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Heat stress in Sint-Annaland:

A step-by-step action plan to reduce heat stress for Sint-Annaland by 2050

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Abstract

Heatwaves are expected to increase in the future due to climate change. Heatwaves cause heat stress to humans and some of the effects are dehydration and hyperthermia. In general it is known what can be done to reduce heat stress. However, applying this knowledge on a local scale requires a clear overview of what factors need to be taken into account.
The goal of this research is to develop an adaptive action plan that can be used to reduce heat stress in Sint-Annaland, a village in the municipality of Tholen. In order to achieve this, the following research question was set up: What steps can be taken to mitigate and adapt to heat stress in Sint-Annaland by 2050?

To answer the research question, desk research was carried out, as well as focus groups and interviews with experts. A questionnaire was shared with inhabitants of Sint-Annaland to determine social feasibility of heat stress measures. The result of these research methods is a 7-step road map:

1. Determine the heat stress in an area using a heat stress map
2. Determine age of the population, insulation value of homes and locate risk groups (including elderly, those in care-centres, children and those in sporting facilities)
3. Create an overview showing heat stress in relation to the factors described in step two using GIS-Software
4. Determine the location where measures against heat stress are necessary and/or desirable
5.
    a. Determine per location what measures <u>can</u> be taken against heat stress
    b. Determine for each measure per location what the heat reduction will be
    c. Determine financial and social feasibility per measure for each location
6.
    a. Determine where water nuisance and drought are and what plans are in place to reduce this
    b. Determine what plans there are for infrastructure (f.e. renovation plans)
7. Create an overview showing possible measures against stress per location with their impact, together with water nuisance, drought, and plans for those climate effects and plans for infrastructure, using GIS-Software.

Based on this, it is recommended to create cool spots throughout Sint-Annaland using large trees to create shadow. Further research can be done to investigate how cool spots can be designed in such a way that they reduce heat stress the most effectively. This can include the minimum size of a cool spot, the minimum amount of shade that should be there and what the dispersion of these cool spots should be.

1. Introduction

Climate change is currently affecting the entire world, with disastrous effects in some places. According to Jackson (n.d.), climate change will have the following effects: more extreme weather events, heat, drought, precipitation (increased heavy rainfall), storms and a rise in sea level (between 0.3m and 2.5m by 2100). In the Netherlands, the consequences of climate change are divided into four aspects: flooding, water nuisance, drought and heat (Klimaateffectatlas, 2021). Klimaateffectatlas have developed an interactive online map, which will give a first impression about the future threats of these effects. Generally, the causes for these effects are known for the country, as well as for provinces (Expert 1, Expert 2, pers. comm., 2021).

In the province of Zeeland the climate effects will also have an influence on the environment and society (Bosboom, 2020). Bosboom states that large parts of the province can be flooded; heat and drought may damage buildings, increase the risk of new diseases, and decrease the amount of fresh water. Heat can also increase the temperature of homes, schools and care-centres to suboptimal levels (Bosboom, 2020). Because of this, the Province of Zeeland, Rijkswaterstaat and ProRail are developing a strategy to make Zeeland climate-resilient by 2050 (Bosboom, 2020).

To address heat stress in Zeeland, more knowledge about what measures can be taken is still required (Expert 1, Expert 2, pers. comm., 2021). The municipality of Tholen, together with the province of Zeeland has asked to develop a plan for heat stress measures. This plan can help all villages and towns in the area to adapt to the increasing heat, and to mitigate its causes as much as possible. This research will therefore first identify possible causes and effects of heat stress. Subsequently, a vision will be developed for 2050. In order to achieve the vision, a step-by-step or roadmap-like plan is required.

To make sure this research has concrete steps and indications, the focus will be on the town of Sint-Annaland (see Figure 1.1), as a case study. The outcomes can be used as an example for all villages and towns in the province of Zeeland, although adjustments will be required for every single one of them. Many towns and villages in Zeeland are comparable, as was discussed during a meeting with the municipality of Tholen and Middelburg, and the province of Zeeland(2020).

This research will contribute to the literature about heat stress, and it will develop a clear step-by-step plan focussed on Sint-Annaland, and useful throughout the province of Zeeland.

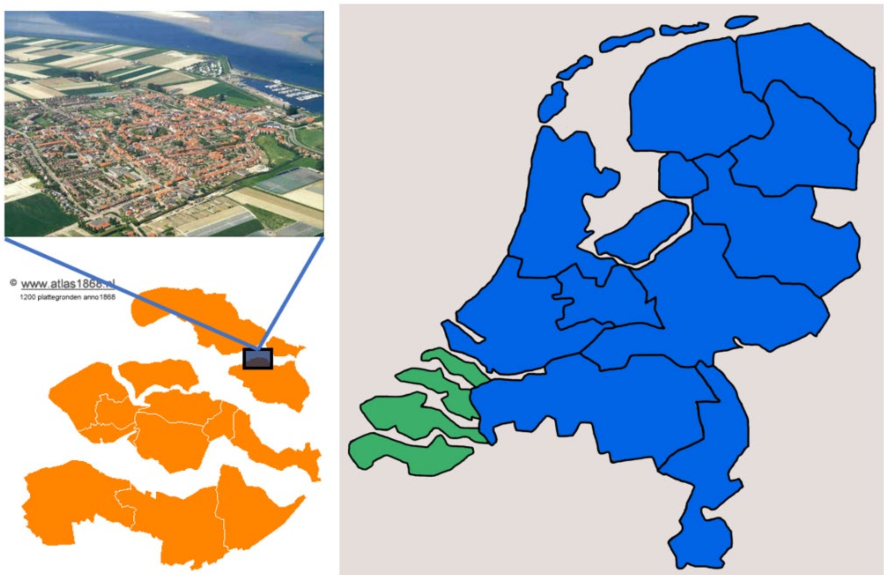

Figure 1.1: The location of Sint-Annaland in the Netherlands

Statement of the Problem

Climate change has influenced many people and places over the last decades (Jackson, n.d.). More extreme weather events, cities heating up, increased droughts, etc. Climate adaptation or mitigation measures are taken to reduce the effects of climate change. The effects of climate change in the Netherlands are heat, drought, flooding and water nuisance (Klimaateffectatlas, n.d.).

Increased heat stress is one of these effects climate change has on cities. Still, this effect is overlooked by many (Provincie Noord-Brabant, 2019), while according to the director of KNMI, it is the most threatening of all climate-related extremes. Zeeland experiences these effects as well, as discussed above. Although general knowledge is available, knowledge about heat stress and possible measures (adaptation and mitigation) on the local scale is lacking. This is true for the municipality of Tholen as well. Since every village, town and city has different surroundings and a different context, local knowledge is essential for mitigation and adaption to heat stress.

Based on the problems described, the Netherlands took and measures and action against the problems caused by climate change as well, among which several funds and subsidies to stimulate climate adaptation (Rijksoverheid, 2019). Zeeland, kept up with these changes too, by doing the following: they pointed out risks, advised people to have more green in their garden and they provided subsidies. Due to the current lack of awareness (Provincie Noord-Brabant, 2019), it can also be said that it is essential to raise awareness and create a vision for the near future to combat heat stress.

To have a clear understanding of local challenges in towns and villages in the integration of adaptations and mitigations, research is required. More research is also necessary to find feasible measures for these local challenges. A certain plan to develop these measures effectively needs to be researched as well.

Research question and sub-questions

The main research question that will be answered during this report is the following: What steps can be taken to mitigate and adapt to heat stress in Sint-Annaland?

The sub-questions, which were briefly mentioned before, are these:

1. What are the causes and effects of heat stress in Sint-Annaland?
2. What are the stakeholders in Sint-Annaland regarding heat stress?
3. What are the most feasible measures to take in Sint-Annaland regarding heat stress?
4. What are the environmental advantages and disadvantages of the most feasible measures, as described in question 2?
5. What is the implementation plan step by step?

Goal

The goal of this research is to create an adaptive action plan, which will first of all help Sint-Annaland to mitigate and adapt to heat stress in public areas outside.

2. Theoretical Framework

In the theoretical framework, all relevant literature will be described. The literature will discuss the following topics: Stakeholder analysis and involvement, causes and effects of heat stress, possible measures against heat stress and how roadmaps can be made.

2.1 Climate change and heat stress

To understand what is at stake, the concepts climate change and heat stress will need to be explained shortly. This will be done here.

Climate change

Climate change is defined by NASA as "a long-term change in the average weather patterns that have come to define Earth's local, regional and global climates." Since the early 1900's, these kind of changes have been proven to be primarily caused by human activity (NASA, 2021). "loss of sea ice, accelerated sea level rise and longer, more intense heat waves" are the result of this human enhanced climate change (NASA, 2021).

The KNMI (2014) has come up with four scenarios which predict a possible future (2050-2085) of climate change, where they use 'high' and 'low' in combination with 'changes in airflow patterns' and 'world-wide temperature increase' (see Figure 2.1).

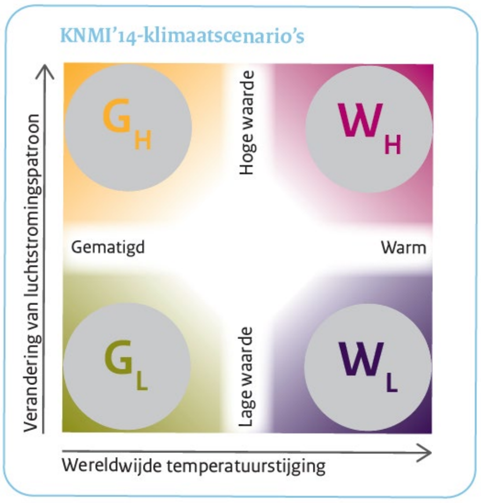

Figure 2.1: KNMI'14 climate scenarios. Retrieved from https://www.knmi.nl/kennis-en-datacentrum/uitleg/knmi-klimaatscenario-s

Since the current change in climate is primarily caused by humans, as explained before, humans can also have an impact on what future scenario the world will be. This is also supported by the IPCC (2013), on which the KNMI climate scenarios are based.

Heat stress

As explained previously, increased heat and heat stress are part of the effects of climate change. "Heat stress occurs when the body cannot get rid of excess heat" (UIOWA, 2020). As the human inflicted climate change also causes an increase in temperature (KNMI, 2014), heat stress is expected to occur more frequently. This means that humans will have to adapt to these higher temperatures, and/or prevent temperatures from rising significantly. The actions of every human can influence climate change and the rising temperatures (IPCC, 2013). Therefore, stakeholders have to be included to reduce heat stress when appropriate.

2.2 Stakeholder analysis and inclusion

Stakeholder involvement cannot be excluded when taking measures against climate effects (Hoffmann et al., 2013). As Rotter et al explains, climate change is a societal problem, which needs to be tackled as a society. Mitigation and adaption to heat stress, one of the climate effects (IPCC, n.d.), thus also requires proper stakeholder involvement. This part of the report will focus on ways to analyse what stakeholders are present, and how these can be involved properly.

Stakeholder analysis and inclusion in general

According to Smith (2000), the term stakeholder is used “to describe individuals, groups, or organizations that have an interest in the project and can mobilize resources to affect its outcome in some way.” He also states that a stakeholder analysis should be conducted before the initiation of a project, and that it can be useful to review this analysis at different moments during the project.

The first step Smith describes, is to identify stakeholders by brainstorming with a group and possibly a facilitator. A suggestion he does to gain a better understanding of the stakeholders, is to identify them “by name rather than generic terms such as customer, owner, sponsor, etc.”

The second suggested step (Smith, 2000) is to analyse the “key interests, potential level of impact to the project, and priority in relation to other stakeholders.”

After this is done, values (H, M, L and + or -) can be assigned to the interests and impacts of stakeholders. This will help, according to Smith, to ‘rank’ the stakeholders in order of importance. Importance of a stakeholder, as Smith explains, “indicates the degree to which the project cannot be considered successful if needs, expectations, and issues are not addressed.”

The influence of each stakeholder can be determined by considering hierarchical, economic, social and political position, as well as connections to others with high influence. Expert knowledge, negotiation and consensus building skills, charisma and holder of strategic resources can be other indicators of the influence a stakeholder can have on a project (Smith, 2000).

Combining these two factors, influence and importance, will show interactions between stakeholders, as well as additional risks (Smith, 2000). This results into a stakeholder matrix as can be seen in Figure 2.2 & 2.3.

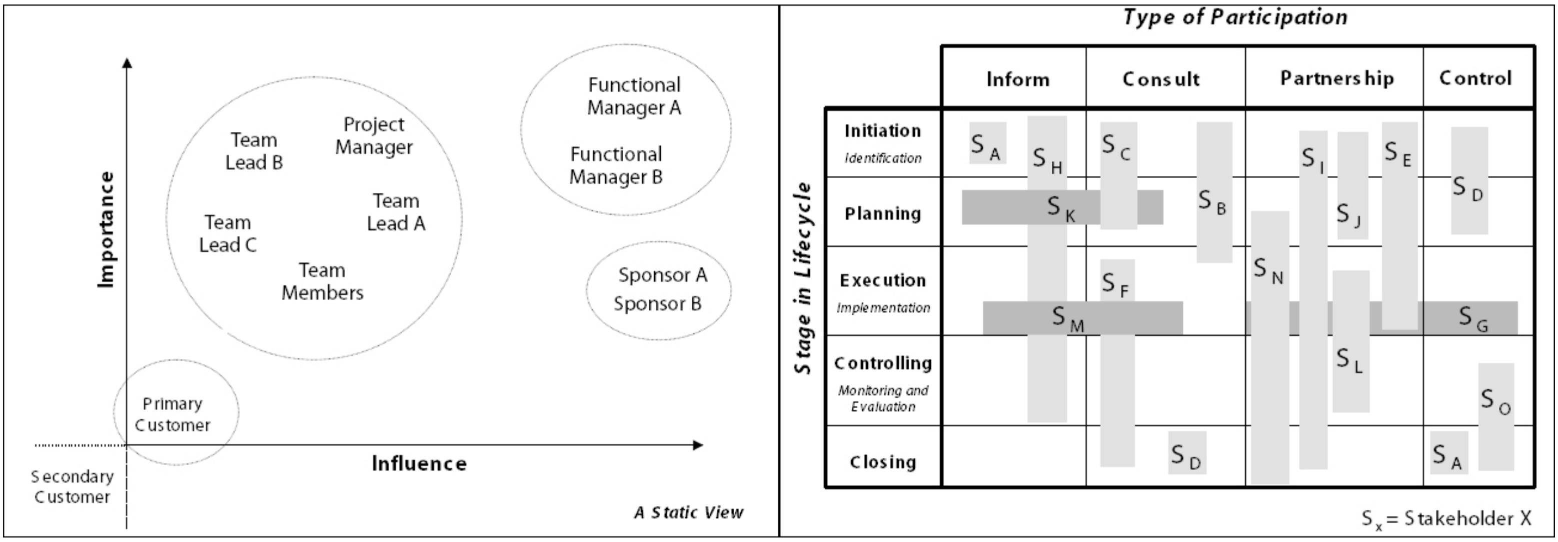

Figure 2.2 & 2.3: Stakeholder participation matrix. Retrieved from: https://www.pmi.org/learning/library/stakeholder-analysis-pivotal-practice-projects-8905

Including civilians

Wassink (3 December 2020, pers. comm.), underlined the importance of involving inhabitants when taking climate adaptation or mitigation measures during a meeting about Civilians Participation in Climate adaptation. One of the reasons he specified, was the fact that inhabitants can have a large impact on the neighbourhood’s climate resilience, for instance by the way they fill their garden (pavement vs. plants). Since, as mentioned before, one of the climate effects is heat stress, it can be said that including civilians should have a certain amount of focus when developing measures to mitigate and adapt to heat stress.

Kind et al (2020) has explored the link between climate adaptation and social resilience. In their document, they explain how measures to adapt to climate change can be combined with other measures in general, but especially how it can strengthen the social resilience. They found that, when including civilians properly, taking such measures will contribute to social resilience and the neighbourhood's climate resilience. Several groups of people were distinguished (see Figure 2.4). They all need a different way of involvement, similar to how stakeholders in general can be included in different ways.

	Laag sociaal kapitaal *Horizontale participatie heeft weinig potentie*	Hoog sociaal kapitaal *Horizontale participatie heeft veel potentie*
Laag economisch en cultureel kapitaal *Veel barrières voor verticale participatie*	**Groep I** Overheid realiseert maatregelen die mede bijdragen aan sociale veerkracht, en zorgt dat de maatregelen goed worden ingebed in de gemeenschap	**Groep III** In samenwerking maatregelen realiseren, in dit proces de drempels voor participatie actief wegnemen en mensen leefstijl-gericht aanspreken
Hoog economisch en cultureel kapitaal *Weinig barrières voor verticale participatie*	**Groep II** Overheid realiseert maatregelen die mede bijdragen aan sociale veerkracht, mensen worden daarbij leefstijl-gericht uitgenodigd te participeren	**Groep IV** Maatregelen realiseren door voort te bouwen op het aanwezige kapitaal en dit kapitaal leefstijl-gericht triggeren

Figure 2.4: An insight in groups of inhabitants. Retrieved from Kind et al., 2020.

2.3 Causes of heat stress

According to Patz (2005) and Van Hove et al.(2015), several factors influence the urban climate: height and spacing of buildings, aspect ratio, the sky view factor, thermal properties of building materials, the amount of green areas compared to impervious surfaces and the urban albedo. The influence of these factors will be explained in this part. Urban albedo can be explained as follows: "the proportion of the incoming solar radiation reflected by the various surfaces in the urban environment (reflection coefficient), defined as the ratio of incoming to outgoing radiation" (Kent, 2021).

De Jong (2012) examined the correlation between the above-mentioned factors, as well as some other factors and surface temperature for Rotterdam (see Table 2.1). A -1 value for the Pearson correlation means a negative relation, while a +1 value means a positive relation. The closer the value is to 0, the weaker the correlation. This means that, for instance a higher albedo-value will result in a lower surface temperature.

Table 2.1: Average values and range of values of heat factors for the neighbourhoods of Rotterdam. Retrieved from: https://edepot.wur.nl/238028

	Heat factor	Range of values	Average value	Pearson correlation
Direct factors	Albedo	0.06 - 0.16	0.10	-0.64
	Emissivity	0.92 - 1.00	0.97	-0.90
	Sky view factor	0.52 - 1.00	0.77	-0.61
indirect factors	built-up area (%)	0 - 39	15	0.54
	paved surfaces (%)	0 - 96	60	0.62
	public green (%)	0 - 42	11	-0.52
	total green (%)	2 - 66	24	-0.83
	building height (m)	3 - 38	10	0.52
	water (%)	0 - 63	14	0.13
	population density (ha-1)	0 - 256	67	0.36
	NDVI	-0.07 - 0.78	0.39	-0.81

The values in Table 2.1 are only applicable for the neighbourhoods of Rotterdam. However, it does indicate differences between the several factors. For example, albedo, emissivity, sky view factor and total green have a negative correlation, meaning that a reduction of these factors will increase surface temperature (De Jong, 2012). On the other hand, built-up area, paved surfaces and building height have a positive correlation, which in turn means that a decrease of these factors will also increase surface temperature. Emissivity is defined as “the ratio of the energy radiated from a material's surface to that radiated from a perfect emitter, known as a blackbody, at the same temperature and wavelength and under the same viewing conditions” (NPL, n.d.). To gain a better understanding of the influence certain factors have on the surface temperature in cities, these will be further explained in Appendix A1.

2.4 Effects of heat stress

The effects of heat stress will be examined in this part, to understand the impact of it.

Human-related effects

Vandenbriele (2019) describes several consequences heat stress has. First of all, increased temperatures can lead to sleep deprivation, which can in turn increase the chances of a stroke of cardio-vascular diseases. Secondly heat stress can be more dangerous for elderly and people with underlying diseases or conditions. On top of that there were more fatalities (400) during a heatwave in 2019 in the Netherlands compared to conventional summer weeks. All of the above are, at least to some extent, confirmed by others, for instance by the organisations HSE (n.d.) and CDC (2017). These are all related to humans, but there are other consequences as well. An overview of the effects of heat stress on humans can be found in Figure 2.5, which was made by WHO (n.d.).

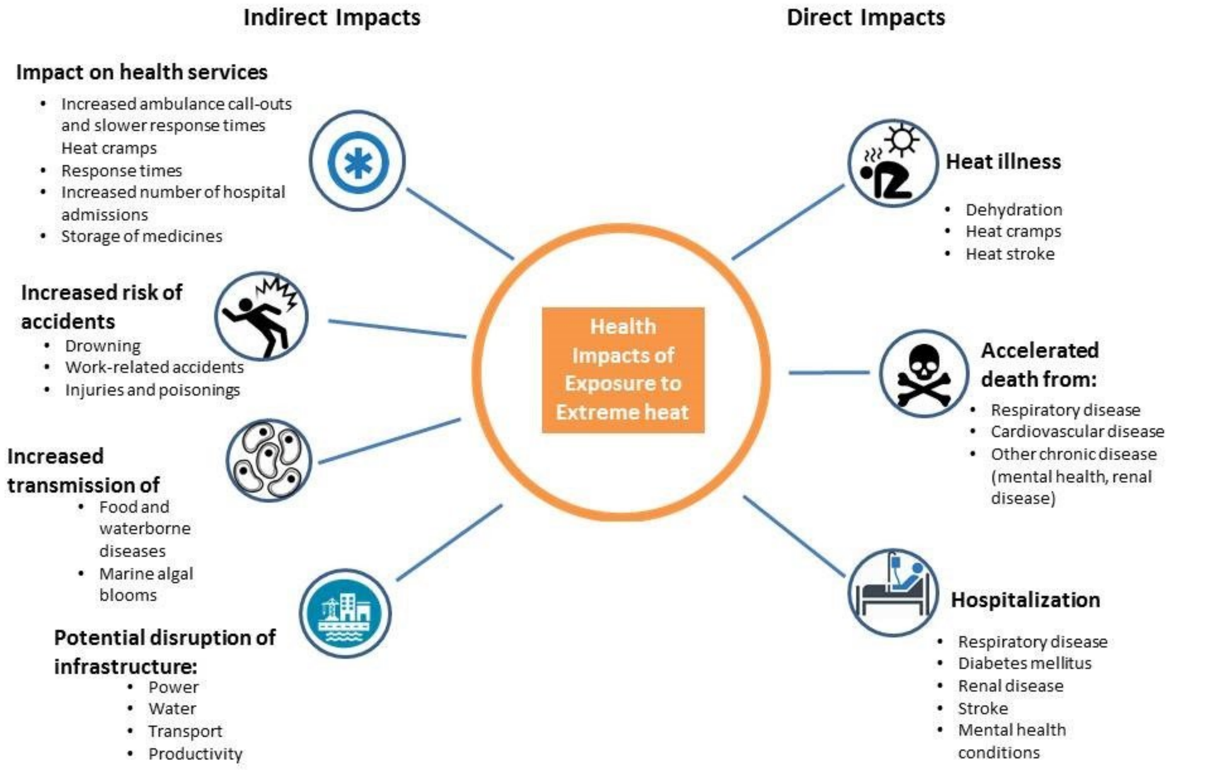

Figure 2.5: Health impacts of Exposure to Extreme heat. Retrieved from: https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health

Non-human-related effects

Vandenbriele (2019) studied a few non-human-related effects. For instance, old buildings cannot keep the heat out, while new buildings also have trouble doing so; next to that, usage of air-conditioning results in an increased temperature in the surroundings of a building; nature is damaged by the heat; drinking water quality decreases, while it is used more; increased algae growth is caused, which does not only lead to death of fish and plants, but waterborne diseases as well; infrastructure is damaged; and last of all, energy consumption rises, while the lack of cooling water can increase power failures. Robbins (2020) confirms the disastrous effect heat stress has on nature as well. Klok (2015) stresses the fact that heat stress will have a negative effect on the functioning of current infrastructure, and that there will be high costs involved in adapting to the increasing temperature.

Woetzel et al (2020) mentions that due to heat, "solar panels can lose efficiency" (0.1-0.5% per 1^0C increase), and grid efficiency is reduced.

2.5 Adaptation and mitigation measures

After examining the various causes and effects of heat stress, possible measures are described. More details about the mentioned measures can be found in Appendix A2.

Adaptation refers to the action of preparing for and adjusting to "both the current effects of climate change [and] the predicted impacts in the future"(European Commission, 2017). Mitigation means "the act of reducing how harmful, unpleasant, or bad something is" (Cambridge Dictionary, n.d.), in this case heat stress.

Heat stress adaptation and mitigation measures can be classified in three different categories: blue (referring to water), green (referring to plants and trees) and grey (referring to buildings) (Wetlands International, 2019).

A list of several measures can be found here, classified as blue, green or grey.

Blue

- Pavement watering (Adaptation) (Hendel et al., 2015)
- Increasing surface water (Adaptation) (Kind et al., 2020)

Green

- Green roofs (Mitigation) (Zinzi, 2012)
- Green areas (Mitigation) (Gill et al., 2007)

Grey

- Blinds (Adaptation) (Kind et.al., 2020)
- Air-conditioning (Adaptation) (Kind et.al., 2020)
- White roofs/buildings (Adaptation) (Coutts et al., 2013)
- Narrow streets (Adaptation) (Vandenbriele, 2019)
- Urban development (Mitigation) (Vandenbriele, 2019)

2.6 Adaptation approach

The main goal of this research is to develop a roadmap towards a Sint-Annaland that is adapted to heat stress in 2050 as well as possible. There are, however many ways to make a roadmap or a step-by-step (dynamic) plan. Several of these will be discussed in this part of the report.

DAPP approach

This approach combines two existing ways of planning, namely Adaptation Pathways and Adaptive Policymaking (Haasnoot et al., 2012).

In short, Adaptation Pathways show which actions can be taken after a certain tipping point, to reach clearly specified objectives (Haasnoot et al., 2012). The moment in time of such a tipping point should be specified roughly, but does not need to be specific, says Haasnoot (2012). A method is described by Haasnoot (2012) to develop Adaptation Pathways. This results into a map with different pathways, all leading to the same or similar result. The lay-out that is normally used, is that of a Metro map (Figure 2.7), since it shows "alternative routes to get to the same desired point in the future".

Adaptive Policymaking, as Haasnoot describes (2012), "is a generic structured approach for designeing dynamic robust plans."

What these approaches both look like, and how they are developed, can be seen in Appendix A3

The Dynamic Adaptive Policy Pathways (DAPP) uses the strengths of both approaches and combines them into one method (Haasnoot, 2012):

> *"In short, this integrated approach includes: transient scenarios representing a variety of relevant uncertainties and their development over time; different types of actions to handle vulnerabilities and opportunities; Adaptation Pathways describing sequences of promising actions; and a monitoring system with related contingency actions to keep the plan on the track of a preferred pathway."*

The steps which need to be taken to develop a DAPP can be found in Figure 2.6. An example of a DAPP with preferred pathways can be seen in Figure 2.7.

