Communicating climate adaptation in a digitised world

An exploration of climate adaptation communication using a digital localised tool

MSc Thesis Landscape Architecture | Ineke Weppelman | Wageningen University

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COMMUNICATING CLIMATE ADAPTATION IN A DIGITISED WORLD

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PREFACE

Before you lies the thesis “Communicating climate adaptation in a digitised world”, in which two versions of an interactive tool were developed and subsequently evaluated by means of pre- and post-surveys. This thesis was written between July 8, 2019 and January 20, 2021 as part of the graduation requirements of the Landscape Architecture Master Program at the University of Wageningen.

The project has changed direction several times, mainly because of difficulties and restrictions caused by the outbreak of the COVID-19 virus. Whereas I started off with the idea of creating workshops with physical models, the workshops had to be cancelled and I had to rethink my project. As I had already finished the analysis phase and started the designing phase, I decided to keep as much as possible of the work I had done and use it to explore the potential of digital communication tools. As I did not have any experience with the programs and skills necessary for developing such a tool, it was not always an easy process. However, while sometimes frustrating, I have very much enjoyed this project.

I would like to thank my supervisor, Agnès Patuano, for her great feedback, guidance and support wherever necessary. I also wish to thank my participants and all the people who shared my research invitation or were so kind to provide me with feedback.

I furthermore would like to thank my family and friends, for providing me with feedback at different moments throughout my thesis. And of course Maud, whom I could always ask for feedback and share my thesis struggles with. Last but not least I want to thank my boyfriend, who was always there for proofreading and mental and statistical support. You have all kept me motivated even when the project was not so easy.

I hope you enjoy your reading.

Ineke Weppelman

January 20, 2021

ABSTRACT

Most risks related to climate change, like flooding and heat stress, are concentrated in urban areas. As private gardens cover a large part of urban areas, the cooperation of residents is vital in creating a truly climate adaptive city. However, citizens are rarely involved in climate adaptation. Effective communication is necessary to raise awareness for climate change and adaptation options and increase citizens' willingness to take action. Communicating actions for climate adaptation on a local scale and in a personally relevant environment is recommended, but not yet further specified in the existing knowledge base.

This thesis aims to gain more insight into the effectiveness of digital communication at a local scale to improve residents' awareness and willingness to act towards climate adaptation. To this aim, two digital tools were designed and tested amongst Dutch residents. The two tools incorporated existing knowledge on communicating climate change and adaptation options and differed only in the type of 'local' they addressed: a personalised or standard private garden environment. Personalised environments were created based on a typology of houses and gardens found in a neighbourhood of Arnhem. Participants, both from this neighbourhood and elsewhere, were randomly assigned to one of the tools and asked to fill out a questionnaire before and after they used it.

The results showed that both interactive tools representing adaptation measures in a private garden environment increased participants' willingness to take action for climate adaptation. However, although qualitative data revealed participants' appreciation for a personalized digital environment, both tools showed to be equally effective to stimulate residents' willingness to act. Thus, digital interactive tools offering practical information on solutions show they can be effective in motivating citizens for climate adaptation, using either a standard or personalised garden environment. Further research could focus on long-term effects and actual action-taking.

CONTENTS

1. General Introduction

1.1. PROBLEM STATEMENT

1.1.1. Climate change

Climate change is becoming an increasingly pressing issue as its impacts become more evident, with many of the risks being concentrated in urban areas (Field, 2014). As we are living in an era characterised by rapid urbanisation, with over half of the global population living in cities (Zhang, 2016), liveability in these urban areas is increasingly important for our present day society.

Urban heat stress and flooding are considered the most important climate related challenges in urban areas (Runhaar et al., 2012). Urban flooding often brings material damage and can in extreme cases lead to injuries and even deaths. Urban heat stress has proven to have a significant negative effect on health, even increasing mortality rates (Huynen, 2001).

1.1.2. Climate adaptation

To minimise further costs for the damage that climate change can cause, climate adaptation and mitigation are increasingly important (Ministry of Infrastructure and Environment, 2016; Global Commission on Adaptation, 2019). **Mitigation** focuses on limiting the effects of climate change, for example by reducing greenhouse gas emissions. **Adaptation** focuses on being able to cope with those effects of climate change which are inevitable, by creating a more resilient environment (Ministry of Infrastructure and Environment, 2016). To achieve such a resilient environment, actions can be taken like the exchange of paving for planting to lower temperatures and to allow infiltration of rainwater; and the collection and retention of rainwater for use in dry periods (Kennis voor Klimaat, 2014).

One of the first two cities that has done thorough research on its urban heat problem, is the city of Arnhem, (Kennis voor Klimaat, 2014), which will be used as example throughout this thesis.

1.1.3. Importance of the citizen

To create a complete and effective climate adaptive environment that includes both public and private space, the cooperation of citizens is required (Sheppard, 2011; Field, 2014; Moser & Pike, 2015; Hegger et al., 2017; Woudstra et al., 2018; Uittenbroek et al., 2019). Figure 1 illustrates this, showing the North part of the city of Arnhem. Large green parks and other green areas reaching into the city are the property of the municipality. In the urban fabric however, a large share of land in cities (around 40%) is private property (Atlas Natuurlijk Kapitaal, n.d. a; Trell & van Geet, 2019). Here, citizens are (the most) important influencers in the urban outdoor space (Trell & van Geet, 2019).

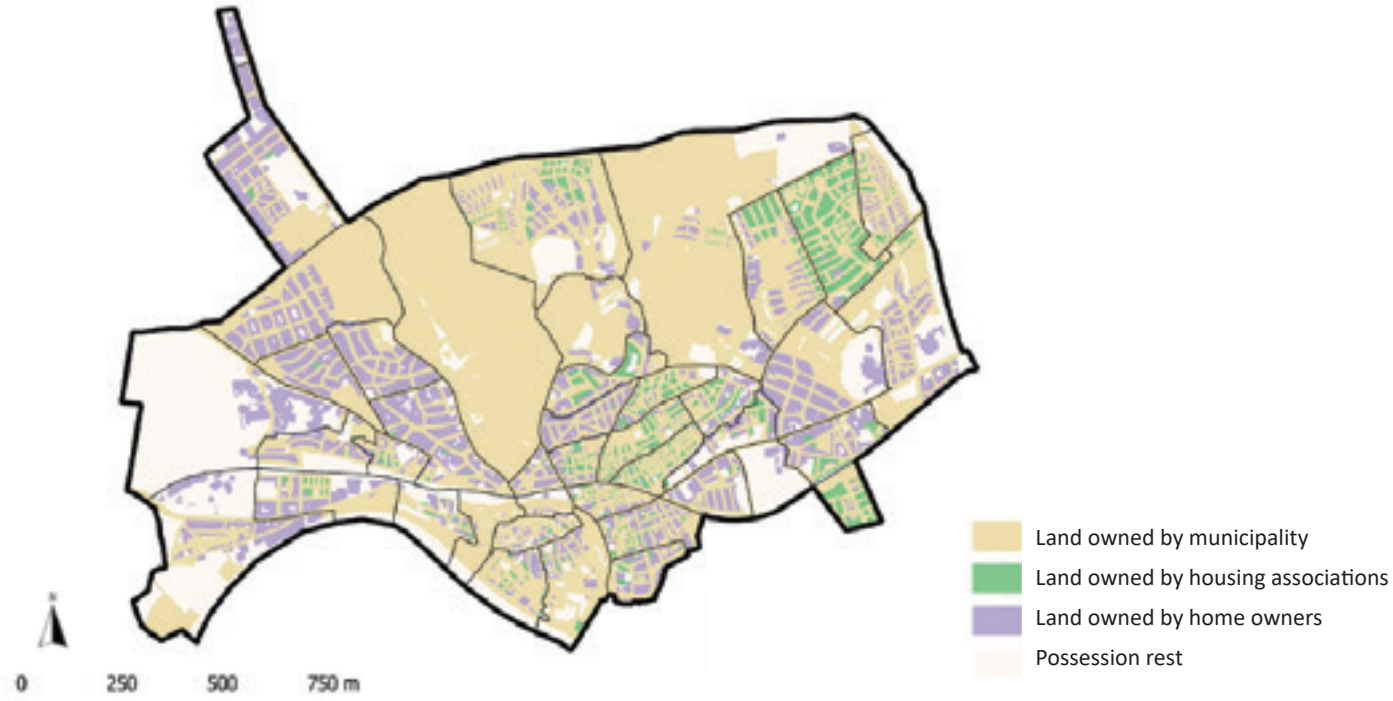


Figure 1: Land ownership in the North of Arnhem (Trell & Van Geet, 2019)

Citizens can contribute to a more climate adaptive environment by making changes to their garden and house, like exchanging pavement for planting, adding rain barrels or installing a green roof (Arnhem Klimaatbestendig, n.d. a; Lenzholzer, 2015). In Arnhem, most neighbourhoods have around 50% of the garden surface paved, built or left empty (Bingen, 2019), leaving room for improvement. Additionally, citizens could play a role in helping to maintain the public greenery. This can positively influence social cohesion and feelings of accountability and belonging, and add to economic robustness and societal support (Boonstra & Boelens, 2011). Although this 'self-organisation' also has some critical connotations, mostly concerning its effectiveness (Boonstra & Boelens, 2011), the municipality of Arnhem seems positive and interested in further stimulating and facilitating this process (Raats, 2019).

1.1.4. Achieving action

Although citizens *could* play an important role in achieving a more resilient environment, it often remains only a possibility. People need a motivation and be willing to take action (Lorenzoni et al., 2007). But several barriers are obstructing people from taking action, such as: a lack of awareness or further understanding of climate related problems and their solutions; a lack of (financial) resources (Lorenzoni et al., 2007; Biesbroek et al., 2011); and confusion or denial regarding responsibility (Hegger et al., 2017; Trell & van Geet, 2019). Furthermore, as climate change seems so abstract and far away, it might be hard to grasp and other issues are prioritised. Finally, sometimes taking action against climate change simply seems too inconvenient to people, not fitting into their current lifestyle (Lorenzoni et al., 2007). To overcome these barriers, communication plays an important role (e.g. Sheppard et al., 2011; Wirth, Prutsch & Grothmann, 2014). By communicating effectively, people can gain knowledge and awareness of the problems and solutions around climate change, as well as of which actions they can take themselves, which in turn can give them a sense of control (Lorenzoni et al., 2007; Wirth, Prutsch & Grothmann, 2014).

Previous research has indicated the efficacy of communicating adaptation measures in a local and relateable setting, using a visual (three-dimensional) medium and connecting to problems citizens perceive themselves (Wirth, Prutsch & Grothmann, 2014).

1.2. Theoretical framework

1.2.1. Communication

In order to communicate climate adaptation options effectively, some important aspects should be taken into account. Awareness, of both the problems and the actions that can be taken against them (adaptation measures), is considered of high importance and necessary in the process towards action-taking (e.g. Grothmann & Patt, 2005; Burningham, Fielding & Thrush, 2008; Wirth, Prutsch & Grothmann, 2014; PBL Netherlands Environmental Assessment Agency, 2015).

Creating awareness is considered a first step towards action, which allows people to assess the probability of something happening and the severity of this happening, as well as what they could do against it. This should allow them to judge the situation and respond to it in a fitting way (Lieske, Wade & Roness, 2014).

Bamberg & Möser (2007) furthermore state that "*problem awareness is an important but indirect determinant of pro-environmental intention*" (Bamberg & Möser, 2007, p.1). In addition, this pro-environmental intention, or willingness to engage in pro-environmental actions (hereafter: willingness to act) (Arlt, Hoppe & Wolling, 2011; Evans, Milfont & Lawrence, 2013), is an indicator for the actual action-taking (Bamberg & Möser, 2007). It can be regarded as a factor that mediates or summarizes different factors that determine people's action-taking behaviour (Biesbroek et al, 2011; Bamberg & Möser, 2007).

In line with the importance of these indicators, efficient communication of climate change and adaptation helps achieve a raised level of awareness of problems and solutions (Wirth, Prutsch & Grothmann, 2014; Lenzholzer, 2020), and motivates taking action for climate adaptation (Wirth, Prutsch & Grothmann, 2014). The latter should increase the willingness to act, possibly resulting in action-taking (Bamberg & Möser, 2007).

To achieve effective communication, several studies have defined important factors to apply. In the following paragraphs, these factors will be addressed, as summarised by Wirth, Prutsch & Grothmann (2014) and supplemented with information from other authors.

Raising awareness - providing knowledge

First of all, **credibility** of information is an important factor. The information provided should be as scientifically certain and sound as possible, from a source trusted by the target audience (Nicholson-Cole, 2005; Wirth, Prutsch & Grothmann, 2014). Furthermore, scientific findings should be communicated in a **comprehensible** way, which requires clear information and an understandable medium (Nicholson-Cole, 2005; Sheppard et al., 2011; Wirth, Prutsch & Grothmann, 2014; Schroth, Pond & Sheppard, 2015).

As many climate adaptation measures have a spatial character or implication, a medium is needed that shows these spatial implications. As "*laymen cannot usually imagine three-dimensional effects and connections on the basis of two-dimensional diagrams*" (Gänshirt, 2007, pp. 136), a better medium to use in this case would be three-dimensional images or models (Gänshirt, 2007).

Two relating factors are to **translate** climate adaptation **to everyday life** situations and **frame the message to the target group** (Moser, 2010; Wirth, Prutsch & Grothmann, 2014). Making personal risks and benefits in everyday life situations more salient and localised should help increase the awareness levels for climate adaptation (Lorenzoni et al., 2007; Shaw et al., 2009). This requires knowledge about the target group, for example about their problems and their environment. Therefore, it is recommended to analyse the needs of the target group for improved communication (Wirth, Prutsch & Grothmann, 2014).

Motivating for action – increasing the willingness to act

To increase willingness to act, information alone seems insufficient. Some state that **emotions** should be reached (Moser, 2010; Roeser, 2012; Wirth, Prutsch & Grothmann, 2014). Emotions can be invoked in different ways and directions (Moser, 2010; Wirth, Prutsch & Grothmann, 2014). Positive feelings and addressing solutions to avoid risks are recommended, as they can give people a sense of control (Tobler, Visscher & Siegrist, 2012). Emotions can be reached for example through visualising realistic, recognisable and personally relevant environments, including symbols like people or animals, where impacts of actions can be made visible (Sheppard, 2005).

Another factor that should motivate action-taking, is **collaboration, or dialogue**. Coming to a problem analysis and possible solutions, including the where, what and how of these solutions together with others, is an important aspect in effective communication of climate risk and adaptation options (Shaw et al., 2007; Moser, 2014). This can be done best in dialogical settings, like a workshop or face to face setting, where people can learn from each other (Shaw et al., 2007; Moser, 2014; Wirth, Prutsch & Grothmann, 2014).

Unfortunately, many people do not want to attend physical workshops or do not see the possibility to make time for it, even if it is located in their own environment (Citisens, 2018). In addition, it is not always possible to explain complex matter in the short timespan of regular participatory meetings (Evans-Cowley & Hollander, 2010). The studies of Evans-Cowley & Hollander (2010) and Shen & Kawakami (2010) illustrate that online workshops or meetings could provide a good alternative to physical workshops for spatial planning and design. However, Shen & Kawakami (2010) do point out that people are sometimes hesitant and uncomfortable making decisions about private spaces in a (group) workshop setting.

A stand-alone digital tool that could be consulted whenever one would want to, could be an option for those who do not want to or cannot make time for attending a physical workshop. Furthermore, individual use of such a tool would take away the discomfort of discussing private space design in a workshop setting. Collaboration with others in a group would not be a possibility in this case, but (real-time or delayed) dialogue with the sender of the information remains an option.

Due to a digitalising trend as defined by Evans-Cowley & Hollander (2010) and the outbreak of the Covid-19 virus during the writing of this thesis, this research is focussed on the development and exploration of a stand-alone digital tool to communicate climate adaptation to citizens.

Focus on selection of factors

Factors that can be realised in a digital setting, and are therefore included in this thesis, are the provision of **credible** and **comprehensible** information, which is **framed to a certain target group** (although it may reach others as well) and **translated to everyday life**. Also **emotional** content is possible to include in

digital visual information. The factor of **collaboration** or **dialogue has been** included as (delayed) **dialogical** function.

There are two additional factors identified by Wirth, Prutsch & Grothmann (2014) that should enhance effective communication for climate adaptation: to use **norms and values** and a **'trusted messenger'**. This requires an advanced fine-tuning on the norms, values and beliefs or motives of the target group, to ensure more trust. Due to their high complexity and the short timespan of this thesis, these factors will not be included.

To conclude, there are many factors considered important in communication for climate adaptation, an overview of which can be found in Table 1. Combining these factors should lead to an effective communication of climate adaptation.

Table 1: Recommended factors for effective communication of climate risks and adaptation options. The factors in cursive will not be included in this thesis.

PROVIDE KNOWLEDGE AND RAISE AWARENESS
Credible use sound scientific data and be technically correct
Comprehensible Text short and concise, explain or avoid technical terms.
Translate to everyday life Cast the information into a story that communicates people's personal risks (and benefits), building on personal experience
Frame to target group Relate the information to knowledge about the target group (e.g. local neighbourhood, prior knowledge etc.)
INCREASE WILLINGNESS TO ACT
Emotions Use positive emotions (solutions to problems), a personally relevant environment, virtual with dynamic/ animated imagery and strong affective content, and show what will happen with & without measures
Collaboration/dialogue Offer an option to communicate with others or the sender about the offered information
Norms and values *Use norms and values to show the importance of people's contribution*
Trusted messenger Use a trusted messenger to present the information

1.3. KNOWLEDGE GAP AND RELEVANCE

Although good communication seems to be of vital importance for reaching action in climate adaptation, still little seems to be known of the subject. Especially relating to actions one can take in their immediate environment.

1.3.1. Academic knowledge base

Several authors indicate the importance of factors like making the information local, framed to the target group, and understandable, as well as linking it to people's everyday life (e.g. Lorenzoni et al., 2007; Wirth, Prutsch & Grothmann, 2014; Schroth, Pond & Sheppard, 2015). Other authors, like Sheppard (2005; 2011; 2015), have furthermore specifically addressed the importance of visual information. However, after an extensive literature search (see text box for the method), it can be concluded that much of the literature on the communication of

For the literature review, the following search strings were used:

Interactive climate communication online

- *Digital interactive climate communication*
- *Digital climate communication*
- *Digital climate communication visual*
- *Internet-based participation tools*
- *Internet-based participation tools climate*

Besides literature resulting from these search strings, all literature found from S. R. J. Sheppard on visual communication was taken into consideration as well as any literature that had cited:

- Sheppard, S. R. (2015). Making climate change visible: A critical role for landscape professionals. *Landscape and Urban Planning, 142,* 95-105.
- Sheppard, S. R., Shaw, A., Flanders, D., Burch, S., Wiek, A., Carmichael, J., ... & Cohen, S. (2011). Future visioning of local climate change: a framework for community engagement and planning with scenarios and visualisation. *Futures, 43*(4), 400-412.
- Wirth, V., Prutsch, A., & Grothmann, T. (2014). Communicating climate change adaptation. State of the art and lessons learned from ten OECD countries. *GAIA-Ecological Perspectives for Science and Society, 23*(1), 30-39.

climate matters is either focused on the evaluation of existing and/or already executed tools and methods (e.g. Mitchell, Burch & Driscoll, 2016; Schmid, Knierim & Knuth, 2016; Swart et al., 2017; Rozmi et al., 2019), or are a review of existing literature on the matter (e.g. Lyle, 2015; Fook, 2015; Moser, 2016).

Studies that do report producing and testing of own communication tools, are mainly focusing on either (participative) scenario building (e.g Ferguson, Frantzeskaki & Brown, 2013; Beach & Clark, 2015; Bennet, Kadfak & Dearden, 2016), map portals (considering regions or whole countries) (e.g. Rød, Opach & Neset, 2015), or 3D interactive games (e.g. Dulic, Angel & Sheppard, 2016). Moreover, only very few studies were found that were more or less comparing different methods of visual (interactive) communication of climate change and/or adaptation to laymen (e.g. Schroth, Pond & Sheppard, 2015; Grothmann et al., 2017; Westerhoff et al., 2018). Of the studies found where a communication method was developed, only some deployed a pre- and post-test (e.g. Schroth, Sheppard & Dulic, 2014; Monani et al., 2018), whereas often only a post- use evaluation of the method was deployed, often by means of a focus group and/or interviews (e.g. Schroth, Pond & Sheppard, 2015; Schroth, la Valle & Sheppard, 2015).

In over 300 papers, only two studies were found on online workshops using a virtual environment (Evans-Cowley & Hollander, 2010; Shen & Kawakami 2010) and no studies were found that addressed standalone digital tools on climate adaptation in one's own garden and immediate environment. This limited amount of testing theory in practice and remaining lack of clarity especially regarding 'local' environments, might be considered problematic. Firstly because citizens' cooperation is, due to the large share of private gardens in the urban fabric, considered of high importance in climate proofing the city (Hegger et al., 2017; Trell & Van Geet, 2019). But also because making personal risks and benefits more salient and 'local' is considered an important aspect for both awareness-raising and motivating action (Lorenzoni et al., 2007; Shaw et al., 2009; Wirth, Prutsch & Grothmann, 2014).

1.3.2. Existing communication formats

Looking at existing online content communicating climate adaptation options on private property and its close environments, several formats stand out. Many formats seem to incorporate the previously mentioned factors, including credible (**credibility**) and comprehensible information (**comprehensibility**), sometimes through pop-ups, and depicting positive images with happy people or animals and beautiful sceneries (**emotion**). Most are aimed at a local scale (**framed to target group** & **emotion**) including one or two streets, or two or three houses with gardens (see Figure 2 & 3) and display the information so that it is easily translated **to everyday life**, (e.g. de straaD, 2016; Tuinhappy, n.d.; Arnhem Klimaatbestendig, n.d. b; Province Noord-Brabant, n.d.). All seem to depict a 'standard' environment. No formats were found where it was possible to change the kind of house or street that was illustrated.

In conlusion, there seems to be a significant knowledge gap in the expected and actual effectiveness of the defined factors in climate communication and the translation thereof into digital tools, specifically for the 'local' scale level of private houses and gardens. Potential lies in exploring the actual effectiveness of guidelines as described in the current knowledge base and investigating the 'local' aspect. Linking to already existing formats may furthermore provide more insight in the possible effectiveness of the existing communication means in this field.

Figure 2: Infographic from de straaD (de straaD, 2016)

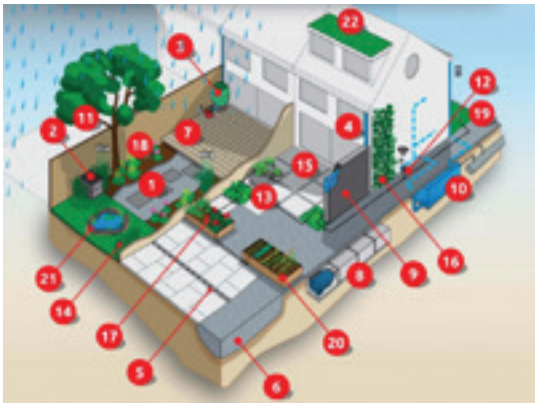


Figure 3: Infographic from Provincie Noord-Brabant (Province Noord-Brabant, n.d.)

1.4. OBJECTIVE AND RESEARCH QUESTIONS

This thesis aims to explore the effect of online communications tool for climate adaptation aimed at 'local' environments on citizen's levels of awareness and willingness to act for climate adaptation. This is achieved by specifically focusing on the effectiveness of the defined factors in climate communication and their translation into digital tools. 'Local' in this thesis will be used to primarily designate private homes and gardens.

To guide the research process, several research and design questions were formulated.

Main Research question

What are the effects of digital interactive tools to communicate climate adaptation measures on a 'local' scale on citizen's levels of awareness and willingness to act for climate adaptation?

To answer this question, the following sub-questions were formulated:

***DQ1:** How can digital interactive tools facilitate effective communication of climate adaptation measures?*

a. How can the 'local' environment be represented to facilitate effective communication of climate adaptation measures?

b. How can the adaptation measures be represented to facilitate effective communication of climate adaptation measures?

c. How can the different adaptation measures be implemented in 'local' environments, to create a climate adaptive, pleasant and comprehensible environment?

d. How can the interface facilitate effective communication of climate adaptation measures?

