3. Interview acceptance letter

The present interview aims at contributing to a master thesis research. By signing this document, you agree with the following terms:

A. The content of this interview will add value to a master thesis research. The research is developed in the master of Environmental and Infrastructure Planning of the Rijksuniversiteit Groningen (RUG), in cooperation with Witteveen+Bos, where an internship was performed. The supervisors of the research are Christian Zuidema (RUG) and Jimme Zoete (Witteveen+Bos).
B. By means of this interview, you will contribute to a study about urban thermal comfort (UTC). The research created an assessment tool for assisting the development of UTC strategies for urban policies and urban design.
C. This interview will investigate the use of tools for assisting the urban design process of the city of Groningen. It will be proposed to you a new tool, over which your perception will be asked. This interview should take approximately one hour.
D. For carefully processing the information provided in this interview, with your permission, it is proposed that the interview is recorded. Only the researcher and the research supervisors will have access to sound recordings and transcripts.
E. Everything discussed in this interview will be confidential. In case the respondent wishes to keep his / her identity anonymous, he / she can be mentioned according to his / her function. If this is also not desired, a pseudonym will be given in the transcript.
F. The results of this interview will be published in the final version of the master thesis and may be used for further academic publications.

Please mark YES or NO for the following options and sign the document.

- *I would like to proceed with this interview* ***(YES) (NO)***
- *I would like my function to be mentioned in the research* ***(YES) (NO)***
- *I would like my name to be mentioned in the research* ***(YES) (NO)***
- *I would like to receive a copy of this interview* ***(YES) (NO)***
- *I would like to receive a copy of the research* ***(YES) (NO)***

Name of respondent:	Name of Interviewer:
Signature of respondent:	Signature of interviewer

Date:

8.4. Guideline of semi-structured interviews

Semi-structures interviews

1. Could you briefly describe what your function (s) at the *Gemeente* Groningen is?

PART 1	Goal: objective reflection on **tools** used for urban design

2. According to your experience with urban projects in the municipality, can you describe any tools used by the municipality for developing urban design, if there is/was any?
3. Within these tools, are there any theoretical or conceptual frameworks to guide urban design in any way?
   a. If yes, how did these frameworks contribute to the urban design process?
   b. Do any of them approach both urban policies and planning practice?
4. What urban planning or design challenges in the city do you believe a new framework could help achieve positive results?

PART 2	Goal: reflecting on **UTC** in practice

5. What are the main priorities of the municipality regarding urban design?
6. What is the usual scale to which an urban design is proposed in the city? (e.g. one standard urban design for the whole city or according to area / neighbourhood)
7. How concerned do you believe the municipality is with outdoor temperatures when proposing and urban design?
   a. Is there also an attention to very low outdoor temperatures?
8. How concerned do you think the municipality is with how comfortable people feel with outdoor temperatures?

PART 3	Goal: reflecting on the **tool**

Outdoor temperatures are a result of microclimate variables (air temperature, wind, humidity and solar radiation) and the urban design. This is because the characteristics of the urban design (urban form, materials and elements used) can influence the performance of such microclimate variables (mention examples), intensifying or alleviating extreme temperatures. According to the resulting temperature outdoors, people will feel more comfortable or not, feeling more attracted - or not - to use public spaces. Therefore, it is perceived that urban thermal comfort can influence space use.

Based on this concern, an assessment tool was created for assisting the development of UTC strategies. This tool considers both urban policies and urban design in the provision of UTC.

(Show figure of tool - without assessment table → explain tool)

9. Is this tool of clear understanding to you?
10. What do you think of the dimensions and the criteria approached?
11. How do you think this tool could help the municipality with the current visions for Groningen as a healthier and climate-proof city?
12. At this moment, would you suggest any improvements for the tool? (other dimensions, criteria, the design of the tool)

PART 4	Goal: preparation for focus group (closure)

Before taking actions towards UTC, it is believed that it is important to analyse if any initiatives related to urban thermal comfort (e.g. approaching outdoor temperatures) have been taken. For this reason, a method was developed for this framework to assess the current approach to UTC in urban policies and urban design. By means of signalizing colours, the tool points out where have actions already been taken towards UTC and suggests actions to be considered.