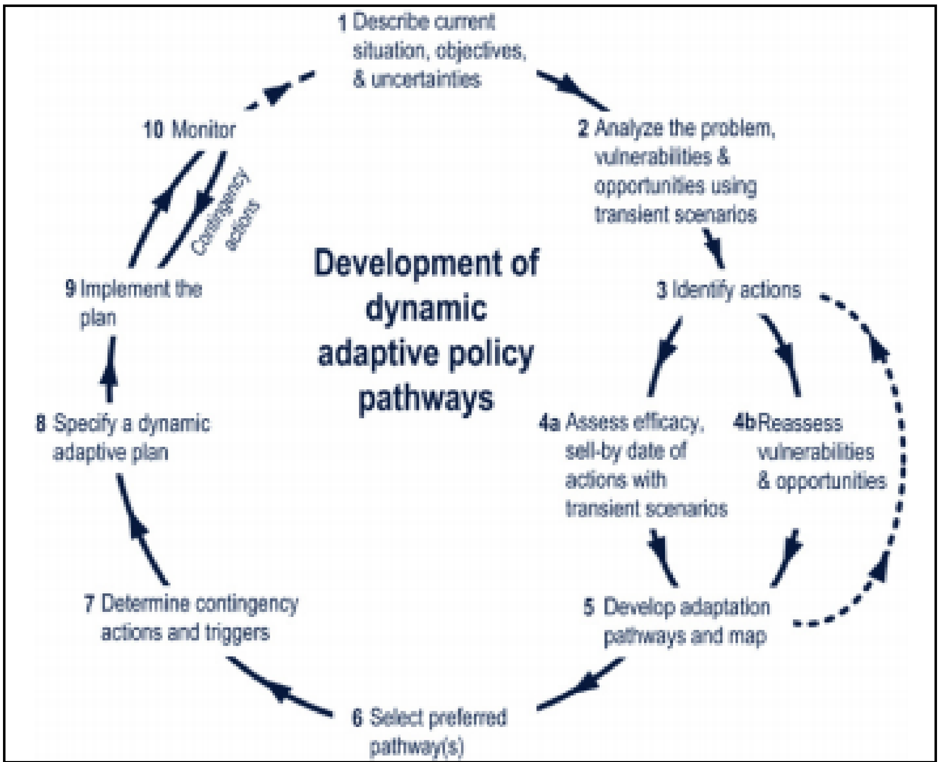

Figure 2.6: The Dynamic Adaptive Policy Pathways approach. Retrieved from Haasnoot et al., 2012.

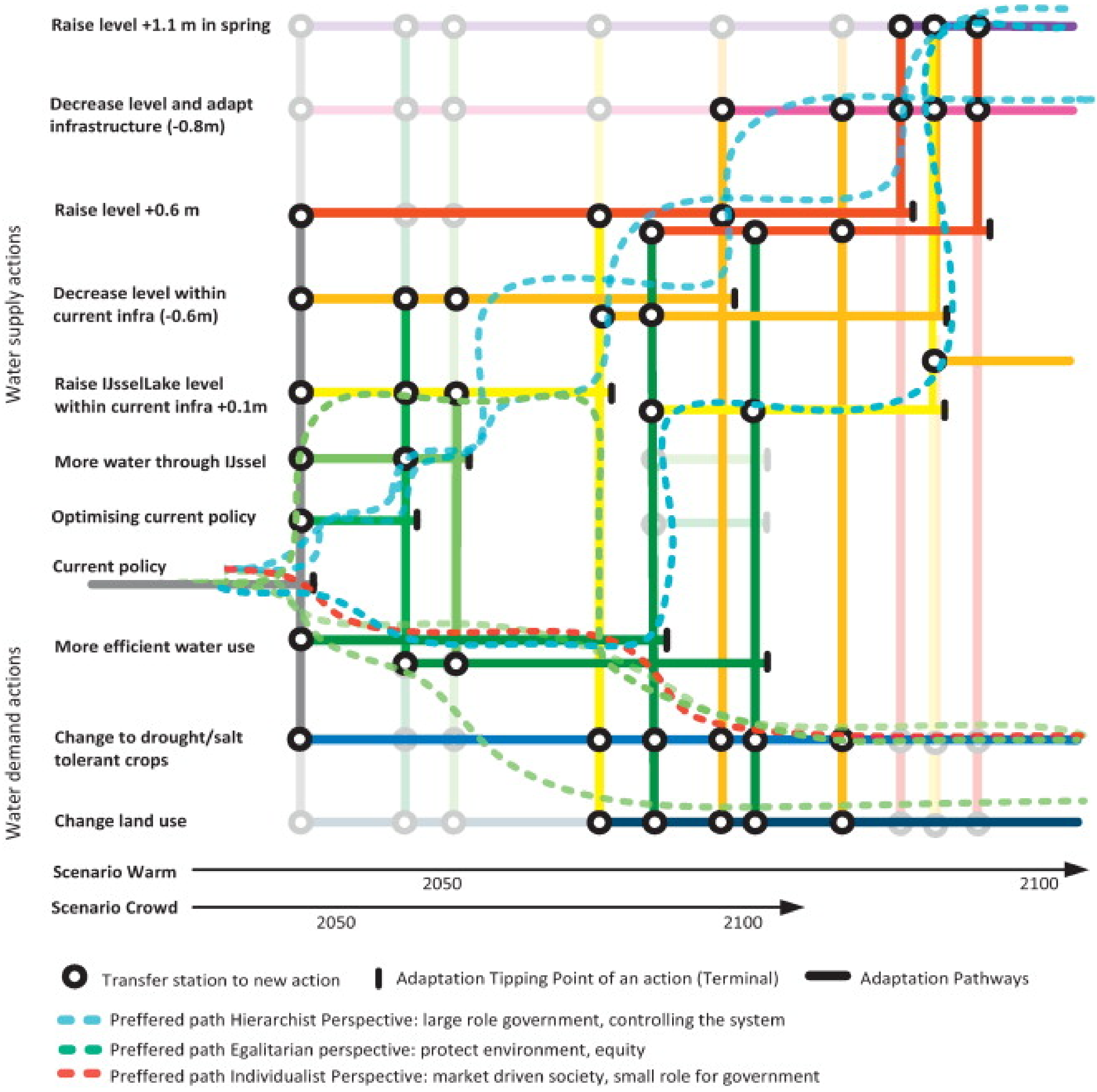

Figure 2.7: Adaptation pathways map with preferred pathways for three different perspectives. Retrieved from Haasnoot et al., 2012.

3. Methodology

To answer the research questions described in the introduction, several different methods were used. These were mainly qualitative and partially quantitative, specified as follows: literature review, focus groups discussions, webinars, semi-structured interviews, an online survey and a feasibility analysis

3.1 Literature review

The background of heat stress, its causes and effects in Sint-Annaland were researched with desk research. This also was useful to determine the desired situation in 2050. Further in-depth knowledge about the advantages and disadvantages of feasible measures was gained through desk research. This desk research helped to determine the stakeholders in the study area and the sequence of the steps taken.

3.2 Focus group discussions

A list of risks was developed using literature review. This list was analysed for Sint-Annaland with eight experts from the municipality of Tholen, the municipality of Middelburg, the Province of Zeeland and the GGD. There were three separate sessions, which lasted roughly one hour and thirty minutes. The first two focussed on human-related risks, and the last one on nature- and infrastructure-related risks. All eight experts were invited to every session, but since some of the disciplines were overlapping and all experts had busy schedules, the second and third sessions were joined by 6 of the experts. The first one was joined by all eight experts.

During the focus group discussions the risks were analysed by rating their probability outside and inside, and their severity (Low, medium or high). This resulted in a rating of 1 through 9 for all risks, which was translated into a risk landscape. During the discussions possible measures and actors were also thought about and included. This was done using the COMPACT-method (Ten Gevers, 2001). The focus group discussions also helped to find the stakeholders in Sint-Annaland regarding heat stress.

3.3 Webinars

To deepen knowledge on heat stress and its measures, two webinars were followed from Stadswerk: “Klimaatveiligheid: Hittestress” and “Klimaateffectief groen en de toekomstige stad”. These both explained what can be done to reduce heat stress in urban areas.

3.4 Feasibility analysis

This part of the research is quantitative. Based on costs, impact on temperature and results from the questionnaire, scores were given for the feasibility of the measures. The costs were found using sources the municipality of Tholen uses. The impact on temperature was researched by Kluck et al. (2020). This study was used to determine environmental feasibility. The scores were not added up or averaged, because no research was done on which feasibility is more or less important.

3.5 Semi-structured interviews

Semi-structured interviews were held with four experts, to deepen and broaden the knowledge gained during the focus group discussions regarding measures that can be taken against heat stress. All these experts work for the municipality in the field of climate adaptation, except for one, who works for the GGD. This expert was interviewed because he could give a better insight on the effects of heat stress on humans. He also works with municipalities and informs them. These experts were asked the following six questions:

1. Which (3-5) criteria should heat stress measures meet? Why?
2. How is heat stress addressed in your organisation at this moment? What plans are there for the future?

3. What are the advantages of the measures your organisation has taken?
4. What are the disadvantages of the measures your organisation has taken?
5. How are citizens involved in heat stress adaptation and mitigation?
6. How can one prevent that an open waterbody becomes hazardous due to waterborne diseases?

3.6 Survey research

An online survey was spread through social media and the website of municipality of Tholen, and social media of the local Village Community. 146 people responded. Figure 3.1 shows how many respondents there were per age-group. Figure 3.2 shows how many people responded per street.

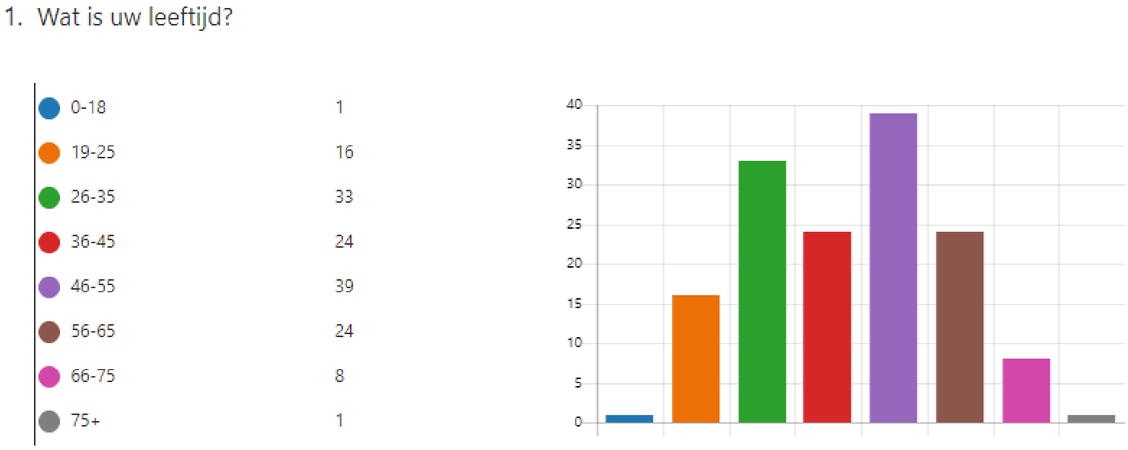

Figure 3.1: Respondents of the survey per age-group

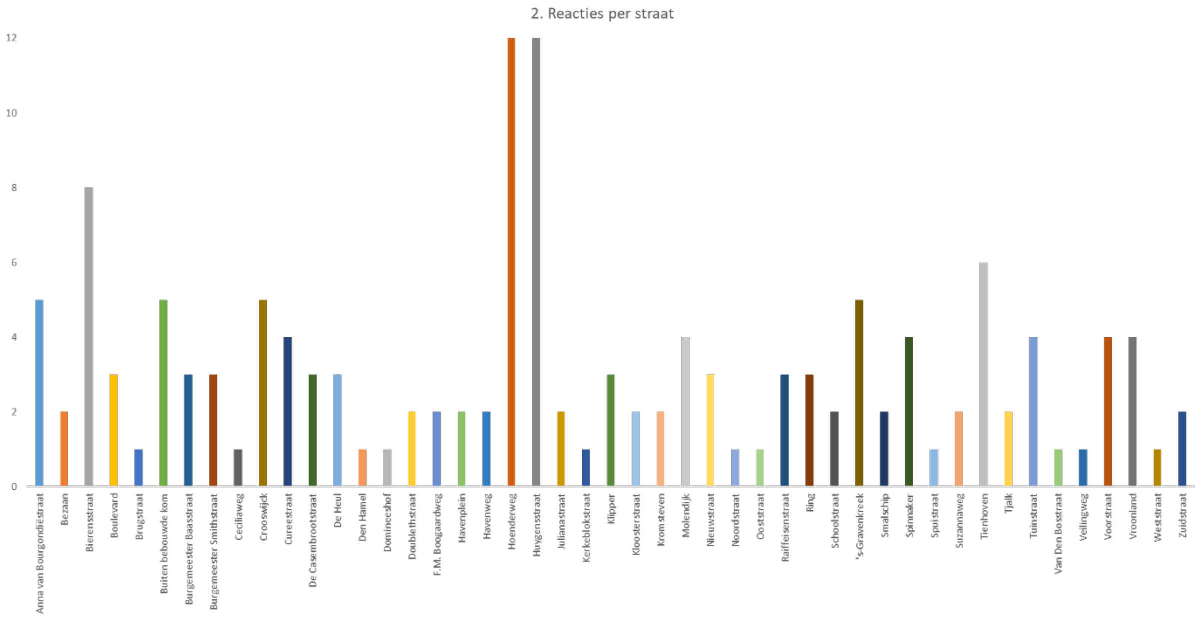

Figure 3.2: Respondents of the survey per street

The survey was done to measure awareness of heat stress, by asking if respondents have ever experienced heat stress (and how) and whether they think heat waves will occur more often in the future. They were also asked how they try to reduce heat stress. Another goal was to measure the social feasibility of heat stress measures. A percentage was calculated to determine this feasibility. On top of that the results of the survey showed to what extent inhabitants want to be involved in projects regarding heat stress, using the ladder of participation. The results of the questionnaire were analysed using the programme “Pandas”.

Table 3.1 Shows which type of research will be done to answer every sub-question.

Table 3.1: Which type of research is used per sub-question

	What are the causes and effects of heat stress in Sint-Annaland?	What are the stakeholders in Sint-Annaland regarding heat stress?	What are the most feasible measures regarding heat stress?	What are the environmental advantages and disadvantages of the most feasible measures, as described in question 2?	What is the implementation plan step by step?
Literature review	X	X	X	X	X
Focus group discussions	X	X	X	X	X
Webinars			X	X	
Feasibility analysis			X		
Semi-structured interviews			X	X	X
Survey research	X			X	

4. Results

In this chapter the results are shown and explained. These results include maps that show the causes of heat stress, figures that show the effects of heat stress, indications of where measures can be taken against heat stress, and an assessment of the measures that can be taken. In the end a step-by-step plan is developed using the DAPP-approach.

4.1 Causes and effects of heat stress in Sint-Annaland

There are several factors which can cause heat stress, resulting in multiple effects for people and the environment. These factors and effects have to be taken into account to make sure effective measures against heat stress can be taken. The causes and effects of heat stress are based on desk research, the input from experts and local inhabitants and will be discussed here.

Causes of heat stress in Sint-Annaland

Heat stress in Sint-Annaland is caused by the following factors: albedo, emissivity, green vs built-up, sky view factor and shadow (see theoretical framework). Other factors that can contribute to heat stress can be explained as follows: drought on farmlands blows heat in village (Expert 1, risk sessions, 2021, pers. comm.), water contributes to temperature rise when a heatwave lasts for an extended period of time, parking-problems cause people to pave their gardens, energy labels give an indication of heat stress inside houses.

A heat stress map for Sint-Annaland can be seen in Fig. 4.1. According to Nelen & Schuurmans, the developers, this map is based on albedo & emissivity, and shadow (provided by both trees and buildings). The red spots in this map indicate a low albedo and emissivity, and little to no shadow. On the other hand, using data of Open Dataportaal Zeeland, a new map was developed to indicate possible heat stress, where the felt temperature can be seen (Fig. 4.2). This map uses shadow, trees, Bowen Ratio, sky-view factor and other factors (established by RIVM (2019): *Ontwikkeling Standaard Stresstest Hitte)* to visualize heat stress. It is called a PET (Physiologic Equivalent Temperature)-map (Appendix C1). Red spots in this map indicate a lack of trees and shadow and a low sky-view factor. The large red area in the bottom right of Fig. 4.1 is the industrial area of Sint-Annaland. This area is not part of the study area.

There are some differences between the two maps. These are indicated with circles. The areas in these two circles do not show the same amount of heat stress. The cause for these differences can be found in the fact that different factors were taken into account to develop the two different maps. According to the developers the PET-map (Fig. 4.2) more accurately indicates heat stress than the first map (Open Dataportaal Zeeland, 2021).

Figure 4.1: Heat stress map based on albedo, emissivity and shadow. Differences indicated with circles. Source: Nelen & Schuurmans, 2015

Figure 4.2: PET-map. Circles indicate differences between the first heat stress map and the PET-map. Source: https://dataportaal.zeeland.nl/dataportaal/srv/dut/catalog.search#/metadata/d928f29c-2878-42d4-8e4d-942c8a6b0c6b, 2019.

Input village community

When asked what were the weak spots regarding heat stress in Sint-Annaland, the village community provided some pointers. First of all, they state that throughout the whole village trees and green areas are lacking. Additionally, they say that inhabitants themselves are not aware of how they can contribute to decrease heat stress, which results in them paving their gardens (sometimes because of a lack of parking spots).

They also specifically name some areas and point out what they think is negatively influencing liveability, with some linkage to heat stress and its causes. A map with these areas can be seen in Fig 4.3. A short summary of the village community's statements is given for each area.

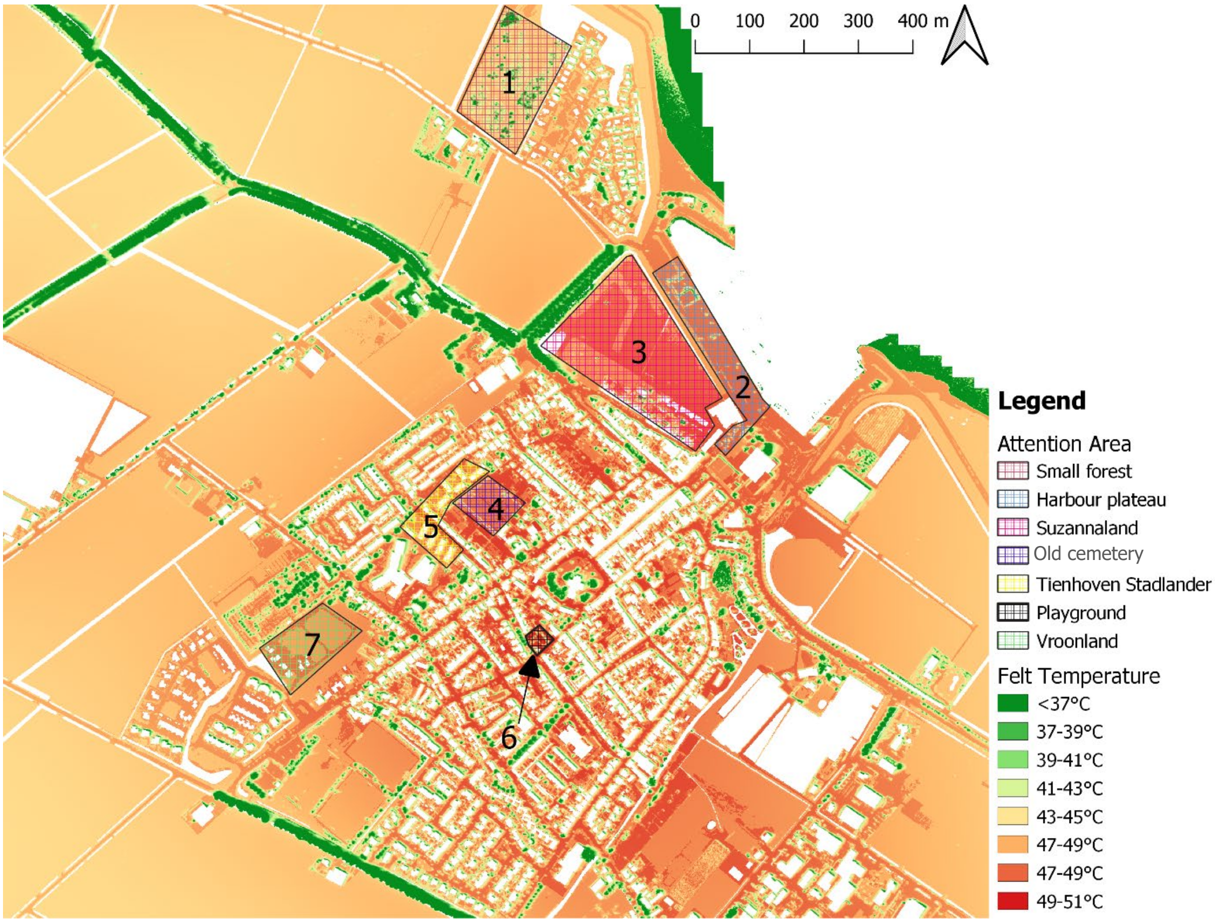

Figure 4.3: Areas prone to heat stress, according to the Village Community

1. *"There are plans for this small forest, but for now it feels like a 'lost forest'.*
2. *The harbour plateau is paved heavily.*
3. *Green is not taken into account in new housing estates like Suzannaland.*
4. *The old cemetery is a bare plane without any trees or vegetation.*
5. *These elderly homes owned by Stadlander are surrounded by green patches of grass that cause the area to have a shabby appearance. This can be improved, combining it with increasing parking spaces.*
6. *This playground is very popular, but it does not have any vegetation or trees to protect against wind and sun.*
7. *Green is not taken into account in new housing estates like Vroonstede*"

As can be seen, area 2, 3, 4, 5 and 6 have relative high felt temperatures. The reasons they give also overlap with what are the causes of heat stress. It can thus be said that these reasons are, at least partially, contributing to heat stress in these areas.

Effects of heat stress in Sint-Annaland

Heat stress risks

To examine the effects of heat stress in the study area, experts from the municipality of Tholen and Middelburg, Province of Zeeland and the GGD gathered. They discussed the probability (inside & outside) and severity of a list of risks (ranked 1-3, low, medium, high), which are based on the NAS climate adaptation strategy (Kennisportaal Klimaatadaptatie, 2016). This tool shows the effects of climate change, among which the risks of rising temperatures. Other sources were used as well (Agentschap Zorg & Gezondheid, 2020; ANP, 2019; Shiva 2015; Zeeland, 2020). Appendix C2 shows the results in the Excel file used. Fig. 4.4 shows the basic risk landscape that can be made using these values, combined with the risks that can be (partly) solved with measures outside. Appendix C3 gives separate overviews of the several risks and a deeper explanation on how the risks were discussed.

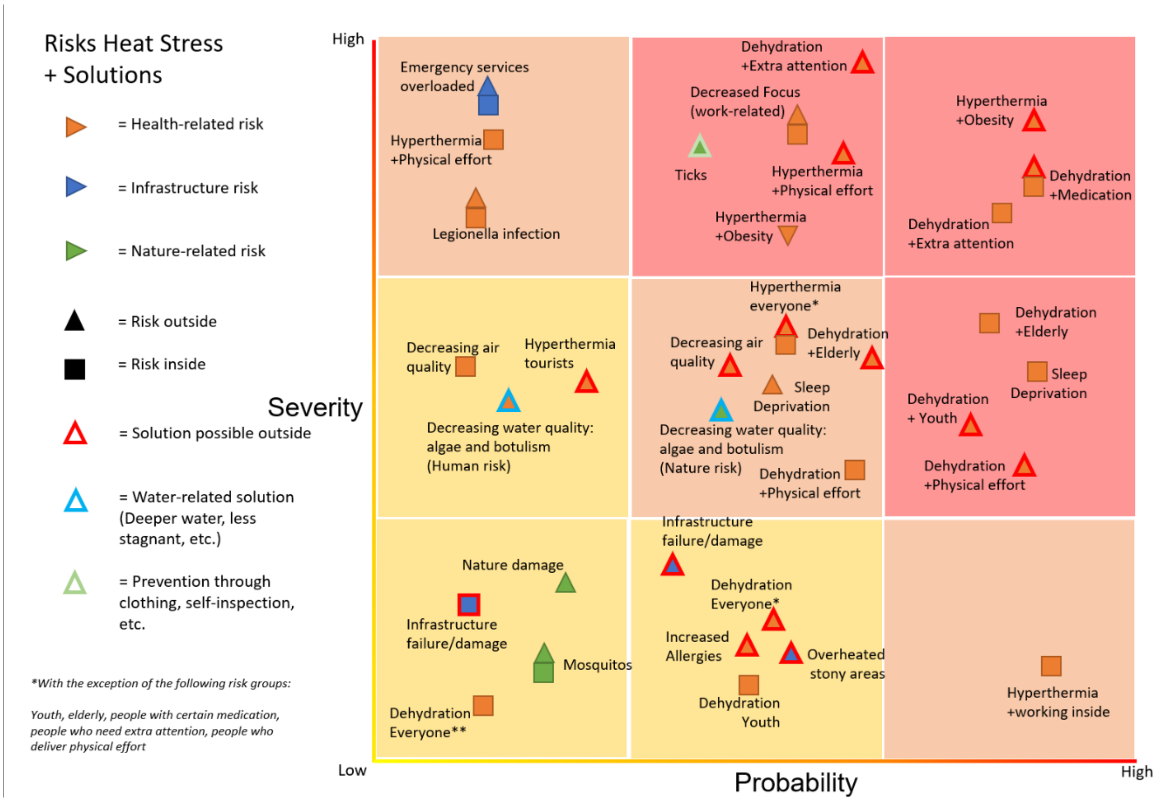

Figure 4.4: Risk landscape, the result of risk sessions with experts

Figure 4.4 shows what the probability (x-axis) and severity (y-axis) of heat stress related risks are. The triangles show risks outside and the squares show risks inside. The red area indicates which risks are the most important to address. These include hyperthermia of people with obesity and people who are physically active during warm periods (f.e. running a marathon); dehydration of youth, elderly, people with certain medication and of those who need extra attention and dehydration of people who are physically active during warm periods (Appendix C4). These are risk groups because they are less aware of the negative effects of heat stress or how to reduce it, or are dehydrated or overheated sooner. The second factor applies to those with obesity or with certain medication and those who are physically active during warm periods. The other risk groups fall under the first category. The risk landscape also includes which risks can be reduced with measures outside, because this is the scope of the research, indicated by a red border around the triangle and square. These measures will be specified and explained later in the report.