***RQ1:** What are the most occurring typologies that exist in the neighbourhood of Rijkerswoerd?*

***RQ2:** Which climate adaptation measures can be selected that are suitable for the test bed area and can be represented in the digital tools?*

***RQ3:** What are the changes in citizen's levels of awareness and willingness to act for climate adaptation after working with the digital tools?*

***RQ4:** What are the differences in effects on citizen's levels of awareness and willingness to act for climate adaptation between the two digital tools?*

To achieve the objective and answer the research questions, first a test bed was identified and analysed. Subsequently, the important factors for successful communication as found in the literature were translated into guidelines suitable for a digital interactive tool. The results of both these processes have been used for the creation of two interactive tools:

1. *The general local tool*: a tool that interprets 'local' as a standardised house and garden;
2. *The specific local tool*: a tool that interprets 'local' as being able to choose a house and garden type that best fits your personal environment.

After creation of the tools, these were embedded on a website and provided with both the same short introduction addressing climate change and adaptation and how to use the tool.

The tools were evaluated by means of presenting questionnaires before and after use of the tool. An attempt was made to indicate long-term effects of the tools, by sending a delayed post-test questionnaire four weeks after participants used the tool.

In the following chapters, this process will be further elaborated on. Figure 4 depicts a schematic representation of the process.

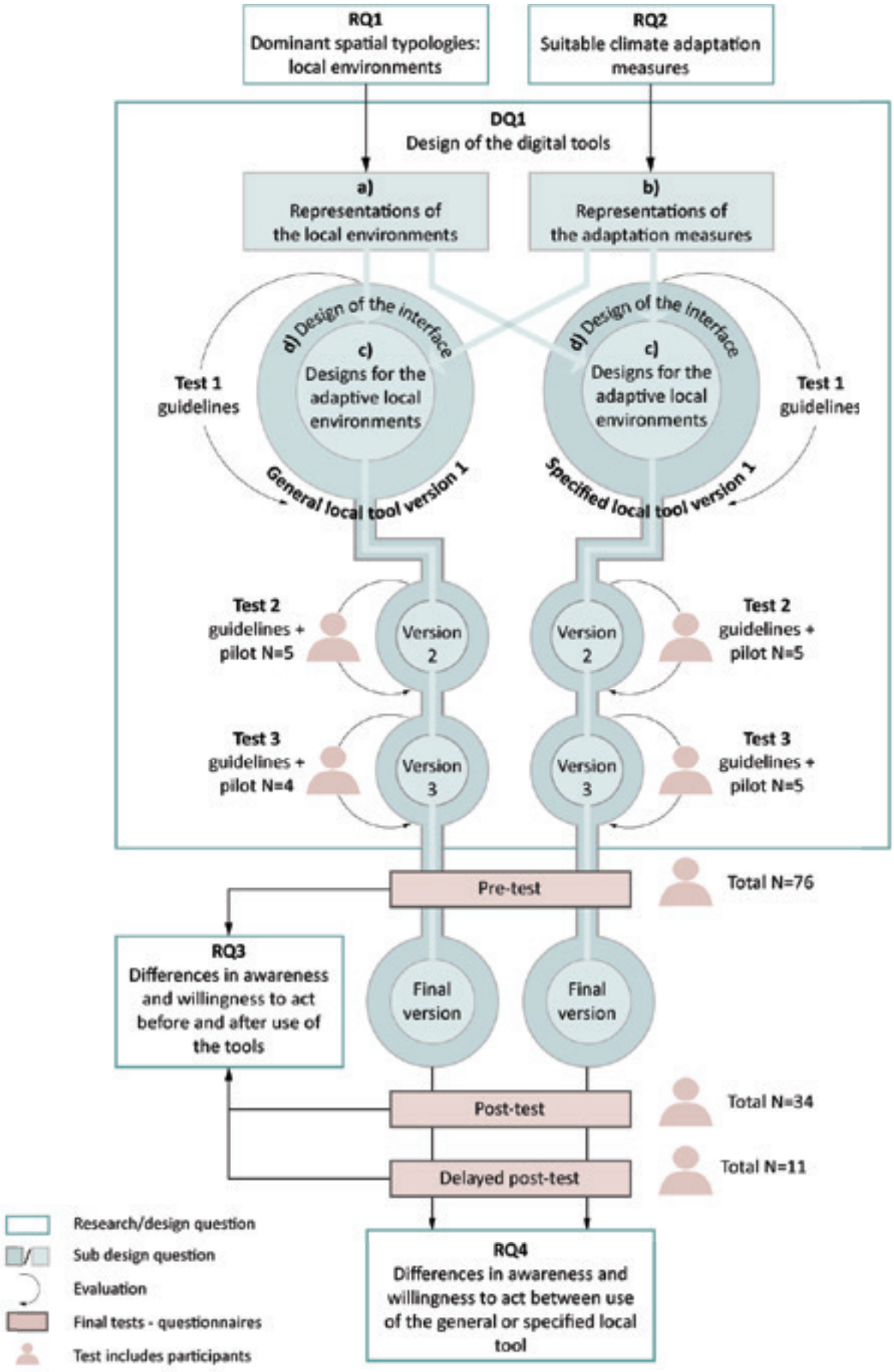
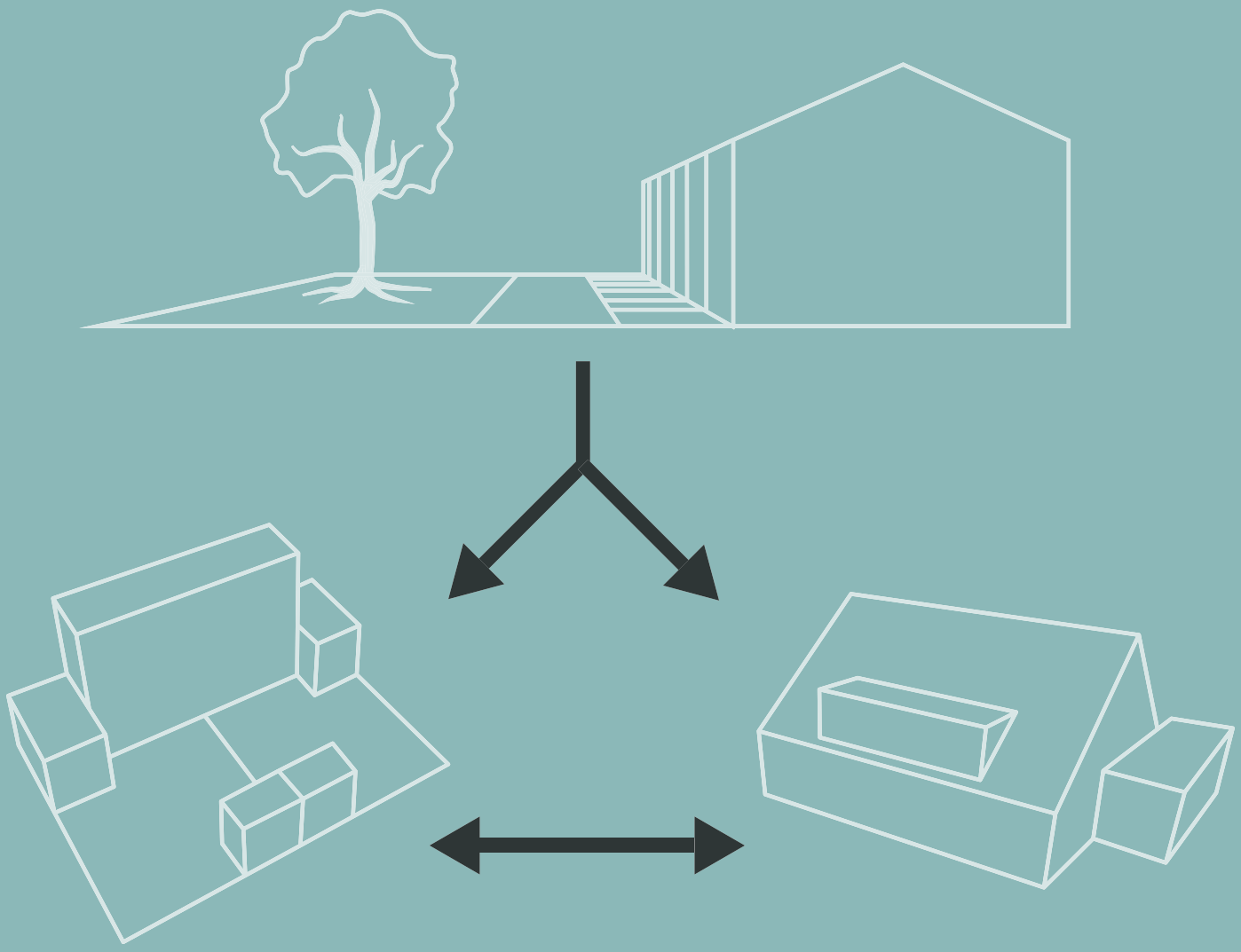


Figure 4: Schematic representation of the overall process

2. Phase 1 – Inventory and analysis



2.1. TEST BED ANALYSIS

In order to include the 'local' aspect, a specific test bed area was identified. This is the neighbourhood of Rijkerswoerd, a relatively new neighbourhood in the South of Arnhem (Figure 5) (Gemeente Arnhem, 2020), in which most houses include (front) gardens (Google Maps, 2017). Although the neighbourhood itself has not had many particular climate related problems as of now (Klimaateffectatlas, n.d.), it has been taken along in the plans to make the city of Arnhem more climate adaptive for the future (Arnhem Klimaatbestendig, n.d. a). Therefore, the area is considered a relevant test bed to study the communication of climate adaptive interventions.

Figure 5: Location of Rijkerswoerd in Arnhem

2.1.1. SOCIO-DEMOGRAPHICS AND SOCIAL CHARACTERISTICS

Socio-demographics and social characteristics of the neighbourhood were analysed by means of the data portal of the Municipality of Arnhem (Gemeente Arnhem, 2020) and interviews with two key persons within the neighbourhood: M. van Duuren and H. Kemper. M. van Duuren is coordinator of the urban farming group 'Stadslandbouw Mooieweg' in Rijkerswoerd. H. Kemper is chairman of the residents' platform. Both the interviews lasted a little over an hour and took place in the canteen of Stadslandbouw Mooieweg (urban farming Mooieweg) and the community center of Rijkerswoerd, respectively.

Socio-demographics

Perhaps the most important aspect of the neighbourhood was already mentioned shortly in the introduction of this section. The vast majority of residents in Rijkerswoerd own a house with a garden (Google Maps, 2017; Gemeente Arnhem, 2020). In most cases, (59%) the property is owned, rather than rented by the residents. This may be a positive aspect taking into account the possible restrictions that might apply to a rental house (e.g. having to ask for permission for certain changes to the property) (Trell&Van Geet, 2019). Finally, most residents of Rijkerswoerd have an average to high income to spend (Gemeente Arnhem, 2020), which may allow for investment in climate-adaptive actions.

People in Rijkerswoerd who have the most free time, motivation and money to make changes, might be elderly people (H. Kemper, personal communication, February 12, 2020; M. van Duuren, personal communication, February 14, 2020). This is an age group that may be less familiar and skilled with online tools (Chiu, Huang & Tsao, 2019; Gil, 2019; Góngora Alonso et al., 2019). This was taken into account in the development of the tools, by creating a simple and comprehensible interface and design. As most of the population living in the test bed area (Rijkerswoerd) speak Dutch (Gemeente Arnhem, 2020), all text in the tools was written in Dutch.

Social characteristics

Within the neighbourhood, there seems to be a small group of residents that is interested and taking part in activities related to themes like nature, climate and green areas (M. van Duuren, personal communication, February 14, 2020). Most important motivations seem to be the enjoyment of greenery and working with it, while there also seems to be recognition for heat stress in the area (H. Kemper, personal communication, February 12, 2020; M. van Duuren, personal communication, February 14, 2020). A 'climate cafe' event held in the neighbourhood has been quite successful (Arnhem Klimaatbestendig, 2019a; Arnhem Klimaatbestendig, 2019b).

Furthermore, there are several communication means such as a neighbourhood newspaper and Facebook and NextDoor page, a residents' platform and an active urban farming group present in the neighbourhood (Rijkerswoerd Arnhem, n.d.a; Rijkerswoerd Arnhem, n.d.b; Stadslandbouw Mooieweg, n.d.). The urban farming group has their own location in the neighbourhood where they grow different crops. Besides this, they organise and help out in activities in the neighbourhood, like exchanging paving for planting (Stadslandbouw Mooieweg, n.d.).

Due to the presence of active organisational groups combined with the spatial setup of the neighbourhood, the neighbourhood of Rijkerswoerd was considered well-suited for offering inspiration for climate adaptation and inviting participants.

Discussion

Testing in a relatively aware community, may lead to more interest in the tool and therefore more participants over a shorter period of time. As only a limited timespan is available in which data can be gathered, this may be the most efficient option for gaining a first indication of possible effects of this communication method.

However, exploring the effects of a communication tool on citizens' levels of awareness and willingness to act may also have some disadvantages. If participants are already quite aware, a ceiling effect might occur, as the differences in their levels of awareness and willingness to act before and after use of the tool may be very small or insignificant. Furthermore, testing in a community of people that are aware and active only gives insight in the effects of the tool for a community like this and may not give an accurate indication of effects with people that are not aware and active.

Still, this thesis aims to give a first indication of possible effects. And if effects are found even in a highly aware sample, this may build a strong case for this communication method. Therefore, aiming at a relatively aware and active target group is considered a good option in the context of thos thesis.

2.1.2. Landscape Characteristics and climate related problems

Landscape characteristics and climate-related problems were analysed by means of several site visits and an inventory of (thematic) maps of the neighbourhood, supplied with information from personal communication with R. Bos, board advisor Public Space and Climate Adaptation of the municipality of Arnhem. In order to gain insight in the perception of climate related problems among residents, several questions regarding this matter were taken up in the interviews with H. Kemper (residents' platform) and M. van Duuren (urban farming group Stadslandbouw Mooieweg).

Landscape

Towards the South of Rijkerswoerd, the share of sandy clay and clay in the soil is increasing (Figure 6) (Alterra, 2014). This results in a lower permeability of the soil (Pazwash, 2016). Furthermore, the groundwater levels in a large part of the neighbourhood are quite close to the surface (Figure 7) (Alterra, 2014). This implies that options relying on the infiltration of water into the soil, like wadi's or infiltration and transport sewage systems (IT-sewage), become less suitable (e.g. Aquaflow, 2016). In the Municipal Sewage Strategy of Arnhem is stated that in the areas with a surface water system, like Rijkerswoerd, leading the rainwater into this system is a realistic option (Municipality of Arnhem, 2015).

At the moment, most of the rainwater in Rijkerswoerd is led to the sewage system. In two areas, there is a different situation (Figure 8). Around the Ank van der Moerdreef, there is a water body where rainwater is filtered by a helophyte system and reused. At the Peppelenwei, rainwater runoff is led to the surface water and to green areas at the edge of the neighbourhood (Figure 9). Measures that are possible considering the handling of precipitation in Rijkerswoerd are for example storing or slowing down water, or let it flow off to the surface water system (R. Bos, personal communication, February 6, 2020).

Figure 6: Soil map Rijkerswoerd (PDOK, 2020)

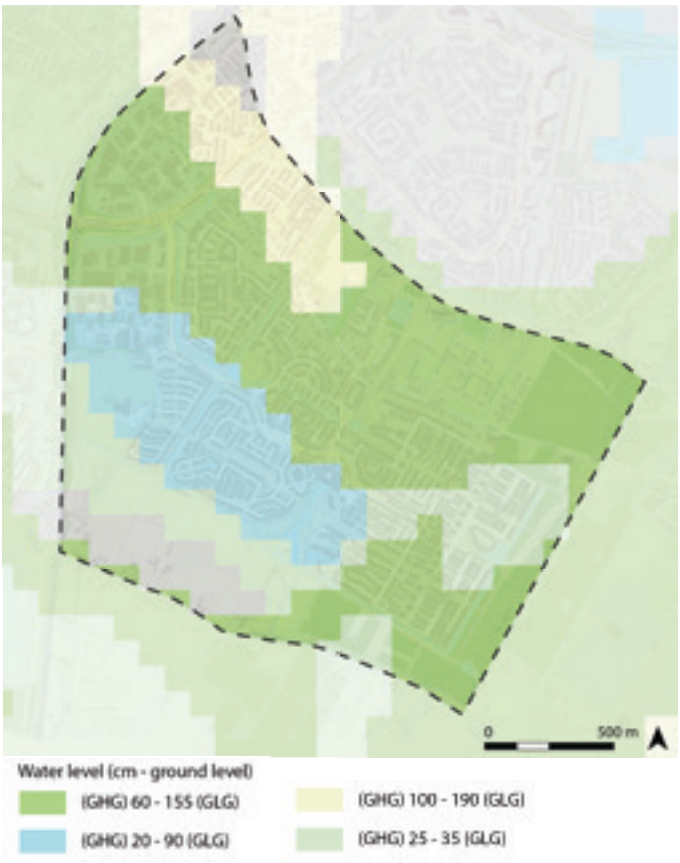


Figure 7: Groundwater levels Rijkerswoerd (Provincie Gelderland, n.d.)

Figure 8: Different systems of water management

Figure 9: Rainwater runoff (Image by author)

Climate

Looking at the data on Rijkerswoerd considering the urban heat island effect and urban flooding, there do not seem to be many severe problems regarding water and heat stress in the neighbourhood (Figure 10 and Figure 11) (Atlas Natuurlijk Kapitaal, n.d. b). However, it seems that people do recognise that some areas get significantly and uncomfortably warmer (than the area outside the neighbourhood) in summer (M. van Duuren, personal communication, February 14, 2020). Heat stress has also been mentioned as one of the top-ten important points of improvement in Rijkerswoerd, as reported in a document that resulted from 400 survey responses in the neighbourhood (H. Kemper, personal communication, February 12, 2020).

Considering the prognosis that more warmer periods will occur due to our changing climate, heat stress will increase globally (Van Hove et al., 2011; KNMI, 2014), thus also in the neighbourhood of Rijkerswoerd. As more densely built areas with more inhabitants, more paving and less green areas are more prone to heat stress, actions that go against this are of high importance (Klok et al., 2012).

Discussion

Generally, it can be concluded that heat is a problem that may well increase in the future (Van Hove et al., 2011; KNMI, 2014) and that it is being recognised as an important point of improvement by residents of the neighbourhood (H. Kemper, personal communication, February 12, 2020; M. van Duuren, personal communication, February 14, 2020).

Water related problems seem to be less present or pressing in the neighbourhood of Rijkerswoerd. Regarding water and infiltration, it is mainly important to consider the poor permeability and infiltration capacity of the soil. Due to this, measures aimed at infiltration of water in the soil are not recommended in the neighbourhood (R. Bos, personal communication, February 6, 2020).

Due to time constraints and the Covid-19 outbreak, it was unfortunately not possible to make a more accurate inventory of the experiences of people in Rijkerswoerd regarding (the consequences of) climate change and adaptation.

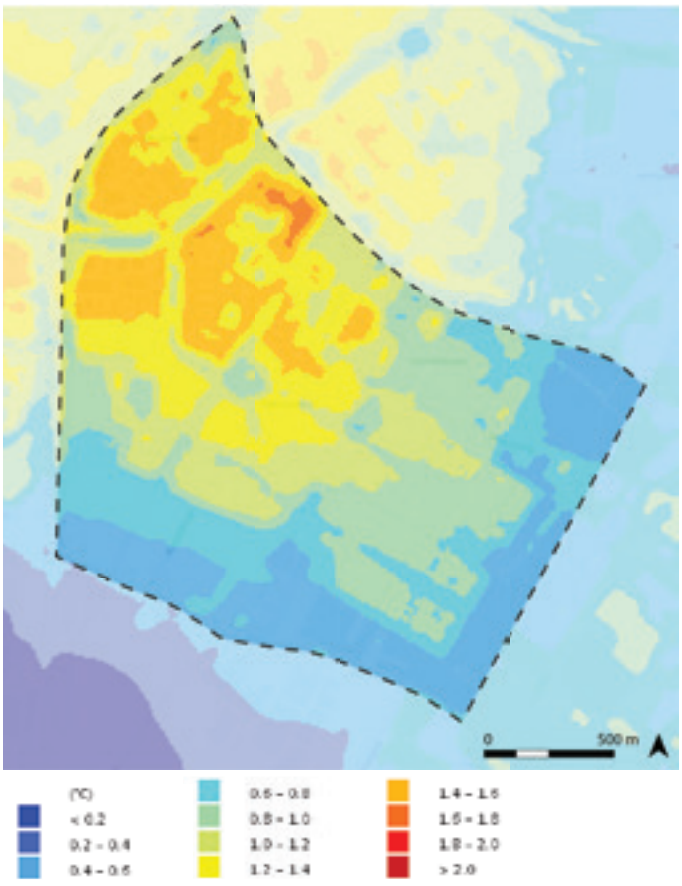


Figure 10: Heat map Rijkerswoerd (*Atlas Natuurlijk Kapitaal, n.d.)*

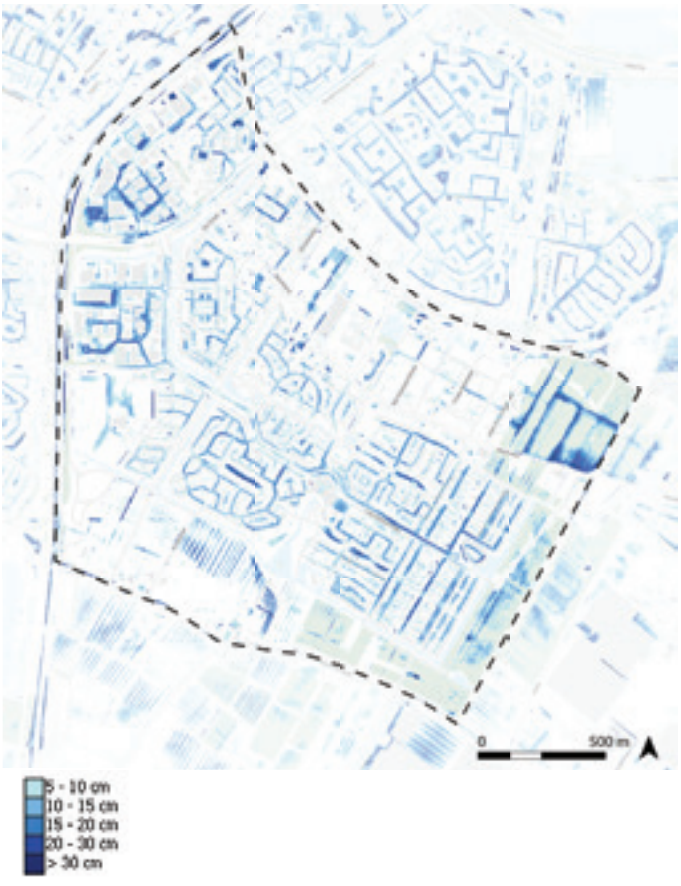


Figure 11: Flooding risk Rijkerswoerd (Atlas Natuurlijk Kapitaal, n.d.)

2.1.3. Spatial typologies

Spatial typologies were analysed by means of a photo analysis of all streets in Rijkerswoerd using Google Street View (Google Maps, n.d.). This was combined with the use of topographic maps and site visits, to verify and adapt the data to the current situation where necessary. To keep the amount of data manageable, this analysis focused first on street profiles, then on building typologies and finally on garden typologies. This way, the amount of building and garden typologies could be narrowed down to those in the most common areas (street profiles) of the neighbourhood. For the photo analysis, a categorisation system was used as shown in Figure 12.

Common building typologies were distilled from the common street profiles as defined in the first part of the analysis. This was done by abstracting and quantifying the building typologies as found in the defined street profiles.

Finally, garden typologies that were most common to the identified building types were analysed. For each building type 'cluster' (multiple buildings of this type clustered together in one or several streets), a garden was picked that was most representative for the gardens within this cluster. Only the standardised situations have been selected.