- **Explain assessment → show assessment tool - with scoring table.**
- **Explain policy-scanning result - further comments focus group.**
- **Schedule focus group meeting.**

8.5. Acceptance letter of focus group

You have been asked to participate in a focus group for a thesis research developed in the master of Environmental and Infrastructure Planning (Rijksuniversiteit Groningen) in collaboration with Witteveen+Bos. Please read the following information and sign the document:

- **Purpose**: assessing the proposed assessment tool of Urban Thermal Comfort (UTC) strategies and reflecting on the operationalization of UTC in urban policies and urban design.
- **Contribution**: improvements towards a final version of the assessment tool.
- Although the focus group will be tape recorded**, your responses will remain anonymous** and **no names will be mentioned** in the report.
- There are **no right or wrong answers** to the focus group questions.
- Please **feel free to share your viewpoints,** even if your responses are not in agreement with the rest of the group.
- In respect for each other, we ask that only one individual speak at a time in the group and that responses made by all participants be kept confidential.

I understand this information and agree to participate fully under the conditions stated above:

Signature:_____ Date:_____

8.6. Structure of focus group

Welcome

Thank you for agreeing to be part of the focus group. We appreciate your willingness to participate.

Introduce moderator, assistant moderator and brief introduction of whole group.

Purpose of focus group

The reason of this focus group is to assess the proposed assessment tool of Urban Thermal Comfort (UTC) strategies and reflect on the operationalization of UTC in urban policies and urban design.

Ground rules

1. We want you to do the talking.

2. There are no right or wrong answers.

3. What is said in this room stays here.

4. We will be tape recording the group (you will remain anonymous).

Start

- Show previous assessment tool.
- Explain suggestions and additional changes.
- Show the new tool - new figure.

Question 1- What is your opinion about the new assessment tool?

Question 2 - What further suggestions would you give for it?

- Show result of policy scanning - adapted to improved tool.

Question 2 - What do you think about the new policy scanning result?

Question 3 - Do you think UTC can me operationalized in urban policies and urban design by means of this assessment tool?

8.7. Further research: creating UTC strategies for a neighbourhood in the city of Groningen

The software *Climate Consultant*[5] is mostly used in Architecture for finding out bioclimatic strategies for promoting thermal comfort indoors. However, because the output data illustrates outdoor climate conditions and comfortable ranges, it is a good parameter for thinking or UTC strategies. The software is of free download and requires only the weather file[6] (type *.epw)* of the specific location. In this appendix, it is shown simulation outputs (Figures 35 – 39) for the city of Groningen, which consist of annual weather performances (including temperature and humidity) and the comfort zone (range of comfortable temperatures). As previously discussed (Lenzholzer, 2012), air temperature and humidity are the microclimate variables which most affect UTC; wind and solar radiation are the variables through which urban design can directly influence outdoor temperatures. Based on this information, annual performances of the four microclimate variables are presented, as following in two groups:

- Microclimate variables that most affect UTC:

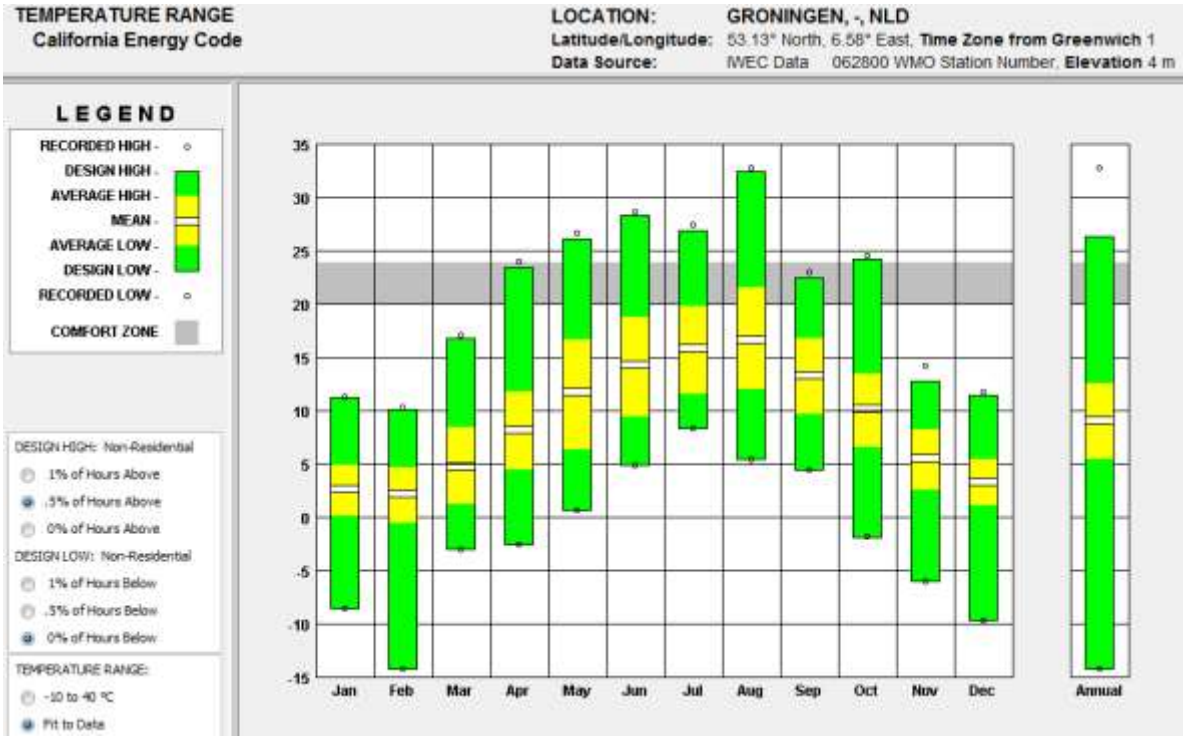

Figure 35 – Annual temperature performance and comfort zones for Groningen (Source: Climate Consultant, 2017)

According to Figure 35, the comfort zone for Groningen (regarding temperature) is between 20°C – 24°C, so thermal discomfort by cold is predominant during the year. Average temperatures are never above the comfort zone and recorded temperatures are mostly under it, meaning *cold stress* overcomes *heat stress*.

[5] Software available at: http://www.energy-design-tools.aud.ucla.edu/climate-consultant/request-climate-consultant.php

[6] Weather file available at: https://energyplus.net/weather-location/europe_wmo_region_6/NLD//NLD_Groningen.062800_IWEC