The risks in orange areas are mostly overlapping with those in red areas, which means those will be addressed simultaneously. These risks are rated as slightly less dangerous, but still important to monitor. The four risks that are not present in red areas are: Decreasing water quality (nature risk), Hyperthermia + working inside, Emergency services overloaded and Legionella infection. These four risks thus need attention too, albeit slightly less than those in red areas.

Risks in yellow areas are even less of a threat, and also partially overlap with risks in red and orange areas. These risks do not require as much attention as those in the other areas. Risks that are only present in the yellow area are: Decreasing air quality, Decreasing water quality (human risk), Infrastructure failure/damage, Nature damage, Dehydration for everyone (except risk groups), Mosquitoes, Increased allergies, overheated stony areas and Dehydration youth.

Vulnerable groups and areas

Figure 4.5 shows where the risk groups can be in Sint-Annaland and average age of the population per street. Interestingly, the majority of the village has an average age of 35-45. This does not mean that there are no elderly living in this area. However, the map shows a general overview of where risk groups are located. The care-center and apartments for elderly, as well as daycare and schools are situated in an area with a felt temperature of 47-51°C. These locations require extra attention when deciding on measures against heat stress, because these people are the most vulnerable.

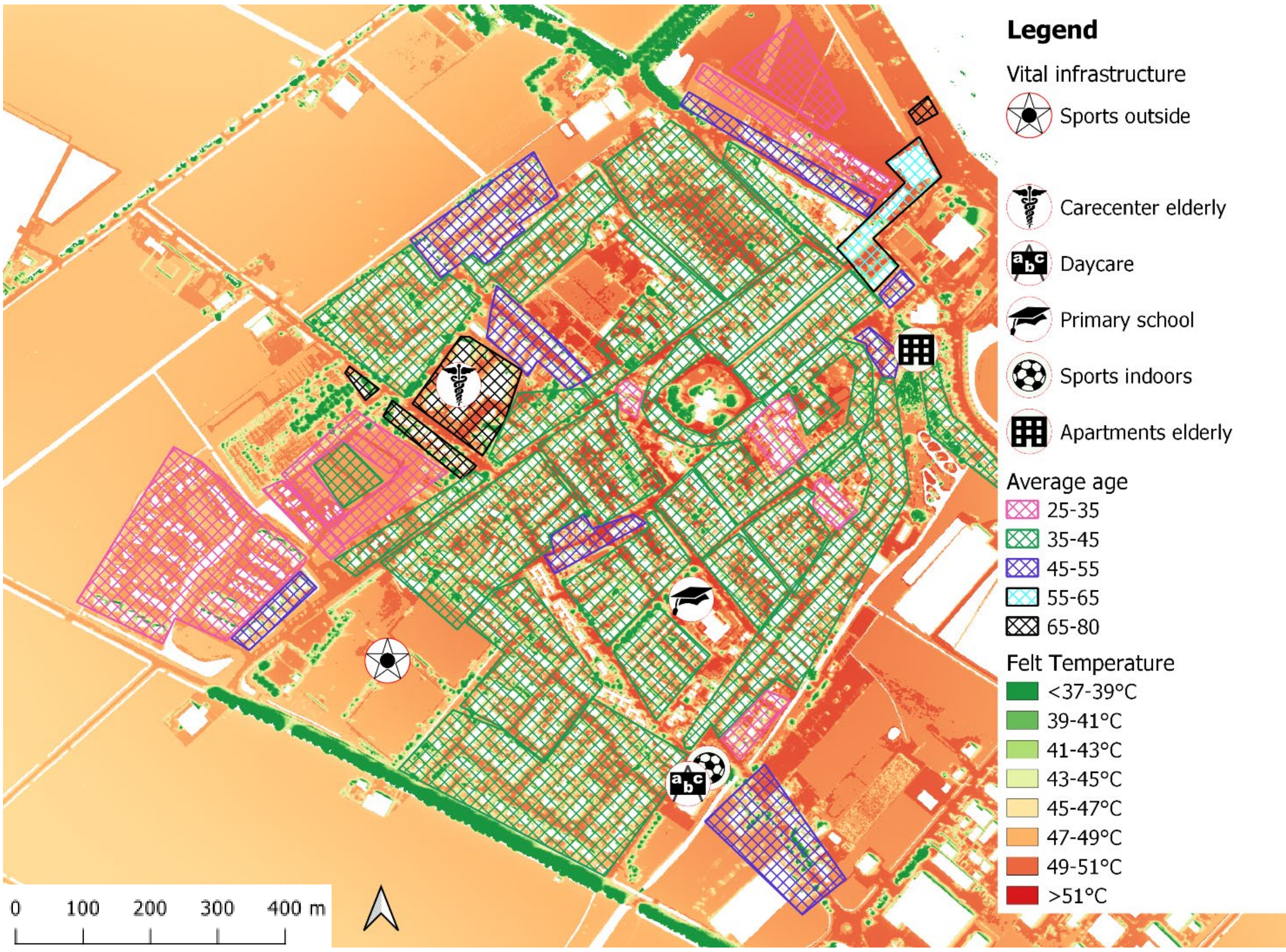

Figure 4.5: Special buildings, average age of inhabitants and felt temperatures in Sint-Annaland. Data from: Nedbrowser municipality Tholen, 2021

People living in buildings with a certain insulation value (energy label) can experience heat more severely, resulting in more heat stress (Expert 1, risk sessions). Fig. 4.6 shows what the energy labels of houses in Sint-Annaland are. It is not required to have an energy label, which is why not all buildings are indicated in the map. It also shows in what period buildings were built. The areas that are not coloured are built after 1980. Due to renovations some houses in the old centre can be built after 1980 (Expert 2, pers. comm., 2021).

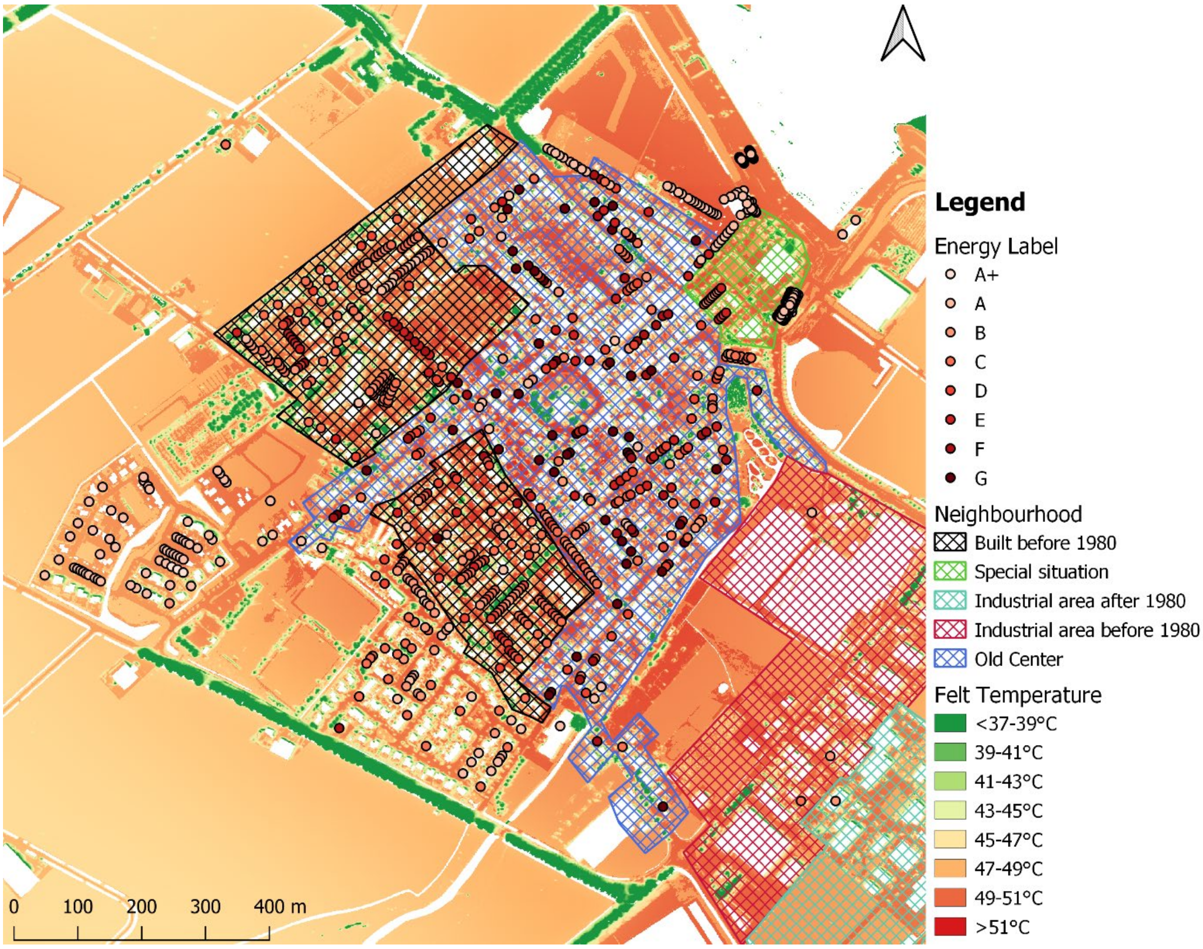

Figure 4.6: Energy label, neighbourhood age/type and felt temperature in Sint-Annaland. Data from: Nedbrowser municipality Tholen, 2021

The value of the energy label is based on how well a building is insulated and on the electricity supply. Thick facades, a well-insulated roof and triple-layered glass will mean a building is insulated properly, which results in a high energy label (G is low, A+ is high), because electricity use will be low as well in these circumstances. If solar panels are installed, the energy label will be even better. (Rijksoverheid, 2021). Generally, houses with low insulation are more prone to heat stress than those with good insulation. However, better insulation means more heat is trapped, which will increase heat stress in these homes as well, given a heatwave lasts long enough (Risk sessions, 2021).

It is remarkable to see that older areas contain more houses with a low energy label (D or worse (Vattenfall, 2021)). This is logical, because older buildings were built according to guidelines that are less strict than current ones, regarding insulation. This means that heat stress will be higher in older neighbourhoods. This has to be taken into account when deciding when and where to take measures against heat stress.

Additional influences

Other factors influence heat stress, its causes and its effects. These factors can be divided in enablers and obstacles. In this case enablers will be factors that reduce heat stress effects and causes, while obstacles will be factors that increase heat stress effects and causes.

Enablers:

- The climate adaptation strategy of Zeeland includes heat stress measures. This strategy is followed by municipalities in the province.
- Municipality Tholen has been investigating heat stress (for instance by developing a Heat stress map, and because this research is taking place) which means they are aware of heat stress and want to reduce it when necessary
- The Village Community tries to create awareness and reduce climate effects (Village Community, pers. Comm., March 2021).
- Opportunities to combine heat stress measures with reduction of other climate change effects

Obstacles:

During conversations with the Village Community it became clear that the following obstacles are present for inhabitants of the study area:

- Parking problems
- Lack of awareness about heat stress
- Lack of knowledge on how to reduce heat stress

Other obstacles are:

- During a questionnaire that was taken the last question provided feedback from participants. This resulted in several comments about the amount of people that paved their gardens. If this trend continues, it may increase heat stress in the future.
- Lack of space in compact streets/neighborhoods can reduce possibilities of heat stress measures, as is explained in Appendix C9.

4.2 Stakeholders in Sint-Annaland

The risk groups defined during the risk sessions have an interest in the reduction of heat stress, so they can be seen as stakeholders.

The risk sessions also resulted in actors that can take measures. Since these organisations or people have a certain influence when it comes to reducing heat stress, they can also be seen as stakeholders. An overview of both these groups of stakeholders, additional stakeholders and their interest and influence can be found in Table 4.1 and Fig 4.7. Appendix C5 shows which stakeholders can be indicated as affected groups and which can be seen as actors, based on the risk sessions.

Table 4.1: Stakeholders in Sint-Annaland

Stakeholders	Interest	Influence
Elderly*	Health, comfort	
Those with certain medication*	Health	
Sporters and physical workers*	Health	
Youth*	Health	
Obese people*	Health	
Local inhabitants	Comfort	Support (e.g. votes), ideas
Tourists*	Health, comfort	
Employers	Well-functioning employees	Determining working hours (tropics schedule)
Emergency services*	Preventing overload	Knowledge
Municipality of Tholen	Satisfying inhabitants, meeting climate goals	Knowledge, subsidies, permits
Provincial government	Reducing heat stress in the future, satisfying inhabitants	Knowledge, subsidies, permits
National government*	Reducing heat stress in the future, satisfying inhabitants	Knowledge, subsidies, permits
GGD	Protect people's health	Knowledge, research
Omroep Zeeland*		Inform local inhabitants
Brede School*	Health of students and employees	Inform children (and their parents), schoolyard as example
Shopkeepers*	Comfortable shop (inside & outside)	Support, money, ideas
Recreational sector*	Attracting tourists	Money, ideas
Stadlander*	Comfortable homes and neighbourhoods	Money, buildings & squares
Activa*	Comfortable shop (inside & outside)	Money, support
Village Community	Comfortable village, satisfying needs of village's inhabitants	Connections to inhabitants, ideas, local knowledge
v.v. WHS*	Comfortable sporting	Sporting field & surrounding area, connections to inhabitants
Anna Zorgt*	Health of their occupants	Money, buildings & squares
WSV*	Comfortable harbour area	
Jumbo Supermarket*	Publicity	Money
Foundation Weezen Armen*		Money, real estate

*The influence and interests of these groups were partly based on common sense, in combination with: 1) input from the Village Community,2) the outcome of the risk sessions and 3) what could be found on the websites of organisations that are seen as stakeholders, because not all parties could be talked to during this research. This means their interests and influence may slightly differ

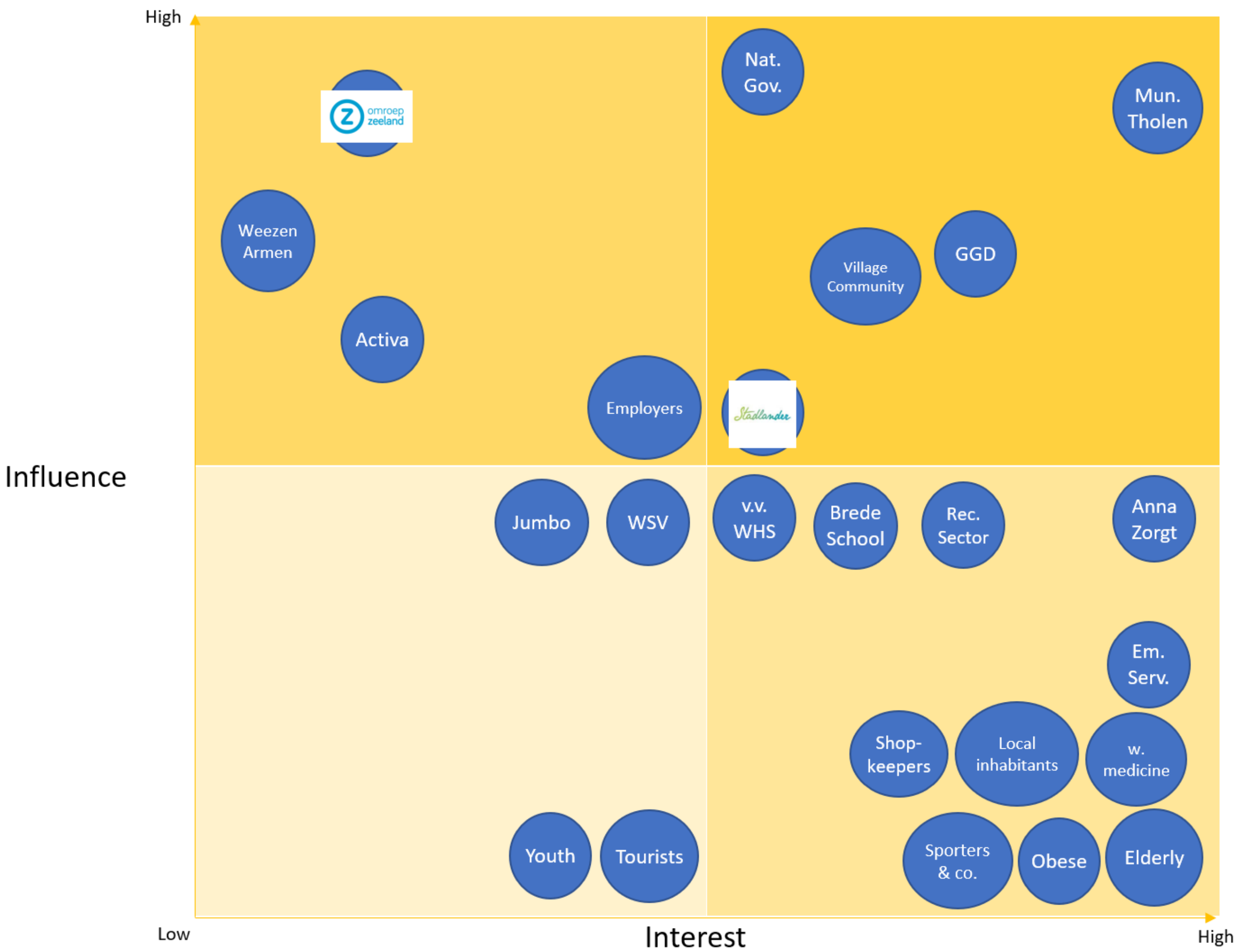

Figure 4.7: Stakeholder matrix of Sint-Annaland

Using this overview can help to decide how to involve stakeholders in the decision-making about heat stress measures. For instance, the Village Community can be included to develop a plan for the village and they can stimulate support from the local community. They can also help implementing measures when appropriate. On the other hand, the needs of people in risk groups can be taken into account throughout a heat stress project, without completely involving them in the project. This can be different depending on specific circumstances.

Fig. 4.8 shows that the majority of respondents expect the municipality to act first when it comes to reducing heat stress. This means the municipality can take a leading role, but more than half of the respondents do want to be involved in the project. This has to be taken into account when making plans to reduce heat stress.

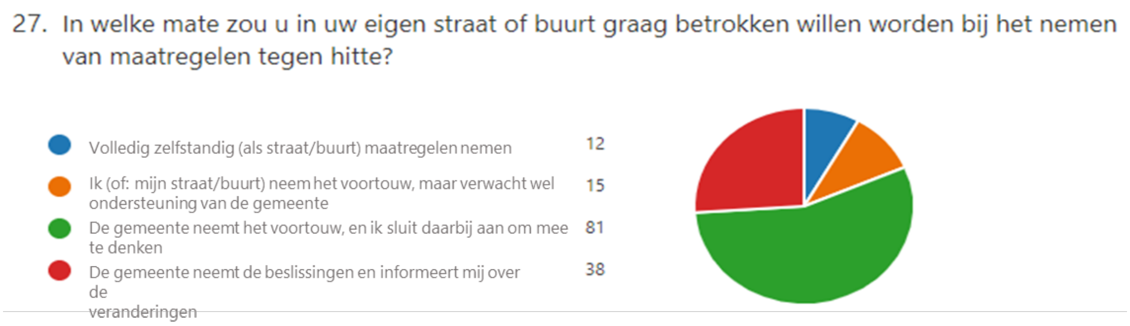

Figure 4.8: The majority of inhabitants in Sint-Annaland expect the municipality to lead the way in taking heat stress measures

4.3 Feasibility of possible heat stress measures in Sint-Annaland

This part of the report will examine which measures against heat stress are the most feasible. Financial, social and environmental feasibility are taken into account, because these provide the desired overview of what measures are possible for the study area. However, first some additional measures will be discussed which were found during the research. These are additions to the list of measures of the theoretical framework (also see Appendix C6).

Additional measures and information

A conclusion Kluck et al. (2020) drew was that planting trees is the most effective way to decrease heat stress in an area. One variation on planting trees is the "tiny forest", invented by Shubhendu Sharma and trademarked by IVN. It has been implemented in the Netherlands in multiple locations. The advantages and disadvantages of this measure will be discussed in the next research question.

As has been stated before, creating shadow is one way in which heat stress can be decreased. In areas where trees cannot be planted, shading covers can also be used to create shadow (Pycke, Webinar Klimaatveiligheid: Hittestress, 2021).

During the webinar "Klimaateffectief groen en de toekomstige stad" Kleerekoper (2021, Webinar Klimaateffectief groen en de toekomstige stad) gave the advice to not necessarily focus on the areas in a city [or village] with the highest felt temperatures, but to create a certain amount of cool places, well-distributed throughout the city [or village] and along walking routes. Adding drinking water points in these cool spots can be done as well.

Feasibility

This section explains the feasibility of the adaptation measures against heat stress

According to Argosino (2013) there are 12 aspects of feasibility when executing a process. This is business-related, so one can say that not all are applicable for a municipal decision on where and how to reduce heat stress. For example, "Market Feasibility" has to do with supply and demand in a certain market, market competition, etc (Argosino, 2013). These kinds of things are not related to taking measures against heat stress. To maintain this research's scope, the following three aspects of feasibility will be assessed: financial (Costs of the measures), social (support for the measures), and environmental (do the measures have the desired effect, namely decreasing local or village-wide temperatures). The paragraph after this will describe several other environmental advantages and disadvantages, and includes some that have to do with the technicality of these measures too.

The costs are just an indication, retrieved from the following sources: BouwkostenOnline (2021), ImproveNet (2021), and Informatiebord (2021) (using the highest value per unit). Through a questionnaire, local inhabitants were asked if they would like certain measures (before-mentioned blue, green & grey). The answers to this question can be seen in Fig. 4.9. The full results of this questionnaire are shown in Appendix C7. The environmental effect of many measures was researched by Kluck et al. (2020). An overview of feasibility for the measures that have been described, can be found in the Table 4.2. The values range between 1 and 5, with 1 being a low feasibility and 5 a high feasibility. A '?' means it is unclear what this aspect of feasibility is.

To determine the score for financial feasibility a 4-part scale (2-5) is used by dividing the cost ranges evenly between €0 and €100/ Green roofs and facades are exceptionally expensive, which is why that measure will have a rating of 1 (least feasible).

To determine social feasibility the percentage of people was calculated to see and five even ranges between 0 and 50% are used (see Fig. 4.9), because the highest percentage is 56%, and this is the only one above 50%. Respondents could give multiple answers, which is why the total answers exceed the amount of respondents. These ranges correspond with the values 1 through 5, with 1 being low feasibility (0 - 10%) and five high feasibility (40 - >50%).

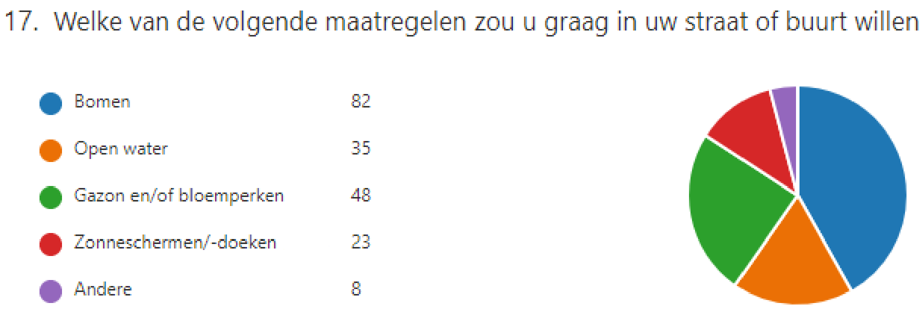

Figure 4.9: Results of the questionnaire for inhabitants of Sint-Annaland when asked which measures they desired to see in their neighbourhood

To determine environmental feasibility, the study of Kluck et al. (2020) was used. The values they found are included next to the feasibility score. Since many measures have a wide range of temperature reduction, an evenly distributed scale cannot be used. The scores are therefore given as follows. Any measure reducing more than 5°C is valued 5. Any measure reducing between 3,5°C and 5°C is valued 4. Any measure reducing between 2°C and 3,5°C is valued 3. Any measure reducing at least 0,1°C is valued 2 and any measure not reducing the temperature is valued 1.

Table 4.2: Financial, social and environmental feasibility of possible measures against heat stress

Measure	Financial feasibility	Social feasibility	Environmental feasibility	Remarks
Trees	5 (€23/m2)	5	5 (3,4-19,0°C PET)	
Green spaces (parks, grass and bushes)	5 (€13/m2)	4	4 (0,4-4,9°C PET)	
Green roofs/facades	1 (€450-800/m2)	4	3 (0,2-1,6°C AirTemp)	
Green parking lots (using grass-concrete pavement)	3 (€60/m2)	?	1 (0°C reduction)	
Open water	5 (€15/m2)	3	3 (0,6-3,6°C PET)	Open water sources can be a source of water-borne diseases, especially when stagnant, which decreases environmental feasibility by 1
Fountains	2 (€100/m2)	?	3 (1,0-5,0°C PET)	Similar to open water sources, fountains can be a source of water-borne diseases.
Wet streets in the evening and morning	?	?	3 (0,8-3,0 AirTemp)	
Polderroof	1 (€450-800/m2)	3	1 (0°C)	

Shading (Umbrellas, canvas, etc.)	5 (€10/m2)	2	5 (2,0-17,0°C PET)	
Open spaces	Depends on situation	?	?	
Light-coloured buildings	4 (€30/m2)	3	1 (0,9°C max. AirTemp)	
Light-coloured streets	5 (€16/m2)	?	2 (1,9°C max. AirTemp)	

The four measures with highest feasibility in Sint-Annaland are trees, green spaces, open water and shading with covers or umbrellas. Trees are one of the least expensive measures, they also were the most desired by respondents of the questionnaire, and their maximum temperature reduction is the highest. Green spaces are even cheaper than trees, were desired by respondents of the questionnaire too, and have a maximum temperature reduction of 4,9°C. Open water is almost as cheap as green spaces, and is desired moderately by respondents of the questionnaire. Open water also reduces temperatures by 3,6°C at most. Lastly, shading is the cheapest of all measures and temperature reduction is almost equal to that of trees, 17°C at most. Shading is not as desired by respondents of the questionnaire, but still almost moderately. However, the fact that this solution has almost the same effect on temperature as trees means it is a very viable option to reduce heat stress.

4.3 The environmental advantages and disadvantages of the most feasible measures

To further give an insight on the feasible measures, their advantages and disadvantages need to be explored. Table 4.3 shows an overview of advantages and Table 4.4 shows the disadvantages, which resulted from literature review, information gained during webinars and focus group discussions. Only the three most feasible measures are included here. An 'X' is used to mark which advantage or disadvantage applies to which measure. The advantages and disadvantages of the other measures can be found in Appendix C8.