From these gardens, the following characteristics have been noted:

- Width and depth;
- (Standard) shed or not;
- Position of the shed, if present;
- Size of the shed, if present;
- Front garden functions as parking space or not.

To further narrow down the amount of garden types, a choice was made to include only the formats that are applicable for multiple housing types. In combination with some abstraction, this allowed for the housing types to be switched while not having to change the garden types. In this way, it would be possible to minimise the amount of gardens that had to be switched in the digital tool.

Finally, the amount of environments was reduced by conducting a shadow analysis. As most streets in the neighbourhood are oriented approximately South-East to North-west or South-West to North-East, a shadow analysis was conducted for these situations, with the Shadow Analysis plug-in for Sketch-up.

In the following paragraphs, the results of the spatial typologies analysis are laid out per segment, starting with street profiles, followed by buildings and gardens.

Street profiles

Several street profiles have come forward from the analysis. These are shown on the left in Figure 13. For purpose of clarity and simplicity, all street profiles are depicted with the same type of houses.

Buildings

On the right in Figure 13 is shown which building typologies are most common in the above identified street profiles. Two main groups can be identified, being row houses and semi-detached houses. The typologies shown in Figure 13 have already been selected on suitability of being interchangeable with the different garden types.

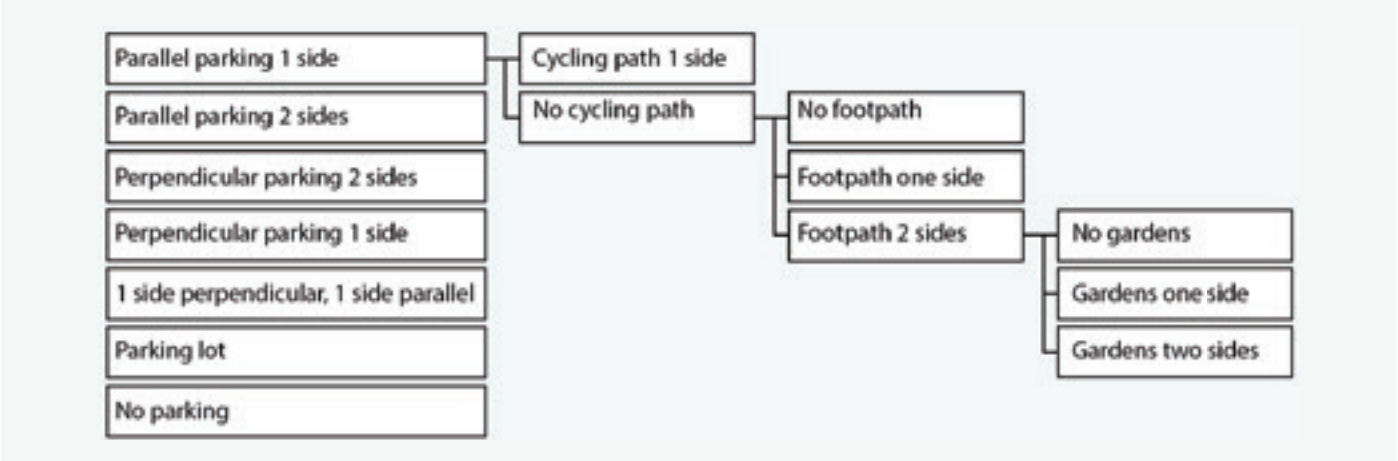


Figure 12: Overview of categorisation system of street profiles

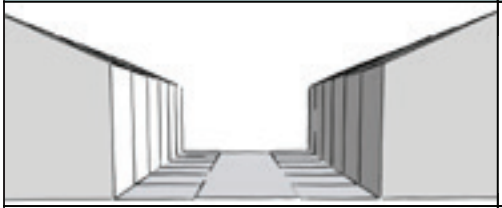
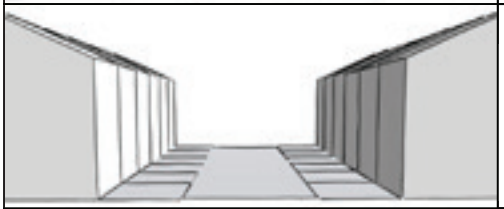
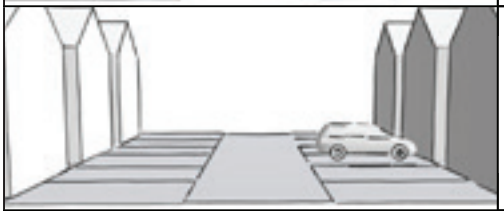
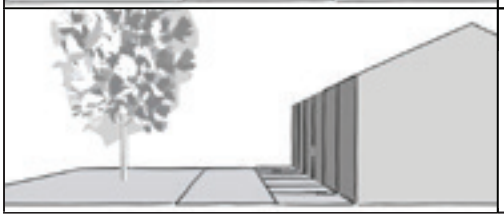
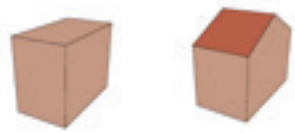
Street profile	Housing types
Perpendicular parking, footpath one side	
	
	
Perpendicular parking, footpath two sides	
	
Perpendicular parking, footpath two sides	
	
No parking, no footpath	
	
	
	
	

Figure 13: Common street types (left) with corresponding common housing types (right)

Gardens

In total, four common garden types were identified, that form one set of front and back garden matching the common row-housing types and one set of front and back garden matching the common semi-detached housing types (Figure 14).

Orientation

Most streets in the neighbourhood are oriented approximately South-East to North-west or South-West to North-East. For these main orientations present in the neighbourhood, shadows were analysed for the different environment types. This analysis was executed in the Shadow analysis plug-in for Sketch-up. The sun hours were measured from 1,5 hours after sunrise to 1,5 hours before sunset on the 21st of June, to indicate the warmest hours of the day (City of Mississauga, 2011).

Both North orientations and both South orientations gave a very similar shadow pattern in the shadow analysis (Figure 15). Thus, the choice was made to show both garden sets once oriented North and once oriented South, resulting in four garden environments.

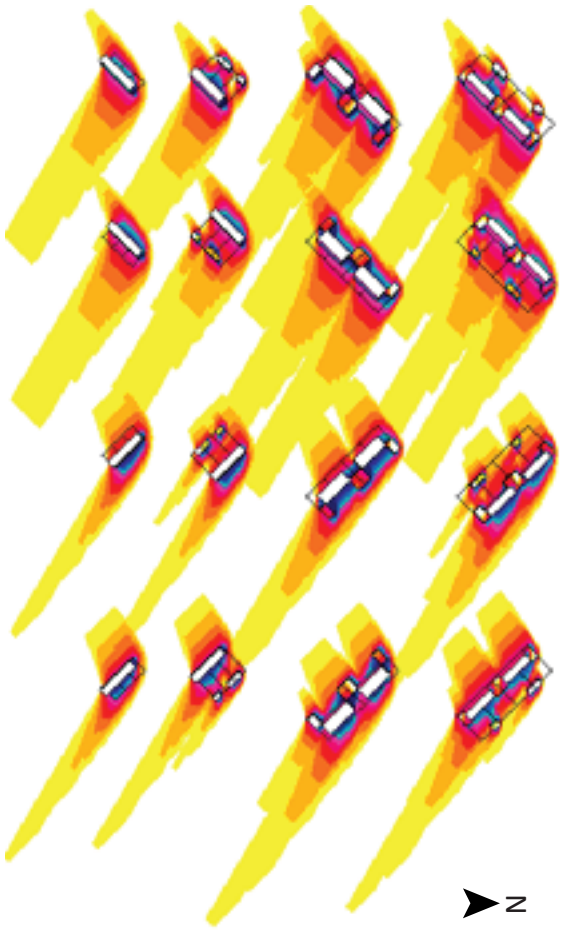


Figure 15: Shadow analysis of defined garden types

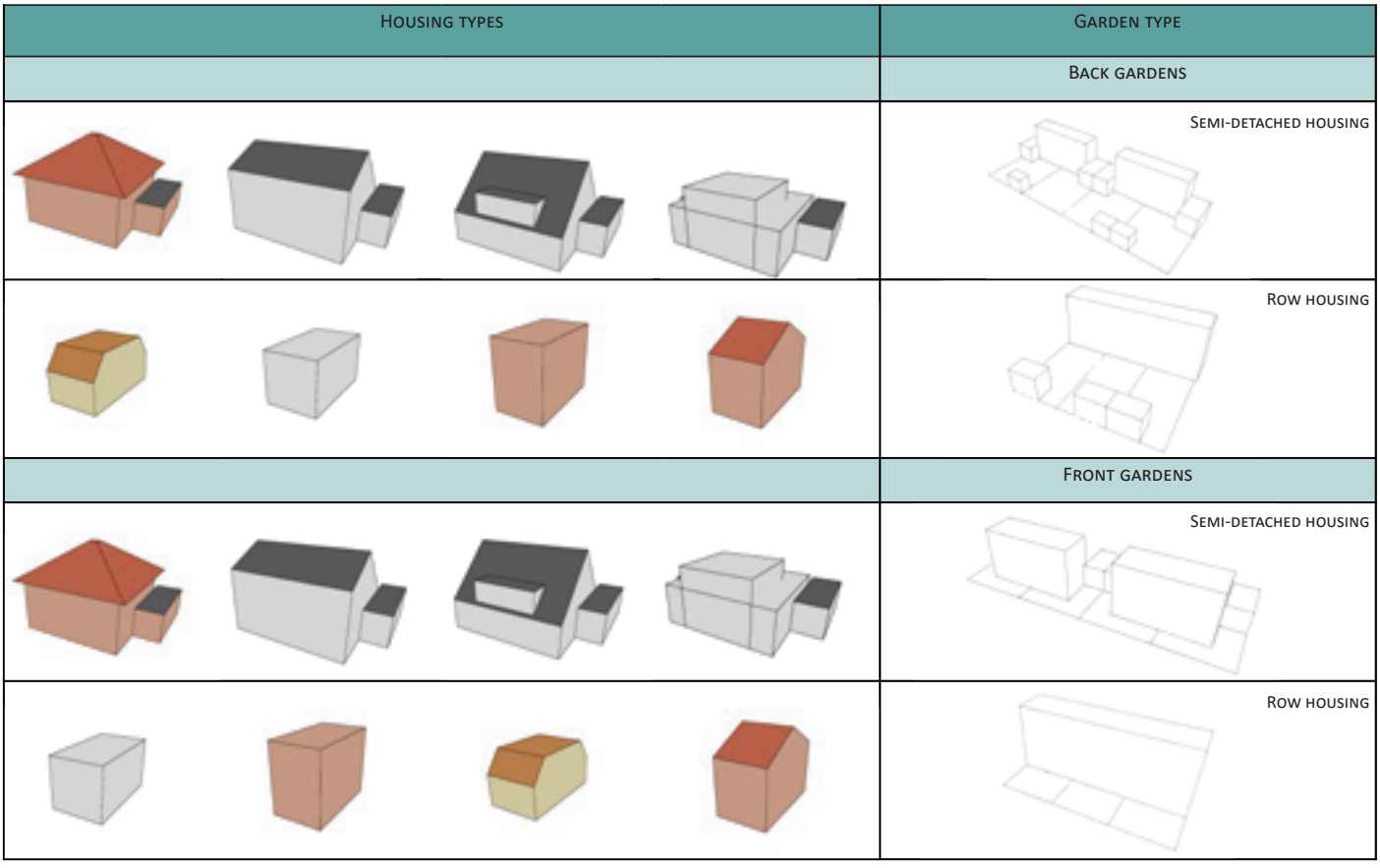


Figure 14: Corresponding common garden types

Discussion

An attempt was made to be as correct and complete as possible in selecting the environments that were to be used in the tool. The whole neighbourhood was thoroughly looked at and several data sources (topographic maps, satellite view, street view and own photo's of site visits) were used to bring the amount of incorrect or outdated environmental aspects to a minimum.

Still, of course, selecting 'most common' typologies from photos of street profiles may not give an entirely accurate representation. Some streets are longer than others and although an attempt was made to take images from fairly similar distances, it will not be perfect.

The same complications are applicable to the building and garden typologies. Quantifying the amount of times a certain building type occurs in the 'most common' street profile photo database, may not give a completely accurate representation of housing that is found most in the neighbourhood. And especially the gardens had to be simplified quite a lot, to be suitable for use in the digital tool.

Although the method of working per scale level, going from street profile to gardens may have as a consequence that the eventual selection of typologies is not entirely complete and accurate, it has allowed for a manageable selection of typologies. Without this, the tool would not be able to run, because the information would crash the program. Ease of use and a smoothly functioning application demanded a limited amount of fairly simple environments, which has been achieved through this method of analysis.

Even if the selected environments and building types form a good representation of the neighbourhood, it may still be that participants interested in using the tool would disagree on this. For best results, the environments could have been evaluated by residents of the area. Due to time constraints, means and possible loss of participants (that may want to evaluate the environment but not participate in the evaluation of the tool itself), it was decided to take up several questions in the evaluation questionnaire that controlled for the representativity and relatability of the environment (see appendix I - Evaluatie van de lokale tool, p. 66).

2.2. SELECTION OF ADAPTATION MEASURES

The main focus of the tool is the communication of climate adaptation measures and seeing the effects of this on citizen's levels of awareness and willingness to act for climate adaptation. To this aim, an inventory of suitable climate adaptation measures has been compiled for use in the tools. These measures are a vital aspect of the tool and were hereafter fit to the previously defined environments and the general interface of the tool.

Methods

To come to a selection of suitable adaptation measures, first of all a literature study was done using books, websites and scientific articles on climate adaptation measures suitable in an urban context. An overview of the full inventory and the selection of the adaptation measures is enclosed in Appendix II.

When no new measures were found, a selection was made of measures suitable for the test-bed environments and the format of the tools. To this aim, the following criteria were used:

- Suitability for the soil structure in Rijkerswoerd (mostly clay and heavy clay)
- Suitability for implementation on a private property
- Suitability for existing buildings
- Suitability for being carried out (at least partly) by a home owner

Many adaptation actions require help or advice at some point, certainly if one is not very familiar with constructing outdoor elements like pergola's, paving or ponds. It was therefore estimated that it can not be entirely guaranteed that every measure can be carried out completely by homeowners themselves.

Suitable adaptation measures

After applying the several selection criteria to the inventory of adaptation measures, an elaborate list of measures was deemed suitable for use in the tools.

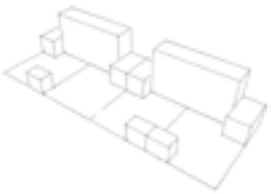
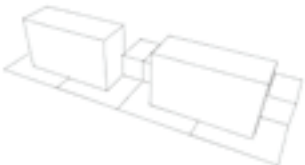
After selection, the measures were linked to the 'local' settings that they suited (see Table 2) and a description was written for each of them, including cost and maintenance indications and an indication of benefits for water management, heat and biodiversity.

Discussion

The process of gathering new measures has been continued until no new measures were found. Although every effort was made, it can not be guaranteed that the list of adaptation measures is exhaustive. Within the timespan of the project and taking into account that this field of knowledge is constantly progressing, it was attempted to create a list as extensive as possible.

Considering the space for representation in the tool and purpose of the tool (testing the communication of climate adaptation measures in a specific way), the amount of measures to be represented in the tool should be sufficient.

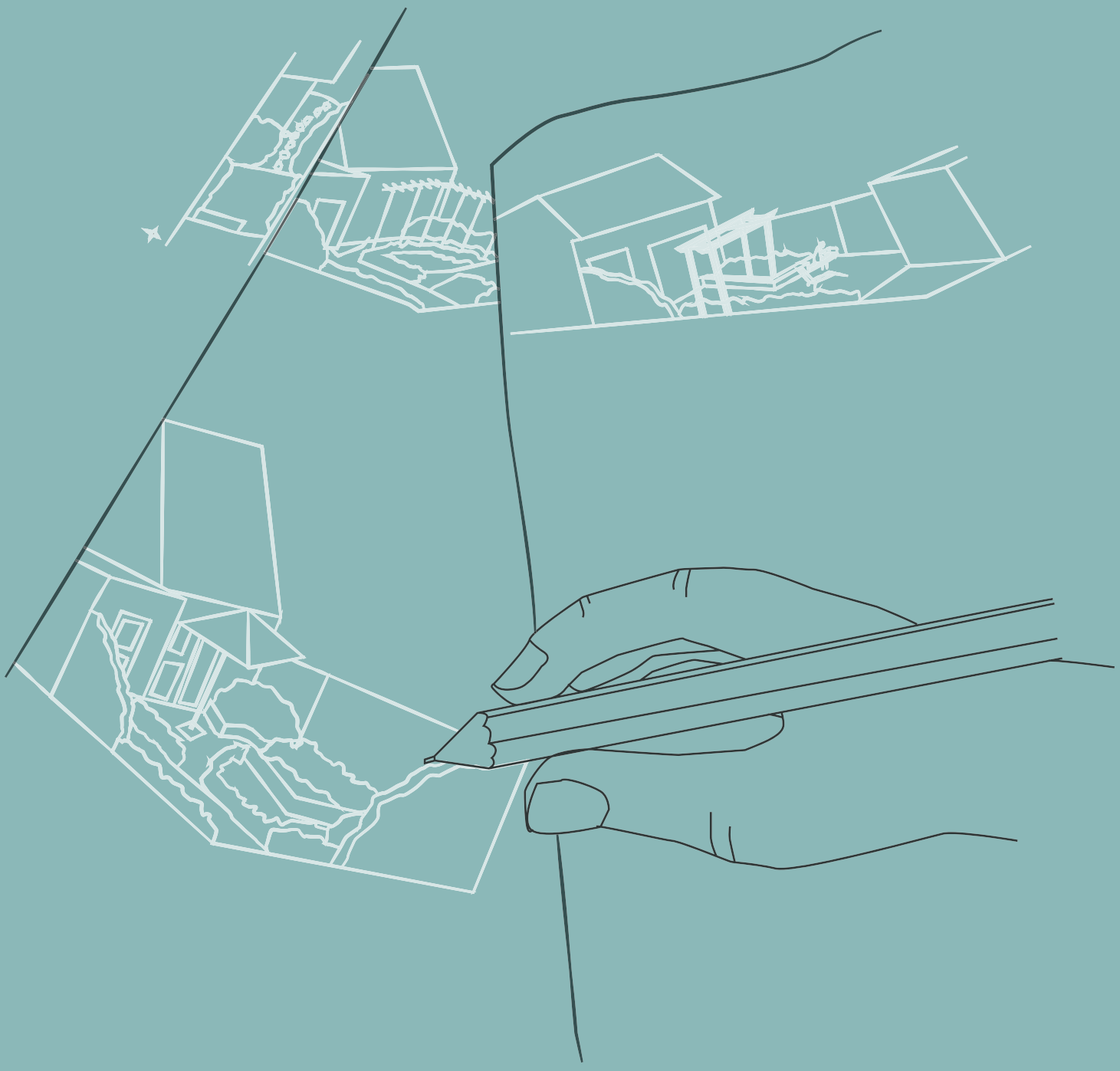
Table 2: Gardens with suitable measures

Garden type	Adaptation measures			
Back gardens	**Building modification**	**Material use**	**Objects/constructions**	**Planting**
Semi-detached housing 	• green roof • green facade • water roof/blue roof	• high albedo • low density (e.g. wood) • depaving • porous/permeable paving/ groundcover • covering the soil	• shading (built) • demarcation elements (built) • wind break (screen) • (rainwater) pond • (open) gutter • rainbarrel/water tank • downspout disconnect • height differentiation	• (espalier) trees • planted screen elements • low/middle/high vegetation • helophyte filters • wind break (green) • demarcation elements (green) • shading (green)
Row housing	• green roof • green facade • water roof/blue roof	• high albedo • low density (e.g. wood) • depaving • porous/permeable paving/ groundcover • covering the soil	• shading (built) • demarcation elements (built) • wind break (screen) • (open) gutter • rainbarrel/water tank • downspout disconnect • height differentiation	• planted screen elements • low/middle/high vegetation • wind break (green) • demarcation elements (green) • shading (green)
Front gardens				
Semi-detached housing 	• green roof • green facade • water roof/blue roof	• high albedo • low density (e.g. wood) • depaving • porous/permeable paving/ groundcover • covering the soil	• shading (built) • demarcation elements (built) • (open) gutter • rainbarrel/water tank • downspout disconnect • height differentiation	• (espalier) trees • planted screen elements • low/middle/high vegetation • demarcation elements (green) • shading (green)
Row housing	• green roof • green facade • water roof/blue roof	• high albedo • low density (e.g. wood) • depaving • porous/permeable paving/ groundcover • covering the soil	• shading (built) • demarcation elements (built) • (open) gutter • rainbarrel/water tank • downspout disconnect • height differentiation	• planted screen elements • low/middle/high vegetation • demarcation elements (green) • shading (green)

Measure represented in garden specified

Measure already represented in back/front garden

3. Phase 2 – Developing the local tools



3.1. TRANSLATING THEORY TO A DIGITAL TOOL

In the first phase, the test bed area was broken down into different 'local environments' and a selection was made of suitable adaptation measures that could be implemented in these environments.

Subsequently, in the second phase, the theory on how to communicate climate change and adaptation (as mentioned in the introduction) was translated to practical guidelines to create a digital tool. With the help of these guidelines, the test bed analysis and the selection of suitable adaptation measures, designs were made for both the *general local tool* and the *specified local tool*. The methods and results of these processes are further discussed in this chapter.

3.1.1. Methods

As described in the theoretical framework, several factors were defined that are deemed important in communicating climate change and adaptation.

To clarify the process and increase the usability of the theory for application in online tools, the theory was transformed into several groups of guidelines (Table 3). This was done by simplifying the previously defined theory and splitting the information into short and concise guidelines. These guidelines were used for the creation and evaluation of the online tools. In the development process, three overall designs for the tools were tested and adapted. This process is described in the next section: 3.1.2. Design process.

All designs were designed and tested by sketching and building the designs in Blender and Dreamweaver. An additional Blender plug-in, Blend4Web, allowed the tool to be run in most browsers and operating systems on PC and laptop. This way, users would not have to install any new applications in order to use the tool.

Table 3: Constructed guidelines (based on Wirth, Prutsch & Grothmann, 2014; Moser, 2010; Moser, 2006; ICLEI, 2009; Pandermaat, 2004; McKenzie-Mohr & Smith, 1999; Nicholson-Cole, 2005; Sheppard, 2005; Dykes, 2000; Lorenzoni & Langford, 2001; Furness et al., 1998; Grothmann, 2011; Moser, 2014)

 Credible	Use sound scientific data
	Be technically correct
 Comprehensible	Text short and concise
	Minimise use of technical terms
	Explain technical terms
 Translate to everyday life	Cast the information into a story
	Communicate personal risks
	Communicate personal benefits
	Build on personal experiences
 Frame to target group	Connect to prior knowledge
	Connect to what people find important
	Focus on what people can do
	Consider why no action was taken yet
 Emotions	Counter risks with solutions
	Make abstract information concrete
	Show a personally relevant environment/relateable symbols
	Show people/animals
	Use dynamic/animated imagery
	Show consequences of (in)actions
 Dialogue	Offer an option for communication

3.1.2. Design process

Three main designs have been tested, against the previously defined guidelines and through pilot studies. The first design (see Figure 16) consisted only of the interactive tool itself and was tested against the guidelines defined above, while taking into account the boundaries of the website and program. The two main problems with this first version were 1) that it crashed in the browser and 2) it did not explain any basic information on what the tool was about. There was no explanation of climate change, local risks and disadvantages and what the tool's actions were supposed to offer. This might be confusing and impair the comprehensibility of the tool.

In the second design, an introduction was added, explaining the purpose of the tool and its content and leading the user towards the tool. To maintain consistency and improve comprehensibility within the website, three main formats were used to layout the different pages of the website (see Figures 17 to 19) (Galitz, 2007).

Furthermore, some alterations were made to the tool itself. It no longer included a wider environment around the building, only the front and back garden. This could allow the tool to run properly in the browser.