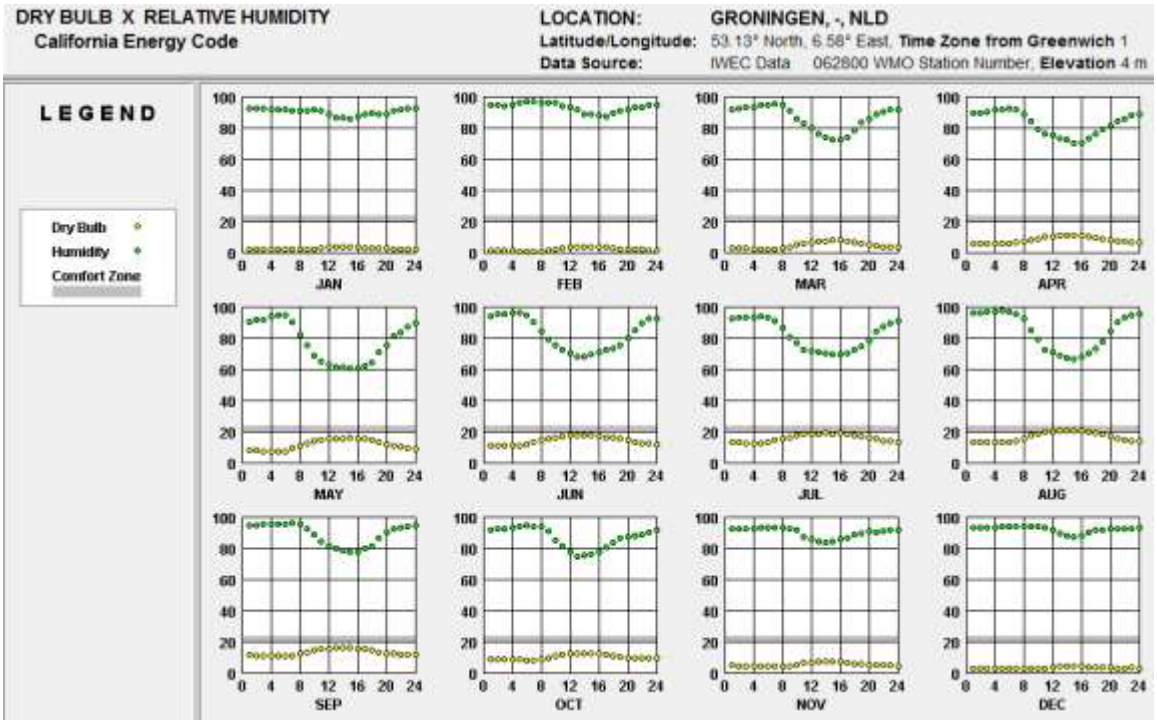

Figure 36 – Humidity and temperature annual performances and comfort zones for Groningen (Source: Climate Consultant, 2017)

Figure 36 shows air temperature (*dry bulb,* in yellow) and humidity performances (in green) per month. According to Ashrae (A. N. S. I., 2013), the comfortable range of humidity is between 30% and 60%. Thus, it is perceived that levels of humidity during the whole year are uncomfortable.

- Microclimate variables through which urban design can directly influence outdoor temperatures:

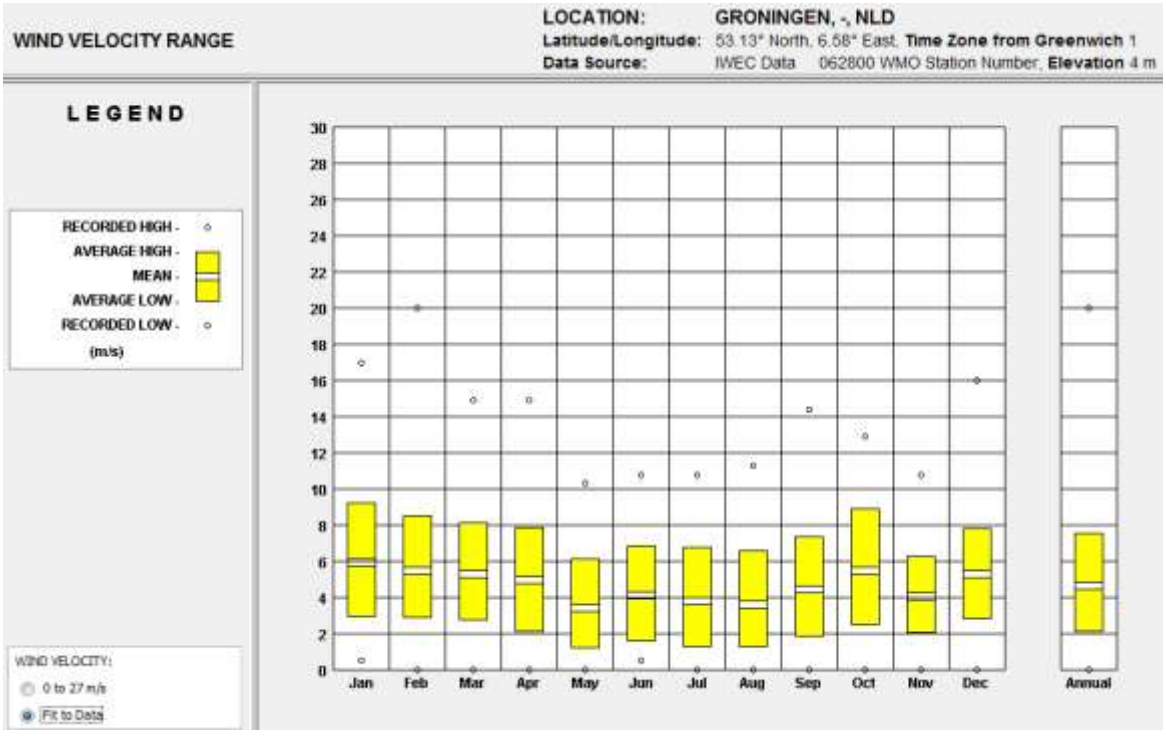

Figure 37 – annual wind speeds for Groningen (Source: Climate Consultant, 2017)