Table 4.3: Advantages of the most feasible measures against heat stress

Advantages	Decreases felt temperature	Decreases pluvial flooding	Decreases drought	Can decrease heat stress inside
Trees	X	X	X	X
Grass & bushes and green parking lots	Not during long warm periods (no ET)	X		
Open water	X, but only larger waterbodies	X	X	
Shading	X, especially useful in places where trees cannot be planted	Does not reduce retention-time significantly, but can protect pedestrians from rain		X

Table 4.4: Disadvantages of the most feasible measures against heat stress

Disadvantages	Needs open space	Can damage streets	Temporarily loses cooling effect of ET during long warm periods	Does not provide shade	Increases nightly UHIE	Potential source of waterborne diseases	Energy consumption may increase?
Trees	X	X	X				
Grass	Can be the base of other functions (f.e. a playground)		X	X			
Open water	X		X	X	X, but only larger waterbodies	X, especially when stagnant	
Shading			Does not do this at any time				X

The advantages and disadvantages will be explained in more detail now.

Trees

Advantages:

- Kluck et al. (2020) explains that trees are the most effective measure against heat stress (up to almost 20°C lower temperatures near trees). Trees provide a cooling effect through two manners: evapotranspiration and shade (Kluck et al., 2020).
- Trees have a positive effect on the local air-quality (Traverso, 2020.). They also reduce drought (Rally for Rivers, 2021).
- Suttie (2019) states that trees improve physical and mental health and wellbeing. More specifically, according to Van Assen et al (2017), a study of 64000 births showed "that women living within 300m of a green space in the city have healthier babies."
- Trees increase biodiversity (Woodland Trust, 2020)
- Trees decrease the risk of pluvial flooding
- Trees can also provide a social benefit, when combined with for instance a bench or a playground or something similar.

Disadvantages:

- When placed in front of buildings, one might complain that the tree is blocking sunlight. Tree roots can also damage a street (GreenBlue Urban, 2017).
- Trees cannot be placed in narrow streets or sidewalks. As a rule of thumb, depending on the size of a tree, a sidewalk needs to be 2 to 3 metres wide (Berkely, 2021).
- Trees take time to grow and young trees do not have the same impact on their environment as older trees (f.e. less shadow, because they are smaller).
- According to Kleerekoper (2021, Webinar Klimaateffectief groen en de toekomstige stad) evapotranspiration is limited during warm periods in summer, because there is not enough water available for this process. However, the shade of a tree still provides the same cooling effect as in other seasons (Kleerekoper, 2021). An example of how trees can provide shade can be seen in Fig. 4.10 .

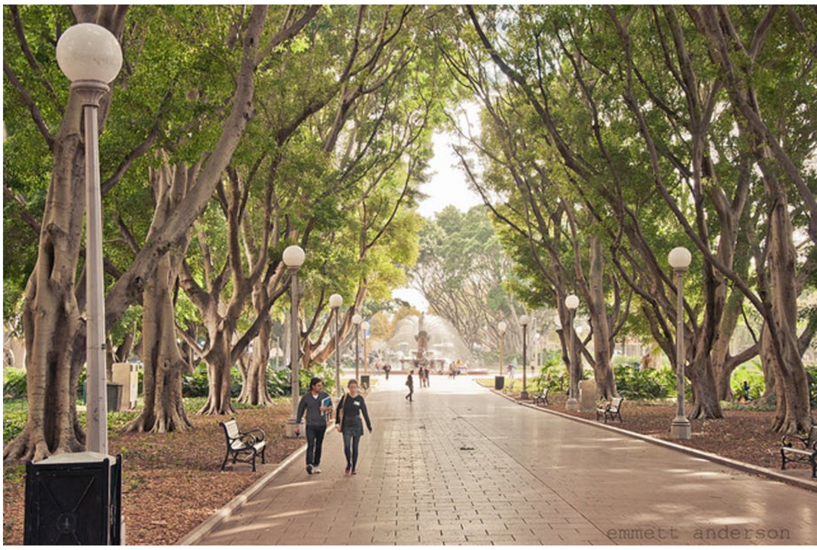

Figure 4.10: How trees provide shade. Retrieved on 20-5-2021 from: https://theconversation.com/trees-are-a-citys-air-conditioners-so-why-are-we-pulling-them-out-21890

Grass & bushes and green parking lots

Advantages:

- Besides advantages of green in general (included in Table…), the following are the advantages of grass, bushes and green parking lots.
- According to Kluck et al. grass and bushes are up to 20°C colder at the surface than concrete because of evapotranspiration. In combination with an altered way of reflecting solar energy, it also affects felt temperature by 5°C (Kluck et al., 2020).
- The advantage of grass and bushes is that compared to trees, there are more places in which one can implement this measure. Although it has less impact than trees, grass and bushes still cool down the local area, as stated above. The same can be said for green parking lots.

Disadvantages:

- Grass, bushes and green parking lots do not provide a cooling effect through shade, which as stated before is the more dominant method in which green lowers the local felt temperature. One can thus question how effective grass and bushes are during extended periods of extreme heat, like heatwaves.

Open water

Advantages:

- During the day, evaporation causes a cooling effect as Kluck et al. (2020) explains. However, this effect is not as significant as that of trees and only noticeable with a large waterbody (Urban Technology, 2020).
- Moreover, open water, when treated properly, can be used as a swimming facility, which further decreases heat stress and creates a place for people to go to during warm periods.
- Open water also reduces the risk of pluvial flooding, as it catches rainwater.

Disadvantages:

- Since only large enough bodies of water create an impact on the felt temperature, small waterbodies do not decrease heat stress, as said before.
- Larger waterbodies increase nightly heat stress
- Especially when stagnant, water can be a source of waterborne diseases (Risk sessions, pers. comm., April 2021).

Shading

Advantages:

- Similar cooling effect as trees on felt temperature is provided by shading with covers or umbrellas.
- Streets that are not wide enough for trees to be planted (or any other reason why trees cannot be planted there), can implement covers or umbrellas to create shade (Tensarch, 2021). This is done, for instance, in the city of Aguéda, Portugal (Fig. 4.11).
- Little maintenance is required as well, compared to, for instance, green measures.
- As can also be seen on this figure , this kind of shading can be done in such a way that it creates a certain atmosphere in the city. It can also be used to convey a certain message or story. This is unique for this kind of heat stress measure.
- Pycke (2021, Webinar Klimaatveiligheid: Hittestress) explained that shading covers can also serve as protection against rain during other seasons.

Figure 4.11: Umbrella sky project in Aguéda, Portugal. Retrieved on 20-5-2021 from: https://www.pps.org/places/umbrella-sky-project

Disadvantages:

- Aside from providing shade and protecting against rain, shading with covers does not have the additional benefits of trees.
- *Assumption*: Shading this way may block so much light that artificial lights have to burn more and longer in streets where this method is used, increasing energy consumption.

Fig 4.12 shows where in Sint-Annaland trees, grass and bushes can be planted to create cool location indicated by green dots. The cool spots are located near walking routes (Eiland Tholen, 2020), as advised by Kleerekoper (2021, Webinar Klimaateffectief groen en de toekomstige stad), as well as near the risk groups that are described before. The areas are owned by the municipality, which will probably *(assumption)* decrease the amount of time and money before implementation can be started. The map also shows where covers and umbrellas can possibly be installed. The blue dots show where there are cool spots at this moment, according to the PET-map. Kleerekoper (2021) also advised that every house should have at least one cool spot near them in flip-flop distance (~250-500 metres). The buffer around the dots show how well this advice is met: almost the whole village is covered with a radius of 250 metres around the cool spots.

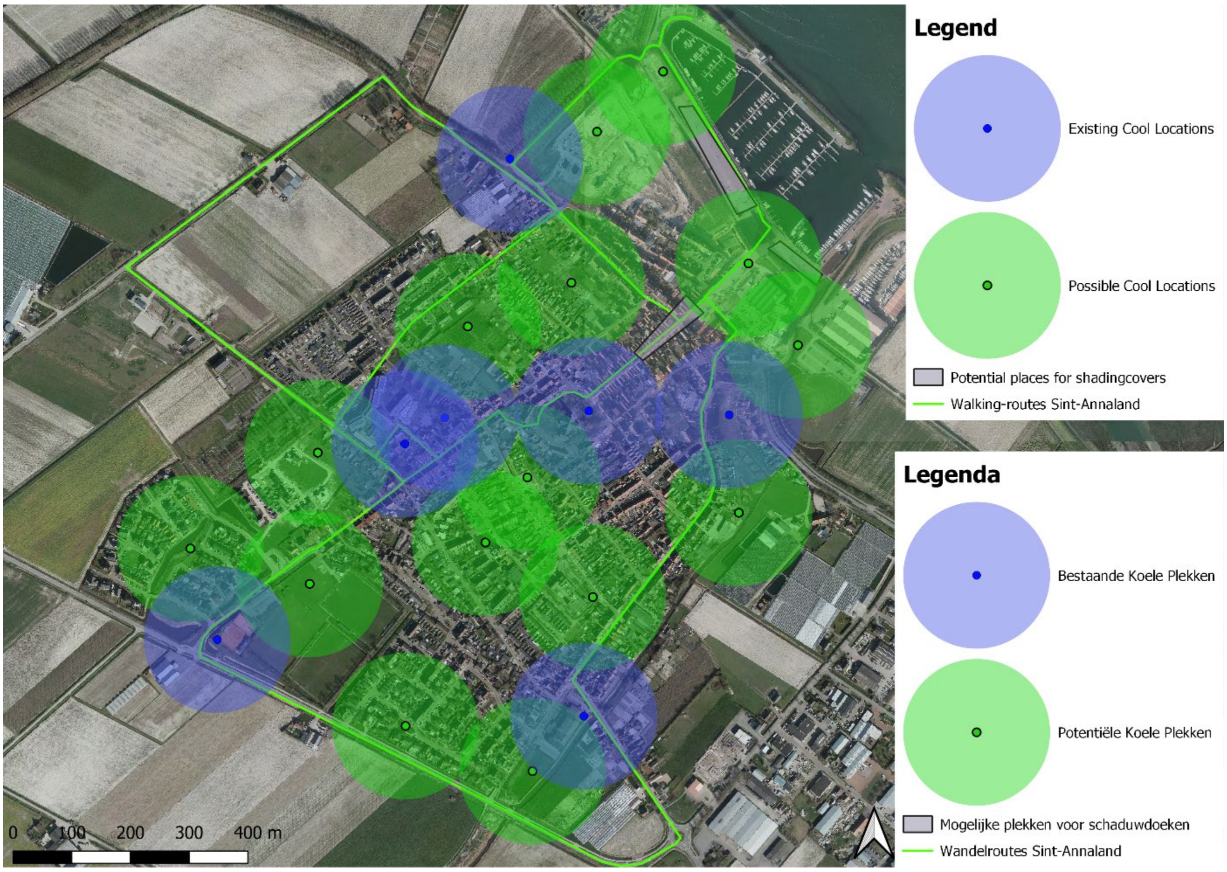

Figure 4.12: Map containing walking route, existing cool spots, possible locations for new cool spots and shading with covers.

The following two figures (4.13 & 4.14) show what happens to the felt temperature when these cool spots are created. Fig. 4.13 shows the current situation and 4.14 the situation with the possible cool locations. The cool spots in Fig. 4.14 contain large trees (largest option in the N&S heat tool), grass and bushes. The effect of covers and umbrellas for shading can unfortunately not be shown in this map.

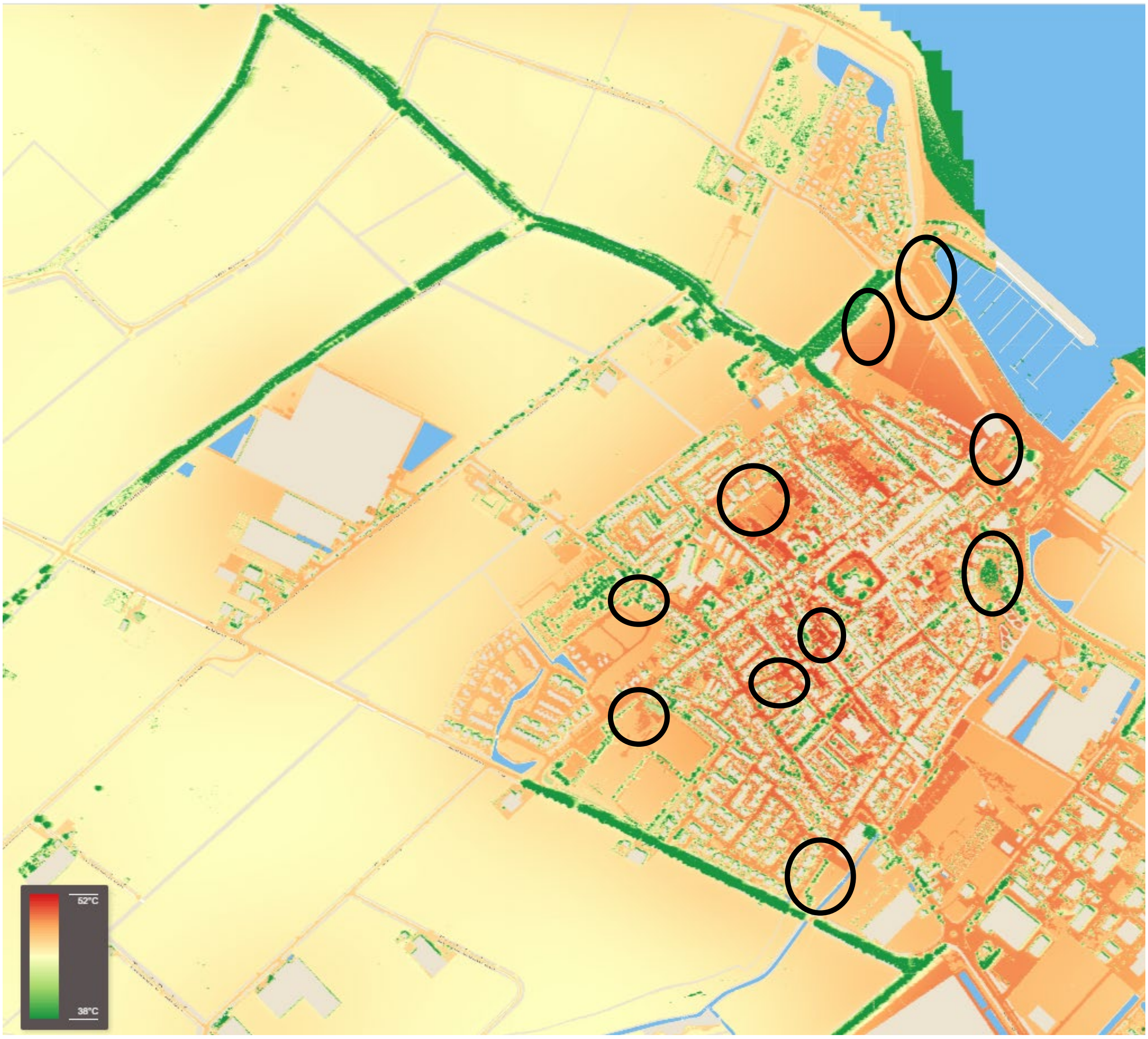

Figure 4.13: Felt temperature without cool spots (current situation)

Local felt temperatures are decreased from at least 45°C to 38°C or less by planting trees, grass and bushes. These locations will thus feel more comfortable than their surroundings during warm periods. To make sure inhabitants can feel the positive effect of these measures, it is advised to add elements like benches, picnic-tables or similar things in the shade of the trees.

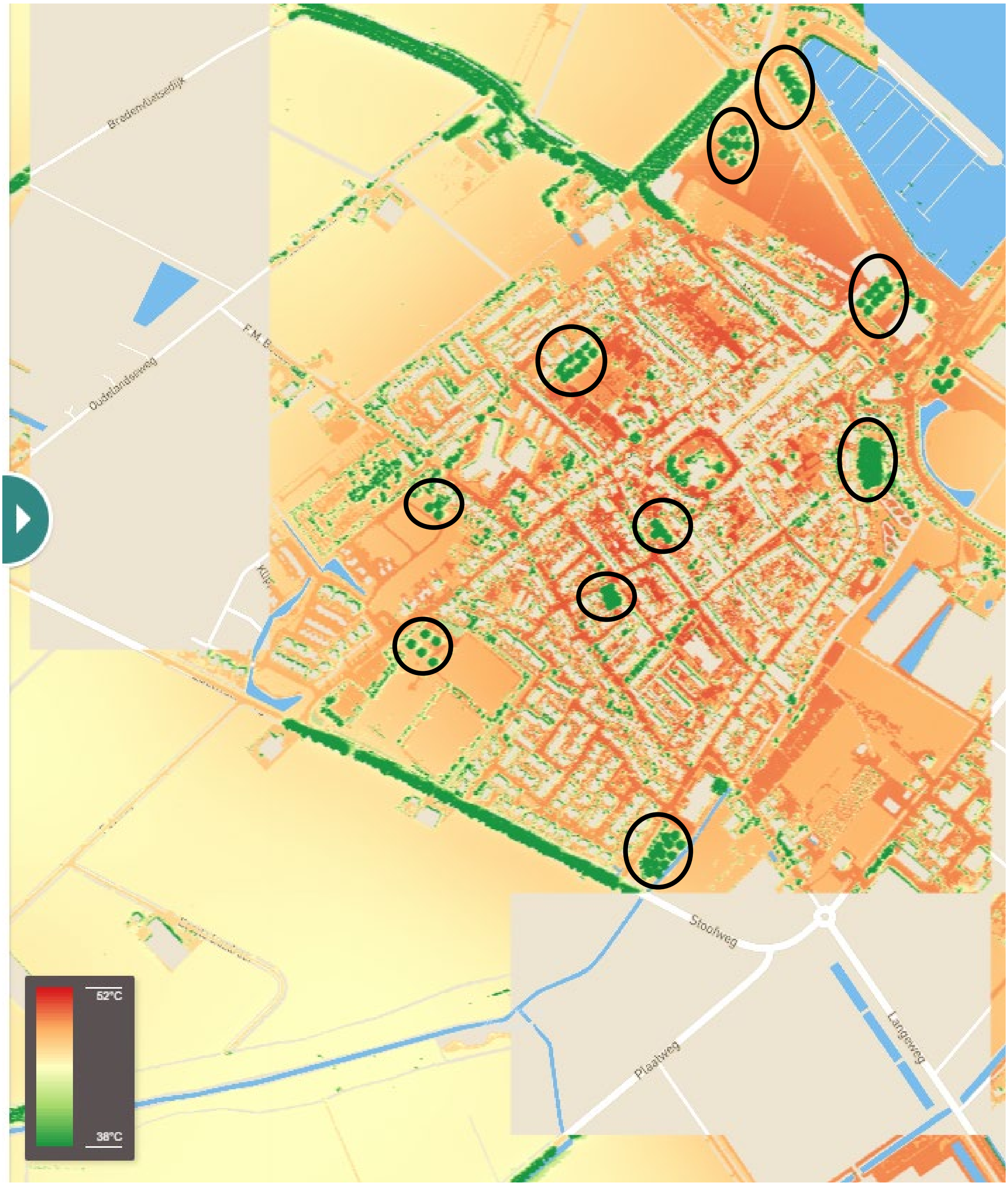

Figure 4.14: Felt temperature with cool spots (possible future situation). Source: Nelen & Schuurmans heat stress tool, 2021

4.4 The implementation plan

During this research, the stages of the DAPP-approach were followed and adjusted up until stage 3. The 4th stage is has been done by examining the advantages and disadvantages of the most feasible measures in the study area, which corresponds with assessing efficacy and reassessing vulnerabilities & opportunities (see Fig. 4.15). To complete this stage, the checklist can be used which is shown in Fig. 4.16. These questions will help to further assess efficacy, sell-by date and to reassess vulnerabilities & opportunities of heat stress measures.

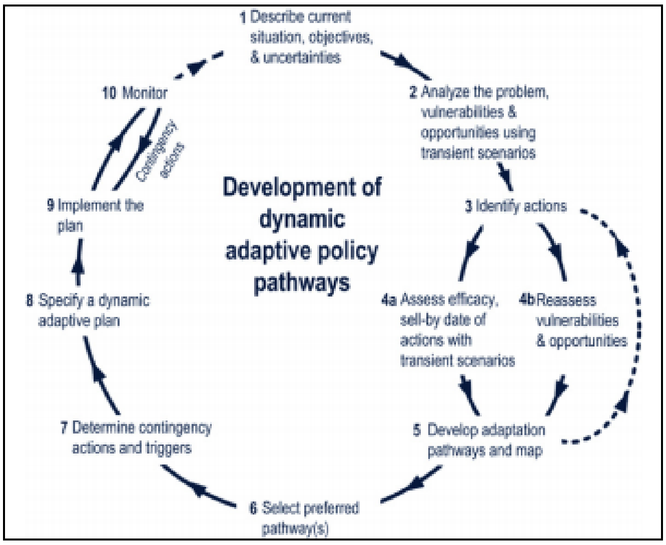

Figure 4.15: Stages of the DAPP-approach. Retrieved from Haasnoot et al., 2012

Checklist

Environment and climate

- ✓ What are the areas prone to water nuisance? (Expert 4, 5 & 6, per. comm., 2021)
- ✓ What are the areas prone to drought? (Expert 4, 5 & 6, per. comm., 2021)
- ✓ What plans are currently under development to solve drought and water nuisance? (Expert 4, 5 & 6)
- ✓ What are the plans for cemeteries in the area? (In Sint-Annaland f.e. memorial park)
- ✓ How can awareness about the positives of green measures be spread among inhabitants? Can they be involved in the process/project? (Risk sessions, 2021)
- ✓ How can biodiversity be improved? (Risk sessions, 2021)

Spatial Planning

- ✓ Where and when are restructuring projects planned? (Expert 2, pers. comm. 2021)

Infrastructure

- ✓ What plans are there for sewerage and roads? (Expert 1, risk sessions, 2021)
- ✓ When will roads be broken open (for renovation, for instance)? (Expert 1, risk sessions, 2021)
- ✓ Where are parking problems? (Expert 4, per. comm., 2021)

Figure 4.16: Checklist with questions that need to be asked to develop a plan against heat stress

Using this checklist will help to see overlap between the plans of different departments. The data that comes out of these questions can be combined in a map, together with the measures mapped during step 5 using QGIS (see Table 4.5). This should provide an overview of what heat stress measures can best be taken in a certain place at a certain time.

The steps taken for the case of the Sint-Annaland can be summarized as can be seen in Table 4.5, where they are also linked to the stages of the DAPP-approach. The steps with '*' are not taken during this research, but are based on literature review, focus group discussions and interviews with experts. Appendix C10 provides a Dutch explanation and overview of these steps.

Table 4.5: DAPP-approach stages linked to steps to reduce heat stress

Stages of the DAPP approach	Steps to reduce heat stress
1. Describe current situation, objectives & uncertainties	**1)** Determine the heat stress in an area using the PET-map by Province of Zeeland
	2) Determine age of the population, insulation value of homes and locate risk groups (including elderly, those in care-centres, children and those in sporting facilities)
2. Analyze the problem, vulnerabilities & opportunities	**3)** Create an overview showing heat stress in relation to the factors described in step two using QGIS
3. Identify actions	**4)** Determine where measures against heat stress are necessary and/or desirable
4a. Assess efficacy, sell-by date & **4b.** Reassess vulnerabilities & opportunities	**5a)** Determine per location what measures can be taken against heat stress
	5b) Determine for each measure per location what the heat reduction will be
	5c) Determine financial and social feasibility per measure for each location
	6a) Determine where water nuisance and drought are and what plans there are to reduce this*
	6b) Determine what plans there are for infrastructure (f.e. renovation plans)*
	6c) Answer all relevant questions in the checklist*
	7) Combine all the data with the heat stress map and measures using QGIS to find overlap and decide where and when to take measures against heat stress*
5. Develop adaptation pathways and map	**8)** Use the knowledge gained during all previous steps and apply the DAPP-map accordingly*

To determine the implementation plan, stage 5 of the DAPP-approach has to be followed. Fig. 4.17 shows the DAPP-map for Sint-Annaland (it can also be applied for any other village). This map contains all measures described in this report. As can be seen, all measures *can* be implemented at the same time, generally speaking. However, step 6 and 7 determine what the order of the measures will be. Not all measures *have* to be taken to reduce heat stress in Sint-Annaland, but the map shows all the possible ones. At the end of the questionnaire people could manually write messages. 'Create more beach' was added because various people mentioned that they would like to see that in their village. A Dutch version of this map is included in Appendix C9.

Determining which measures should be taken first depends on the situation. However, since planting trees is the most feasible measure for Sint-Annaland, and because it takes time for them to grow and provide the cooling effect through their shade, this measure should be taken first. This can be done in combination with grass and bushes, when circumstances allow it. Shading with covers can also be done early on, because this reduces temperature up to 17°C, and it is relatively easy to implement. At what moment open water can be implemented is difficult to determine, because of its possible threat to spread waterborne diseases, especially when more warm periods occur, as explained before.

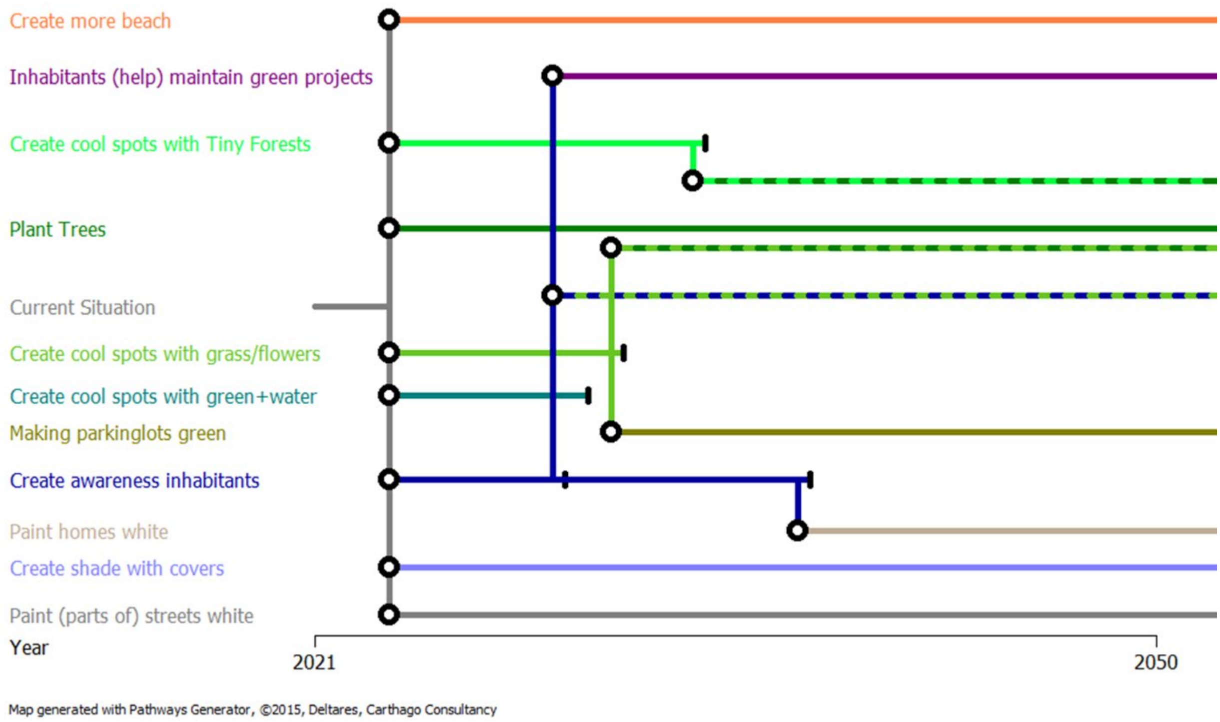

Figure 4.17: DAPP-map containing measures that can be taken against heat stress

Discussion

During this thesis desk research, focus groups, interviews, surveys and a bit of quantitative research was used to investigate what can be done against heat stress in Sint-Annaland until 2050. Focus groups were used to examine the severity and likelihood of effects of heat stress and what measures can be effective against these effects. Since there were 7 experts involved in these focus groups and because this was accompanied by desk research throughout the report, it can be said that these results are reliable for Sint-Annaland.