The *specified local* version enabled the user to choose subsequently between 1) row house or semi-detached house, 2) type of row house/semi-detached house (depending on previous choice) and 3) the main orientation of the back garden (mainly to the North or mainly to the South).

The *general local* version (Figure 18) showed the row house condition right away. Instead of being able to view from all angles, there were two viewpoints to choose from. One showing the front of the house and the other showing the back of the house.

This second version was tested against the previously defined guidelines and subjected to a pilot with 12 participants. A new version (design 3) was created after that. Changes mainly concerned credibility, comprehensibility and emotional aspects, as shortly addressed in the next sections.

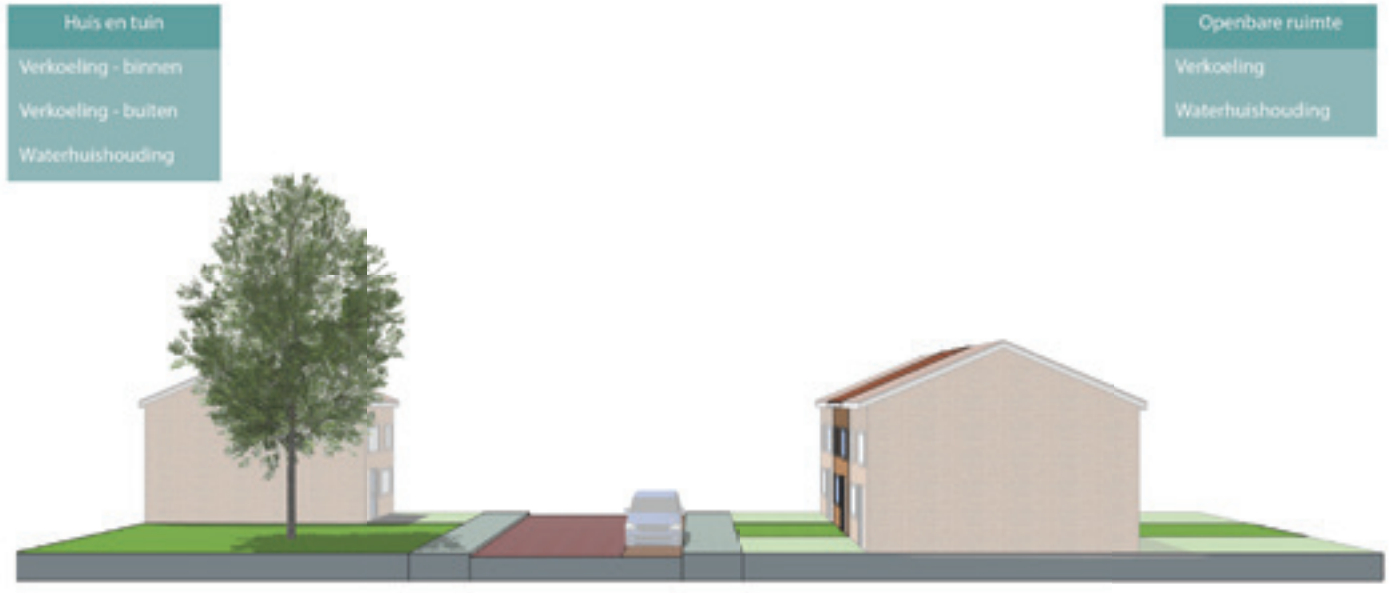


Figure 16: Indication of design 1. Street profile, functions across the street and the housing types would be changeable (beforehand) in the specific local version and the user would be able to view all around in both versions of the tool.

Figure 17: A short introduction to climate change in general, in the first page layout format.

Figure 18: A short explanation of flooding risks and consequences for the local environment, in the second page layout format. Pages in this format are subsequently: heat, drought, flooding and a short explanation on climate adaptation.

Figure 19: The general local tool, in the third page layout format. The specific local tool is executed in the same format.

Credibility

The APA referencing style was regarded by some pilot participants as confusing and distracting. Therefore this was changed to using footnotes with (a simplified) reference in combination with a numbering system where deemed relevant (where one piece of information is clearly only stated in a different source) (Figure 20).

Comprehensibility

The animations were unclear in their function and it was for some hard to see what exactly they were meant to show. Therefore, the important happenings were more enhanced, such as the rain and water level rise in the drought and flooding animations and the glowing lines in the heat animation. Furthermore, the animations were referred to more extensively in the explanatory texts (Figure 20).

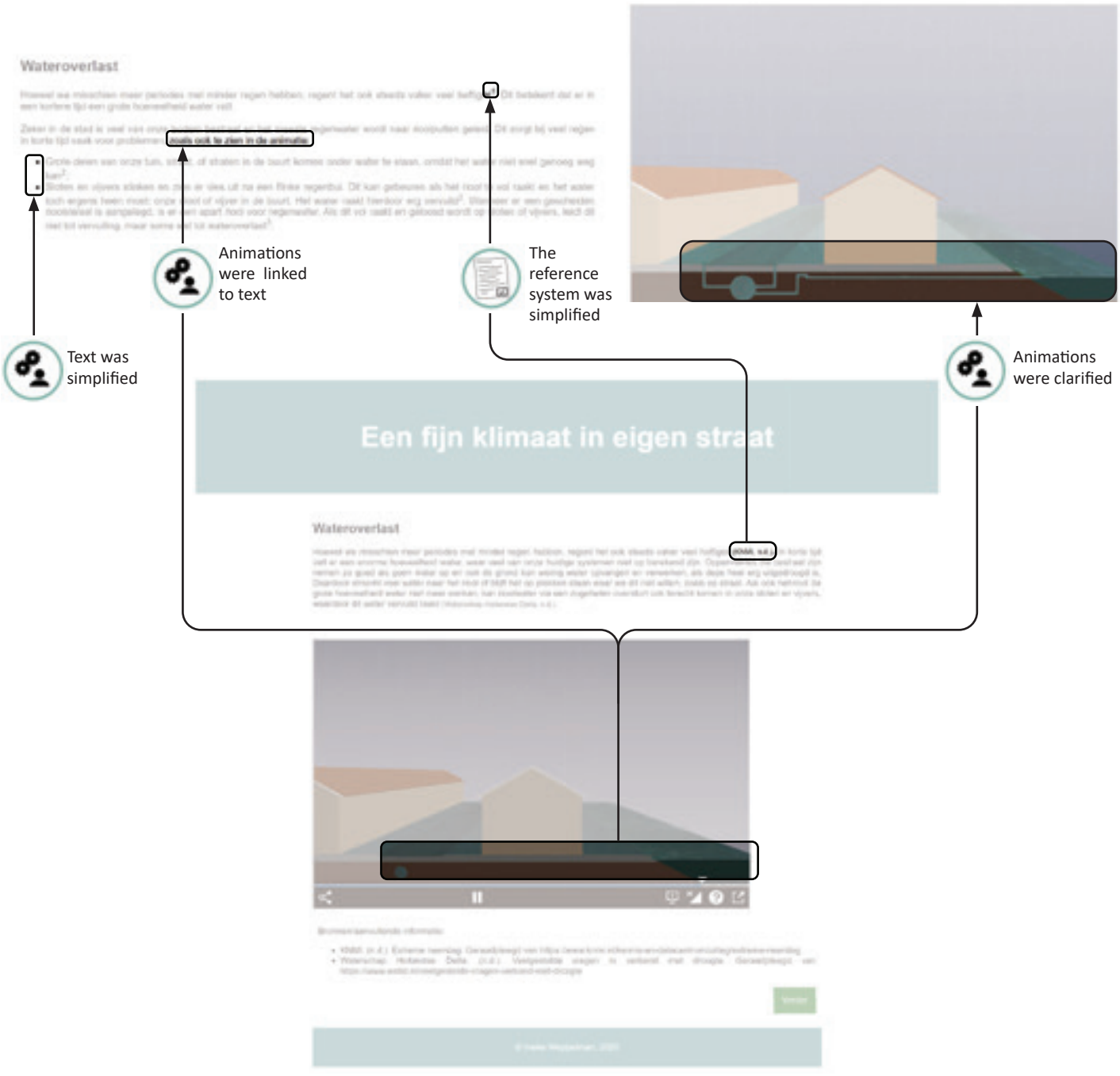


Figure 20: pilot version (below) and the improvements (top). The icons indicate which guideline the improvements followed.

As some participants were missing a clear link between the text on the measures and the garden visualisations, a glow interaction was added. When users would click on a measure, the corresponding visualisation of that measure in the example garden would light up for a second 5 times subsequently, with a white glow outline (Figure 21). To make sure all measures/actions (and as many as possible) were visible in the gardens, all gardens were revisited and improved on these aspects as well.

Furthermore, while people were quite positive on the texts explaining the measures, many mentioned that the indications of biodiversity, water, cooling, cost and maintenance were not quite clear. Therefore, symbols were added so that these indications would become more clear and easily visible (Figure 21).

Emotions

As there seemed to be some confusion on which garden orientation to choose when a garden is not clearly oriented on the north or the south, the wording was changed. 'Oriented on the South' became 'mainly oriented on the South' and 'oriented on the North' became 'mainly oriented on the North', to avoid situations where participants would consider the choice too limited and become confused.

In the pilot version of the tool and website, no people or animals were included in the visualisations. These were added as well, for a stronger emotional value (Figure 21).

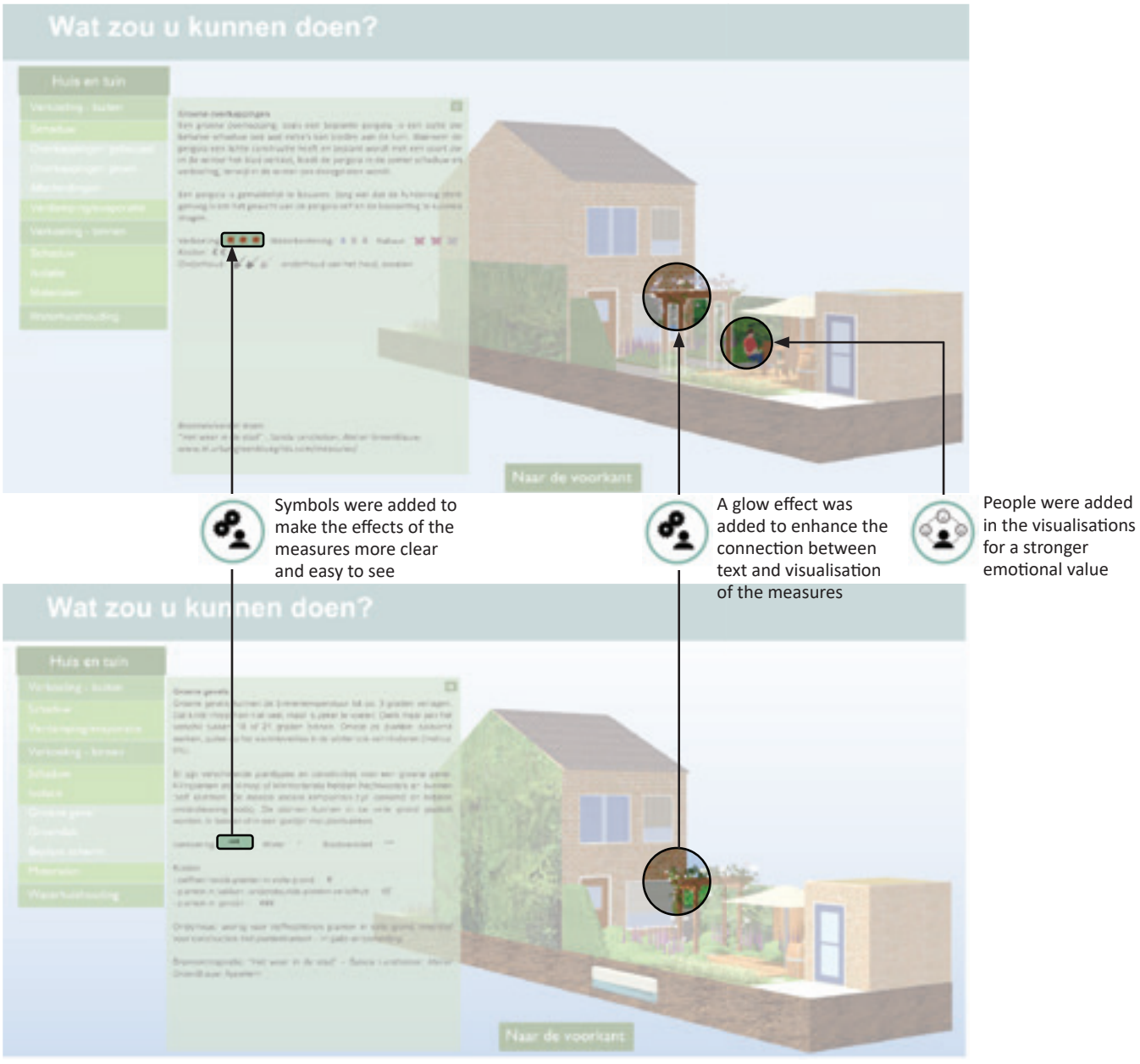


Figure 21: pilot version (below) and the improvements (top). The icons indicate which guideline the improvements followed.

After a final pilot (N=9) to test if everything was running well on different operating systems and with different browsers, the tool was released for the main testing.

Of all versions, several check-ups were done on which guidelines could be and were eventually incorporated. An overview of this can be found in Table 4.

Table 4: Overview of the previously defined guidelines and the scoring on of the different designs on the different factors

		DESIGN 1			DESIGN 2					DESIGN 3				
		General/interface	Information on measures - text	Information on measures - visual	General/interface	Introductory information - text	Introductory information - visual	Information on measures - text	Information on measures - visual	General/interface	Introductory information - text	Introductory information - visual	Information on measures - text	Information on measures - visual
 Credible	Use sound scientific data		•			•		•			•		•	
	Be technically correct		•			•		•			•		•	
 Comprehensible	Text short and concise		•					•		•	•		•	
	Minimise use of technical terms		•			•		•			•		•	
	Explain technical terms		•			•		•			•		•	
 Translate to everyday life	Cast the information into a story				•					•				
	Communicate personal risks					•	•				•	•		
	Communicate personal benefits		•	•		•	•	•	•		•	•	•	•
	Build on personal experiences		•			•		•	•		•	•	•	
 Frame to target group	Connect to prior knowledge		•			•		•			•		•	
	Connect to what people find important		•	•		•	•	•	•		•	•	•	•
	Focus on what people can do		•	•		•		•			•	•	•	•
	Consider why no action was taken yet		•			•		•			•		•	
 Emotions	Counter risks with solutions						•				•	•		
	Make abstract information concrete		•	•					•		•	•	•	•
	Show a personally relevant environment/relateable symbols			•			•		•			•		•
	Show people/animals			•								•		•
	Use dynamic/animated imagery	•		•	•		•		•	•		•		•
	Show consequences of (in) actions			•			•		•			•		•
 Dialogue	Offer an option for communication	•			•					•				

The first design was scored only by the researcher, the second and third were evaluated by pilot participants as well (N=10 for design 2 and N=9 for design 3). For the pilot scoring, questionnaire scales were used that evaluated the incorporation of the different design guidelines, each scale consisting of at least 3 statements that could be answered on a five-point Likert-scale (see Appendix I - Evaluatie van de lokale tool, p. 65-67). If a guideline scored above 3 on average, it was marked as 'present' in Table 4.

As not all guidelines were applicable to all parts of the tool, a subdivision was made between introductory information and information considering the various measures, as well as between textual and visual information.

The introductory information includes an introduction of climate change and climate adaptation, closing with an invitation to take a further look at the possible actions that people can take. The information is in text, supported by short animations.

The information considering the measures includes the main part of the website: the interactive tool where people can interact and look at different actions they could take to create a more climate adaptive and pleasant garden. This part consists of both textual and visual information as well: measures are explained in text and can be chosen from a menu, while the textual information corresponds to a visualisation of the measures in an example garden environment.

The following sections further elaborate on the final designs for the interface, introductory information and information on the measures.

3.1.3. Interface

Comprehensible

The overall interface (Figure 22) was designed to be comprehensible, minimising the amount of text and creating a clear lay-out (Galitz, 2007; Wirth, Prutsch & Grothmann, 2014), in order to stimulate participants to not give up, but stay on the website (Galitz, 2007). Within the text, bulleted lists, short alineas, sub-headings and/or images are used to increase understandability (Wirth, Prutsch & Grothmann, 2014) and offer the possibility to quickly scan the page (Galitz, 2007).

The lay-out was created to be user-friendly: with a quite standard and simple website framework, offering a header and footer and a consistent and structured placement of text and visual information. Within the interactive tool, the menu to navigate trough the different measures was placed on the left of the screen, a position generally preferred by visitors (Galitz, 2007). Furthermore, the overall lay-out of the website was kept very similar for all pages, so that participants would more easily understand the structure of the website (Galitz, 2007).

Translate to every day life

In addition, a logical story was created leading users towards the tool and the use of the tool itself, so that it would be easier to connect to one's everyday life experience (Wirth, Prutsch & Grothmann, 2014). The principle of creating a 'story' was for this context interpreted as creating a logical sequence of events that people would be able to identify with. In this case, this meant that first climate change was explained and what this means for our environment. Thereafter comes a short explanation of what can be done to cope with climate change and its repercussions in our environment. And after this the tool was presented, with several specific measures explained in further detail.

Collaboration/dialogue

Furthermore, several opportunities for communication were built into the interface. Interaction between sender and receiver of information is considered to be highly valued (Wirth, Prutsch & Grothmann, 2014; Moser, 2014). As direct interaction was not possible, the choice was made for this (perhaps) less optimal, but still available option.

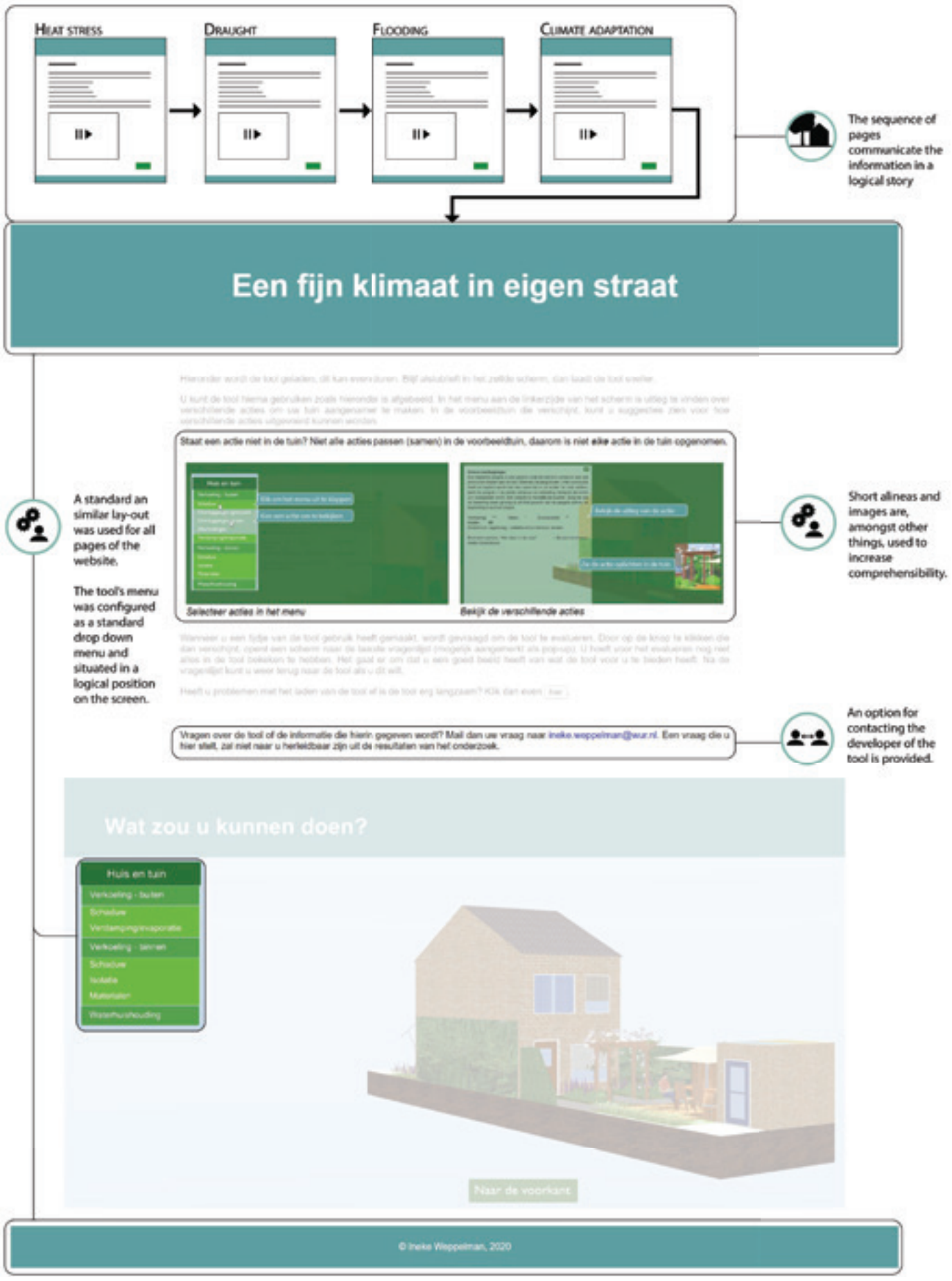


Figure 22: Interface with the respective guidelines where they are applied.

3.1.4. Introductory information

The introductory information (Figures 23 and 24) offers a short introduction on climate change, its repercussions and what can be done to cope with these.

Textual component

Credible

The text was written based on data from scientific papers and other sources like the KNMI (KNMI, 2014) and was made sure to be technically correct (ICLEI, 2009; Wirth, Prutsch & Grothmann, 2014). To increase credibility and to provide opportunities for further reading, references were listed in the text and at the bottom of the page.

Comprehensible

To keep the text comprehensible for a wide audience, technical terms were avoided where possible and explained where necessary. Furthermore, text was kept as much as possible short and concise, only providing a short introduction (Wirth, Prutsch & Grothmann, 2014).

Translate to every day life

Instead of only introducing the vague (global) concepts of climate change and climate adaptation, the text discusses what people might (have) notice(d) in their own environment (Wirth, Prutsch & Grothmann, 2014): *"In dry periods we will for example see more yellow grass and withered planting..."*. It furthermore highlights the impact of climate change in their personal environment (Wirth, Prutsch & Grothmann, 2014; Moser, 2014): *"A lot of paving and buildings retain heat, because of this, you will often be able to feel a significant difference between a (densely) built area and a green area.".* And it highlights benefits people might experience when implementing adaptation measures (Wirth, Prutsch & Grothmann, 2014): *"By creating more shaded areas, we can make our environment even more pleasant in summer."*.

Frame to target group

An attempt was made to depart from knowledge that may be with the target group already, to stimulate engagement (Lentz & Pander Maat, 2004; Moser, 2010; Wirth, Prutsch & Grothmann, 2014). As not much was known of the knowledge base of the target group, information in the tool departs mainly from common knowledge and a very basic understanding of climate change and adaptation (e.g. climate change results in warmer cities and measures exist to adapt to this). This is applicable for example to the use of certain technical terms and knowledge about certain processes like infiltration of water in the soil. Furthermore, the target group should be able to ponder over possible changes in a specific garden, as otherwise the information in the tool would not serve its purpose.

From this starting point and an assumption of what the target group might find important (e.g., a pleasant personal environment, greenery, working in the garden and/or the local or even global climate) (H. Kemper, personal communication, February 12, 2020; M. van Duuren, personal communication, February 14, 2020), solutions are suggested that people may be able to implement easily themselves. It may be that people have certain reasons for not taking action before, for example because of a lack of time and/or money) (Lorenzoni et al., 2007; Biesbroek et al., 2011; H. Kemper, personal communication, February 12, 2020). If this is suspected, advantages are mentioned that refute or lessen the perceived barriers.