Figure 37 shows that wind speeds during colder periods of the year are higher in the city of Groningen. In practice, this information can be combined with wind directions for identifying wind corridors and wind convergence spots (e.g. squares). This assists the design of landscape equipment and layout for strategically buffering the wind when it is colder. Because wind directions are different in colder and warmer periods, a similar strategy can be done for the summer, but focusing on allowing more wind circulation in pedestrian level. For new urban developments, *urban forms* can also be proposed according to wind performances.

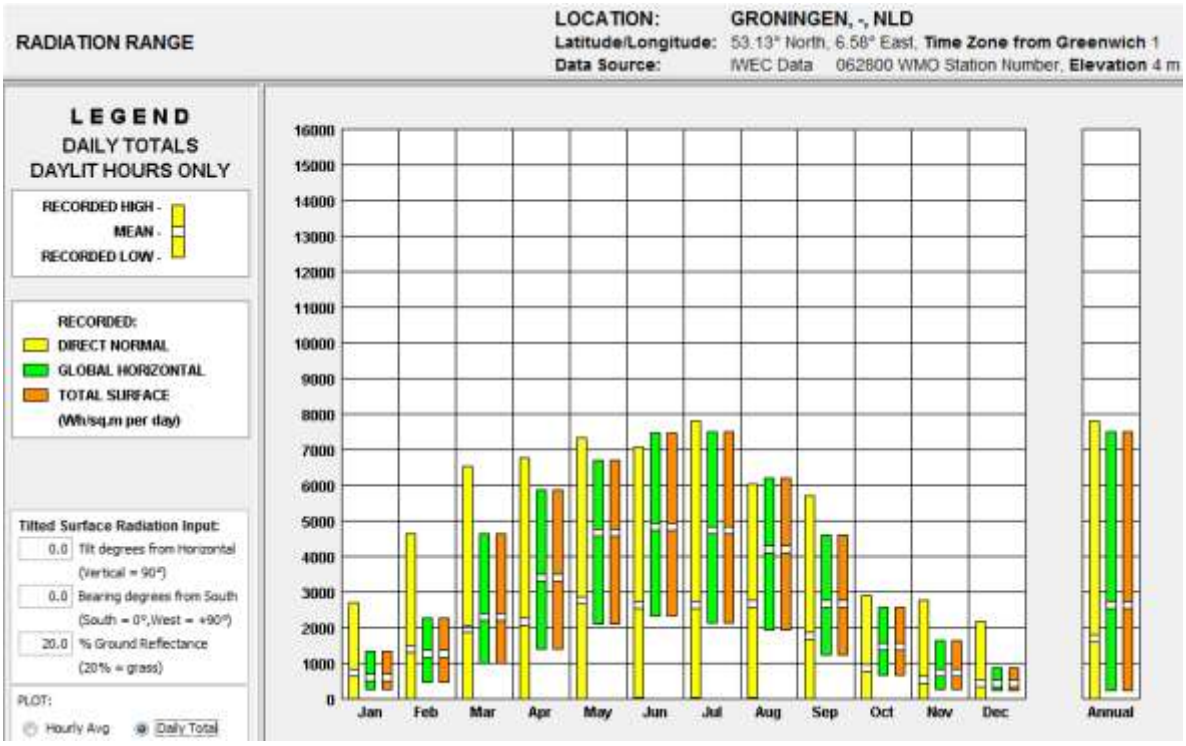

Figure 38 – annual radiation ranges for Groningen (Source: Climate Consultant, 2017)

Figure 38 illustrates short radiation ranges is colder periods and higher ranges during the summer. In this case, *design elements* can be proposed according to the need of shading in colder and warmer periods. For new urban developments, shallow urban forms can also be proposed for allowing sun light in pedestrian level and not retaining much heat through landscape materials (e.g. on facade). Distribution of *green + blue* can also replace paved areas in order to reduce retained heat in site.