The survey was carried out using participants from Sint-Annaland only, to make it applicable for the village. The results can therefore only be used for this village. The same questionnaire can be used to research heat stress among inhabitants of other villages, however. The maps showing age of the population and special buildings can be improved by updating them with more recent and more detailed data. This data was not available during this research. The reliability of energy labels was questioned at the end of this research by Experts 1, 2, 3 and 7. It may therefore not be correct to use it as a main-component in decision-making, but rather as a supporting one.

The financial and environmental feasibility of the measures, as well as the advantages and disadvantages and the map that was made using the DAPP-approach can be applied to areas outside Sint-Annaland. This can be said because these parts of the report are all based on solid literature, like the research by Kluck et al. The findings of this research are comparable to those Kluck et al. found regarding heat stress measures. The costs, effects and steps for measures against heat stress are similar in all places in Zeeland and even in the Netherlands, but the order in which these steps need to be taken are different in every situation.

It is interesting to see that the areas where green is lacking indeed increase felt temperature and heat stress the most, as expected. As expected, trees are the most effective against heat stress. An interesting thing is that this effect only comes from shade during warm periods, because the cooling effect of evapotranspiration cannot be felt due to drought in these periods. It is clarifying to find that water increases nightly temperatures, which is disadvantageous. This is a logic thing to find, however, because the reason water decreases heat stress during the day is because it heats up slower than its environment, which in effect also means it cools down slower. This is supported by interviews, focus group discussions and the results of the survey as well.

During this research it has also become clear that creating cool spots with shadow is better than decreasing temperature in areas with a lot of heat stress. The expectation was that it would be necessary to decrease the temperature of a complete village by several degrees to reduce heat stress, so this finding is an eye-opener. Laura Kleerekoper and Kluck et al. have explained this thoroughly. The results of the survey show this too.

Since integration is a term stumbled upon regularly, it was also expected that taking measures against heat stress is something that has to be done while taking into account the context around it. The DAPP-map is therefore a good tool to use when deciding on what measure to take in what situation, provided that the checklist for step 1 of the preparation phase is filled out thoroughly as well. This research confirms the necessity of integration when implementing heat stress measures.

This study provides a plan of what to do in Sint-Annaland to reduce heat stress outside during the day, but the results of this research cannot be directly applied to other villages. However, it can be used as a general framework of measures that can be taken in various orders, as the situation suits. Each situation is therefore to be investigated thoroughly, which can be done by following the seven steps that are described in this report using Sint-Annaland as an example.

It is beyond the scope of this study to describe all linking opportunities between heat stress and other subjects. However, the seven recommended steps serve as a tool to find these linking opportunities. The research done is based on literature that describes general advantages and disadvantages of measures against heat stress. It makes this knowledge applicable for Sint-Annaland specifically and shows what needs to be taken into account when defining the order in which the measures should be taken in other areas.

If no action is taken against heat stress now, it will become increasingly warm in villages and cities. Their liveability will decrease because of this. There are only a few places that provide a cooling effect in and around Sint-Annaland, which may become more crowded the warmer it becomes. Those who cannot access these areas, especially the risk groups, will experience more heat stress and may even die.

If the step-by-step plan and DAPP-map are not used, inefficient choices may be the result. Double work may be necessary to reduce heat stress in some places. This can be avoided when following the advised steps.

It can be useful to investigate what behavioural changes of people are during heatwaves in the Netherlands, Zeeland and Tholen. This will help to take effective measures against heat stress. Another follow-up study can investigate how cool spots can be designed in such a way that it reduces heat stress the most effectively. This can include the minimum size of such a cool spot, the minimum amount of shade that should be there and what the dispersion of these cool spots should be.

Researching the effect of implementing trees, grass and bushes, open water and shading with umbrellas and covers combined can be useful to see how these measures act against heat stress together. Before implementing water to reduce heat in Sint-Annaland, it should be investigated if this positive effect weighs up to the increased UHIE and the risk of waterborne diseases. Ways of preventing contamination by waterborne diseases can also be done as a follow-up study.

Conclusion

During this research the following question has been investigated: "What steps can be taken to mitigate and adapt to heat stress in Sint-Annaland?" This question was answered using qualitative research, desk research, survey research and a small portion of quantitative research.

It turned out that Sint-Annaland is one of the most paved villages of the municipality. This increases heat stress in an area. A lack of cool, shadow-rich places also increases heat stress in Sint-Annaland.

Using a focus group the main effects of heat stress were examined. The conclusion can be drawn that the following effects impend the highest risk regarding heat stress: Hyperthermia for people suffering from obesity, Hyperthermia for those who perform physical activities during warm periods, Dehydration for elderly, people who have certain medication or require special attention, Dehydration for young people (0-12) and for those who perform physical activities during warm periods, and Sleep deprivation in general. (capitalized words to highlight the start of a new effect).

The stakeholders that are most affected by heat stress are those in risk groups, which were defined during focus group discussions. The interest of these people should be taken into account when deciding on measures against heat stress. The municipality is one of the most important 'actors' when it comes to taking heat stress measures. The results of the questionnaire showed that the majority of inhabitants of Sint-Annaland think the municipality should take the lead when it comes to taking these measures.

Based on financial, social and environmental feasibility, trees are the most feasible measure against heat stress. Next to that, green spaces without trees, open water and shading with umbrellas and covers are good options to reduce heat stress in Sint-Annaland. Green spaces without trees and shading with umbrellas and covers can be done when there is no space for trees. It also is clear that creating cool spots divided around the village is a better method of reducing heat stress than reducing heat stress at the areas with the highest temperatures. This has to be taken into account when taking these measures.

The advantage of trees and other green measures is that these also reduce water nuisance and drought. This means that there is an overlap in addressing these climate effect. It can be concluded that linking solutions to each other and taking them simultaneously is useful and efficient to do.

Combining all of the results obtained, a step-by-step plan is set up which can be used by all municipalities in Zeeland. The seven steps can be seen on the next page in the form of a poster. Based on these seven steps, a path can be chosen in the DAPP-map shown in the figure below, which shows possible measures that can be taken to reduce heat stress.

In conclusion, there is no fixed way to address heat stress in every area. Trees are the most effective measure to address heat stress, especially when used to create cool spots, because they provide shade. However, each situation has to be carefully analysed, the future plans for the area have to be clear and solutions of all climate effects have to be combined to efficiently reduce all of them.

Recommendations

- Based on the results of this research, it is recommended that cool places with shadow are created close to the risk groups first (indicated with circles in Fig. R1). These people will be the first to suffer from incresasing temperatures, so they should be close to cool spots first as well.

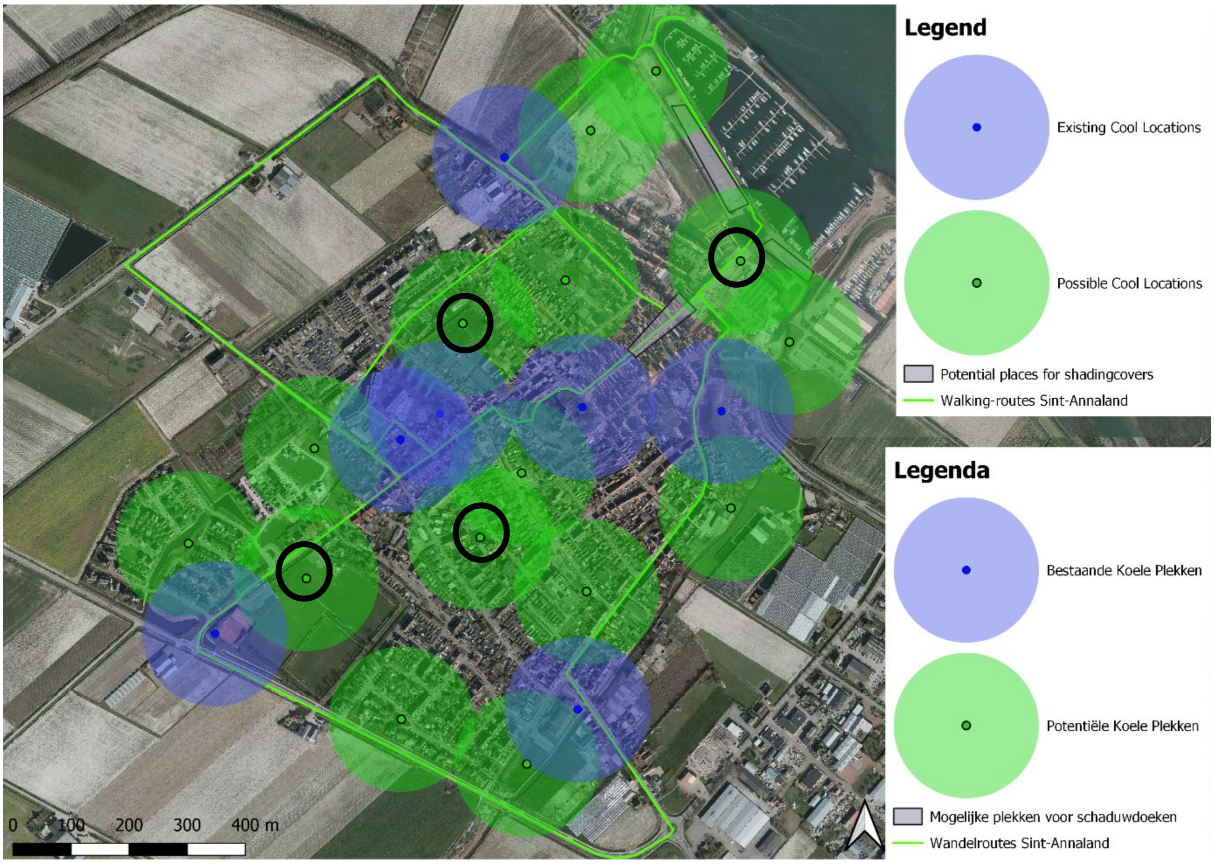

Figure R1: Recommended locations to take measures

- Trees should be planted as early as possible to create the cool spots. Trees planted should also preferably grow to a height of at least 12m. The trees have to grow before they provide shade which gives the cooling effect during warm periods, so the sooner trees are planted, the sooner these trees will reduce heat stress. The higher a tree grows, the more shade it can also offer. The trees should also be able to withstand periods of drought, which is another climate change effect.
- Cool spots should contain benches, picnic-tables, playgrounds/facilities for children and other elements which create an inviting atmosphere. These elements have to be placed in such a way that they are in the shadow, especially during the warmest part of the day. Doing this will stimulate people to use the cool spots, which is the goal. People have to be able to be cooled by the shade provided in these locations.
- If open water is implemented, it is advised to keep it flowing to prevent waterborne diseases as well as possible. Based on the current advantages and disadvantages of open water, it should only be used as a solution when combined with other measures, like trees and green spaces.
- The importance of technical, social and environmental feasibility should be investigated by asking 10 experts rank them. This will create the possibility of calculating total feasibility for the measures.

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Appendix A1: Factors influencing urban heat

Albedo & Emissivity

As stated before, urban albedo refers to the capacity of urban surfaces to reflect solar radiation (University of Kent, n.d.) and emissivity means the amount of energy emitted from a material's surface compared to that of a perfect emitter (NPL, n.d.). These two terms have very similar meanings, which is why these will be discussed together.

Figure A1 shows the value of the albedo for various materials and Figure A2 the emissivity values of several materials. These can all only be values between 0 and 1. The closer the value is to 0 the lower the capacity to reflect solar radiation (albedo), or emitted energy when temperature rises.

Black built-up roof	0.04 - 0.05
Built-up roof (white gravel)	0.30 - 0.50
Asphalt	0.04 - 0.15
Light gray asphalt	0.25 - 0.27
Dark concrete tiles	0.05 - 0.35
White concrete tiles	0.70
Metal roof unpainted, corrugated	0.30 - 0.50

Table Albedo values of different types of materials.

Figure A1: Albedo values of different types of materials. Retrieved from: https://www.urbangreenbluegrids.com/heat/

Aluminium, polished	0.05
Aluminium, oxidized	0.25
Brick	0.85
Concrete	0.54
Glass	0.92
Black varnish, mat	0.97
Black varnish, gloss	0.87
White varnish	0.87
Paint, silver color	0.31
Water	0.98
Zinc	0.20

Table emissivity values of a few materials.

Figure A2: Emissivity values of a few materials. Retrieved from: https://www.urbangreenbluegrids.com/heat/

According to Urban Green-Blue Grids (n.d.), lower albedo results in a higher surface temperature, which in turn leads to more heat stress. Using Figure A1, one can see that, for instance, white concrete tiles have a high albedo, relative to the other materials. Urban Green-Blue Grids also points out that the albedo value is higher for areas with vegetation than for areas with pavement or built-up areas.

Urban Green-Blue Grids states that, regarding emissivity, stony materials will start radiating heat even when their temperature rises slightly, while metals will only radiate energy when their temperature has risen significantly. However, when metal surfaces are painted, the emissivity value will be that of the paint (Urban Green-Blue Grids, n.d.).

Skyview Factor

Figure A3 explains what the term skyview factor contains.

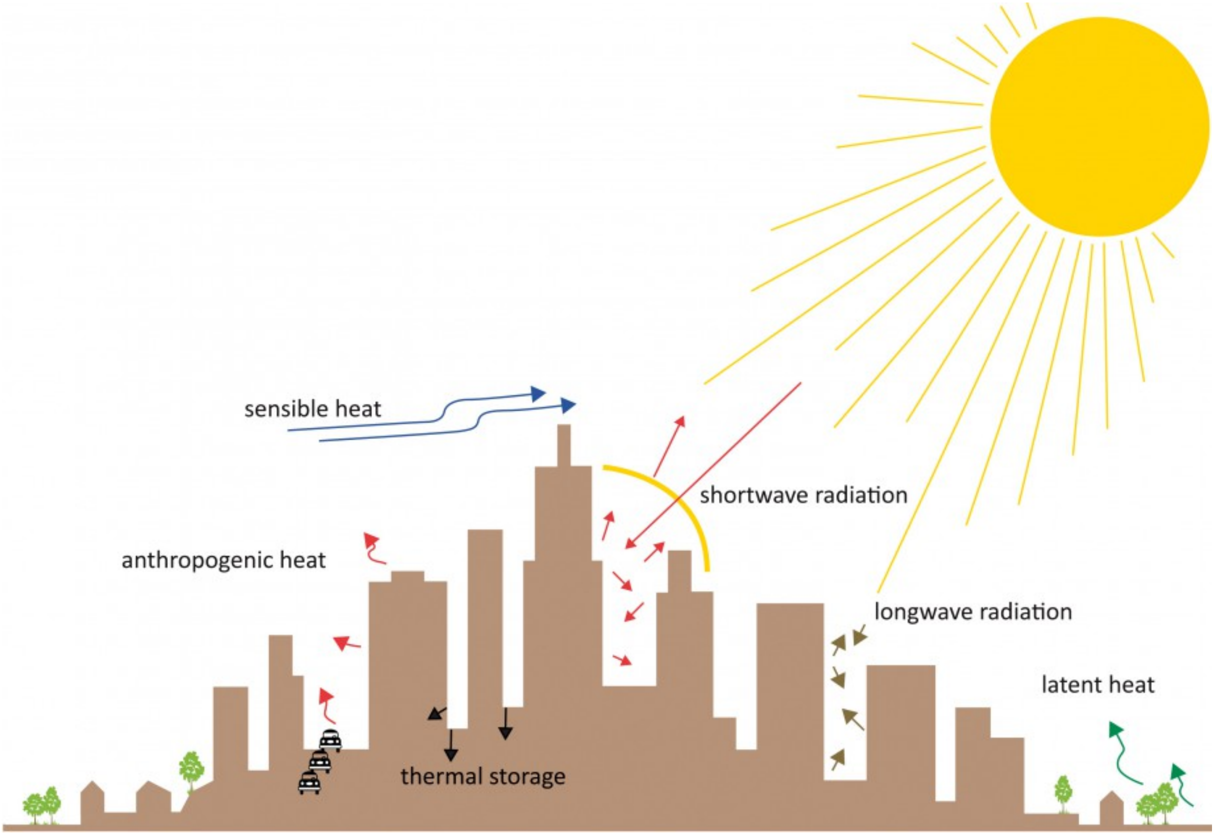


Figure A3: Sky view factor and internal reflection. Retrieved from: https://www.urbangreenbluegrids.com/heat/

Urban Green-Blue Grids (n.d.) clarifies the term effectively as well:

> *"Closely-built high-rises that form urban canyons offer shade during the day but do not allow the area to cool down at night. This is described using the concept of the sky view factor, which indicates what percentage of the firmament is visible from a given location on the surface. A high sky view factor, for example in an open field, enables reflection of short-wave sunlight radiation because of the absence of internal reflection. In urban canyons, the low sky view factor interferes with the night-time emission of long-wave radiation (the heat coming off buildings at night)"*

Built-up vs. Green areas

In the description of the previous factors, the difference between green and built-up has been slightly discussed. This part will further elaborate on the influence of built-up areas on urban temperature compared to that of green areas.

Foster (2020), suggests four causes for the Urban Heat Island Effect (UHIE) (see Appendix A4):

- *"Change in land use (the removal of trees and green space and the addition of heat-absorbing materials);*
- *Waste heat (mainly from energy use in buildings and transportation);*
- *Air pollution (UHIs create ideal conditions for formation of smog, which acts as a heat-trapping barrier); and*
- *Urban geometry (the pattern in which streets and buildings are arranged as well as the size and shape of a city are influential determinants of UHI intensity)."*

Based on her statements, one can say that built-up areas increase the UHIE, while green areas can decrease it.

Appendix A2: Heat stress adaptation and mitigation measures

Blue measures

Pavement watering

Hendel et al. (2015) explains that this method has been used in Paris, and that it can reduce air temperature by 0.4-4^{0}C. He also explains that pavement dries 30 minutes after watering it during insolation, which should be kept in mind with this method

Increasing surface-water

Kind et al. (2020) states that surface-water can decrease heat stress in urban areas. Evaporation is increased, which can lead to a cooling effect as discussed before. There are two side-effects to this solution, explains Kind et al: it improves the neighbourhood's/city's capability of dealing with water nuisance and dry periods; when the water is stagnant, blue-green algae can grow in it during hot periods, which decreases the water quality.

Green measures

Green roofs

Zinzi (2012) explains that green roofs mitigate urban heat through enhancing evapotranspiration. He also states that roof surfaces amounts for about 20-25% of built area in a city, which makes this mitigation measure a viable option. The shade it provides, evapotranspiration and increased thermal mass also have a cooling effect on the indoor climate of a building.

However, as Coutts et al (2013) explains, green roofs need irrigation, especially in times of drought to maintain its cooling effect.

Green areas

Green areas are a source of shade, when trees are present; evaporative cooling reduces heat stress; additional advantages are rainwater intercept, storage and filtration and the reduction of carbon emissions (Gill et al., 2007). On top of that, Steeneveld et al. (2011) has found that 10% more green area would decrease 0.6^{0}C UHI in Dutch cities.

In addition, Vandenbriele (2019) states that each tree in public green can account for 20-30 kW cooling, with larger trees having a more positive impact. The best trees, as he mentions, are the alder and the linden.

According to Kind et al. (2020), creating more green areas in a neighbourhood can have the following side-effects (positive & negative):

- Increased health
- Improved biodiversity
- More gathering points for local inhabitants
- Possible decrease in air-quality, due to the fact that exhaust gasses are trapped by vegetation
- The trees provide shadow, which increases spatial quality. An alternative to trees, for shadow, is to install sunshades

Grey measures

Adapting buildings

Coutts et al. (2013) also suggests what can be done as a grey measure: cool (or white) roofs. These roofs have a relatively high albedo (0.7), which cools a town significantly, when installed on a larger scale (Coutts et al., 2013; Zinzi, 2012). To add to this, Vandenbriele (2019) explains that building as a whole can be of a lighter colour to reduce heat stress. On top of that, he states that narrow streets can also have a positive impact on heat stress.

Other adaptions can be to install blinds and air-conditioning (Kind et.al., 2020). This will decrease heat stress inside buildings (Kind et al., 2020), but on the other hand, as was discussed before, air-conditionings do increase the temperature of their surroundings. Other actions that can be taken, are listed and explained below.

Urban development

Urban development can have an effect on heat stress in cities, as Vandenbriele (2019) explains. He states that optimised urban ventilation decreases urban temperatures. He suggests future urban developments should decrease this ventilation as little as possible. One of the things he proposes, is the Finger Plan (see Figure A6). One disadvantage this idea has, according to Vandenbriele, is that growth of a city is limited by it.

This plan is used by the city of Copenhagen (Norman, 2020). Along with some other principles they want to use this structure to develop their city in the future. They want to combine this plan with developing public transportation, they try to encourage people to use the bike instead of their car, they attempt to make their city 'walkable', or pedestrian-friendly, and last of all, another element they take into account is to add green spaces and playgrounds (Norman, 2020).

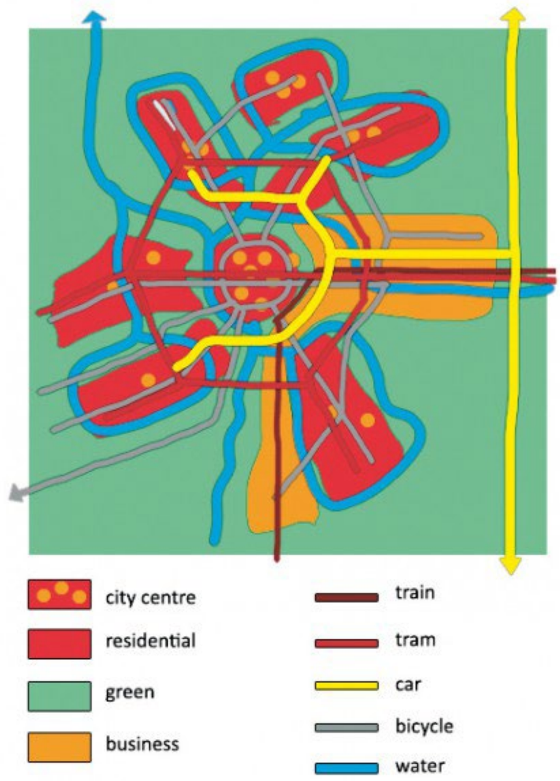


Figure A4: Finger Plan city. Retrieved from B. Vandenbriele (2019)

Appendix A3: Adaptation Pathways & Adaptive policy-making

Adaptation Pathways

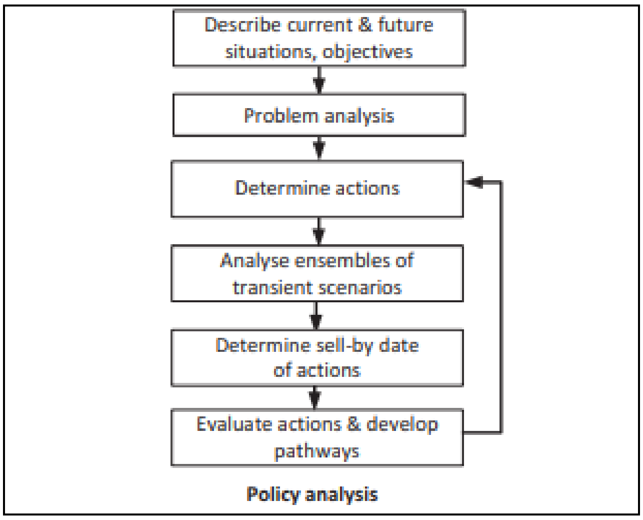


Figure A5: Stepwise policy analysis to construct Adaptation Pathways. Retrieved from Haasnoot, et al., 2012

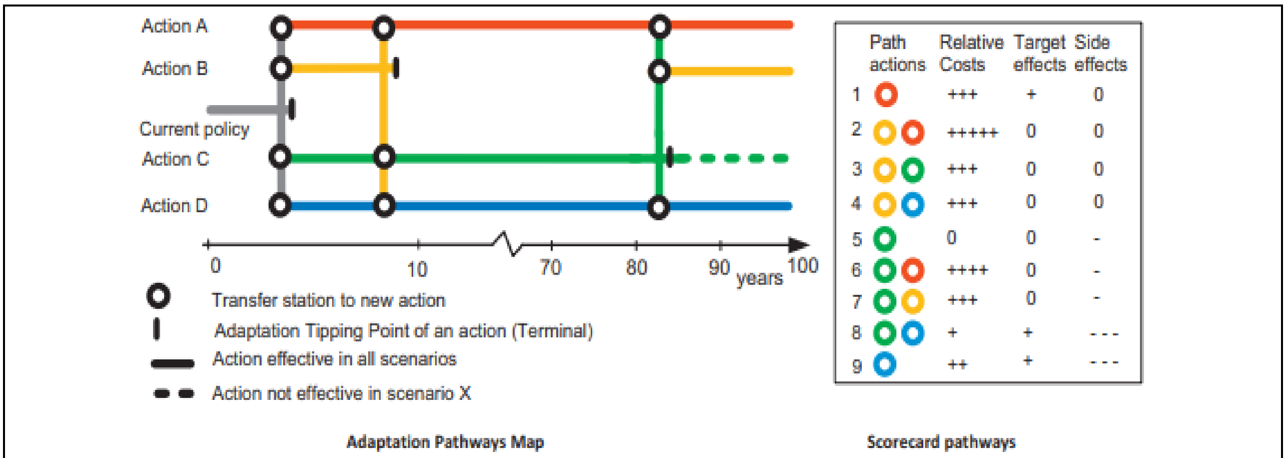


Fig. 2. An example of an Adaptation Pathways map (left) and a scorecard presenting the costs and benefits of the 9 possible pathways presented in the map. In the map, starting from the current situation, targets begin to be missed after four years. Following the gray lines of the current policy, one can see that there are four options. Actions A and D should be able to achieve the targets for the next 100 years in all climate scenarios. If Action B is chosen after the first four years, a tipping point is reached within about five years; a shift to one of the other three actions will then be needed to achieve the targets (follow the orange lines). If Action C is chosen after the first four years, a shift to Action A, B, or D will be needed in the case of Scenario X (follow the solid green lines). In all other scenarios, the targets will be achieved for the next 100 years (the dashed green line). The colors in the scorecard refer the actions A (red), B (orange), C (green), and D (blue).