Emotions

To keep a positive mindset, the introduction to climate change and adaptation closes off with a hint towards possible solutions and an encouragement to continue to the tool to learn more about the possibilities (Wirth, Prutsch & Grothmann, 2014): *"There are several possibilities to make our environment more pleasant. Not only for the future, but just as well in our current situation. Shall we go on and take a look at the different possibilities?"*

Figure 23: Introductory info (textual) with the respective guidelines where they are applied

Figure 24: Introductory info (visual) with the respective guidelines where they are applied

Visual component

Emotions

To further concretise and illustrate the information brought by text, all introductory text is supported by short animations (McKenzie-Mohr & Smith, 1999; Dykes, 2000) (Figure 24 shows this for the adaptation text). The animations show examples of climate change repercussions and/or what would change if we would apply adaptation measures, as fitting to the text on the respective pages (Furness et al., 1997; Lorenzoni & Langford, 2001). The animations are set in simple, though relatable environments, some with the inclusion of people (Nicholson-Cole, 2005; Sheppard, 2005).

Translate to every day life

The animations introducing climate change show a (future) recognisable situation including the risks when no action is taken, while the animation introducing climate adaptation shows both this situation and some benefits of implemented adaptation measures, such as water infiltrating in the soil and having a shaded spot (Wirth, Prutsch & Grothmann, 2014).

Frame to target group

Furthermore, the animations are designed to connect to what people may find important in their personal environment (Moser, 2006; ICLEI, 2009), such as (no) water on the street and in the garden, and creating a cool pleasant area in their garden where they can sit in summer. The focus lies on what people could do: the measures shown are quite easy to implement by home owners themselves (Moser, 2006).

3.1.5. Information on measures

The information regarding the adaptation measures (Figures 25 and 26) forms the main focus of the tool. An overview of all environment representations can be found in Appendix III - Environments, p. 76.

Textual component

Credible

The information provided on the measures is based as much as possible on scientific data and is written to be matching this information correctly (Wirth, Prutsch & Grothmann, 2014). For further reading and to show credibility, references are listed below each explanation text.

Comprehensible

Though based mainly on scientific sources, the explanations of measures are kept short and concise and technical terms are minimised and where necessary explained clearly for laymen (Wirth, Prutsch & Grothmann, 2014).

Translate to every day life

By communicating the benefits for one's personal and local situation and mentioning the improvements a measure would bring from one's personal perspective, connecting to personal experiences, the effects of the measures would be easier to grasp (Wirth, Prutsch & Grothmann, 2014).

Frame to target group

In the explanation of the measures, the focus is on the advantages when a measure is applied. Aspects are highlighted that users may find important, such as keeping the garden dry instead of muddy or creating a cool environment . Furthermore, the focus is of course on what people *can* do (Moser, 2006; ICLEI, 2009). To ensure easy applicability of the measures, short directions are included of aspects that should be taken into account for implementation. This could for example be a reminder that a pergola should be able to bear the weight of its own construction, but also the weight of the planting. Or suggestions for the depth of a pond to minimise the risk of bad water quality.

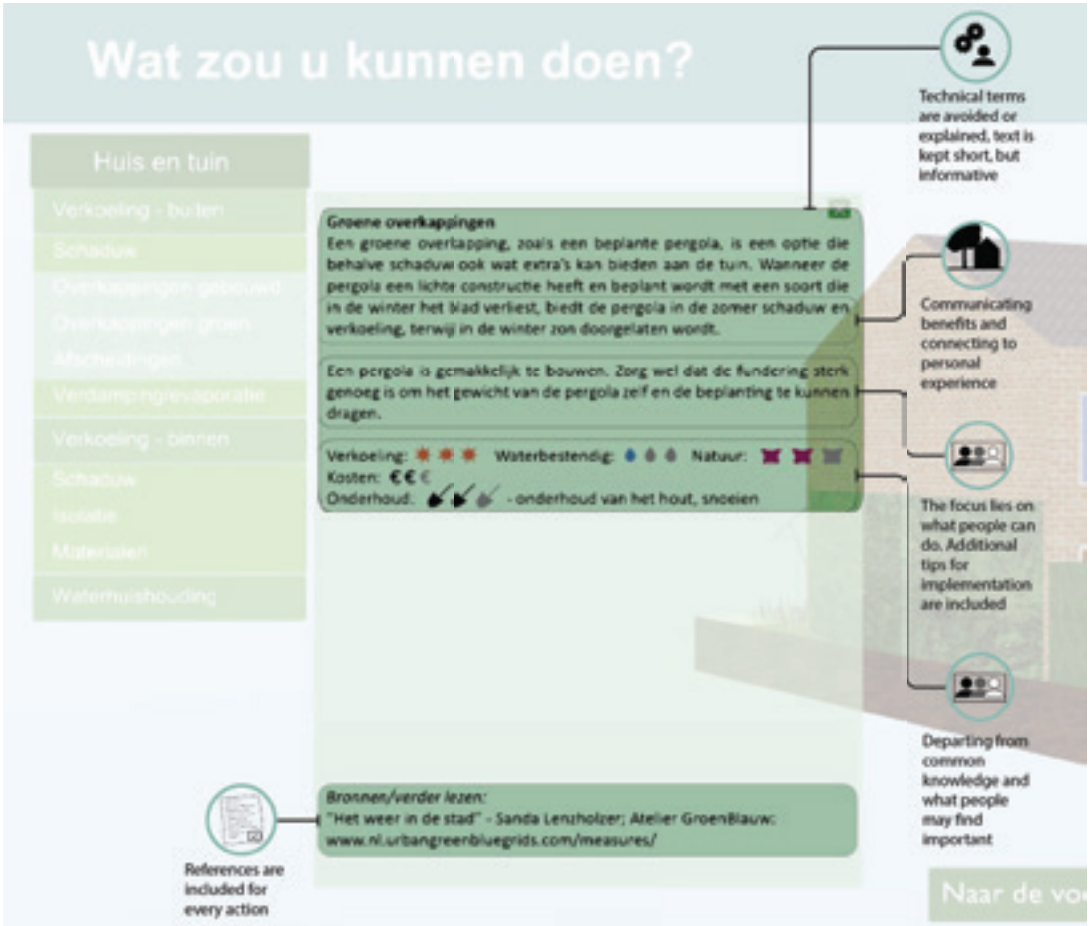


Figure 25: information on the measures (textual) with the respective guidelines where they are applied

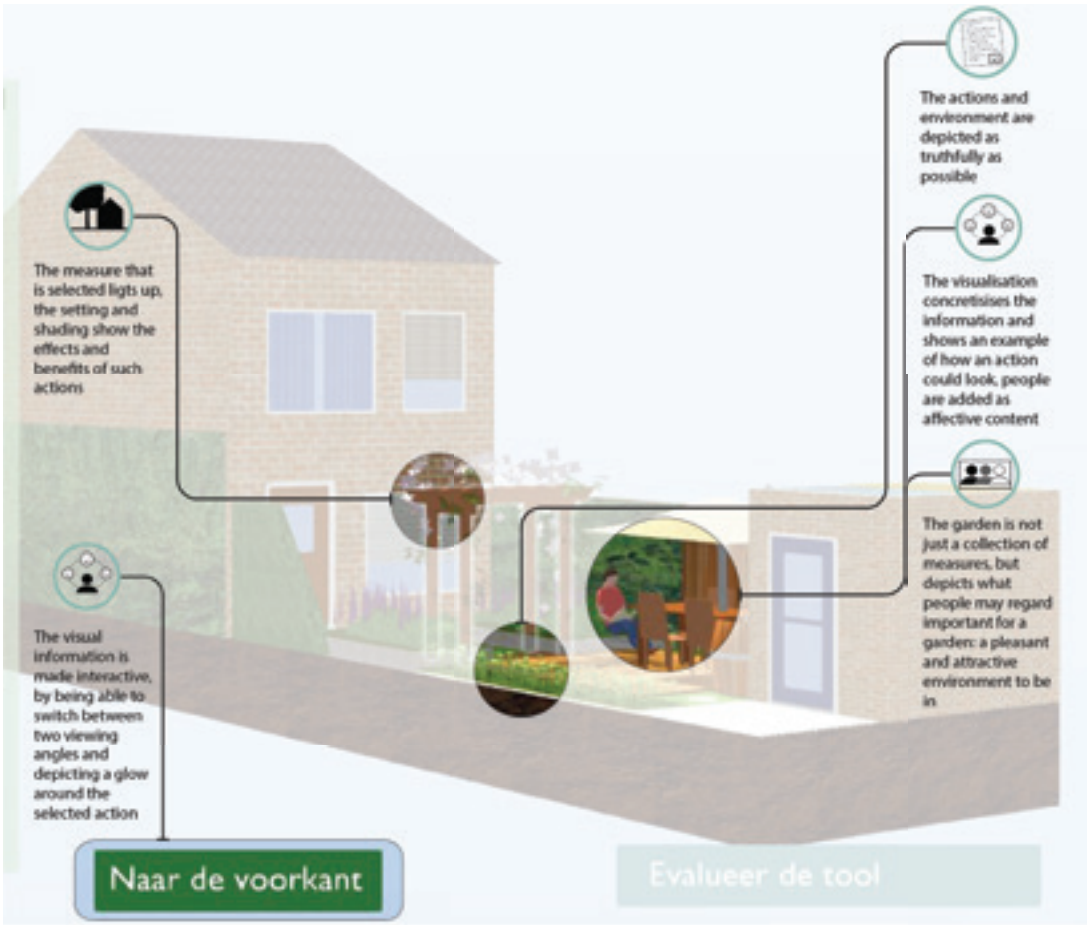


Figure 26: information on the measures (visual) with the respective guidelines where they are applied

Maintenance and cost indications were added to indicate that there are more, but also less time consuming and expensive options. This may take away part of the barriers of inaction (ICLEI, 2009).

Visual component

Emotions

While the visualisations do not show a change before and after implementation of measures, they do depict a concrete example of what could be achieved by implementing (some of) the measures in a relatable (personally relevant) environment (McKenzie-Mohr & Smith, 1999; Lorenzoni & Langford, 2001; Nicholson-Cole, 2005; Sheppard, 2005).

To which extent the environment is relatable for users of the tools, is manipulated by whether the user can choose the best fitting environment (specific local tool) or not (general local tool). In the general local tool, a standard house and garden are depicted that is found in many visualisations of standardised environments (e.g. de straaD, 2016; Tuinhappy, n.d.; Arnhem Klimaatbestendig, n.d. b; Waterschap Zuiderzeeland, n.d.; Province Noord-Brabant, n.d.). In both of the tools, the visualised environment is interactive and can be looked at from two different perspectives (Dykes, 2000).

Credible

The environments were eventually depicted from two different perspectives and contained a large amount of measures. Still, these environments and measures were represented as correctly as possible. All measures were situated in a location where they would be suitable and effects such as shading are depicted truthfully (Wirth, Prutsch & Grothmann, 2014).

Translate to every day life

Displaying the measures in the local garden environment, shows the benefits that one would experience being in this environment. Additionally, people might remember or be able to empathise with these (kinds of) settings from their personal experience (Wirth, Prutsch & Grothmann, 2014).

Frame to target group

Assumingly important aspects to the target group are included in the visualisation, like shading and aesthetic values. Combined with showing what a garden could look like with relatively easy measures one can implement themselves, this may give off a positive and hopeful message that resonates with the target group (Moser, 2006; ICLEI, 2009).

3.1.6. Discussion

Not all factors/guidelines have been implemented fully and elaborately. Consequences of actions and inactions are only represented together in a simple animation illustrating climate adaptation, but not, for example, in the visualisation representing the adaptation measures. This is due to constraints on time, resources (the power of the program that the visualisations were created with) and abilities to construct more complex environments.

Loading times and performance

Loading times and performance of online media are known to influence the mood (frustration/ satisfaction) (Ceaparu et al., 2002; Reips, 2002; Heidig, Müller & Reichelt, 2015) and the motivation of the user to continue using the website (Reips, 2002; Heidig, Müller & Reichelt, 2015). Loading time seems to be among the most affecting aspects, although the impact and the threshold when loading times become intolerable vary widely, ranging from approximately 2 to 42 seconds.

Furthermore, having no indication of progression and how long the loading might take, is considered to increase the negative impact of a longer loading time (Heidig, Müller & Reichelt, 2015). Therefore, an attempt was made to keep the loading times as short as possible within the scope of showing the selected environments including the measures and some interactive features. Pilots were run amongst 19 participants, to find a balance between the functionality and appeal of the tool.

Functionality and interface design

Other aspects that may negatively influence user satisfaction and motivation to continue on the website are layout and design, functionality and

appeal (Ceaparu et al., 2002; Heidig, Müller & Reichelt, 2015). These factors as well were taken into account where possible. However, as the project was started with no experience in creating interactive and dynamic environments or websites and only very little money was available for purchase of other programs or (technical) support, some of these aspects could still be improved.

Considering this, it would be advisable to hire or consult a person who would be able to build the actual interface and functionality of the tool and website, might similar research be conducted in the future. This would not only allow for more opportunities in functionality and an overall better performance, as stated to be important for user satisfaction and lowering drop-out rates (Reips, 2002; Heidig, Müller & Reichelt, 2015). It would also allow for the Landscape Architect to focus more on the design of the measures and environments, which may well result in an overall higher quality of the product.

Representation of environments

As for the environments, the choice was made to display them from two viewpoints in a perspective view, as this may be easier to relate to and easier to read than for example a plan view (Gänshirt, 2007). The chosen perspective views show the house and garden from some distance. A more realistic or relateable view (deemed important for emotion), may be achieved by a view from inside the house looking out at the garden, or viewing the garden from a point sitting somewhere in the garden (see for example Figure 27). However, a view like this does much less so offer an overview of the garden with the implemented adaptation measures. Therefore, more perspectives would be necessary to show a similar amount of measures as in the overview that was achieved by viewing from a distance.

Furthermore, the level of detail in the garden environments should ideally be higher, if viewed from a closer distance. These actions required a more complex interface design, more actions being defined in the coding and more rendering capacity. As these factors greatly hampered the performance of the tools, the decision was made to use two main perspective views that provided an overview, combined with a straightforward interface. That way, it was possible to illustrate many measures in quite a realistic setting and it would still maintain its interactivity while not having to use as much data as allowing the camera to hover.

However, important to note is that the different environments are thus optimised for being viewed from a certain angle. Therefore, the designs that are depicted are not optimised as they would be actual garden designs. They could be implemented as such, but this has not been the main focus and the result of this may very probably not result in an ideal garden design.

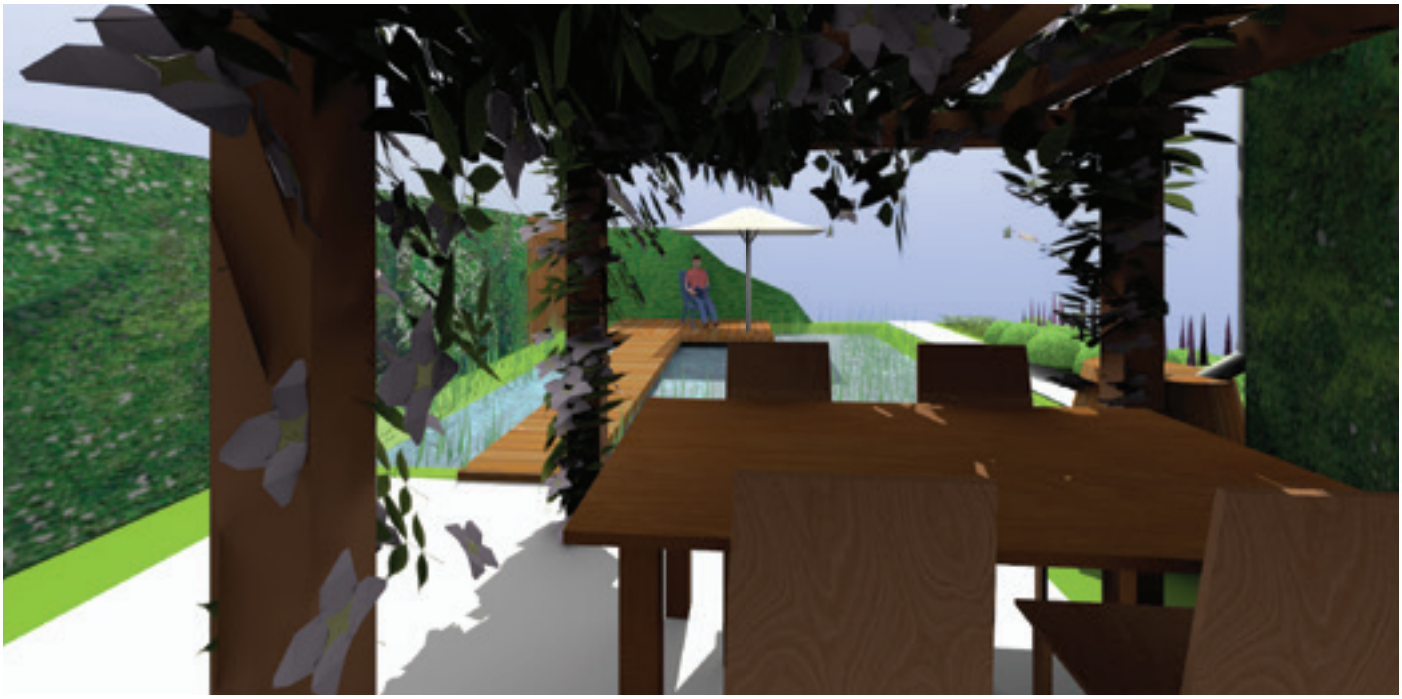


Figure 27: (rendered) view from inside out towards one of the gardens

4. Phase 3 – Testing the local tools

4.1. DESIGN AND MATERIALS

To test both tools, a distinction was made between two participant groups: one group using the general local tool and one group using the specified local tool (Figure 28). This allowed for comparison between two levels of 'local' (see definition in the text box), a factor deemed important (Lorenzoni et al., 2007; Shaw et al., 2009; Wirth, Prutsch & Grothmann, 2014) but lacking specification. To gain insight in the effects of the two tools, a questionnaire measuring climate change awareness, willingness to mitigate and willingness to adapt was offered before (pre-test) and after (post-test) using the tools. An additional questionnaire (delayed post-test) was prompted four weeks after use of the tool, to give an indication of long-term effects. Questions regarding climate change awareness, willingness to mitigate and willingness to adapt were identical in the pre-test, post-test and delayed post-test.

The questionnaires measuring these aspects (see Appendix I) were adapted from Evans, Milfont & Lawrence, (2014).

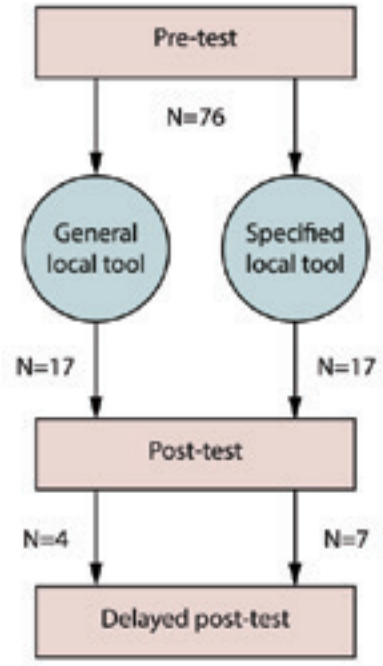


Figure 28: Research design

'Local' in this thesis was defined to primarily designate private homes and gardens. The general local tool interprets 'local' as a standardised house and garden, while the specific local tool interprets 'local' as being able to choose a house and garden type that best fits participants' personal environments.

The introductory texts, answer options and questions considering climate change awareness and willingness to mitigate were translated into Dutch. Added to this, were a sub-scale considering participants' willingness to implement climate adaptation options (willingness to adapt) and several questions on participants' own experiences (climate change effects in personal environments) and the barriers they perceive to not take action.

Only in the pre-test questionnaire, several questions were asked considering personal situation and demographics. Participants could fill in their age and zip code (open questions); indicate their education level, gender, if they had no garden, only a front garden, only a back garden, or both; and if they are renting or have bought their house (multiple choice). In addition, several questions were asked where participants could indicate if they thought climate change influenced their own environment and if action should be taken in order to maintain a pleasant environment (five-point Likert scales).

Only in the post-test questionnaire, an additional part was taken up considering the representation of the previously defined guidelines (see 3.1. Translating theory to a digital tool, p. 22) and the performance of the tools. The representation of the guidelines was measured by the sub-scales **credibility**, **comprehensibility**, **translating to everyday life**, **framing to target group** and **dialogue**. Questions within these scales were inspired by the questionnaire from Klemm (2018): formulation was similar, but the content was altered to match the guidelines and subjects of this thesis. Similar to the questions regarding climate change awareness and willingness to act, these questions could be answered on a five-point Likert-scale. For all measured scales, reliability was checked, see Appendix I for internal consistency values (p. 60, 61, 64, 65, 70 and 71 for scales measuring awareness and willingness to act and p. 66 and 67 for scales measuring the representation of guidelines).

To link the questionnaires without compromising participants' privacy, participants were asked to fill in a personal code at the start of each questionnaire. The code was composed of the second letter of their first and last name and a two-digit notation of their day of birth.

All questionnaires were offered through Microsoft Forms.

4.2. PARTICIPANTS

Participants were recruited by various different platforms. First of all, residents from the test-bed area (Rijkerswoerd) were invited, by placing an invitation on the Rijkerswoerd Facebook and NextDoor platform and putting up invitation pamphlets at the Rijkerswoerd shopping centre. The invitation was furthermore sent to the neighbourhood newspaper "Het Woerdje". In addition, some residents that were for example already contacted in the analysis phase of the project were invited individually, by email.

When, after approximately two weeks, not many residents from the test-bed area were responding (anymore), the invitation was posted publicly on Facebook and sent to acquaintances, family and friends with the request if they would like to participate or share.

In total, 85 people completed the pre-test (see Figure 29). However, not all of them continued to finish the post-test as well (Figure 30).

Besides this, 9 participants were excluded from the analysis. Three participants took more than 5 hours between the pre-test and the post-test, while others all remained under two hours. Six other participants were excluded because of technical issues (performance issues of the tool, duplicate entries and a faulty link).

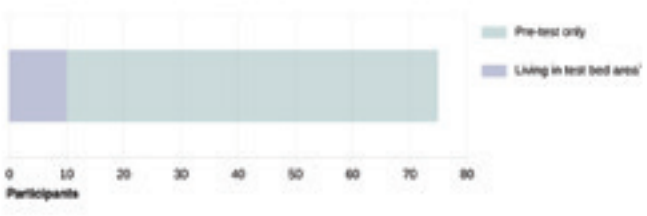


Figure 29: Total amount of pre-test participants, with proportion of participants from the test-bed area

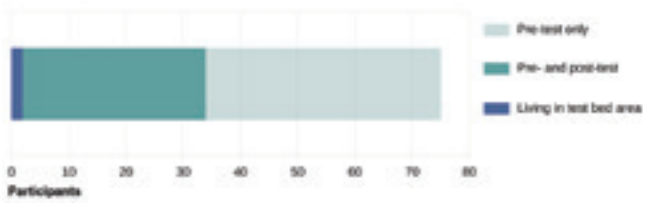


Figure 30: Total amount of pre-test and post-test participants, with proportion of participants from the test-bed area

Eventually, 76 participants participated in the pre-test and 34 participated in both the pre- and post-test (17 for the *general local tool* and 17 for the *specified local tool*). The delayed post-test was completed by only 11 participants. Of the total sample of 76 participants, 10 were living in the test bed area; of the sample participating in both pre- and post-test, only two participants lived in the test bed area (Figure 30). Still, it seemed that most participants were of the opinion that the environment presented in the tools matched their personal environment quite well. Both the composed scale measuring translation to everyday life, as well as a specific statement within this scale referring to similarity to personal environment reflects a mean value of approximately 3.5 (composed scale: M = 3.70, SD = .62 ; specific statement M = 3.50, SD = .96), measured on a 5-point Likert-scale.

The different invitation methods did lead to participants of different ages. However, still the age group of people between 20 and 30 was clearly most represented in the eventual sample of 34 participants (M = 38.48, SD = 16.22) (Figure 31). Besides this, the majority of participants (30) indicated that they had finished or were enrolled in Bachelor (15) or Master (15) education, leading to a fairly highly educated sample. Furthermore, there were slightly more female (20) participants.