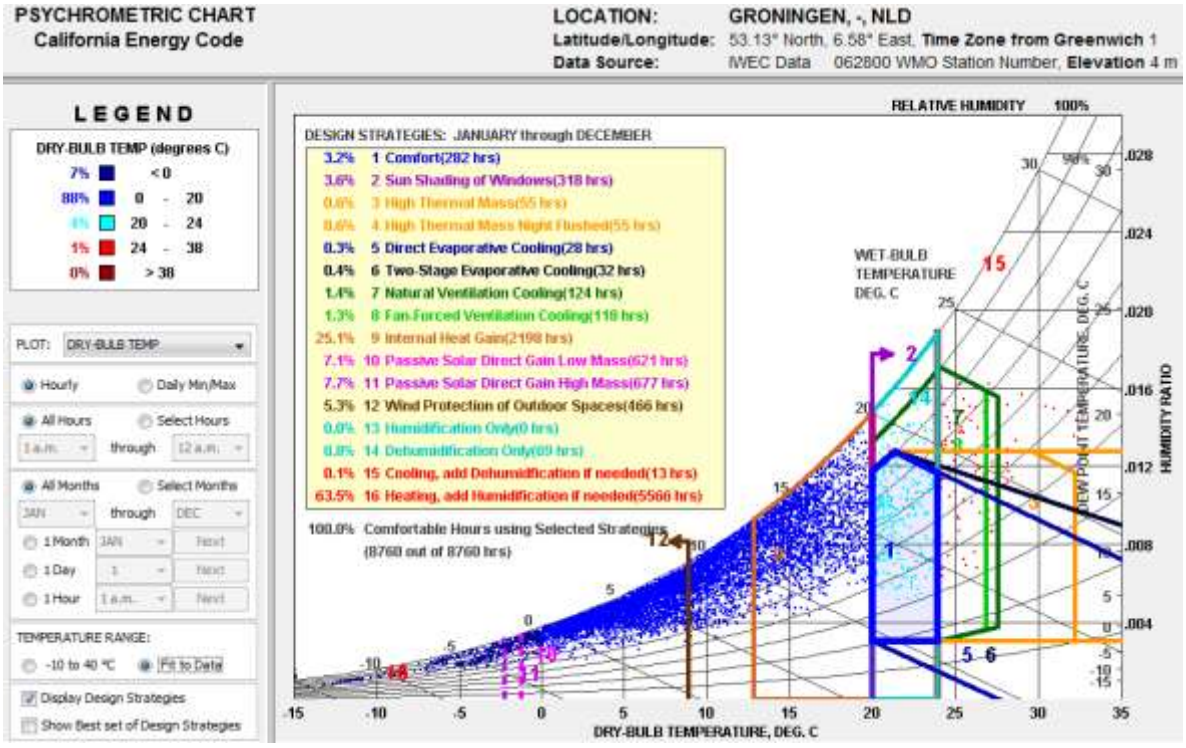

Figure 39 – Psychrometric chart for Groningen (Source: Climate Consultant, 2017)

The psychrometric chart (Figure 39) is mostly used in architecture for making a climate assessment in order to find out bioclimatic strategies. In sum, the chart analyses temperature (vertical lines) and humidity (ascending curves). The chart marks the 8760 hours per year according to average temperature and humidity of each hour. The dark-blue polygon illustrates the comfort zone (temperature: 20°C – 24°C; humidity: 20% - 80%, more tolerant). The legend of the graph points out that only 4% of the annual hours is within the comfort zone, being 95% of hours with thermal discomfort by cold and 1% by heat. The chart also suggests bioclimatic strategies for indoor environments. Naturally, the strategies focus mostly on heating (and humidification indoors in case heating highly reduces air humidity). Because the urban landscape is not a confined environment, UTC strategies should focus, in practice, on the criteria of the design dimensions, which influence directly wind and solar radiation and, indirectly, humidity and air temperature.