Fig. A6: Adaptation Pathways and an explanation (see description above). Retrieved from Haasnoot et al., 2012

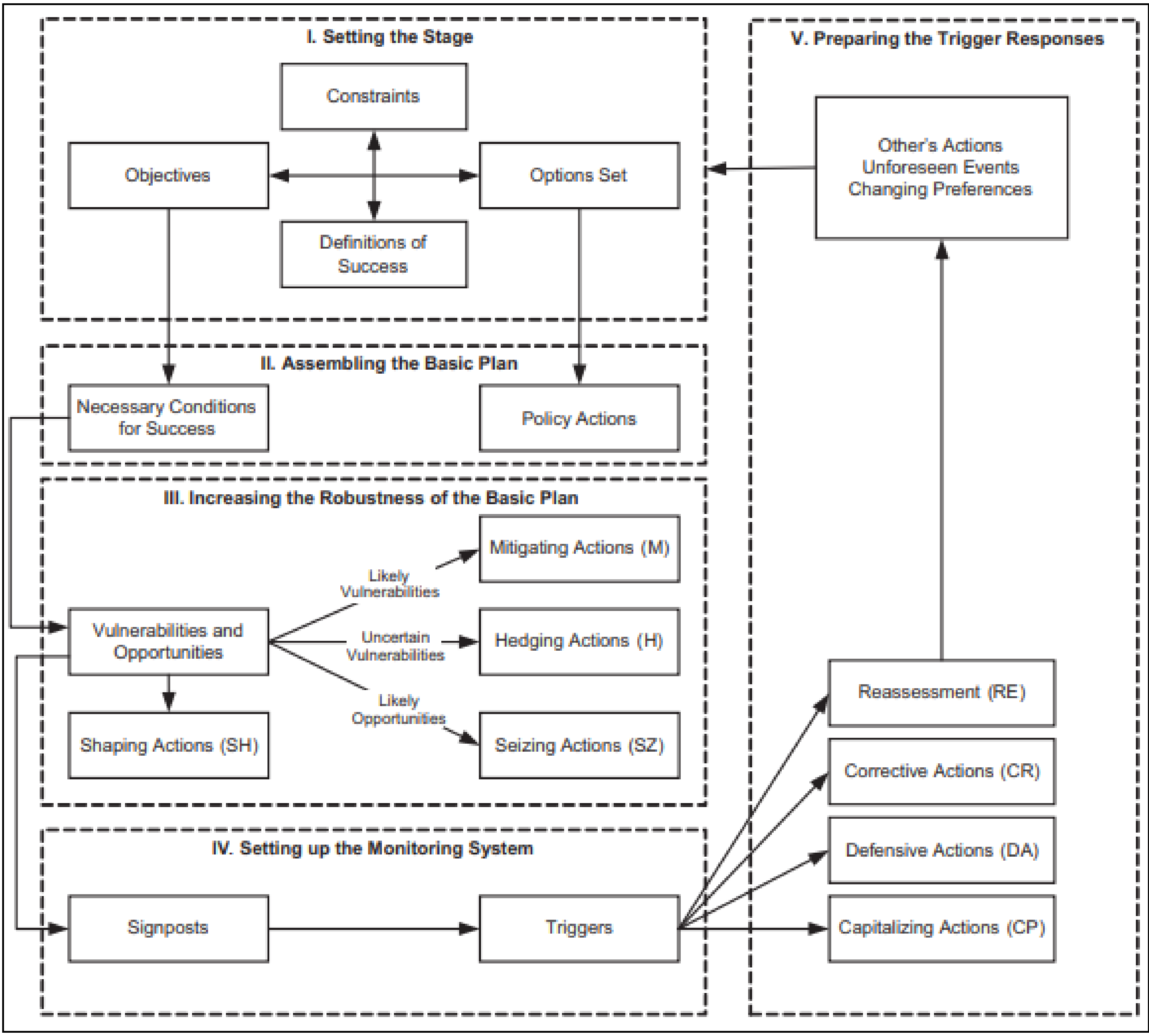


Figure A7: The Adaptive Policymaking approach to designing a dynamic adaptive plan. Retrieved from Haasnoot et al., 2012.

Appendix A4: The Urban Heat Island Effect

The phenomenon of higher temperatures in urban areas, compared to surrounding rural areas is also called the Urban Heat Island Effect. This is due to the fact that cities contain more dark materials, which absorb more heat (low albedo) (Jolma, 2018).

On top of that, water is quickly transferred to and stored in sewers underground. This decreases the amount of evaporation of the water, while the evaporation of water creates a cooling effect in rural areas (Jolma 2018).

One might say the urban heat island effect is not applicable to smaller towns like SA. However, according to T. Terpstra et al. (2019), as agricultural areas around such towns dry out during high-temperature periods, their cooling effect decreases because evapotranspiration takes place to a lesser extent. This in return causes higher temperatures in the towns, because warm wind is blown into it (Expert 1, pers. comm., 2021). The result is that the UHI is apparent in smaller towns equally as in cities (Expert 1, pers. comm., 2021).

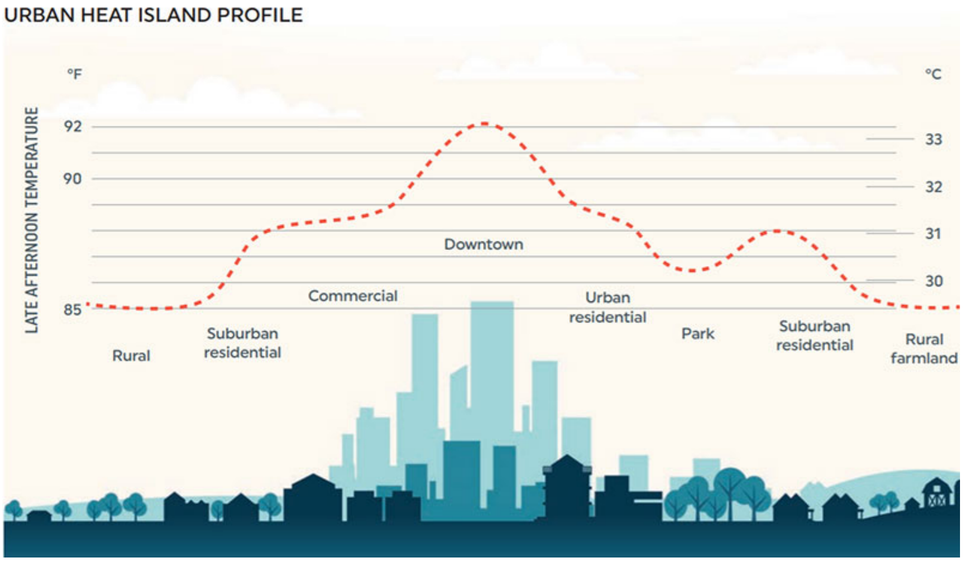


Figure A8 to-
reducing-

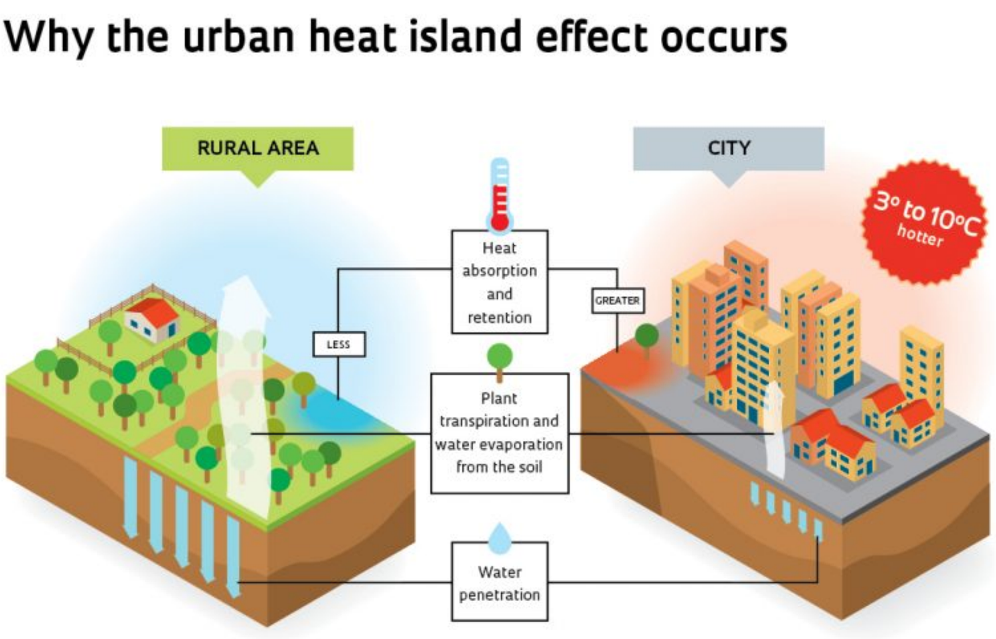


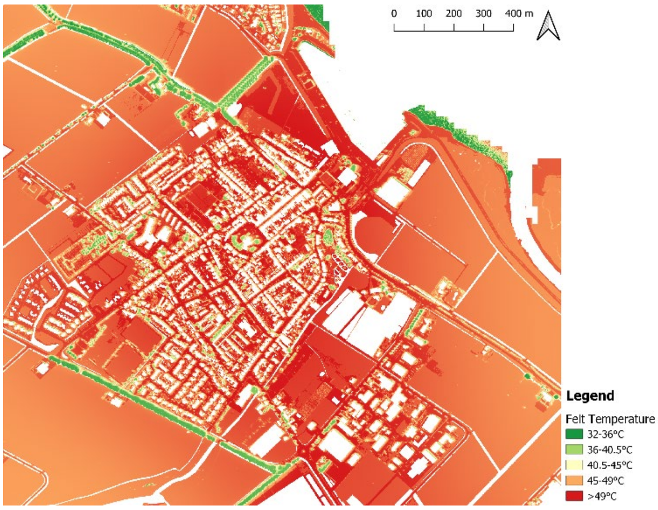
Figure A9: Why the urban heat island effect occurs. Retrieved from: https://land8.com/how-landscape-architecture-mitigates-the-urban-heat-island-effect/

Appendix C1: Background PET-Map

The standard PET-map ranges from 32°C to 49°C. This shows the difference between urban and countryside, but differences within the city are difficult to distinguish (Fig. C1). Therefore, the same scale was used as N&S use in their online tool: 37-51°C. This allows more difference to be visible (Fig. C2). Open Dataportaal Zeeland explains the background of the PET map in more detail (https://dataportaal.zeeland.nl/dataportaal/srv/dut/catalog.search#/metadata/d928f29c-2878-42d4-8e4d-942c8a6b0c6b).

The Bowen Ratio is part of the build-up of the PET-map. This concept is defined as “the ratio of heat flux to moisture flux near the surface” (Encyclopaedia of Atmospheric Science, 2015). Simply put, the Bowen Ratio is one of the components used to calculate evapotranspiration (Buttar et al., 2018).

Fig. C1 & C2 are put side by side to show the difference between the original (left) and the map used in this report (right).



Figures C1 & C2: difference between the standard PET-map and the one used in this research.

Appendix C2: Risk sessions excel-file

See excel-file “Risicosessie lijst”.

Appendix C3: Background risk-sessions

To determine the severity and likelihood of a risk, a method called ‘focus groups’ was used. There was an open discussion between multiple experts from different disciplines (urban green, urban development, human health, etc.) and organisations: experts from the GGD, municipality Middelburg, municipality Tholen) and Province Zeeland, nine participants in total. There were three sessions in which the risks were discussed. During these sessions, possible measures and strategies were discussed as well, using the COMPACT method (Contingency, handing Over. Monitoring, Prevention, Accepting, Correction, Transformation) (Gevers, 2001, *Kansrijk risicomanagement in projecten*).

The outcome can be seen in Figures C3-C4. These figures show the risks outside and inside, which risks can be decreased by taking measures outside and which measures have an interconnection. The distinction between outside and inside shows which risks and measures are within the scope of this research, since this research only focusses on measures outside.

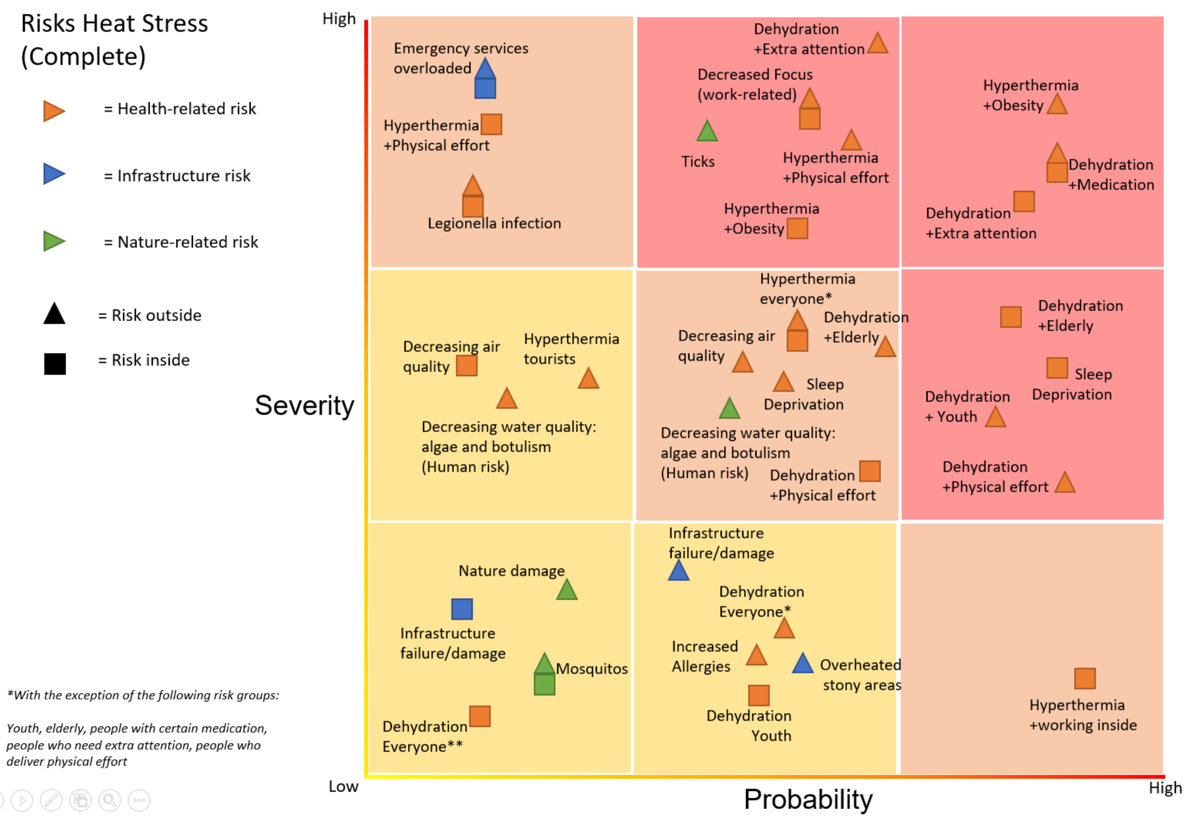


Figure C3: Risks regarding heat stress

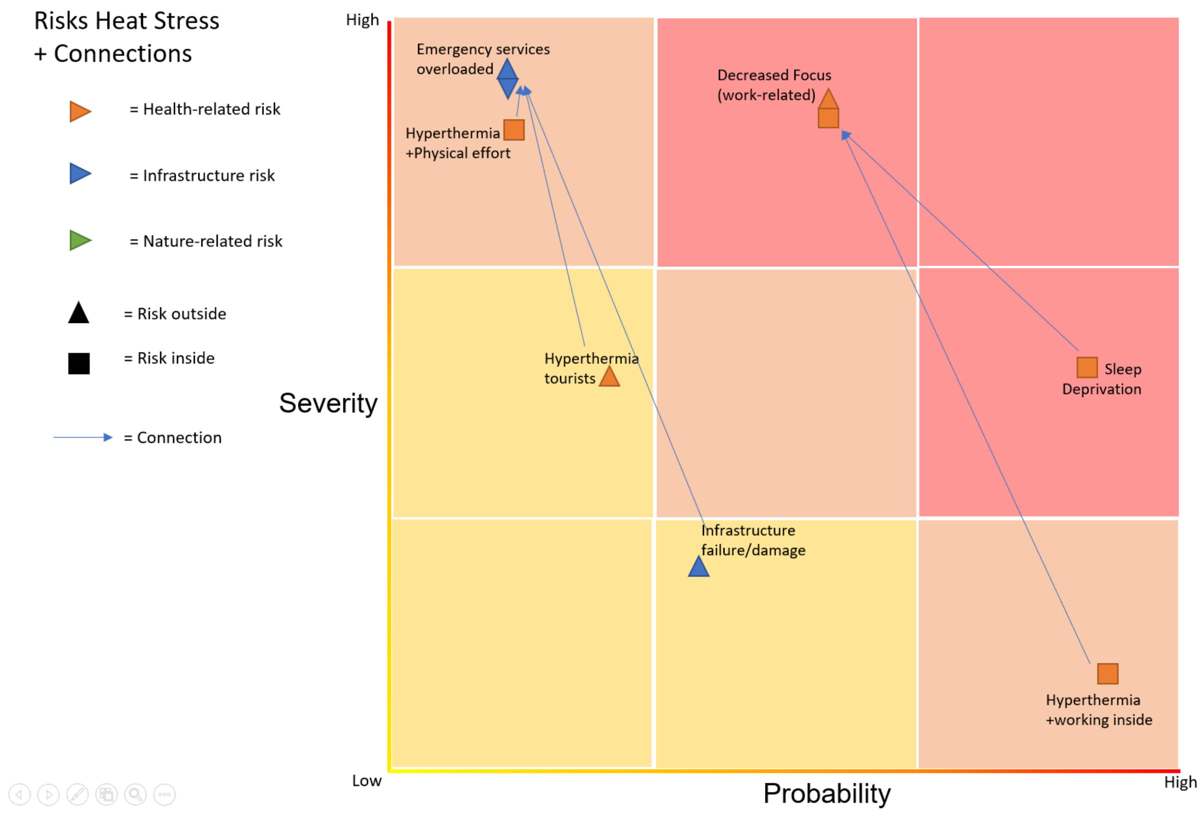


Figure C4: Relations between risks regarding heat stress

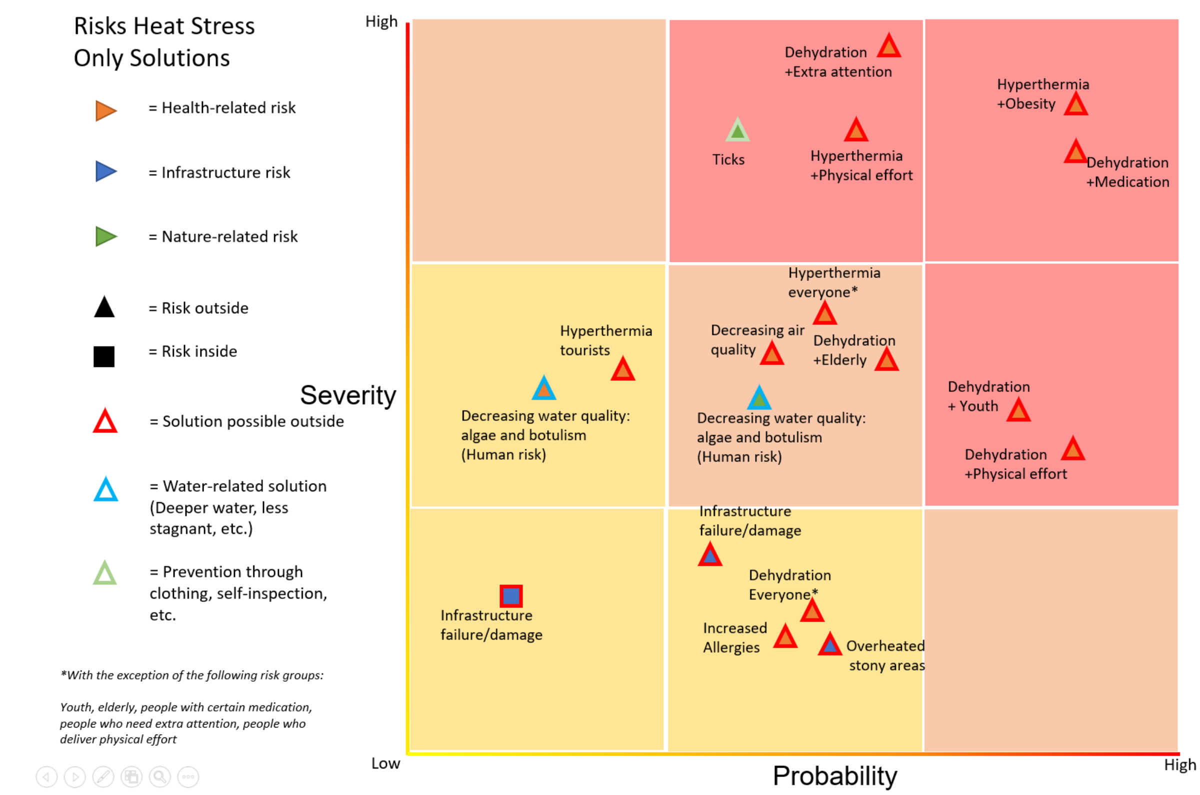


Figure C5: Risks regarding heat stress with a possible solution outside

Appendix C4: Medication increasing heat stress and groups that require extra attention (Dutch)

Medicatie

- anticholinergica bij parkinsonpatiënten, astma- of COPD-patiënten
- vaatvernauwende middelen (vasoconstrictoren) bij sinusitis of rinitis
- vaatvernauwende middelen, bètablokkers, anticoagulantia, ARB- en ACE-inhibitoren bij hartpatiënten of mensen met hypertensie
- diuretica (plaspillen) en laxeermiddelen bij hartpatiënten of mensen met constipatie
- bewustzijns-verlagende medicatie zoals sedativa, antidepressiva en antipsychotica
- ontstekingsremmers (NSAID's) bij mensen met gewrichts- en spierproblemen
- anti-epileptica bij epilepsiepatiënten
- antihistaminica bij allergieën en luchtwegproblemen
- bloedverdunners (voor bijvoorbeeld mensen die een herseninfarct gehad hebben) hebben een uitdrogende werking op het lichaam (Let op: uitdroging is een van de factoren die bijdragen aan een hitteberoerte (herseninfarct door oververhitting))

Groepen waar extra aandacht voor moet zijn tijdens hittestress

- Baby's & kleine kinderen
- Geestelijk/Fysiek gehandicapten
- Dementerende mensen
- Mensen met autisme
- Minder- tot niet-mobiele ouderen (bijvoorbeeld in verzorgingshuizen, maar vooral zij die nog thuis wonen)
- Nieuwe immigranten & buitenlandse toeristen (onvoldoende kennis van bijv. waterkwaliteit uit de kraan in NL, en waterafnamepunten; onzekerheid kan wellicht voor 'verlamming' zorgen)

Appendix C5: Stakeholders Sint-Annaland

During the risk sessions, the stakeholders were divided into two groups: those affected and those who can change the current situation (actors). An overview of this can be seen in Table C1.

Table C1: Stakeholders divided in affected groups and actors

Affected groups	**Actors**
Elderly	Municipality of Tholen
Those with certain medication	Schools
Sporters and physical workers	GGD
Youth	National government
Obese people	Local broadcaster (omroep Zeeland)
Tourists	Employers
Emergency services	Provincial government
Local inhabitants	Shopkeepers
	Recreational sector

Appendix C6: Measures Sint-Annaland and their feasibility

Soort	Maatregel	Verkoelings-principe	Maatregel vooral voor		Typisch schaal-niveau waarop maatregel effectief is		Verkoelende effecten gevonden in literatuur			Extra informatie
							Luchttemperatuur [°C]		Gevels-temperatuur [°C PET]	
			Dag	Nacht	Stad	Lokaal	Stad	Lokaal	Lokaal	
Groen	**Bomen/ leibomen**	verdamping, beschaduwing	X		X	X	0,2 - 2,7	0,7 - 2,7	3,4 - 19,0	Effect afhankelijk van boomtype en -grootte en het lokale klimaat. Referenties zie voetnoot[13]
	Gras/Struiken	verdamping, reflectie	X	X	X	X	0,1 - 1,1	0,9 - 1,2	0,4 - 4,9	Effect van een gezond goed verdampend grasveld. Gras heeft ook effect op oppervlakte-temperatuur (tot 20°C kouder dan beton). Referenties zie voetnoot[14]
	Grasbeton-tegels	verdamping	X	X		X	–	–	–	
	Groene gevels	verdamping	X	X		X	0 - 1,9	0,2 - 1,5	??	Hoe smaller de straat, hoe groter het effect op de luchttemperatuur. Groter effect voor gevels met meer zonnestraling. Referenties zie voetnoot[15]
	Groene daken (extensief)	verdamping		X	X		0 - 1,8	0 - 0,8	–	Een met sedum bedekt groen dak geeft weinig verkoeling 's nachts (vergeleken met een wit dak). Effect op stadsniveau is als 100% van alle daken in de stad groen zijn. Referenties zie voetnoot[16]
	Groene daken (intensief)	verdamping	X	X	X		0 - 1,7	1,0 - 1,6	–	Effect op stadsniveau is als 100% van alle daken in de stad groen zijn. Referenties zie voetnoot[17]
	Park/groene wiggen/vingers in de stad	verdamping, beschaduwing	X	X	X		??	1,1 - 2,0	1,9 - 4,2	Effect afhankelijk van vegetatietype (boom versus gras), boomgrootte , grootte van het park en het lokale klimaat. Effect op PET gemeten in schaduw is groter dan hier genoemd. Referenties zie voetnoot[18]

13 Nouri & Matzarakis (2019); Klok et al. (2019); Lee et al. (2016); Amani-Beni et al. (2018); Wong & Jusuf (2010), Skelhorn et al. (2014); Spangenberg et al. (2008); Abreu-Harbich et al. (2015).
14 Takebayashi & Moriyama (2009); Lee et al. (2016); Amani-Beni et al. (2018); Yang et al. (2018); Klemm et al. (2015); Xi et al. (2012); Chatzidimitriou & Yannas (2016); Cheng & Ng (2013); Lobaccaro & Acero (2015).
15 Hoelscher et al. (2016); Djedjig et al. (2015); Djedjig et al. (2017); Wong et al. (2010); Herath et al. (2018).
16 Solcerova et al. (2017); Santamouris (2014); Sun et al. (2016); Peng & Jim (2013); Ouldboukhitine et al. (2014); Alcazar et al. (2016); Berardi (2016); Herath et al. (2018).
17 Santamouris (2014); Peng & Jim (2013); Speak et al. (2013); Lee & Jim (2019); Jin et al. (2018).
18 Amani-Beni et al. (2018); Klok et al. (2019); Jansson et al. (2006); Klemm et al. (2015); Spangenberg et al. (2008).