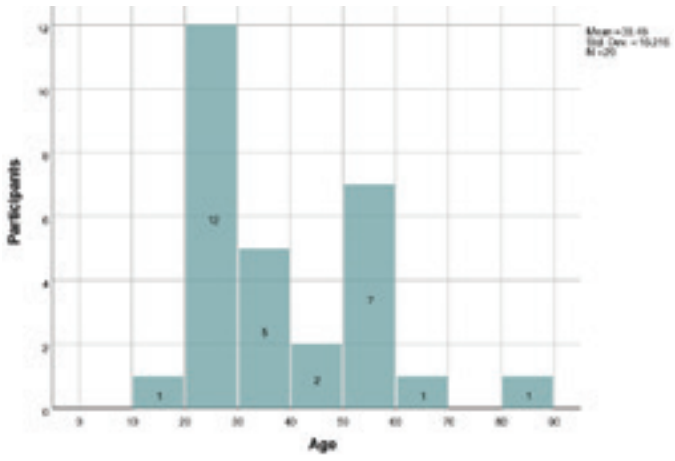


Figure 31: Division of age groups over the total sample

4.3. PROCEDURE

Participants could find the website by following a hyper link of 'mijnklimaatregelen.wur.nl' in the invitation text, or by typing it in manually their browser address bar. When on the website, they were led through a sequence of steps, as displayed in Figure 32.

The landing page shortly introduced the research and contained the information necessary for an informed consent form. Agreement to continue could be given by ticking off several statements indicating understanding of their rights as stated in the informed consent and clicking an 'agree and continue' button. Participants not agreeing, could not continue on the website. Those who did agree to participate, were first asked to fill in a questionnaire (adapted from Evans, Milfont & Lawrence, 2014) giving an indication of their current levels of awareness and willingness to act regarding the concept of climate change and mitigation and adaptation measures (see appendix I - Inventarisatie, p. 60).

After completing the first questionnaire, participants were sent trough a sequence of pages where climate change and adaptation were shortly introduced. Thereafter, participants were, by means of a Java script function, randomly assigned to one of both tools: the *general local tool* or *specified local tool.* After the optional choosing of their specific housing type (in the specific local tool only), participants were shown an environment consisting of a house and garden, with various adaptation measures included that would be fitting the environment. In both tools, one could click on different measures in a menu on the left of the screen, to open a panel with more information, like effectiveness and maintenance. When a measure would be clicked, this measure would light up in the garden environment.

After approximately 90 seconds, a pop-up would show in the center of the screen, asking participants for an evaluation of the tool. Participants could choose to evaluate immediately or first look around for a little longer. In the latter case, the evaluation button would wait in the right down corner of the screen and the pop-up would show every minute as a reminder.

When clicking the evaluation button, participants were sent through to a questionnaire that evaluated (1) the extent to which the factors identified in the theoretical framework are represented in the tool and (2) the new levels of awareness and willingness to act for climate change and adaptation (for the complete questionnaire, see appendix I - Evaluatie van de lokale tool, p. 64). After completing this questionnaire, participants could return to the tool in the previous tab, if they wanted to. In addition, participants could indicate (1) if they wanted to receive a link to 'their' version of the tool without the evaluation function and (2) if they would want to participate in a final questionnaire a month later: the delayed post-test.

This delayed post-test would allow for an indication of longer term effects. A month after using the online tool, participants who had given permission to be contacted for the delayed post-test were sent an email with the delayed post-test questionnaire measuring awareness and willingness to act for climate change and adaptation (see appendix I - Terugkoppeling, p. 70).

On the first page of the website and on the pages of the tools, an option was available to send the author a message, for example about one of the measures. This contained a simple mail-to option that could be answered over email. The questions that were asked through this function were not linked to the specific participant. They were however traceable to one of the tools, as for each tool version a different e-mail address was linked.

The website was open for new participants for seven weeks, to allow for enough participants to use and evaluate it. After this period of time, the website was closed to new participants, but those who received a link to visit the general local tool or the specific local tool without the evaluation function could still visit these respective pages.

4.3.1. Discussion

Of course, online sampling and conducting complete internet-based research in general are not without disadvantages. Often, very little is known of the sample population, as was the case in this thesis as well. Because all data is furthermore self-reported, there is no guarantee that all information provided by participants is correct and accurate (Wright, 2005).

As no specific sampling frame could be established, all participants were recruited by means of convenience sampling. For example by putting up flyers, posting on social media pages and asking family, friends and previously contacted residents in the test-bed area

Figure 32: Schematic view of the website structure

to participate and pass on the invitation (snowball sampling) (Kumar, 2014).

Attempts were made to send out and post the invitation in many different environments and networks to reach a more diverse sample. However, generally, it still seemed that participants mostly participated if they were either interested in the subject, simply wanted to help out, or (mostly) a combination of both. This suspected self-selection bias (see e.g. Wright, 2005) may have contributed to a highly climate change aware sample.

4.4. DATA ANALYSIS

Several analyses were performed on the collected data. Climate change awareness, willingness to mitigate and willingness to adapt were compared within-subjects and between-groups. The factors evaluating the representation of guidelines in the tools (**Credibility**, **comprehensibility**, **translating to everyday life**, **framing to the target group**, **emotions** and **dialogue**; see also 1.2. Theoretical framework, p. 3 and chapter 3. Phase II - Developing the local tools, p. 19) were only compared between-groups. For all questionnaire scales, normality was assessed via the explore function in SPSS.

For all normally distributed within-participants data, Repeated Measures ANOVAs were run (Field, 2013). For all non-normally distributed within-participants data, the same Repeated Measures ANOVAs were run and supplemented with Wilcoxon Signed Rank tests (Field, 2013).

For all normally distributed between-groups data, the interaction effect was checked from the Repeated measures ANOVAs. For all non-normally distributed between-groups data, this was supplemented with Mann-Whitney U tests (Field, 2013). For these non-parametric tests, composed scales were used, of the pre-test scores extracted from the post-test scores.

Only for willingness to adapt, the data were normally distributed in both the pre-test and the post-test. For climate change awareness, only the pre-test data were normally distributed and for willingness to mitigate only the post-test data were normally distributed.

Of the scales used to evaluate the representation of previously defined guidelines, none were normally distributed.

Textual feedback from the open questions considering (1) barriers holding one back from taking action and (2) positive points and points of improvement considering the tools was analysed by means of open coding and axial coding.

Finally, correlations were checked for the pre- and post-test scales and demographic factors, including age, education level, type of garden, rental or bought house and whether participants lived in the test bed area or not. Furthermore, correlations were checked between seeing climate change influencing the personal environment, feeling that action should be taken and the pre-test scales of climate awareness, willingness to mitigate and willingness to adapt.

All statistical analyses were run in IBM SPSS Statistics 26. All analyses were conducted over the complete sample that participated in both pre- and post-test (N=34), apart from the correlations, which were run with the total sample that participated in the pre-test (N=76). All analyses were furthermore tested two-tailed and with a *p*-criterion of $p = 0.05$.

4.4.1. Results within participants

A significant increase after use of the tools was found only in willingness to adapt from pre-test ($M = 18.50$, $SD = 3.71$) to post-test ($M = 19.15$, $SD = 3.83$), $F(1, 32) = 6.39$, $p = .017$, $\eta p^2 = 0.166$. This shows that willingness to adapt increased after using the tool, as expected from previous literature (e.g. Wirth, Prutsch & Grothmann, 2014). However, while effects were expected for climate change awareness and willingness to mitigate, these remained reliably absent. For mitigation pre-test $M = 37.47$, $SD = 5.11$ and post-test $M = 37.71$, $SD = 4.87$, $F(1,32) = 0.09$, $p = 0.35$, $\eta p^2 = 0.027$ and for awareness pre-test $M = 19.62$, $SD = 3.10$ and post-test $M = 19.56$, $SD = 3.14$, $F(1,32) = 0.04$, $p = 0.84$, $\eta p^2 = 0.001$.

Thus, the results showed that the tools did increase participants' willingness to adapt, while they had no effect on climate change awareness or willingness to mitigate. This will be further elaborated on in the discussion.

As the scores for all three scales of awareness ($M = 3.92$ $SD = 0.62$), willingness to mitigate ($M = 4.16$ $SD = 0.57$) and willingness to adapt ($M = 3.70$ $SD = 0.74$) were generally quite high already in the pre-test, a check was done for a possible ceiling effect. A subgroup of participants was selected that scored below 4 on average on the awareness scale (N = 16) and willingness to mitigate scale (N = 11). As both these samples were not normally distributed either, a Wilcoxon signed-rank test was conducted for these sub-sets. Both these tests again showed no significant differences. Further research might want to include a larger sample size and a larger range of answer option (a seven-point Likert scale), as most participants showed mostly a positive change or no change at all for both measures (Figure 33 and 34).

Delayed post-test

No significant differences ($p > 0.05$) were found between the post-test and delayed post-test scores (N=11).

4.4.2. Results between groups

None of the previously conducted Repeated Measures ANOVAs showed a significant interaction effect ($p > 0.05$). Also the additional Mann-Whitney U tests, conducted on the composed scales of climate change awareness and willingness to mitigate, showed no significant differences ($p > 0.05$). Furthermore, the Mann-Whitney U tests conducted for the scales evaluating the previously defined guideline aspects for both tools did not indicate any significant differences between the tools either. All significance values remained above p = 0.3.

As no significant differences were found between the two tools, it can be concluded that the differences in 'local' between the two tools did not impact the effectiveness of the tools: according to the results, participants responded the same way to the *general local tool* and the *specified local tool*.

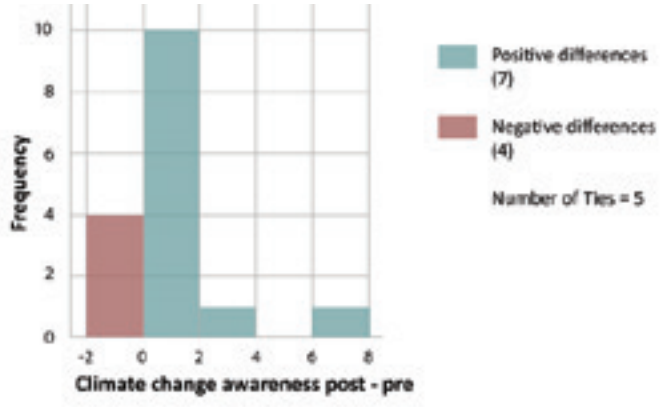


Figure 33: Wilcoxon Signed-Rank Test results for climate change awareness

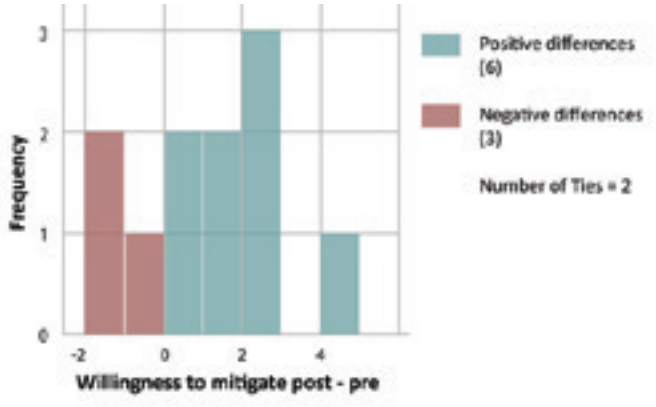


Figure 34: Wilcoxon Signed-Rank Test results for willingness to mitigate

Delayed post-test

The Repeated Measures ANOVAs including the delayed post-test results (N=11) showed no significant difference between the tools when looking at the effects between the post- and delayed post-test ($p > 0.05$). However, significant differences were found between the two tools for willingness to mitigate comparing the pre- and post-test, even though this did not show from the previous analyses considering only the pre- and post-test. This may indicate a low reliability of this test, possibly caused by a too small sample.

General ratings

Both tools scored above 3 on average for each scale, with each question based on five-point Likert scales. Further elaboration on feedback of participants can be found in section 4.4.4. User feedback – Strengths and weaknesses of the tools, p. 42.

4.4.3. Correlations

Correlations were checked for the complete sample of participants that participated in the pre-test (N=76).

Possible relations with dichotomous variables, including living within or outside the test-bed area, being male or female and having a bought or rental house, were checked by means of Kruskal-Wallis tests. Notable outcomes from these analyses are the positive correlations of having a bought versus a rental house with both a higher age and more garden space. Other correlations were investigated by means of Spearman's correlations (see Table 5 and 6). In the following paragraphs, first correlations among demographic factors and awareness and willingness to act are further elaborated on.

Age correlated quite clearly with garden (type/ amount) (r = 0.33, p = 0.007) and with believing that climate change has influenced one's own environment (r = 0.25, p = 0.041) and action should be taken (r = 0.35, p = 0.004). Furthermore, age correlated with willingness to mitigate and to adapt (the environment), but not with awareness.

Table 5: Correlations for demographic and environmental variables with pretest scales awareness, willingness to mitigate and willingness to act

			Education	Garden type	Climate change has influenced my environment	Action is necessary for a pleasant environment	pretest scale climate mitigation	pretest scale climate adaptation	pretest scale climate change awareness
Spearman's rho	Age	Correlation Coefficient	0.185	.329**	.253*	.348**	.321**	.362**	-0.004
		Sig. (2-tailed)	0.141	0.007	0.041	0.004	0.009	0.003	0.971
		N	65	66	66	66	66	66	66
	Education	Correlation Coefficient		-0.167	0.194	.245*	0.177	0.105	.266*
		Sig. (2-tailed)		0.153	0.095	0.034	0.130	0.369	0.021
		N		75	75	75	75	75	75
	Garden type	Correlation Coefficient			-0.096	-0.043	-0.031	0.141	-0.188
		Sig. (2-tailed)			0.400	0.715	0.792	0.225	0.104
		N			76	76	76	76	76
	Climate change has influenced my environment	Correlation Coefficient				.635**	.460**	.385**	.522**
		Sig. (2-tailed)				0.000	0.000	0.001	0.000
		N				76	76	76	76
	Action is necessary for a pleasant environment	Correlation Coefficient					.525**	.429**	.549**
		Sig. (2-tailed)					0.000	0.000	0.000
		N					76	76	76

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Education seemed to correlate with general climate change awareness (r = 0.27, p = 0.021) and feeling that taking action is necessary (r = 0.25, p = 0.03), although not with seeing climate change effects in one's own environment (r = 0.19, p = 0.095) nor with willingness to take action for either mitigation (r = 0.18, p = 0.130) or adaptation (r = 0.10, p = 0.369).

Participants feeling that climate change has affected their own environment, generally were also of the opinion that action should be taken to keep their environment pleasant in the future (r = 0.64, p = 0.000). Furthermore, these two factors both clearly correlate as well with higher levels of general climate change awareness (r = 0.52, p = 0.000) and willingness to act for climate mitigation (r = 0.46, p = 0.000) and adaptation (r = 0.39, p = 0.001). Although especially seeing the effects of climate change in one's own environment shows a lower correlation coefficient for the scales that measure willingness to act.

Perhaps the most interesting insight may be with the correlations between the three scales: awareness, willingness to mitigate and willingness to adapt (see Table 6). While willigness to mitigate correlates very highly with awareness (r = 0.62, p = 0.000) and willingness to adapt (r = 0.60, p = 0.000), the correlation coefficient between awareness and willingness to adapt is much lower (r = 0.38, p = 0.001).

			pretest scale climate adaptation	pretest scale climate change awareness
Spearman's rho	pretest scale climate mitigation	Correlation Coefficient	.603**	.620**
		Sig. (2-tailed)	0.000	0.000
		N	76	76
	pretest scale climate adaptation	Correlation Coefficient		.376**
		Sig. (2-tailed)		0.001
		N		76

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6: Correlations for pretest scales awareness, willingness to mitigate and willingness to act

4.4.4. User feedback

Besides the multiple-choice and Likert-scale questions, some open questions were added asking participants about their (additional) barriers to action and their opinion on the strengths and weaknesses of the tools.

Strengths and weaknesses of the tools

Generally speaking, most positive aspects mentioned by participants were linked to the **comprehensibility** of the tools, the information **connecting to the target group**, the **translation to everyday life** and the clarity and attractiveness of the visualisations (which may be linked to the **emotions** aspect). The points of improvement seemed more scattered over all factors implemented in the tools and contained many suggestions on lay-out and for additional functions or information. Figure 35 gives an overview of most mentioned aspects.

Many participants (26) mentioned finding the tool and its content easy to use and understand. Especially clarity of information in general, a clear overview of possible actions they could take and ease of use was often mentioned.

"A comprehensible tool, which visualises which actions can take place where around the house and in the garden."

Female, 36

Points of improvement mentioned for this aspect were less in numbers (8) and mainly concerned unclarity of animations in the introduction.

"I found the animations at the start of the tool not very clear[,] or perhaps better said not very appealing. Especially [at] the animation warming caused by the sun I thought nothing was happening."

Female, 58

Participants that commented on how well the information connected to their present knowledge and what actions they could take (9), all mentioned somewhat different aspects. The tools were for example called informative, low-threshold, interesting, surprising and offered different options that were not too complicated.

"Very beautiful and clear, inspiring"

Female, age unknown

Three participants (one of whom also mentioned the tool being easy to use) did however mention as point of improvement that there was little information that told them anything new.

"It could tell me little new things. Most things I already do."

Female, 43

The visualisations were marked attractive, beautiful, clear and/or happy by nine participants. There was however also much to improve according to participants, regarding the design and visual information of the tools.

"Beautiful illustrations, clear explanation through the drop-down menus"

Female, 43

Mentioned by multiple (5) participants was the complaint that the font size was too small. Other points of improvement were all mentioned by only one participant each and ranged from visualisations feeling old-fashioned to the animations (introduction) not being spectacular or clear enough, everything being blurry and the menu and font size being to large.

"Small letters [in the] further explanations [of the measures]"

Female, 58

Probably the main problem with the sizing of the tools was due to users using a smaller or larger screen, as the tool would automatically resize with the screen, but no alternative design was set up for screens smaller than a certain size.

While the questionnaire scale of 'translating to everyday life' did not score particularly high for either tool, this aspect was mentioned several times in the additional feedback. Seven participants that had used the specific local tool, mentioned they valued being able to choose their environment, the connection of the text to the garden environments, or that they found it easy because of this to visualise the actions for their own environment. Once was even stated that choosing the environment would improve engagement.

"Choosing of housing type [is] very convincing, increases engagement"

Male, age unknown

In addition, one participant that had used the general local tool mentioned as point of improvement that it would have been nice if the tool would be more specific to their personal situation.

"It would be nice if my current living situation could be integrated in the tool, where – taking into account the aspects that I did or did not implement – my personally to be achieved climate adaptation profit would be shown."

Male, 29

Further points of improvement for this aspect were mentioned by two participants that used the specific local tool, that more selection options could be possible and that gardens could also be facing East or West (not only primarily North or South).

The option to contact the developer of the tool was reported being hard to find or not very noticeable by three participants.

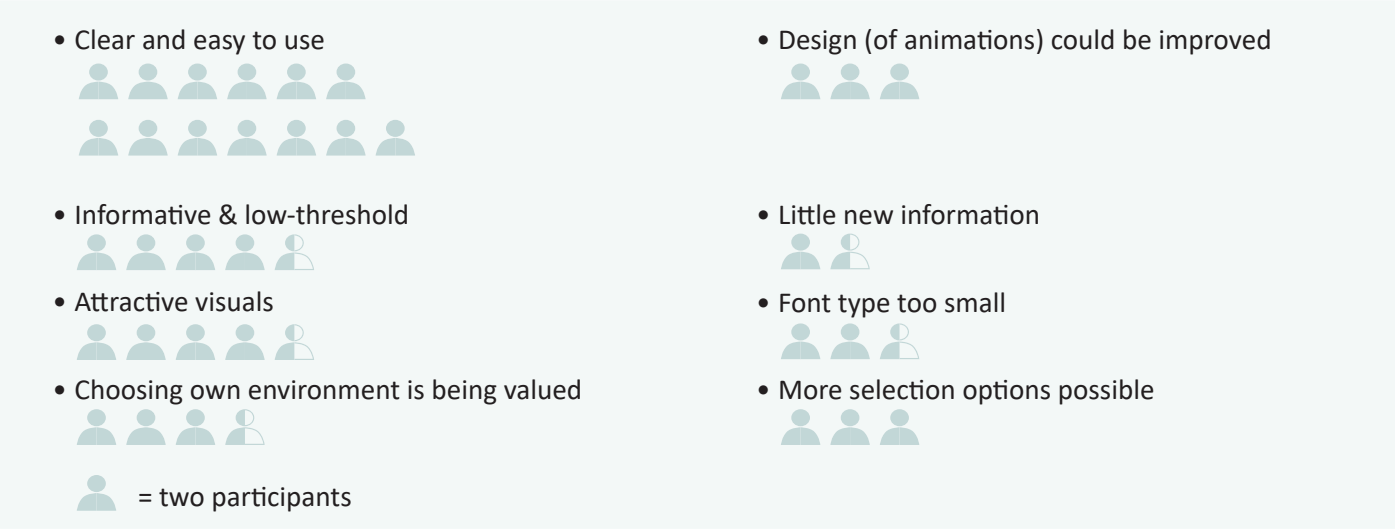


Figure 35: Overview of feedback mentioned by participants

There were however participants that did send an email through this option, which suggests that at least for some it served its purpose.

In addition, there were several suggestions for further development of the tools. Three participants mentioned that they were curious what for example a low or high cost indication meant, as no specific amounts were specified. Other suggestions were to include more options for the neighbourhood/larger environment, adding more in-depth information, adding more viewpoints for a better overview of the garden environments and more attention for nature including animals as well.

"More depth. As a garden- and landscape architect, more depth is interesting, but I completely understand that this is not the approach of this tool. It is low-threshold and thereby exactly fitting for the target group that currently should be addressed."

Male, 25

Finally, performance may be improved especially for the specific local tool, as some participants (3) reported that the tool could be slow. And it seemed that many participants started the website on their phone or tablet, even though the instructions mentioned it being suitable only for desktop or laptops. Probably, for greater usability, the tool would be much more used when also suitable for more portable devices. Several participants used the contact option on the website to report performance problems that hampered them to continue to or with the tool.

4.4.5. Barriers to action-taking

The barriers people mentioned to be in their way of taking action, were categorised within the framework of Lorenzoni et al. (2007), as this seemed fitting to the barriers on an individual level best. Most mentioned reasons for not taking action could be marked as reluctance to change lifestyles (10), helplessness (9) and importance of other priorities (7).

Reasons to not change lifestyles were for example practicalities and convenience; not wanting to give up traveling (by plane); or not wanting to invest because of moving plans or living in a rental house.

"Distance and accessibility of the workplace, combined with the time it takes"

Female, age unknown

Helplessness reasons mostly had to do with physical constrains or health issues; not being able to construct something themselves and thus having to find a reliable executor; or having to ask for permission before implementation.

"[I] cannot do physically hard work. Some matters like greening the roof, has to be in accordance with the housing association I am renting from."

Female, 63

Other priorities simply went out to spending time, money and space to aspects in life they deemed more important. Mostly people only mentioned not having enough time, money or space to spend.

Also a lack of knowledge concerning the different possibilities and effects of actions was mentioned by multiple (5) participants. Others (3) mentioned a lack of support and help from others such as neighbours or the municipality (advice and subsidies). And two mentioned pressure of social factors: others in the household that do want to eat meat and being afraid to be the only one in the street to make changes. Finally, two participants mentioned that although they felt they did their part, they sometimes felt like just being a drop in the ocean, considering what they saw from others and from their municipality.

"My actions are a drop in the ocean if all residents in the street fully pave their gardens."

Female, 43

4.4.6. Discussion

Effects within groups

Both tools only showed to induce a significant increase of participants' willingness to adapt. As the tools including the introduction did focus on climate change awareness and adaptation, no significant change for willingness to mitigate would be a logical outcome. However, as awareness was regarded a first step towards action (Lieske, Wade & Roness, 2014) and "*an important but indirect determinant of pro-environmental intention*" (Bamberg & Möser, 2007, p.1), seeing a significant increase in willingness to adapt but not in climate change awareness is somewhat surprising.