Figure C6: Background on green measures according to Kluck et al., 2020

Soort	Maatregel	Verkoelings-principe	Maatregel vooral voor		Typisch schaal-niveau waarop maatregel effectief is		Verkoelende effecten gevonden in literatuur: Luchttemperatuur [°C]		Gevoels-temperatuur [°C PET]	Extra informatie
			Dag	Nacht	Stad	Lokaal	Stad	Lokaal	Lokaal	
Blauw	**Vijvers**	verdamping	X			X	0,5 - 1,3	0,5 - 0,7	0,6 - 3,6	Effect afhankelijk van het temperatuurverschil tussen water en lucht en de grootte van het waterlichaam. Referenties zie voetnoot[19]
	Meer	verdamping	X		X		1,0 - 2,0	0,5 - 1,6	??	Effect afhankelijk van het temperatuurverschil tussen water en lucht en de grootte van het waterlichaam. Referenties zie voetnoot[20]
	Singels/ grachten/ sloten	verdamping	X			X	??	0,1 - 0,8	0,2 - 2,0	Effect afhankelijk van het temperatuurverschil tussen water en lucht en de grootte van het waterlichaam. Referenties zie voetnoot[21]
	Rivier	verdamping, ventilatie	X		X		??	0,5 - 4,0	1,0 - 4,0	Effect afhankelijk van het temperatuurverschil tussen water en lucht en de grootte van het waterlichaam. Referenties zie voetnoot[22]
	Fonteinen	verdamping	X			X	–	1,0 - 4,7	1,0 - 5,0	Referenties zie voetnoot[23]
	Vernevelings-installaties	verdamping	X			X	–	0,7 - 3,0	??	Data zijn van Japanse studies. Referenties zie voetnoot[24]
	Besprenkeling straten	verdamping	X			X	–	0,8 - 3,0	??	Referenties zie voetnoot[25]
	Polderdaken	verdamping	X		X		??	–	–	Effect vergelijkbaar met dat van een intensief groendak. Referenties zie voetnoot[26]

19 Klok et al. (2019); Jacobs et al. (2020); Syafii et al. (2017); Taleghani & Berardi (2018); Taleghani et al. (2014); Fung & Jim (2020).
20 Theeuwes et al. (2013); Saaroni & Ziv (2003); Huang et al. (2008).
21 Klok et al. (2019); Jacobs et al. (2020).
22 Klok et al. (2019); Völker et al. (2013); Hathway & Sharples, (2012).
23 Jacobs et al. (2020); Nishimura et al. (1998); Xue et al. (2015); Gómez et al. (2013).
24 Ishii et al. (2009); Farnham et al. (2011); Yamada et al. (2006); Yamada et al. (2008)
25 Solcerova et al. (2018); Hendel et al. (2016).
26 Andenæs et al. (2018).

Figure C7: Background on blue measures according to Kluck et al., 2020

Soort	Maatregel	Verkoelings-principe	Maatregel vooral voor		Typisch schaalniveau waarop maatregel effectief is		Verkoelende effecten gevonden in literatuur			Extra informatie
							Luchttemperatuur [°C]		Gevoelstemperatuur [°C PET]	
			Dag	Nacht	Stad	Lokaal	Stad	Lokaal	Lokaal	
Grijs	**Parasols/ doeken/per-gola's/arcades/ loggia's/luifels/ schuttingen**	beschaduwing	X			X	–	0 - 1,0	2,0 - 17,0	Genoemde effecten betreffen alleen schaduw door gebouwen. Referenties zie voetnoot[27]
	Zonneschoor-steen	ventilatie	X			X	–	??	??	
	Windcorridors	ventilatie	X		X	X	??	??	??	Windcorridors verhogen de windsnelheid tot 1,5 m/s. Effect op luchttemperatuur en PET is niet gekwantificeerd. Referenties zie voetnoot[28]
	Grote oppervlaktes	ventilatie	X	X	X		??	??	??	De openheid wordt weergegeven door de SVF (sky view factor). Een lage SVF leidt in de zomer tot een hogere temperatuur vanwege het blootgestelde oppervlak en het gebrek aan schaduw. Een 10% hogere SVF zorgt ook voor een toename van de windsnelheid met 8%. Totaaleffect van SVF op temperatuur of PET hangt ook af van albedo, aanwezigheid van vegetatie en hoogte-breedte verhouding straten. Referenties zie voetnoot[29]
	Hoogte-breedte verhouding straten	ventilatie, beschaduwing	X			X	–	??	??	Studies richten zich vaak op droge en hete klimaatzones, niet passend bij de Nederlandse context. Referenties zie voetnoot[30]
	Oriëntatie straten	ventilatie, beschaduwing	X			X	–	max 0,4	max 10,2	Referenties zie voetnoot[31]
	Lichte gevels	reflectie	X			X	–	0,1 - 0,7	??	Referenties zie voetnoot[32]
	Lichte bestrating	reflectie	X			X	–	max 1,9	??	Het wordt aanbevolen om reflecterende trottoirs alleen te gebruiken als als de hoogte-breedte verhouding van de straat niet groter is dan 1,0, anders wordt de straling gereflecteerd naar de gevels. Referenties zie voetnoot[33]
	Witte daken	reflectie	X		X		max 0,9	–	–	0,1-0,3 °C per 10% albedo verhoging Referenties zie voetnoot[34]

27 Nouri et al. (2018); Martinelli et al. (2015); Watanabe et al. (2014); Paolini et al. (2014).
28 Loibl et al. (2010).
29 Yang et al. (2013).
30 Bijvoorbeeld Shashua-Bar et al. (2004); Johansson (2006); Ali-Toudert & Mayer (2006), Andreou (2013).
31 Taleghani et al. (2015).
32 Nazarian et al. (2019); Zhang et al. (2018), Shashua-Bar et al. (2012).
33 Santamouris et al. (2012); Taleghani et al. (2014); Taleghani & Berardi (2018)
34 Santamouris (2014).

Figure C8: Background on grey measures according to Kluck et al., 2020

The feasibility of all these measures can be seen in Table C2

Table C2: Feasibility of all measures described

Measure	Financial feasibility	Social feasibility	Environmental feasibility	Remarks
Trees, tiny forests	5 (€23/m2)	5	5 (3,4-19,0°C PET)	
Green spaces (parks, grass and bushes)	5 (€13/m2)	3	4 (0,4-4,9°C PET)	
Green roofs/facades	1 (€450-800/m2)	3	3 (0,2-1,6°C AirTemp)	
Green parking lots (using grass-concrete pavement)	3 (€60/m2)	?	1 (0°C reduction)	
Open water	5 (€15/m2)	3	3 (0,6-3,6°C PET)	Open water sources can be a source of water-borne diseases, especially when stagnant, which decreases environmental feasibility by 1
Fountains	2 (€100/m2)	?	3 (1.0-5.0°C PET)	Similar to open water sources, fountains can be a source of water-borne diseases.
Wet streets in the evening and morning	?	?	3 (0,8-3,0 Air Temp)	
Polderroof	1 (€450-800/m2)	3	1 (0°C)	
Shading (Umbrellas, canvas, etc.)	5 (€10/m2)	2	5 (2,0-17,0°C PET)	
Open spaces	Depends on situation	?	?	
Light-coloured buildings	4 (€30/m2)	3	1 (0,9°C max. AirTemp)	
Light-coloured streets	5 (€16/m2)	?	2 (1,9°C max. AirTemp)	

Appendix C7: Questionnaire results

See powerpoint "Questionnaire Results".

Appendix C8: Advantages and disadvantages of the measures

This appendix will explain the advantages and disadvantages of all measures excluded from the research.

Tiny Forest

Tiny forests have certain advantages, which are described here (see also: factsheet tiny forests at the end of this Appendix).

Advantages:

Social cohesion is increased, because the idea is that local neighbours plant the trees together (Sharma, 2020). This should also raise awareness about nature, and may have the effect that people will put more green in their garden (Sharma, 2020). On top of that, the forest can be an ideal place for children to play in (Sharma, 2020).

Disadvantages:

Because it is a collection of trees, a tiny forest needs space. One cannot plant a tiny forest in the middle of a street, as it would block traffic. This limits possibilities of placement in a densely populated area.

Green roofs/facades and polderroof

Fig. C9 shows how a polderroof works, which is a green roof with additional water storage De Dakdokters, 2021).

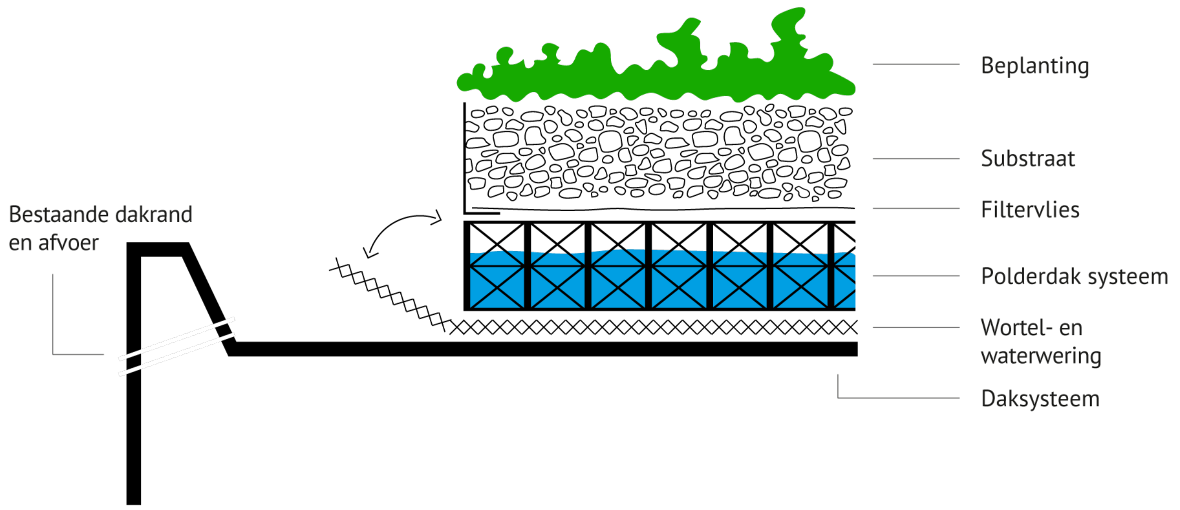


Figure C9: Polderroof schematic. Retrieved from De Dakdokters, 2021

Advantages:

When applied on large scale, green roofs and facades reduce the UHIE. It also reduces temperatures inside the building it is installed on. Green roofs and facades also have a watering system which keeps the plants alive during any period (Pycke, 2021, Webinar Klimaatveiligheid: Hittestress).

Green roofs and facades have, as a main goal, to reduce rainwater run-off. This is thus another advantage (Maslog-Levis, 2014).

Additionally, green roofs and facades increase lifespan of the building it is installed on (Maslog-Levis, 2014)

Disadvantages:

Apart from a slight difference in air temperature and a positive impact on the temperature inside a building, green roofs and facades do not influence felt temperature in any way, as shown in the table by Kluck et al.

On top of that, technical requirements need to be met before a building can support a green roof, which decreases the possibility of implementing this measure on a large scale to reduce the UHIE.

Wet streets in the morning and evening

Advantages:

As with open water, evaporation decreases heat stress here. By applying water in the morning and evening stones do not heat up as much, and cool down faster, which decreases the local temperature, as explained in the theoretical framework.

Disadvantages:

As stated in the theoretical framework, it costs water to apply this measure, while during longer warm periods, water is already scarce.

Open spaces

Advantages:

A large open space means a higher SVF, which in turn causes wind (Kluck et al., 2020). Wind decreases felt temperature, as stated before. An open space can also serve a public role, such as a podium, parking lot, playground, etc. An open space can be the combination of various measures and solutions for a variety of problems.

Disadvantages:

According to Kluck et al (2020) open spaces alone do not necessarily decrease felt temperature, since it also depends on albedo, vegetation and the dimension of streets. One can thus say that just creating an open space is not enough.

Open spaces also require “space” (obviously), which is not always readily available in existing neighbourhoods.

Light-coloured streets and buildings

As can be seen in Fig. C10, in countries like Spain, where mean temperatures are higher than in the Netherlands, buildings are white to keep cities cooler.

Figure C10: White buildings in Spain. Retrieved from Reality Check team, 2019

<u>Advantages</u>:

Making elements in a city or village white decreases the albedo of this element, which decreases the local temperature. This measure is relatively simple to implement and does not require any change in the way a village is built-up, nor does it need as much maintenance as green, for example. White buildings are also cooler inside (Reality Check team, 2019).

<u>Disadvantages</u>:

As Kluck (2020) also indicated, there are certain limits regarding whitewashing streets, since white streets can reflect sunlight in- and onto buildings. This would in turn heat up the buildings, increasing heat stress within them. Therefore, only small parts of a street (or pavement) can be painted white. Blinding traffic should also be avoided.

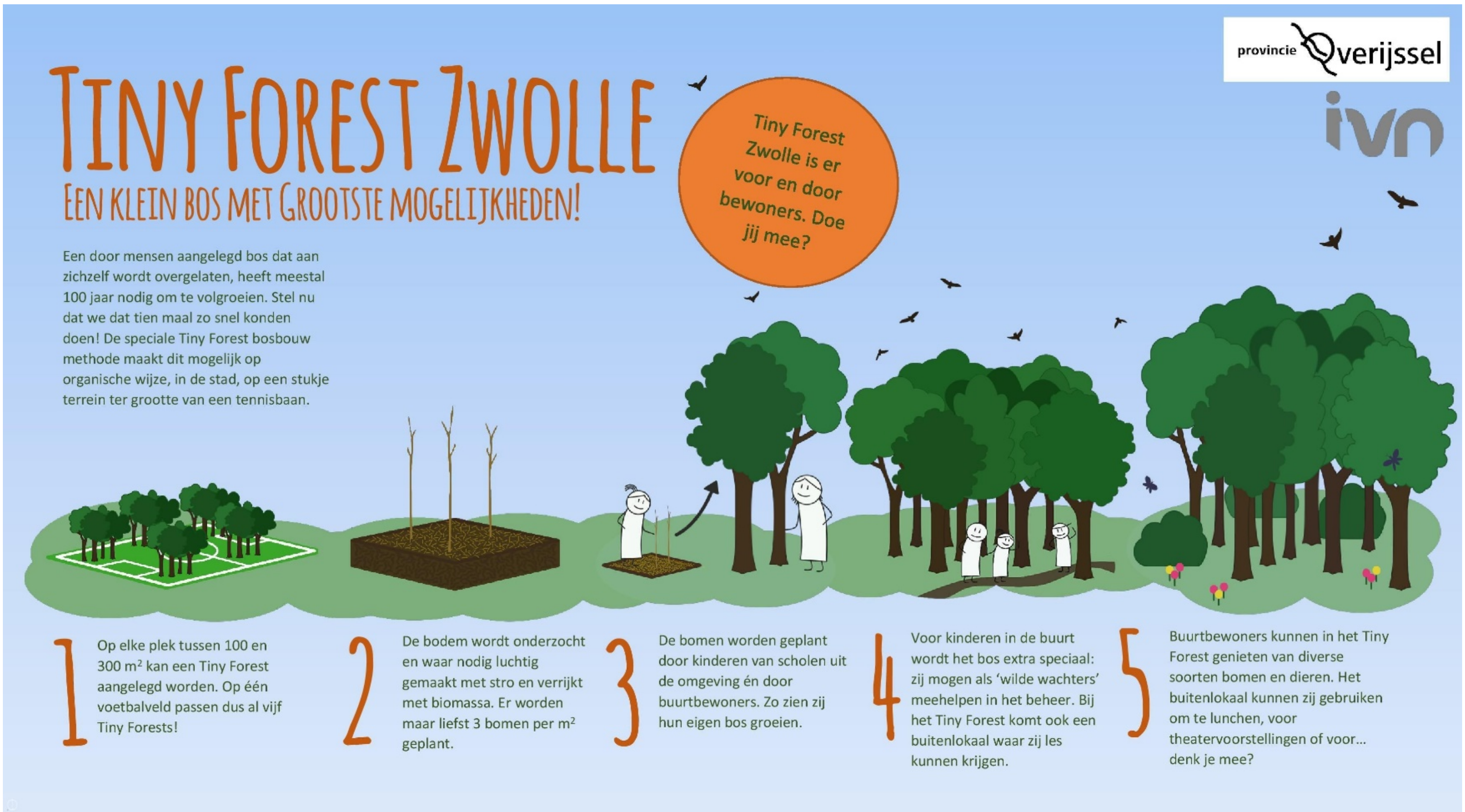


Figure C11: Tiny forests fact sheet, retrieved on 19-5-2021 from http://www.natuurenmens.be/wp-content/uploads/2018/03/c.jpg

Appendix C9: Step-by-step plan explained in Dutch

Op pagina 69 staat het stappenplan in het Nederlands. Hieronder zullen de stappen uitgelegd worden.

1. Hittestress in kaart brengen
    - Open de PET-kaart van Open Dataportaal Zeeland met QGIS
    - Verander de limieten naar 37°C als minimum en 52°C als maximum
    - Een hoge PET-waarde resulteert in meer hittestress (op plekken waar mensen zijn)
2. Leeftijd van inwoners, energie label van woningen en risicogroepen in kaart brengen
    - <u>Indien mogelijk</u>: bepaal het percentage 70-plussers in kaart (TNO, 2010). <u>Anders</u>: gebruik gemiddelde leeftijden van het doelgebied
    - Mensen die in huizen met lage energielabels (D-G) wonen, zullen binnen eerder hittestress ervaren, en daarom misschien eerder buiten verkoeling gaan zoeken. LET OP: dit is een aanname. Daarnaast is de betrouwbaarheid van energielabels twijfelachtig, en niet ieder huis heeft een energielabel, dus gebruik dit aspect alleen als ondersteuning.
    - <u>De volgende mensen vallen onder risicogroepen</u>: jeugd (4-12 jaar), ouderen (70+), mensen met bepaalde medicatie, mensen die extra aandacht nodig hebben, mensen die fysieke inspanning leveren op warme dagen. (de medicatie- en speciale-aandacht-groep wordt uitgediept in Appendix C4)
    - <u>Plekken waar risiscogroepen wonen of overdag hun tijd besteden zijn</u>: Zorgcentra, woningen voor ouderen, scholen, kinderdagverblijven, sportvelden en sportfaciliteiten binnen. De omgeving van deze plekken kunnen extra behoefte hebben aan maatregelen tegen hittestress.
    - Koele plekken moeten ook langs wandelroutes geplaatst worden, zodat wandelaars verkoeling kunnen zoeken op warme dagen. Het wandelknooppuntennetwerk is hierbij een handige hulp (https://www.eilandtholen.nl/wp-content/uploads/Wandelkaart-Tholen-2020.pdf bevat de kaart van Tholen als voorbeeld).
3. Combineer al deze gegevens met QGIS
    - Vergelijk waar de PET-waarde hoog is én risicogroepen aanwezig zijn. Deze plekken hebben het meest behoefte aan verkoeling in de buurt. Hetzelfde geldt voor plekken waar veel woningen energielabel D-G hebben (dit is geen hoofdcriterium) en voor plekken waar meer 70-plussers wonen (of een hogere gemiddelde leeftijd), in combinatie met een hoge PET-waarde. Voeg een laag toe waarin de wandelroutes te zien zijn (of teken ze handmatig in als er geen laag beschikbaar is)
4. Bepaal waar maatregelen nodig zijn
    - Zet een enquête onder de bevolking uit waarmee bewustzijn van hittestress, mate van participatie en wens voor maatregelen gemeten wordt. De resultaten van deze enquête kunnen gebruikt worden bij de besluitvorming. Gemeente Tholen beschikt over een goed voorbeeld van een dergelijke enquête.
    - Pak niet de gebieden aan met de hoogste PET-waarden, maar verspreid koele plekken over het doelgebied op dusdanige manier dat iedere bewoner op flip-flop afstand (maximaal 250 meter) van een koele plek woont (Kleerekoper, 2021).
        - Dit kan in kaart worden gebracht met QGIS door op de PET-kaart een puntenlaag toe te voegen en deze punten een buffer met 250 meter radius te geven. Als het hele doelgebied bedekt is door de punten kaart, woont

iedereen op flip-flop afstand van minimaal één koele plek. Houd hierbij ook rekening met de wandelroutes.

- De plekken met lage PET-waarden kunnen als plekken dienen waar mensen verkoeling kunnen zoeken

5. a) Bepaal per locatie welke maatregelen genomen kunnen worden
    - Op volgorde van geschatte plaatselijke temperatuurreductie zijn bomen (tot -19°C), schaduwdoeken/paraplu's (tot -17°C), open groene plekken (tot -4,9°C) en oppervlaktewater (tot -3,6°C) de beste oplossingen, afgaande op dit onderzoek.
    - Als er voldoende ruimte is, zijn bomen altijd de beste keus
    - Winkelstraten en plekken waar bomen niet mogen/kunnen staan kunnen verkoeld worden met schaduwdoeken/paraplu's. Let hierbij wel op dat verkeer niet wordt belemmerd.
    - Een nadeel van grotere oppervlaktewateren is dat het de nachtelijke hittestress (hitte-eiland effect) juist bevordert bij langdurige warmte. Kleine oppervlaktewateren hebben dit nadeel niet, maar verkoelen de omgeving ook aanzienlijk minder. Ook kan dit water in warme periodes een broedplaats zijn voor ziekteverwekkers. Dit kan ingeperkt worden door een goede stroming in het water te houden. De voor- en nadelen moeten goed worden afgewogen.

    b) Bepaal voor elke maatregel per locatie hoeveel de temperatuur zal dalen

    - Ter verzekering kunnen de maatregelen ingetekend worden in de PET-kaart met behulp van de hittetool van Nelen & Schuurmans, of iets vergelijkbaars (zie bijvoorbeeld Toolbox Klimaatbestendige Stad van Kennisportaal Klimaatadaptatie). Deze tool kan laten zien hoe de omgevingstemperatuur verandert als, bijvoorbeeld, bomen van verschillende groottes geplaatst worden in het doelgebied.

    c) Bepaal de financiële en sociale uitvoerbaarheid per maatregel op iedere locatie

    - De plaatsings- en onderhoudskosten kunnen per situatie verschillen. Dit kan invloed hebben op de besluitvorming. Bereken de kosten met inbegrip van ten minste 1 jaar onderhoud
    - De sociale uitvoerbaarheid kan bepaald worden met resultaten van eerder gehouden enquête. Afhankelijk van de situatie kan er ook voor gekozen worden informatieavonden te organiseren of werkgroepen met bewoners in het leven te roepen.

De volgende stappen gaan in op de implementatie van hittestressmaatregelen. Het doel van deze stappen is de meekoppelkansen goed in beeld te brengen. Het samenwerkingsverband AZON kan hier een grote rol in spelen.

6. a) Ga na waar droogte of wateroverlast is en welke plannen hier al voor zijn
    - Oplossingen voor hitte kunnen vaak ook helpen bij het verminderen van droogte en wateroverlast (bomen bijvoorbeeld kunnen alle drie verminderen). Hier kan dus meegekoppeld worden. Het beste kan in QGIS één kaartlaag met water overlast, één met droogte en de PET-kaart gebruikt worden om overlap te vinden tussen de drie

    b) Onderzoek welke plannen er al zijn op gebied van infrastructuur

- Als vantevoren bekend is wanneer een weg opengebroken of gerenoveerd wordt, kan hiermee rekening gehouden worden bij het plannen van hittestressmaatregelen. Ook dit kan inzichtelijk worden gemaakt met QGIS
    - Dit kan bijvoorbeeld gedaan worden door wegen rood, geel of groen aan te merken, afhankelijk van hoe snel ze opengebroken of gerenoveerd zullen worden. (*aanname*)

c) Beantwoord alle relevante vragen van de checklist (zie volgende bladzijde)

- Deze antwoorden helpen wederom bij het vinden van meekoppelkansen.
- Of een vraag relevant is, moet per situatie beslist worden.

7. Combineer alle informatie en data met QGIS, onderzoek waar overlap is met hittestressmaatregelen en bepaal waar en wanneer een maatregel zal worden uitgevoerd
    - Alle informatie inzichtelijk in kaart brengen helpt om te beslissen welke maatregelen direct moeten worden uitgevoerd, welke kunnen wachten, en welke (nog) niet nodig zijn. Hieruit volgt een volgorde waarin maatregelen tegen hittestress genomen kunnen worden.

Als laatste kunnen de gekozen maatregelen gevisualiseerd worden op de DAPP-kaart (zie Appendix C10). Deze kaart bevat de onderzochte maatregelen. Door voorgaande stappen te volgen kan een volgorde gemaakt worden. Dit kan in deze kaart met een lijn gevisualiseerd worden.

Stappenplan tegen hittestress

1 Hittestress in kaart brengen met PET-kaart

2 Leeftijd van inwoners, energie label van woningen en risicogroepen in kaart brengen

3 Combineer deze gegevens met QGIS

4 Bepaal waar maatregelen nodig zijn

Risicogroepen:

Jeugd (4-12 jaar)

Ouderen

Mensen met bepaalde medicatie

Mensen die extra aandacht nodig hebben

Mensen die fysieke inspanning leveren op warme dagen

5 Bepaal per locatie welke maatregelen genomen kunnen worden → Bepaal voor elke maatregel per locatie hoeveel de temperatuur zal dalen → Bepaal de financiële en sociale uitvoerbaarheid per maatregel op iedere locatie

6 Ga na waar droogte of wateroverlast is en welke plannen hier al voor zijn → Onderzoek welke plannen er al zijn op gebied van infrastructuur → Beantwoord alle relevante vragen van de checklist

Checklist

Omgeving en Klimaat

- ❑ Welke gebieden zijn gevoelig voor wateroverlast?
- ❑ Welke gebieden zijn gevoelig voor droogte?
- ❑ Welke plannen zijn er op dit moment om droogte en wateroverlast tegen te gaan?
- ❑ Welke plannen zijn er voor de begraafplaats van het dorp?
- ❑ Kunnen deze gecombineerd worden met maatregelen tegen hittestress?
- ❑ Hoe kunnen bewoners bewust gemaakt worden van de positieve effecten van groen? Kunnen zij bij het proces/project betrokken worden?
- ❑ Hoe kan biodiversiteit bevorderd worden?