This result may be explained by several factors. The mean scores on all scales were quite high already in the pre-test, indicating that most people were already quite aware and were already quite willing

to act for both mitigation and adaptation. Thus, it is possible that no effect showed because of a ceiling effect: participants could not score much higher. Checking for a ceiling effect did not show a significant difference in awareness either. However, as the Wilcoxon signed-rank tests for climate change awareness and willingness to mitigate did indicate, there may be a chance that with a larger sample and extended (seven-point) Likert-scale, significant effects may show for these factors after all.

Another explanation may be that the total sample size in this thesis was too small to show any significant effects for climate change awareness. It is possible that smaller effects in the other factors were not visible.

However, a significant change in willingness to adapt did show clearly, with a similar pre-test score and the same sample size.

Seeing that awareness levels were already considerably high in the pre-test, it may well be the case that overall, participants did already posess a certain sufficient level of climate change awareness. Subsequently, the information on climate change provided in the tool did not increase this level. However, and additionally, it may be that although participants did not become more aware of climate *change*, their awareness of *adaptation* options did increase. Although climate change awareness was addressed in the questionnaires, awareness for climate adaptation was not. Therefore, it may be the case that only awareness for climate adaptation increased, while this was not measured. Feedback from participants on the tools does seem to indicate a possible rise in awareness for climate adaptation. Most valued aspects were not only clarity of information in general, but also a clear and informative overview of possible actions they could take, and ease of use. Participants seemed to value mostly the practical knowledge that was offered in the tools. Several authors (e.g. Grothmann & Patt, 2005; Burningham, Fielding & Thrush, 2008; Wirth, Prutsch & Grothmann, 2014; PBL Netherlands Environmental Assessment Agency, 2015) have already stated that, next to problem awareness, also solutions should be communicated. In extension of this, results from this thesis suggests superiority of practical information over problem awareness.

This would not deny that awareness may be an indirect determinant for willingness to adapt, as was suggested by Bamberg & Möser (2007). In line with Lieske, Wade & Roness (2014), creating awareness may still be the first step towards action, allowing people to judge the situation and respond in a fitting way. Communication remains important for raising awareness and walking the path towards climate adaptation (e.g. Wirth, Prutsch & Grothmann, 2014; Lenzholzer et al., 2020). However, recognising the value of practical information is certainly recommended to be kept in mind, as it might be more effective (at least in a highly aware group) for motivating action.

A significant increase for the adaptation scale only, could furthermore indicate that a higher level of awareness for climate change in general may not be necessary for stimulating a higher level of willingness to act (for adaptation), at least in cases where this level of awareness is generally already quite high.

In addition, it should be kept in mind that all scores and results from the questionnaires are self-reported and no indication is given of actual action-taking. Therefore, the risk exists that participants have filled out (perceived to be) desirable answers, thus not reporting their honest opinion. And no conclusions can be drawn regarding the effects of the tools on actions taken for climate adaptation.

Long term effects

No significant differences were found between the post-test and delayed post-test scores. This is likely because of the relatively small sample (N=11). From the comparison of the pre-test and the post-test in this sample, also no significant effects were found, while in the total sample, there was a significant increase for willingness to adapt. A final conclusion on long term effects on the tools may not be provided by this thesis. Further research could provide more insight into this matter.

Differences between tools – derived from qualitative and quantitative data

Although no differences in effects showed between the tools, many participants mentioned as feedback that the translation to their own situation and choosing a fitting environment was (much) valued. This shows an interesting discrepancy between the measured effects and qualitative feedback with regards to personalised environments. While the qualitative results suggest a higher appreciation for the *specific local tool*, the two tools did not show a difference in effects. It is of course possible that

the difference in effects of the tools did not show because of a relatively small sample size. Important to note is that the target group of residents from the test-bed area were barely represented in the eventual participant sample. Even though the majority of participants still reported that the environment presented in the tool was matching quite well with their own environment, it is much less likely that for example housing types were an exact fit to participants' real life settings. Thus, this aspect may again be investigated in further research including a larger specific target group.

If indeed both tools achieve the same effects, a personalised environment can be considered a nice feature, but not one that influences the effectiveness of communication for climate adaptation measures. This may save much money and time in development of future tools. Furthermore, a single tool may be valuable to a very large audience, so that not for every specific region a new tool has to be developed.

Although the Repeated Measures ANOVAs including the delayed post-test results, did show significant differences between the two tools for willingness to mitigate in pre- and post-test, this is likely caused by a too small sample size and an uneven distribution over the two conditions (see Figure 27). The results from the previous analyses on the pre- and post-test, conducted with a larger sample are considered more valid.

Barriers

Although the overall sample of participants seemed quite aware already at the post-test, barriers to action (as described by e.g. Lorenzoni et al., (2007) and Biesbroek et al., (2011)) were still mentioned by a majority of participants. Most often, barriers were mentioned that came forth from having different priorities or not wanting to change. However, there were also many that mentioned (physical) inabilities. It may be good to realise that raising awareness may be a solution for resolving barriers such as a lack of knowledge, or illustrate urgency (Sheppard et al., 2011; Wirth, Prutsch & Grothmann, 2014; Moser, 2014), but may not help those that are faced with (physical) disabilities or a real shortage of financial resources. For those that are faced with such barriers, other means like subsidies or initiatives for support by implementation may be valuable as well and should not be forgotten.

Correlations

In the total pre-test sample, it appeared that higher age positively correlates with seeing effects of climate change in one's own environment and willingness to take action for both adaptation and mitigation. A higher age did however not show a relation to participants' levels of awareness. When combined with the finding of high overall awareness levels in the pre-test, this may indicate a high general awareness present in all age groups in this sample.

Although a correlation shows between a higher education level and climate change awareness and action should be taken for a more pleasant environment, these effects may be unreliable. In this participant sample, more highly educated people were much more represented.

It also seemed that seeing climate change impacts in one's own environment is positively correlated with seeing a need to take action, a higher willingness to take action and higher levels of awareness. Of course, this could suggest that seeing the impact happen in a personal environment raises awareness of the problem and the willingness to take action. It could however be just as well the other way around: knowing that climate change is a problem, also makes the impact easier to see. Earlier studies have found that although experiencing hazards may in some cases increase climate change awareness (Withmarsh, 2008; Lujala, Lein & Rød, 2015), this may not be for all types of hazards as for example flooding is not always linked to climate change by residents (Withmarsh, 2008). Furthermore, it seems that residents living in more exposed areas but with no personal experience of damage, does not affect residents' concern for climate change (Lujala, Lein & Rød, 2015).

Finally, willingness to mitigate has been shown to correlate highly positively with climate change awareness and willingness to adapt. Climate change awareness and willingness to adapt do show a positive correlation as well, although to a much lesser extent. This may support the suggestion that other factors (like awareness of adaptation options) are important for motivating participants' willingness to adapt.

5. General discussion and conclusions

5.1. GENERAL DISCUSSION

This thesis has shown a possible way of applying knowledge from previous literature as guidelines to create online communication tools. This section summarises the main results and discusses the possible outcomes of this thesis.

5.1.1. Assessment of the tools

The interactive tools seemed to comply with the guidelines defined from previous literature, as evaluated by both the researcher as the participants (scoring above average on all guideline aspects in the questionnaires, see 4.4. Data analysis, p. 39). Therefore, these tools can be regarded as viable communications means for this subject, according to previous literature (e.g. Wirth, Prutsch & Grothmann, 2014; Moser, 2010; Moser, 2006; ICLEI, 2009; Nicholson-Cole, 2005; Sheppard, 2005; Grothmann, 2011; Moser, 2014). The environments as represented in the tools, although based on a specific neighbourhood, were marked as relatable by a much wider audience than expected and the represented measures were overall regarded as useful and low-threshold.

Several aspects of the tools, considering the guidelines and overall quality of the website, could unfortunately not be fully optimised or improved due to a lack of resources and knowledge. As the tools and the website as a whole were built without any experience with the development programs or the development of such applications in general, there remains room for improvement. Main points for improvement, as most frequently mentioned by participants, considered the clarity and appeal of the animations in the introduction, the lay-out (e.g. a small font size) and performance issues. It is suspected, from the comments in the evaluation questionnaire and from participants reporting performance issues, that the problem regarding performance issues may be bigger than visible from solely these comments. This might have played a part in the low number of participants that after filling out the pre-test, continued and completed the post-test as well.

Seeing that loading times, performance and layout of online media are known to influence the mood (Reips, 2002; Ceaparu et al., 2004; Heidig, Müller & Reichelt, 2015) and the motivation of the user to continue using a website (Reips, 2002; Heidig, Müller & Reichelt, 2015), these are important aspects to improve to prevent drop-out with future users and may be improved in future projects.

5.1.2. Participants

Participants for this thesis were all recruited by means of a convenience sample (Kumar, 2014). Despite the attempts to collect a diverse sample, overall levels for awareness and willingness to act were quite high already in the pre-test. This is likely due to a self-selection bias (Wright, 2005), as most people very likely were motivated to participate by an interest in the topic and to help out with the thesis project. However, the results do seem to give a valuable indication of the effects of the developed tools and herewith can be considered a valuable addition to the existing knowledge base on this subject.

5.1.3. Differences within tools

Both tools only showed to increase participants' willingness to adapt. This was somewhat unexpected, as awareness was regarded a first step towards action by previous authors (e.g. Lieske, Wade & Roness, 2014). In this case, one would suspect that a significant increase in willingness to adapt would go hand in hand with a significant increase in awareness.

These findings can be explained by several factors. (1) The sample was too small or (2) a ceiling effect occurred, causing the effect for climate change awareness to be invisible. These situations would however not explain why the increase in willingness to adapt did show, as this factor scored similarly high in the pre-test and was tested with the same participant sample. Other explanations include (3) the possible existence of a sufficient (base) level for climate change awareness or (4) an increase of awareness for climate adaptation options, which was not measured in this thesis. These hypotheses could be addressed in further research. For now, these findings do not exclude the possibility that awareness is a first step towards action (e.g. Lieske, Wade & Roness, 2014), but they do point towards a higher value of practical knowledge considering solutions, instead of problem awareness.

Further research is necessary to give disclosure on the matter of long-term effects, as the sample size of the delayed post-test was insufficient. Besides this, it is wise to consider that the questionnaires relied on

self-reporting, therefore it is possible for participants to report (what they believe to be) a desired answer. An inventory of cases where action has been taken as a result of the tools, would give a better confirmation of the effectiveness of the tools. This was however not possible to realise within the timeframe of this thesis. Thus, no claims can be made regarding the impact of this method of communication on actual action-taking.

5.1.4. Differences between tools

From the questionnaire results, no differences were found between the effects of both tools on participants' levels of awareness and willingness to take action. However, it may be interesting to note that many participants expressed their appreciation for being able to choose a more personal environment. Moreover, many connected this to higher relateability and ease of imagining the measures in their own garden. According to e.g. Wirth, Prutsch & Grothmann (2014), these are important factors in communicating climate adaptation, thus suggesting that the specified local tool would me more effective. This indicates a discrepancy in the appreciation of a more personalised local aspect as reported by participants and the efficacy of the tools regarding participants' levels of awareness and willingness to act.

5.1.5. Barriers to action-taking

Even though participants were generally highly aware and willing to take action, many still mentioned barriers to action. The barriers that were brought up by participants fit right into the framework of barriers as earlier defined by Lorenzoni et al. (2007). From the barriers mentioned, many were related to having different priorities and simply not wanting to change. However, a substantial amount of mentioned barriers also referred to (physical) disabilities that required them to ask others or find a trustworthy professional. This illustrates the need for more practical help as well, next to raising awareness as a solution for resolving e.g. lack of knowledge, or illustrate urgency (Sheppard et al., 2011; Wirth, Prutsch & Grothmann, 2014; Moser, 2014).

5.2. Recommendations

Some findings ask for further clarification or offer new directions to be investigated. Further research could look into (1) the possible existence of a base level for climate change awareness, (2) the long term effects of digital interactive tools like addressed in this thesis, (3) effects of the tools on actual action-taking and (4) the real value of personalised environments as opposed to generalised environments. As the lack of a significant difference in awareness levels might be due to a ceiling effect, it is suggested to use a seven-point Likert-scale to allow for more variability in answer options. A larger sample could furthermore increase power to detect smaller effects.

Furthermore, it may be valuable to take into account awareness of adaptation options in further research. This factor was not included in this thesis. However, based on the results and reflection of existing literature, it is suspected it may be an interesting and important factor.

For the sake of quality regarding both the development of interactive tools and websites, as well as the research aspect, it is recommended to hire a professional for the website and tool development. A higher website and tool quality may be beneficial as well for a lower drop-out rate, reasoning from the complaints regarding the performance of the tool hampering the continuation to the final questionnaire, combined with knowledge from previous literature (Reips, 2002; Ceaparu et al., 2004).

Finally, there is still one recommendation to be made for this field of research considering effective communication of climate change and motivating action for adaptation. As it seems that the vast majority of published literature on this subject is either based on literature studies (e.g. Lyle, 2015; Fook, 2015; Moser, 2016), evaluating existing communications means (e.g. Mitchell, Burch & Driscoll, 2016; Schmid, Knierim & Knuth, 2016; Swart et al., 2017; Rozmi et al., 2019) or evaluation of a new communications means but without conducting a pre-test (e.g. Schroth, Pond & Sheppard, 2015; Schroth, la Valle & Sheppard, 2015): it may be very valuable to really bring this knowledge into practice and start testing. As without testing both before and after use of a method, there is no evidence to support the actual efficacy of the method.

5.3. CONCLUSIONS

From this thesis, several conclusions can be drawn. A complete overview of the questions, methods and their outcomes can be found in Table 7 (page 52).

First of all, it is possible to build viable communications tools by following the guidelines as defined in this thesis. Both tools were evaluated generally positively, despite some imperfections.

The increase in willingness to adapt shows that the tools are effective for motivating action for climate adaptation, at least on the short term. This finding, combined with the evaluation of the tools, suggests a strong value of practical information regarding adaptation options. Most valued aspects were not only clarity of information in general, but also a clear and informative overview of possible actions they could take, and ease of use. Participants seemed to value the practical knowledge that was offered in the tools most. Communication remains important for raising awareness and walking the path towards climate adaptation (e.g. Wirth, Prutsch & Grothmann, 2014; Lenzholzer et al., 2020). However, recognising the value of practical information is strongly recommended to be kept in mind.

It furthermore seems to be the case that a generalised environment may be just as effective for raising willingness to adapt as a more personalised environment that can be selected by the user. Further research is necessary to give more insight into the self-reported appreciation of personalised environments. However, using a generalised environment as of now seems to be a very viable method for communicating climate adaptation.

The barriers to action as brought up in this thesis seemed to support the barriers as put forward by Lorenzoni et al. (2007). Furthermore valuable to note is that these barriers can still exist even when problem awareness and willingness to act seem high. This indicates that awareness may be a solution for resolving barriers such as a lack of knowledge, or illustrate urgency (Sheppard et al., 2011; Wirth, Prutsch & Grothmann, 2014; Moser, 2014), but may not help those that are faced with (physical) disabilities or a real shortage of (financial) resources. Other means, like subsidies or initiatives for support in implementation may be valuable as well and should not be forgotten.

Generally and most importantly, it can be concluded that perhaps we should shift some attention from creating more awareness of the problem towards offering more practical information on solutions. In landscape architecture, this could for example take shape as increased engagement of residents, including their garden environments, when designing for example a neighbourhood park (Figure 36). Or by showing in our public space designs what adaptation measures are applied, how they work, and perhaps even if they would be suitable as well in a private garden (Figure 37). The study by Lenzholzer et al. (2020) indicates for example that most residents generally do not perceive planting in the public space as a measure of climate adaptation. There seems to be much potential in displaying the effects of the well thought-through design projects to the users of these designed spaces.

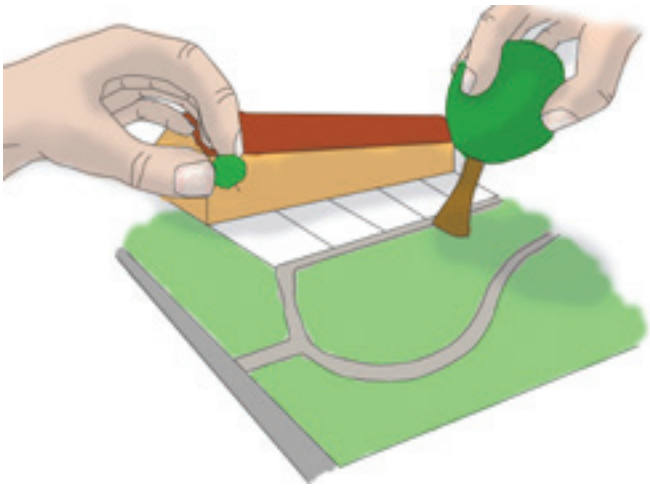


Figure 36: Including citizens and their garden in design processes. Workshop suggestion:

1. Provide a basemap/model with the planned housing and landscaping and bring drawing material and/or 3D planting and other objects.

2. Shortly present design context and include possible climate adaptation measures and their importance.

3. Discuss and design together what could be done in the public space and offer time for participants to think about their own garden design and how it could connect to this public space design.

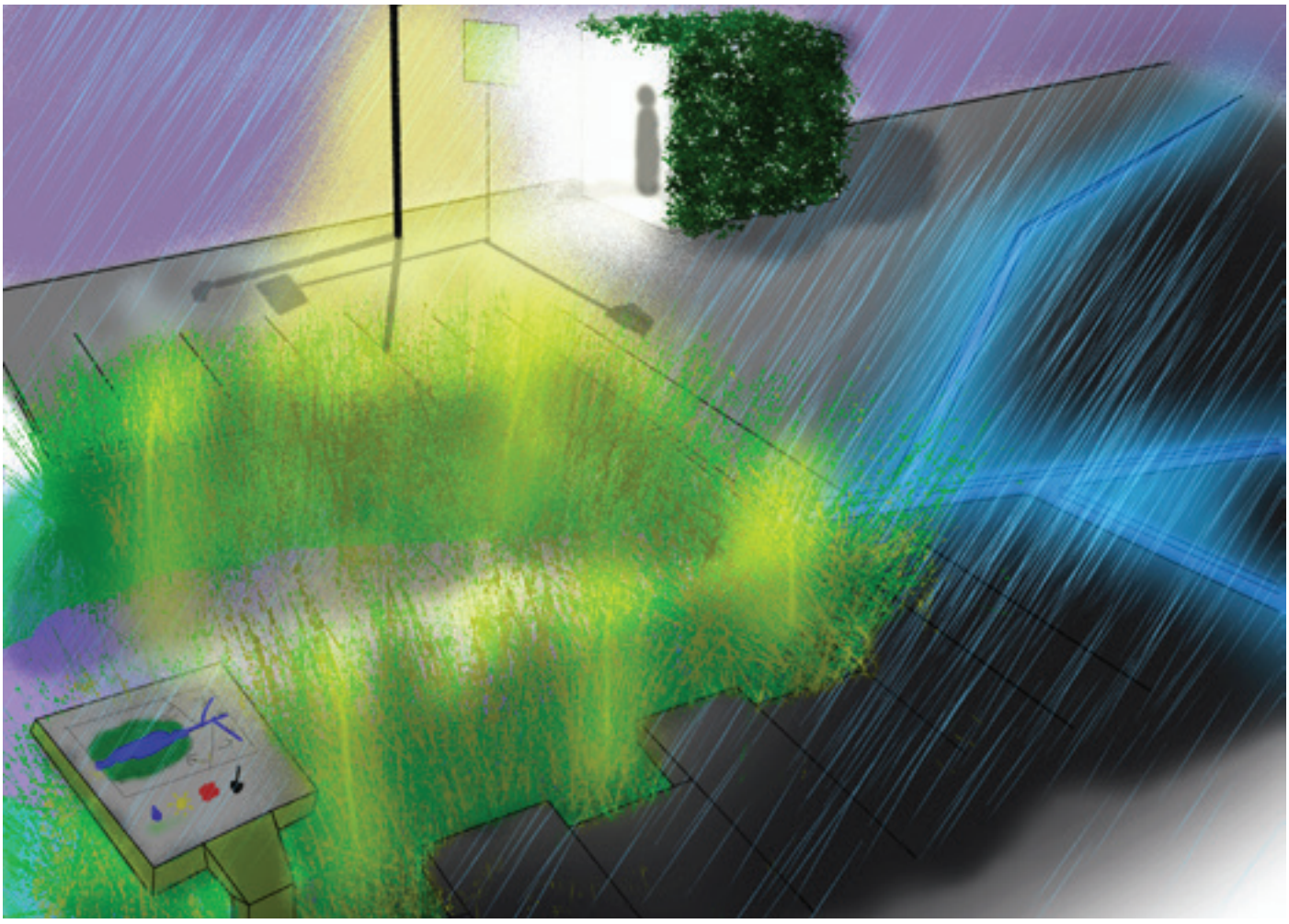


Figure 37: Suggestion for making climate adaptation visible in the public space. Use for example lighting to show where water flows in case of heavy rainfall: perhaps the water flows towards and through several blue-lighted gutters, leading to a wadi. The wadi could be planted with planting that filters the water: a helophyte filter, highlighted with some yellow reed-like lights. If implemented measures can also be applied in private gardens, a sign could be placed with further info and indications of cost and effects.

Table 7: Overview of research questions, methods and outcomes

RESEARCH/DESIGN QUESTION	METHOD	DATA SOURCE	OBJECTIVE	OUTPUT
DQ1 *How can digital interactive tools facilitate effective communication of climate adaptation measures?* a. *How can the 'local' environment be represented to facilitate effective communication of climate adaptation measures?* b. *How can the adaptation measures be represented to facilitate effective communication of climate adaptation measures?* c. *How can the different adaptation measures be implemented in 'local' environments, to create a climate adaptive, pleasant and comprehensible environment?* d. *How can the interface be designed to facilitate effective communication of climate adaptation measures?*	Research for design	Literature and online articles considering: Communicating climate change and adaptation Creating digital interactive tools Creating a functional website and user interface	Gain information on communicating climate change and adaptation through online interactive tools	For guidelines derived from literature, see 3.1 Translating theory to a digital tool, an overview of the guidelines can be found in Table 3, p.20.
	Design		Design & create: Overall interface Specified and general local tool - introductory information Specified and general local tool - information on measures	For the final designs, see 3.1.3 Interface, 3.1.4 Introductory information, 3.1.5 Information on measures and Appendix III - Environments.
	Questionnaires	Residents from within and outside of the test bed area Post-test data (evaluation of the questionnaires)	Get indication on how well the communication guidelines derived from literature are represented in the tools	The guidelines derived from literature were well-represented in the final versions of both tools, according to participants. See also 4.4.2 Results between groups and 4.4.4. User feedback.
RQ1 *What are the most occurring typologies that exist in the neighbourhood of Rijkerswoerd?*	Research for design	Data on different spatial typologies in Rijkerswoerd (maps, images etc.)	Analysing the test bed area for the development of relatable local environments	See environments as depicted in section 2.1.3 Spatial typologies.
RQ2 *Which climate adaptation measures can be selected that are suitable for the test bed area and can be represented in the digital tools?*	Research for design	Data on measures for climate adaptation in urban areas Climate and geomorphological data for Rijkerswoerd (maps, images etc.)	Gather existing measures for urban climate adaptation Gain information on the test bed area: climate, topography & soil Select measures for selected environments in tools	See section 2.2. Selection of adaptation measures and Table 2 for explanation and measures linked to the garden environments. For a list of suitable adaptation measures including the selection criteria per measure, see Attachment II.
RQ3 *What are the changes in citizen's levels of awareness and willingness to act for climate adaptation after working with the digital tools?*	Questionnaires	Residents from within and outside of the test bed area	Gaining insight in the effects of both tools on participants' levels of climate change awareness, willingness to act and willingness to adapt	Only a significant increase was found in willingness to adapt after using the tools. Long-term effects remain unclear due to a too small post-test sample. See also 4.4.1. Results within participants. Results point towards high importance of communicating practical information (adaptation measuress) in motivating action for climate adaptation. See 4.4.6. Discussion.
	Data comparison within groups (Repeated Measures ANOVA & Wilcoxon Signed Rank)	Pre-test, post-test and delayed post-test data		
RQ4 *What are the differences in effects on citizen's levels of awareness and willingness to act for climate adaptation between the two digital tools?*	Questionnaires	Residents from within and outside of the test bed area	Gaining insight in the differences of effects between the tools, regarding participants' levels of climate change awareness, willingness to act and willingness to adapt	Qualitative data suggests a higher appreciation for the *specific local tool*, see 4.4.4. User feedback. From the quantitative data, no difference in effects was found between the two tools. See also 4.4.2 Results between groups.
	Data comparison between groups (ANOVA & Mann-Whitney U)	Pre-test, post-test and delayed post-test data		
Additional findings				Barriers to action-taking as mentioned by participants correspond with the barriers found by Lorenzoni (2007) and still exist when awareness and willingness to act are high.