Ruimtelijke Ordening

- ❑ Waar en wanneer zijn herstructureringsplannen gepland?

Infrastructuur

- ❑ Welke plannen zijn er voor het riool en de weg?
- ❑ Wanneer worden wegen opengebroken?
- ❑ Waar zijn parkeerproblemen?

7 Combineer alle informatie en data met QGIS, onderzoek waar overlap is met hittestressmaatregelen en bepaal waar en wanneer een maatregel zal worden uitgevoerd.

Appendix C10: DAPP-map in Dutch

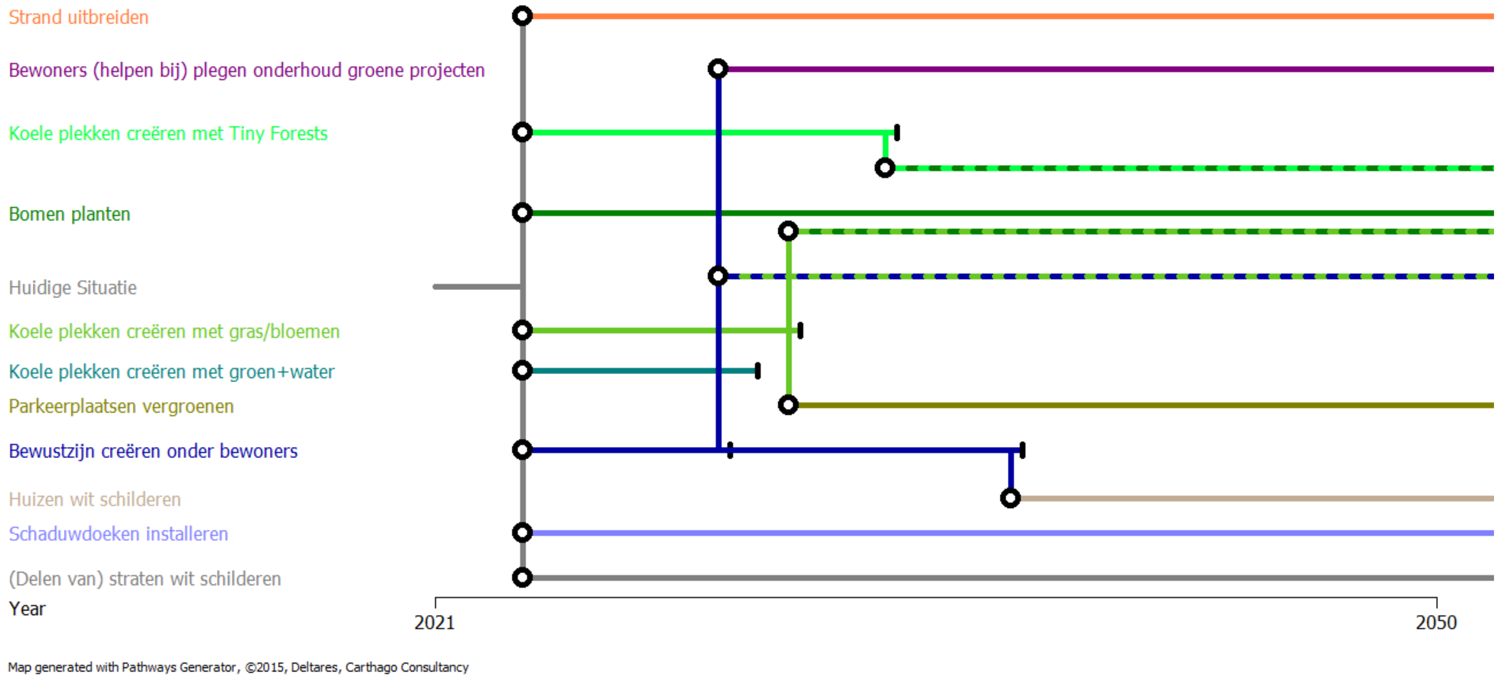


Figure C12: DAPP-map in Dutch

Appendix C11: Summary discussion during risk sessions

Since the results of the risk sessions are included in previous appendices, so this Appendix will shortly summarize the process and highlight the most important details.

In short, the first risk session was used to explain the concept and to start with rating the various risks. During the first two sessions, all human-related risks regarding heat were assessed, since these were the most applicable for the research. The third session was used to discuss the remaining risks and to wrap up this part of the process.

The following experts were part of these risk sessions:

Risk session 1

The risk group youth was added and defined because of advice of several participants. This addition was made because young people (4-12) tend to forget to drink during warm periods. During this risk session it was also explained that this method cannot be compared to thorough science, because it relies on the knowledge and discussion of experts. The list of risks is a result of theoretical research, but rating the severity and likelihood is not done with theoretical research.

At some point during the risk session there was a lot of discussion regarding dehydration of elderly, because the group had difficulty rating the likelihood. Expert 1, who had prior experience filling in similar overviews said that it is best to not think too long about one detail and learn as the process of filling it in continues. This advice was followed.

It was interesting to see that during all these risk sessions prevention through informing is a recurring way to reduce heat stress effects.

During this research it was also proposed that the experts all filled out the table individually, after which all could discuss their outcomes during a next session, but all agreed that the oral discussion was benefitting the results of the risk sessions.

At the section Nature, two different insects were specified (Ticks and Mosquitos), because these two are generally the species that cause the risks, and because the risks are very different from each other. On top of that it is more a risk because of climate change than because of heat stress, said Expert 2. Also, damage to nature is caused because of drought, rather than because of heat, which is why it was scored lower during the risk session.

It was agreed upon to make additions to the table after the first session, so that it can be discussed during the next session. These additions included “Soort gebied”, splitting “Meer algen” into human-related and nature-related risks,

Risk session 2

During the second session, every participant knew how the process went, which made the meeting more smooth. This session again focussed on addressing the human-related risks. Some risks, like the one regarding tourists, are only present either inside or outside, which is why some likelihoods were left blank.

Again prevention through informing was suggested as a measure against multiple risks. For the labourproductivity, the effect of heat stress was also taken into account regarding the impact it may have on the economy, not solely on human health. However, this was difficult to assess, because the period of the heat wave has an impact on the effect a lot, according to the experts. The fact that open water increases temperatures at night during warm periods means that Zeeland has the warmest nights during these periods (Expert 1).

Expert 3 said that sleep deprivation due to heat is not disadvantageous for many, but those who have jobs which require careful attention can experience the disadvantages of it a lot more than the average person.

Many risks after this session also turned out to be solvable by behavioural changes from people themselves.

Risk session 3

During this risk session the remaining risks were assessed. These risks were not necessarily related to human health, but to infrastructure, nature and others.

Expert 1 started a discussion about whether legionella could be present in drinkwater pipes. After some research by the experts it turned out that this was in fact possible. One measure to reduce this risk was to install the pipes in the shadows.

Expert 3 added to the mosquitos part that ended pig-farms can be a source of a mosquito-species that can carry malaria, which is why these farms have to be cleaned fast.

It was decided to not assess "Soort gebied" with numbers, because Expert 1 could give some background information on this subject, but it was not necessary to give numbers. The following is what Expert 1 said:

> *"Inner city has higher temperatures than the sub-urbs. The higher in an apartment block, the higher the temperature, according to BPIKA-research. When it is dry, countryside can become very warm as well. In Middelburg, measurements are taking place. This research is showing that, at night, sub-urbs are cooler than the inner city and a parcel without vegetation (without evapotranspiration, thus) is significantly hotter than the parcel next to it. Shadow of buildings (and trees) does decrease felt temperature outside. Lighter streets decrease temperatures as well."*

The results of all of these risk sessions can be found in previous appendices.

Appendix C12: Summary of the interviews

Four experts were interviewed during this research, to further deepen knowledge gained from the risk sessions. To not rely on verbal communication with experts too much, the choice was made to only interview these four experts and no more. Their information is only used to clarify a small portion of the report, and some of their recommendations are put in this report's recommendations as well. First background questions were asked to interviewees. However not all had enough time to answer these, which is why they are not included in all interviews.

Expert 3(GGD)

Wat is uw rol binnen de organisatie?

Adviseur milieu en gezondheid. Alles wat met omgevingsfactoren en gezondheid te maken heeft. Burgers en gemeentes en gemeente kunnen vragen stellen. Daarnaast geeft de GGD gevraagd en ongevraagd advies over milieu en gezondheid. Ook wordt nazorg geboden bij rampen/grote incidenten, bijvoorbeeld na brand, als aanspreekpunt.
Hittestress heeft vooral met gedragsverandering. Kan Het Weer het beter vertellen dan GGD of overheid. Vanuit de overheid kan het belerend overkomen. Hitteprotocol door KNMI, GGD uitvoerend als informant

Heeft u zelf wel eens met gevolgen van hittestress te maken (gehad)?

Nee, eigenlijk niet. Wel eens slechter slapen door de warmte. De kleine gevolgen van hittestress wel meegemaakt.

Hoe beschermt u zichzelf tegen hittestress?

Woning zo koel mogelijk houden. Geen inspannende activiteiten als het echt heel warm is. Kan met water op het aanrecht laten staan. Moet zichzelf ervoor aansporen.

1. **Aan welke (3-5) vereisten moeten hittestressmaatregelen voldoen? Waarom?**

1) uitvoerbaarheid, geef advies in verschillende gradaties. 2) Begrijpelijk. Leg uit waarom iets moet worden gedaan, dan zijn mensen eerder geneigd om de adviezen op te volgen. Schrijf op een begrijpelijke manier. 3) Specifiek. Laat de boodschap aansluiten bij de doelgroep.

2. **Hoe wordt hittestress door GGD op dit moment aangepakt? Welke plannen zijn er voor de toekomst?**

Vooral in het adviseren, let op binnen in het huis koel te houden. Vragen beantwoorden tijdens warme periodes.

Vraag: Hoe adviseren jullie wat betreft beplanting in tuin?
Antwoord: Twee adviezen: preventief en reactief. Liever preventief, 'dit zijn de maatregelen die je kan treffen, begin op tijd met het gebruik van nachtkoelte.' Daar kan GGD nog een slag in maken. Vaak dus reactief vanwege beperkte capaciteit. Via KASZeeland kunnen ze beter informeren over preventieve maatregelen.
Risico van kind of dier achterlaten in auto in de hitte wordt onderschat.

3. **Wat zijn de voordelen van de maatregelen die de GGD op dit moment neemt (of: voordelen van manier van informeren)?**

Minder oververhitte personen, minder slachtoffers. Minder druk op de zorg. Geen verschil in manier van informeren tussen Gemeente en GGD.

4. **Wat zijn de nadelen van de maatregelen die de GGD op dit moment neemt (of: nadelen van manier van informeren)?**

Doelgroep wordt soms niet bereikt door medium dat gebruikt wordt. Je krijgt een blinde vlek, dus van tijd tot tijd evalueren hoe je informeert en hoe je daarin kan verbeteren. Te weinig preventief informeren.

5. **Welke rol speelt burgerparticipatie volgens jou? En hoe kunnen burgers goed worden betrokken bij hittestress projecten?**

Zodra een project op touw is gezet kan GGD informatie geven, welke soort planten/bomen ivm bijvoorbeeld allergie. Gemeente neemt vaak die rol op zich, met informatie die door GGD verstrekt is.

<u>Vraag:</u> Zou GGD meer autoriteit uitstralen dan de gemeente?
<u>Antwoord</u>: Kan maar dat is afhankelijk van het onderwerp en of er wel of geen argwaan is bij bewoners. Bij hitte en participatie verwacht ik dat niet.

6. **Het gebruik van water (water, fonteinen, etc.) verkoelt een stad, maar bij hoge temperaturen kan open water een bron van ziektekiemen worden. Hoe, denkt u, kunnen we dit voorkomen?**

Het kan voorkomen worden door goed doorstroming. Zodra het stilstaat wordt het een warmtebron. Helemaal voorkomen is moeilijk. Goede zuiveringsinstallatie met name voor zelfaangelegde systemen als fontein etc. Tot een bepaald niveau kan dit, anders als het kan water weghalen, in Rotterdam en Emmen gebeurt dat ook.

<u>Vraag</u>: Technische installaties veroorzaken ook warmte, hoe rendabel is het dan nog?
<u>Antwoord</u>: Klopt, exacte verhouding weet ik niet. Fontein koelt altijd af, maar combineer met bomen, verstening eromheen is inefficiënt.
Onderzoek laat zien: Als je park goed inricht, gebruiken veel verschillende doelgroepen het park op verschillende manieren.

Expert 4 (Municipality of Middelburg)

Wat is uw rol binnen de organisatie?

Senior projectleider. Achtergrond civiele techniek. Mortiere, Essenveld, 2 Europese projecten tegen extreem weer. 4 projecten voor herinrichting openbare ruimte klimaatbestendig inrichten. Meer generalist dan specialist op een bepaald gebied.

Heeft u wel eens met hittestress te maken gehad?

Niet echt. Afgelopen zomers was het best warm, wel wat minder lekker slapen. Ik kan redelijk tegen de warmte, maar ga niet in de zon zitten.

Hoe beschermt u zichzelf tegen hittestress?

Ik zoek de schaduw op, houd het huis dicht, zonwering naar beneden en sabonds wat open zetten.

1. **Aan welke (3-5) vereisten moeten hittestress maatregelen voldoen? Waarom?**

Moeten effectief zijn: niet per se temperatuurverlagend, maar schaduw creëren, gevoelstemperatuur verlagend. Betaalbaar, kostenefficiënt. Op logische plaatsen, plekken waar mensen zijn, aantrekkelijk, niet in een park waar al schaduw is, maar op een markt/schoolplein/plek waar je wil dat mensen naartoe gaan.

2. **Op welke manier neemt Gemeente Middelburg maatregelen tegen hittestress? Welke plannen zijn er voor de toekomst?**

Cool Towns: op twee locaties maatregelen getroffen om hitte te verminderen, om ervaring op te doen. Klimaatkaarten opgesteld om hitte in kaart te brengen. Omgevingsvisie: Richt op openbare ruimte, proberen grijs te vervangen met groen, trends meenemen (in de teokomst bijv. minder autos). In de herinrichting openbare ruimte rekening houden met wateroverlast en hitte, niet bereken met modellen, maar met boerenverstand (schaduw is altijd een goede maatregel). Maatregelen uitvoeren waarvan je later geen spijt krijgt.

<u>Vraag</u>: Welke afwegingen grijs vervangen door groen?
<u>Antwoord</u>: Rekening houden met mobiliteit inwoners, verkeersveiligheid, overmaat aan grijs herinrichten naar groen → grijsonderhoud wordt minder (groenonderhoud is goedkoper), door groen wordt ook de buurt aantrekkelijker. Leefbaarheid is ook belangrijk in gemeente Middelburg. Omgevingsvisie Amsterdam heeft leuke voorbeelden. Meekoppelen proberen we zoveel mogelijk te doen, alles op een hoop vegen en dan kijken waar overlap is.

3. **Wat zijn de voordelen van deze maatregelen?**

Leefbaarheid gaat omhoog, je merkt dat de temperatuur omlaag gaat. Aantrekkelijker dan grijs gebied. Lager in kosten. Beter voor biodiversiteit.

4. **Wat zijn de nadelen van deze maatregelen?**

Als je gaat vergroenen moet er ook beheer bij, dat kan niet zonder elkaar. Je hebt altijd wel een beetje weerstand van bewoners.

5. **Hoe worden burgers betrokken bij de beslissingen van deze maatregelen?**

Participatie staat bij gemeente Middelburg hoog in het vaandel. Bij zo goed als alle grootschalige projecten worden bewoners betrokken. Probeer input te krijgen wat ze anders willen zien en wat ze willen houden. Terug communiceren nadat input is verwerkt en vragen of bewoners zich daarin herkennen.

Vraag: Is het Molenwaterpark-project een voorbeeld van hoe participatie gaat normaliter?
Antwoord: In het verleden was het een molenwater dat gebruikt werd om grachten in de stad door te spoel tegen afval en dichtslibbing, de grachten bevaarbaar houden. Daarna groot verhard park met bomen en grind waar militairen konden marcheren. Na Tweede Wereldoorlog werd Miniatuur Walcheren aangelegd. 2010 is MW verhuisd, toen was het een kaal park. Eerst een mislukt plan waarbij bewoners de touwtjes in handen hadden. Toen heeft gemeente het naar zich toe getrokken en kregen Europese subsidie om wateroverlast wegens extreem weer tegen te gaan. De buurt eromheen werd afgesloten van riool zodat regenwater in het park kan worden opgevangen. Veel bewoners vonden dat het park al prima was.

Vraag: Hoe zijn deze bewoners wel overstag gegaan?
Antwoord: Je krijgt nooit iedereen mee, maar het merendeel vonden het na schetsontwerpen en animaties mooi. Werkgroepen bestonden uit bewoners scholen en andere plaatselijken, onder begeleiding van medewerkers van de gemeente. Ondertussen goed communiceren en laten weten welke stappen er zijn. Van tevoren goede kaders stellen en die ook communiceren naar de belanghebbenden. Anders ontbreekt er samenhang.

Vraag: Hoe verhoudt zich dit tot normaal participatie?
Antwoord: Niveaus participatie. De trede wordt gekozen op basis van grootte en impact van het project. Straat her-bestraten: informeren. Maar als het uiterlijk van een omgeving er heel anders uit gaat zien een hogere trede. Eerst in de krant en op sociale media, in een brief vertellen dat er iets gaat gebeuren. In die brief worden mensen uitgenodigd om mee te denken. Geef ze de gelegenheid om iets te vinden van de plannen.

Vraag: Ook op basis van wat burgers willen que participatie?
Antwoord: Vaak weten we van tevoren niet hoe mensen tegenover participatie staan, dus het is goed om ook hierin vooraf kaders te stellen. Op het moment dat het traject wordt gestart zie je hoeveel participatie er is.

6. **Het Molenwaterpark-project heeft veel open water. Hoe wordt voorkomen dat dit water een bron van ziektekiemen wordt, nu en in de toekomst**

De vijver in het park is niet aangelegd om hittestress te bestrijden, maar dat hoort bij een park, net als de fontein. Het is niet de bedoeling dat erin gezwommen wordt. De bomen en planten eromheen zijn er om hitte te verminderen. Er is de keuze gemaakt om een fontein te plaatsen en mensen te waarschuwen met bordjes dat het geen zwemwater is.

Expert 5 (Municipality of Vlissingen)

1. **Aan welke (3-5) vereisten moeten hittestressmaatregelen voldoen? Waarom?**

Maar 1 vereiste: Het moet efficiënt zijn. Min mogelijk geld, zoveel mogelijk rendement. Maatregelen moeten geen doel op zich zijn, maar moeten een middel zijn om de openbare ruimte goed in te richten. Geen problemen creëren die er niet zijn. Omdenken. Goede afwegingen maken. Burgers zijn bezig met alle aspecten van hun wijk, niet alleen hitte of alleen water of etc. Burger maakt integrale afwegingen. Vlissingen werkt veel integraler dan 10 jaar geleden. Tholen en Vlissingen zijn anders, want het een is landelijk en het andere is stedelijk. Integraal werken is niet gerelateerd aan budget. De opgaven zijn anders in stedelijk gebied dan in kleinere kernen. Integraal werken is efficiënter. Voorbereidingstijd duurt veel langer, alles in kaart brengen, alle belanghebbenden horen.

2. **Hoe wordt hittestress in Vlissingen op dit moment aangepakt? Welke plannen zijn er voor de toekomst?**

Openbare ruimte integraal aanpakken. Meekoppelen. Meerdere problemen aanpakken. Waar opgave riolering, waar groene opgaven, parkeerproblemen, etc. Combineren in GIS en dan beslissen wat aangepakt wordt. Hele openbare ruimte een kwaliteitsimpuls geven. Combinatie van veel verschillende oplossingen voor veel verschillende problemen. Hittestress is er voor iedere straat.
Opgave in Zeeland: Overdag verkoelt de zee, maar het probleem komt 's nachts, wanneer de zee de omgeving opwarmt. Versteende wijken bij zee warmen op. Groene wijken hebben significant lagere temperaturen, vooral 's nachts.
Nachtelijke hittestress is misschien juist de grootste opgave voor heel Zeeland.
Vraag: Het is dus meer een kwestie welke plek ipv welke maatregel in het geval van hittestress?
Antwoord: Als je warmte voorkomt, voorkom je hittestress. Kan bijvoorbeeld door heel de stad wit (zoals in Griekenland) of grasdoorlatende tegels, maar je kan hittestress niet met een soort beslisboom aanpakken. In Vlissingen is het onderdeel van geïntegreerd proces. Alle problemen van verkeer, sociaal, veiligheid, klimaatadaptatie, maar ook alle belanghebbende vragen wat er speelt in een buurt. Dan met alle bewoners overleggen wat zij als verandering willen zien. Bewoners kunnen aangeven welke problemen ze belangrijker of minder belangrijk vinden. Leg de verantwoordelijkheid deels bij de burger zelf weg.

3. **Wat zijn de voordelen van de maatregelen die gemeente Vlissingen op dit moment heeft geïmplementeerd?**

Veel verschillende opgaves tegelijk aanpakken. Je hebt een visie voor lange perioden, waarbij alle buurten en straten op hetzelfde kwaliteitsniveau. Er worden verbindingen gemaakt tussen alle kleine projectjes, het blijft een eenheid. Daardoor is het goedkoper, en van hogere kwaliteit. Het maakt ook implementatie eenvoudiger.

4. **Wat zijn de nadelen van de maatregelen die gemeente Vlissingen op dit moment heeft geïmplementeerd?**

Niet voor elk afzonderlijk onderdeel een 10 halen. Er moeten compromissen gesloten worden. Is het echt een nadeel? Voorwerk is veel langer (aan de andere kant is implementatie eenvoudiger, beter en goedkoper).

5. **Hoe zouden inwoners kunnen worden betrokken bij het verminderen van hitte en hittestress?**

In een nieuwe wijk is geen hemelafvoer aangelegd. Bij veel neerslag gaat water via straat naar plaatselijk oppervlaktewater, dus geen wateroverlast dan. Dat is bij iedereen besproken die daar gaan wonen. Geven van tevoren aan hoe tuin goed in te richten. Soms gaat het mis bij hoveniers. Ook hittestress wordt meegenomen, iedere tuin minimaal een boom. Vraag: Hoe doe je dat in bestaande wijken? Antwoord: Lastiger. In sommige wijken is al veel groen. Woningen van woningcorporaties hebben bewoners met minder groene vingers. Ofwel veel stenen of braakliggend (is dan weer goed voor biodiversiteit. Woningcorporaties vertellen bewoners dat verstening negatieve effecten heeft.

Alle disciplines inventariseren wat de problemen zijn, woningcorporaties bevragen, vervolgens bewoners vragen waar zij problemen zien. Op basis daarvan beslissingen maken door alles te combineren. Vertellen wat gemeentelijke opgaven zijn, en verbinden aan de problemen van de burgers. Niet iedereen krijgt zijn zin, maar iedereen werkt mee aan een zo goed mogelijk plan. Draagvlak kan je niet creëren, dat moet ontstaan, door een goed plan. Een goed plan trekt mensen, een slecht plan stoot mensen af, dat beïnvloedt draagvlak grotendeels.
De meeste dingen die bewoners noemen zijn al lang in beeld, maar door ze te betrekken kan je bepaalde accenten leggen. Als parkeren en groen even belangrijk zijn volgens de gemeente, heeft de bevolking de doorslag, bijvoorbeeld.

6. **Het gebruik van water (water, fonteinen, etc.) verkoelt een stad, maar bij hoge temperaturen kan open water een bron van ziektekiemen worden. Hoe, denkt u, kunnen we dit voorkomen?**

Hittestress wordt ‘s nachts vergroot, zuurstofloze water wordt opgepompt. Ik ben absoluut geen voorstander van fonteinen.

Expert 6 (Municipality of Borsele)

Wat is uw rol binnen de organisatie?

Beleid klimaatadaptatie, ook duurzaamheid, geen plannen maar meedoen aan opstellen KAS. Bewoners informatie geven tijdens infoavonden, adviserende rol. Probeert breder denken, denk aan meekoppelkansen

1. **Aan welke (3-5) vereisten moeten maatregelen tegen hittestress voldoen?**

1) Gezondheid, 2) verkoeling, 3) vermijden van belemmering (zonnepanelen bijv.), 4) beweging mogelijk houden (in schaduw) (sportvelden hebben namelijk vaak geen schaduw rondom)

2. **Hoe wordt hittestress op dit moment aangepakt in Gemeente Borssele? Welke plannen zijn er voor de toekomst?**

Nog niet echt, vooral vergroening (groenstructuurplannen), nu concept maken en ermee aan de slag als er geld is. Groene schoolpleinen IVN is ook een interessant initiatief.
Vraag: Hoe pakken jullie het maken van die plannen aan, alleen of in combinatie?
Antwoord: In combinatie met wateroverlast, dat is vooral leidend, een collega is wel alert op bomen.
Vraag: Wat is de toekomstvisie op gebied van hittestress?
Antwoord: KAS toepassen op Borsele. Ook sociaal begint erover nagedacht te worden (mantelzorgers voor ouderen bijv.)
In nieuwe woonwijk wordt hittestress meegenomen: de "Natuur-inclusieve leefomgeving."

3. **Wat zijn de voordelen van de maatregelen die jullie nu nemen?**

Kwaadendamme: Tiny Forest, leuk voor kinderen. Twee buren: één heeft een versteende tuin, de ander een tuin met boompjes, iemand uit het dorp merkte het verschil. Mensen worden bewust door goed te informeren, ook via sociale media, daarom communiceren wij nu alvast over hitte van komende zomer.

4. **Wat zijn de nadelen van de maatregelen die jullie nu nemen?**

Niet iedereen zit erop te wachten. Onderhoud geeft financieel misschien problemen (nog niet geïnventariseerd). Alles is nog heel onbekend.

5. **Hoe belangrijk is burgerparticipatie bij het nemen van maatregelen volgens u? En hoe kunnen burgers goed betrokken worden bij dit soort projecten?**

Heel belangrijk, er moet draagvlak komen, je kan niet zonder de bewoners. Bijvoorbeeld door concrete voorbeelden tijdens een bewonersavond om het praktisch te maken. Betrek bewoners bij beslissingen. Heel veel koppelingen maken, de meekoppelkansen herkennen en benutten

6. **Het gebruik van water (water, fonteinen, etc.) verkoelt een stad, maar bij hoge temperaturen kan open water een bron van ziektekiemen worden. Hoe, denkt u, kunnen we dit voorkomen?**

Bij warme periodes heb je minder water (droogte). Zit misschien vooral in de grootte en stroming?