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Appendix I - Questionnaires (Dutch)

INVENTARISATIE

Graag zou ik met deze korte vragenlijst willen inventariseren hoe u op dit moment tegenover klimaatverandering en klimaatadaptatie staat. Vult u alstublieft de vragenlijst oprecht en naar waarheid in, zoals u er op dit moment zelf over denkt. Er zijn geen foute antwoorden. De resultaten zullen geanonimiseerd verwerkt worden.

Alvast bedankt voor uw medewerking!

Ineke

Uw persoonlijke code

Om de vragenlijsten in dit onderzoek zo anoniem mogelijk te houden, maar wel aan elkaar te kunnen koppelen, zou ik u willen vragen een persoonlijke code in te vullen. Vult u hiervoor alstublieft in:

De TWEEDE letter van uw voornaam

De TWEEDE letter van uw achternaam

Uw geboorteDAG

Voorbeeld:

Jan Janssen, geboren op 5 februari 1982, vult in: AA05

Wat is uw persoonlijke code?

[open]

Demografische gegevens

Eerst volgen enkele vragen over gegevens die van invloed kunnen zijn op het gebruik van de tool.

Wat is uw leeftijd in jaren?

[open]

Hoe identificeert u zich?

[Man, Vrouw, Geen van beide, Zeg ik liever niet]

Wat is uw moedertaal?

[Nederlands, Anders]

Wat is uw hoogst genoten opleiding? Dit kan ook een opleiding zijn die u nog volgt.

[Geen opleiding; Basisonderwijs, lagere school; Lager vormend onderwijs (VMBO praktijk); LBO, MULO, ULO, MAVO, VMBO-Theorie; Middelbaar Beroepsonderwijs (MBO) – 2 jarig; Middelbaar Beroepsonderwijs (MBO) – 3-4 jarig; HAVO, VWO, HBS, Gymnasium, Atheneum; Bachelor Hoger Beroepsonderwijs (HBO) / Wetenschappelijk onderwijs (WO); Master Hoger Beroepsonderwijs (HBO) / Wetenschappelijk onderwijs (WO); Anders]

Wat is uw postcode?

[open]

Heeft u een koopwoning of een huurwoning?

[Koopwoning, Huurwoning, Zeg ik liever niet]

Heeft u een tuin?

[Ja, een voortuin en een achtertuin (4); Ja, alleen een achtertuin (3); Ja, alleen een voortuin (2); Nee, ik heb geen tuin (1)]

Welk besturingssysteem gebruikt u op het moment?

[Windows 10, Windows 8, Windows 7 of lager, MacOS, Linux, Anders]

Welke browser gebruikt u op het moment?

[Google Chrome, Microsoft Edge, Internet Explorer, Safari, Firefox, Anders]

In plaats van deze tool, zou in eerste instantie een workshop plaatsvinden. Deze kon helaas niet doorgaan vanwege de uitbraak van het COVID-19 virus. Had u zich aangemeld voor deze workshop?

[Ja, Nee]

Waar heeft u de uitnodiging voor dit onderzoek gevonden?

[Op de Facebookpagina van Rijkerswoerd; Op NextDoor; In Het Woerdje; Via een persoonlijke e-mail; Anders]

Uw eigen omgeving

Geef alstublieft aan in hoeverre u het op dit moment eens bent met de volgende stellingen over uw eigen omgeving.

1. In mijn buurt blijft vaak water op de straat staan als het geregend heeft.
2. In mijn buurt is het vaak onaangenaam warm in de zomer.
3. In mijn buurt is er genoeg schaduw in de zomer om me comfortabel te voelen.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Klimaatverandering in uw eigen omgeving

Er is de laatste paar jaren veel discussie geweest over hoe klimaatverandering onze omgeving beïnvloedt. Ik zou graag willen weten hoe u op dit moment denkt over klimaatverandering in uw eigen omgeving.

1. Klimaatverandering heeft mijn omgeving beïnvloed.
2. Om er voor te zorgen dat mijn omgeving aangenaam blijft, ook in de toekomst, moeten we actie ondernemen.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Klimaatverandering in het algemeen

Klimaatverandering is op het moment een populair onderwerp van discussie. Ik zou graag uw mening op dit moment willen horen over de volgende stellingen.

[**Climate change awareness**]

1. Het bewijs voor klimaatverandering is betrouwbaar.
2. Ik geloof niet dat klimaatverandering een echt probleem is.*
3. Klimaatverandering komt volledig door natuurlijke fluctuaties in de temperatuur van de aarde.*
4. Klimaatverandering is misschien complex, maar wetenschappers zijn in staat om waardevolle schattingen te maken van mogelijke veranderingen.
5. De media zaaien vaak te veel paniek over onderwerpen als klimaatverandering.*
6. Klimaatverandering wordt veroorzaakt door zowel natuurlijke oorzaken als menselijke activiteiten.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Cronbachs α for this measure was 0.73 for the total sample of N=76 (pre-test) and 0.74 (pre-test) and 0.74 (post-test) for the sample of N=34 only including participants that participated in both the pre and post-test. Cronbachs α for the delayed post-test was 0.27 (N=11). The total scale score was computed by summing all items in the scale

OMGAAN MET HET VERANDERENDE KLIMAAT

Er zijn een paar suggesties voor wat men kan doen om het klimaat te beschermen. Ik zal nu enkele van deze activiteiten noemen. Laat alstublieft weer weten hoe op dit moment over de stellingen denkt: zijn het acties die u wel of niet zou ondernemen?

Wanneer stellingen niet direct op u van toepassing zijn in uw huidige situatie, bijvoorbeeld omdat u geen auto heeft of geen zeggenschap over uw energieleverancier, stel u dan voor wat u zou doen als u dit wel zou hebben.

[**Willingness to mitigate**]

1. Minder vliegen.
2. Voedsel eten dat lokaal gekweekt wordt of wat in het seizoen is.
3. Dekens of warme kleding gebruiken in plaats van de verwarming aanzetten.
4. Het eten van vlees vermijden.
5. Energiezuinige lampen gebruiken, zoals led lampen.
6. Alleen de kamers verwarmen die in gebruik zijn.
7. Gebruik maken van carpoolen, lopen, fietsen of het openbaar vervoer om naar werk te gaan.
8. Lopen, fietsen of met het openbaar vervoer gaan voor korte reizen (minder dan 5 km).
9. Proactief kiezen voor 'groene' elektriciteitsproducten en services.

[Zou ik zeker niet doen, Zou ik waarschijnlijk niet doen, Zou ik waarschijnlijk bereid zijn te doen, Zou ik zeker bereid zijn te doen, Doe ik al]

Cronbachs α for this measure was 0.75 for the total sample of N=76 (pre-test) and 0.71 (pre-test) and 0.69 (post-test) for the sample of N=34 only including participants that participated in both the pre- and post-test. Cronbachs α for the delayed post-test was 0.56 (N=11). The total scale score was computed by summing all items in the scale.

[**Willingness to adapt**]

1. De tuin vergroenen.
2. Regenwater afkoppelen (laat het water naar een sloot, vijver of groenstrook lopen in plaats van naar het riool).
3. Helpen met aanleg of onderhoud van groen in de straat.
4. Regenwater hergebruiken.
5. Een groene gevel of groendak aanleggen.

[Zou ik zeker niet doen, Zou ik waarschijnlijk niet doen, Zou ik waarschijnlijk bereid zijn te doen, Zou ik zeker bereid zijn te doen, Doe ik al]

Cronbachs α for this measure was 0.73 for the total sample of N=76 (pre-test) and 0.80 (pre-test) and 0.85 (post-test) for the sample of N=34 only including participants that participated in both the pre and post-test. Cronbachs α for the delayed post-test was 0.58 (N=11). The total scale score was computed by summing all items in the scale.

Uw motivatie

Het kan zijn, dat u sommige van de hiervoor genoemde acties al kende en al uit had willen voeren, maar dat iets u in de weg heeft gezeten. Ik zou graag willen weten of dit het geval is en wat voor u de belangrijkste reden(en) is/zijn.

1. Als geld geen probleem zou zijn, zou u dan één of meer van de genoemde acties uit willen voeren?
2. Als tijd geen probleem zou zijn, zou u dan één of meer van de genoemde acties uit willen voeren?

[Zeker niet, Waarschijnlijk niet, Waarschijnlijk wel, Zeker wel]

Zijn er nog overige zaken die u ervan weerhouden één of meer van de genoemde acties uit te voeren? Probeer ze dan zo kort mogelijk hieronder te noemen.

[open]

Tot slot

Heeft u nog op- of aanmerkingen over de vragenlijst of wilt u nog iets kwijt dat niet in de vragenlijst genoemd is?

[open]

EVALUATIE VAN DE LOKALE TOOL

U heeft nu kort de tool kunnen gebruiken. Ik hoop van u te horen hoe u de tool heeft ervaren en of de informatie voor u een verschil maakt.

LET OP: In het eerste deel van de vragenlijst ziet u vragen terug die ook in de eerste vragenlijst gesteld zijn. Het klopt dus als u het gevoel krijgt de vragen al een keer gezien te hebben! Dit is een belangrijk deel van het onderzoek en ik zou het erg waarderen als u dit nogmaals in zou willen vullen.

Het tweede deel van de vragenlijst gaat over uw eigen ervaringen tijdens het gebruik van de online tool.

Vult u alstublieft de vragenlijst oprecht en naar waarheid in, zoals u er op dit moment zelf over denkt. Er zijn geen foute antwoorden. De resultaten zullen geanonimiseerd verwerkt worden.

Alvast bedankt voor uw medewerking!

Ineke

Uw persoonlijke code

Om de vragenlijsten in dit onderzoek zo anoniem mogelijk te houden, maar wel aan elkaar te kunnen koppelen, zou ik u willen vragen een persoonlijke code in te vullen. Vult u hiervoor alstublieft in:

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Uw geboorteDAG

Voorbeeld:

Jan Janssen, geboren op 5 februari 1982, vult in: AA05

Wat is uw persoonlijke code?

[open]

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Geef alstublieft aan in hoeverre u het op dit moment eens bent met de volgende stellingen over uw eigen omgeving.

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[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

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Er is de laatste paar jaren veel discussie geweest over hoe klimaatverandering onze omgeving beïnvloedt. Ik zou graag willen weten hoe u op dit moment denkt over klimaatverandering in uw eigen omgeving.

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2. Om er voor te zorgen dat mijn omgeving aangenaam blijft, ook in de toekomst, moeten we actie ondernemen.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

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[**Climate change awareness**]

1. Het bewijs voor klimaatverandering is betrouwbaar.
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4. Klimaatverandering is misschien complex, maar wetenschappers zijn in staat om waardevolle schattingen te maken van mogelijke veranderingen.
5. De media zaaien vaak te veel paniek over onderwerpen als klimaatverandering.*
6. Klimaatverandering wordt veroorzaakt door zowel natuurlijke oorzaken als menselijke activiteiten.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

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Omgaan met het veranderende klimaat

Er zijn een paar suggesties voor wat men kan doen om het klimaat te beschermen. Ik zal nu enkele van deze activiteiten noemen. Laat alstublieft weer weten hoe op dit moment over de stellingen denkt: zijn het acties die u wel of niet zou ondernemen?

Wanneer stellingen niet direct op u van toepassing zijn in uw huidige situatie, bijvoorbeeld omdat u geen auto heeft of geen zeggenschap over uw energieleverancier, stel u dan voor wat u zou doen als u dit wel zou hebben.

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8. Lopen, fietsen of met het openbaar vervoer gaan voor korte reizen (minder dan 5 km).
9. Proactief kiezen voor ‘groene’ elektriciteitsproducten en services.

[Zou ik zeker niet doen, Zou ik waarschijnlijk niet doen, Zou ik waarschijnlijk bereid zijn te doen, Zou ik zeker bereid zijn te doen, Doe ik al]

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[Zou ik zeker niet doen, Zou ik waarschijnlijk niet doen, Zou ik waarschijnlijk bereid zijn te doen, Zou ik zeker bereid zijn te doen, Doe ik al]

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Uw motivatie

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1. Als geld geen probleem zou zijn, zou u dan één of meer van de genoemde acties uit willen voeren?
2. Als tijd geen probleem zou zijn, zou u dan één of meer van de genoemde acties uit willen voeren?

[Zeker niet, Waarschijnlijk niet, Waarschijnlijk wel, Zeker wel]

Zijn er nog overige zaken die u ervan weerhouden één of meer van de genoemde acties uit te voeren? Probeer ze dan zo kort mogelijk hieronder te noemen.

[open]

Acties en hun weergave in de online tool

De volgende vragen gaan over de verschillende acties die in de online tool zijn weergegeven. Het gaat hierbij om uw eigen ervaring. U hoeft dus niet álle acties bekeken te hebben. Graag zou ik van u willen horen hoe u de informatie en het werken met de tool heeft ervaren. Geef alstublieft uw mening voor elke stelling aan.

[**Credibility**]

Wat vindt u van de kwaliteit van de acties? Geef alstublieft uw mening voor elke stelling aan.

1. Ik geloof dat de getoonde acties zijn gebaseerd op betrouwbare informatie.
2. Ik geloof dat de getoonde acties mijn omgeving aangenamer zouden maken.
3. Ik geloof dat toepassing van de besproken acties er voor zouden zorgen dat mijn omgeving beter om kan gaan met het veranderende klimaat.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Cronbachs α for this measure was 0.71 for the total sample of N=34. The total scale score was computed by summing all items in the scale.

[**Comprehensibility**]

Zijn de acties en de tool duidelijk? Geef alstublieft uw mening voor elke stelling aan.

1. Ik begrijp de effecten van de getoonde acties.
2. Ik begrijp hoe de getoonde acties mijn omgeving zouden verbeteren.
3. Ik begrijp hoe en waar ik de acties toe kan passen om mijn omgeving beter aangepast te maken aan het veranderende klimaat.
4. De online tool is makkelijk te begrijpen.
5. De online tool maakt duidelijk hoe de acties werken.
6. De online tool maakt het makkelijk om de effecten van de acties voor mijn omgeving te begrijpen.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Cronbachs α for this measure was 0.83 for the total sample of N=34. The total scale score was computed by summing all items in the scale.

[**Frame to target group**]

Sluit de tool goed aan op uw wensen en kennis? Geef alstublieft uw mening voor elke stelling aan.

1. De getoonde informatie sluit goed aan op wat ik belangrijk vind.
2. De getoonde informatie sluit goed aan op wat ik al wist.
3. De getoonde acties sluiten goed aan op wat ik zou kunnen doen.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Cronbachs α for this measure was 0.36 for the total sample of N=34. The total scale score was computed by summing all items in the scale.

[**Translate to everyday life**]

4. Ik kan me goed inleven in/identificeren met de getoonde situatie.
5. De getoonde informatie laat zien wat voor mij de voor- en nadelen zijn van verschillende acties.
6. De informatie sluit goed aan op wat ik zelf ervaar in mijn eigen omgeving.
7. De getoonde situatie komt goed overeen met hoe mijn eigen omgeving er uit ziet.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Cronbachs α for this measure was 0.73 for the total sample of N=34. The total scale score was computed by summing all items in the scale.

[**Emotions**]

Hoe voelt u zich na gebruik van de tool? Geef alstublieft uw mening voor elke stelling aan.

1. De online tool geeft me het gevoel dat het niet zo moeilijk is om mijn omgeving te verbeteren.
2. Na het gebruiken van de online tool voel ik me geïnspireerd om actie te ondernemen.
3. De online tool heeft me het gevoel gegeven dat ik echt kan bijdragen aan een omgeving die beter om kan gaan met het veranderende klimaat.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Cronbachs α for this measure was 0.80 for the total sample of N=34. The total scale score was computed by summing all items in the scale.

[**Dialogue**]

Hoe ervaart u de communicatiemogelijkheden? Geef alstublieft uw mening voor elke stelling aan.

1. De online tool biedt de mogelijkheid om met iemand anders te discussiëren over de mogelijkheden.
2. De optie in de online tool om contact op te nemen met de ontwikkelaar van de tool voelt toegankelijk.
3. De optie in de online tool om contact op te nemen met de ontwikkelaar van de tool is makkelijk in gebruik.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Cronbachs α for this measure was 0.83 for the total sample of N=34. The total scale score was computed by summing all items in the scale.

Het functioneren van de online tool

De volgende vragen gaan over hoe u het functioneren van de online tool heeft ervaren.

Hoe functioneerde de online tool? Geef alstublieft uw mening voor elke stelling aan.

1. De online tool functioneerde goed en zonder problemen.
2. De tekst en afbeeldingen in de online tool waren onscherp.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Bent u gewisseld van besturingssysteem omdat de tool niet goed functioneerde?

[Nee; Ja, naar Windows 10; Ja, naar Windows 8; Ja, naar Windows 7 of lager; Ja, naar MacOS; Ja, naar Linux; Anders]

Bent u gewisseld van browser omdat de tool niet goed functioneerde?

[Nee; Ja, naar Google Chrome; Ja, naar Microsoft Edge; Ja, naar Internet Explorer; Ja, naar Safari

Ja, naar Firefox; Anders]

Algemene feedback

Mogelijk hebben de voorgaande vragen nog iets overgeslagen wat u graag kwijt wil over de online tool in het algemeen. Dit kunt u dan nog hieronder vermelden.

Wat vond u goed aan de online tool?

[open]

Wat vond u minder goed aan de online tool?

[open]

Tot slot

Hartelijk dank voor uw deelname, dit is erg waardevol. Hierdoor is het mogelijk om een beter inzicht te krijgen in hoe dit soort acties, zoals u in de tool gezien heeft, op een waardevolle manier weergegeven kunnen worden waar u echt iets aan heeft.

Om ook naar de langere termijn te kijken, zou ik u graag nog een laatste vragenlijst aan willen bieden. Deze zou u over ongeveer 4 weken ontvangen. De vragenlijst neemt ongeveer 2 minuten van uw tijd in beslag.

Naast deze vragenlijst, zou ik graag een paar mensen kort (max. 20 minuten) willen spreken over de tool. Dit kan via bijvoorbeeld de telefoon of een online (video)gesprek. Ook dit gesprek zal geanonimiseerd verwerkt

worden en u mag altijd weigeren of het gesprek stopzetten, zonder reden op te geven.

Wilt u de tool ook later nog kunnen bezoeken, zonder de tool nogmaals te evalueren? Dan kan ik u een link toesturen waar u de tool kunt bekijken wanneer u wilt.

Mag ik u over ongeveer 4 weken een laatste vragenlijst toesturen?
[Ja, Nee]

Mag ik u eventueel benaderen voor een kort gesprek?
[Ja, Nee]

Wilt u een link naar de tool ontvangen om deze later nog te kunnen bekijken?
[Ja, Nee]

Wat is uw e-mailadres? Deze zal alleen gebruikt worden voor hierboven genoemde doeleinden.
[open]

TERUGKOPPELING

Een maand geleden heeft u meegedaan aan het onderzoek waarin u een online interactieve tool heeft getest. Graag zou ik met deze korte vragenlijst nog eenmaal willen inventariseren hoe u op dit moment tegenover klimaatverandering en klimaatadaptatie staat. Vult u alstublieft de vragenlijst oprecht en naar waarheid in, zoals u er op dit moment zelf over denkt. Er zijn geen foute antwoorden. De resultaten zullen geanonimiseerd verwerkt worden.

Alvast bedankt voor uw medewerking!

Ineke

Uw persoonlijke code

Om de vragenlijsten in dit onderzoek zo anoniem mogelijk te houden, maar wel aan elkaar te kunnen koppelen, zou ik u willen vragen een persoonlijke code in te vullen. Vult u hiervoor alstublieft in:

De TWEEDE letter van uw voornaam

De TWEEDE letter van uw achternaam

Uw geboorteDAG

Voorbeeld:

Jan Janssen, geboren op 5 februari 1982, vult in: AA05

Wat is uw persoonlijke code?

[open]

Uw gebruik van de tool

Heeft u de tool nog bezocht in de periode tussen uw deelname aan het eerste deel van het onderzoek en deze vragenlijst?

[Ja, één keer; Ja, een paar keer (ongeveer 2 of 3 keer); Ja, vaak (meer dan 3 keer); Nee; Anders]

Uw eigen omgeving

Geef alstublieft aan in hoeverre u het op dit moment eens bent met de volgende stellingen over uw eigen omgeving.

1. In mijn buurt blijft vaak water op de straat staan als het geregend heeft.
2. In mijn buurt is het vaak onaangenaam warm in de zomer.
3. In mijn buurt is er genoeg schaduw in de zomer om me comfortabel te voelen.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Klimaatverandering in uw eigen omgeving

Er is de laatste paar jaren veel discussie geweest over hoe klimaatverandering onze omgeving beïnvloedt. Ik zou graag willen weten hoe u op dit moment denkt over klimaatverandering in uw eigen omgeving.

1. Klimaatverandering heeft mijn omgeving beïnvloed.
2. Om er voor te zorgen dat mijn omgeving aangenaam blijft, ook in de toekomst, moeten we actie ondernemen.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Klimaatverandering in het algemeen

Klimaatverandering is op het moment een populair onderwerp van discussie. Ik zou graag uw mening op dit moment willen horen over de volgende stellingen.

[**Climate change awareness**]

1. Het bewijs voor klimaatverandering is betrouwbaar.
2. Ik geloof niet dat klimaatverandering een echt probleem is.*
3. Klimaatverandering komt volledig door natuurlijke fluctuaties in de temperatuur van de aarde.*
4. Klimaatverandering is misschien complex, maar wetenschappers zijn in staat om waardevolle schattingen te maken van mogelijke veranderingen.
5. De media zaaien vaak te veel paniek over onderwerpen als klimaatverandering.*
6. Klimaatverandering wordt veroorzaakt door zowel natuurlijke oorzaken als menselijke activiteiten.

[Helemaal mee oneens, Oneens, Niet mee eens/niet meer oneens, Eens, Helemaal mee eens]

Cronbachs α for this measure was 0.73 for the total sample of N=76 (pre-test) and 0.74 (pre-test) and 0.74 (post-test) for the sample of N=34 only including participants that participated in both the pre and post-test. Cronbachs α for the delayed post-test was 0.27 (N=11). The total scale score was computed by summing all items in the scale.

Omgaan met het veranderende klimaat

Er zijn een paar suggesties voor wat men kan doen om het klimaat te beschermen. Ik zal nu enkele van deze activiteiten noemen. Laat alstublieft weer weten hoe op dit moment over de stellingen denkt: zijn het acties die u wel of niet zou ondernemen?

Wanneer stellingen niet direct op u van toepassing zijn in uw huidige situatie, bijvoorbeeld omdat u geen auto heeft of geen zeggenschap over uw energieleverancier, stel u dan voor wat u zou doen als u dit wel zou hebben.

[**Willingness to mitigate**]

1. Minder vliegen.
2. Voedsel eten dat lokaal gekweekt wordt of wat in het seizoen is.
3. Dekens of warme kleding gebruiken in plaats van de verwarming aanzetten.
4. Het eten van vlees vermijden.
5. Energiezuinige lampen gebruiken, zoals led lampen.
6. Alleen de kamers verwarmen die in gebruik zijn.
7. Gebruik maken van carpoolen, lopen, fietsen of het openbaar vervoer om naar werk te gaan.
8. Lopen, fietsen of met het openbaar vervoer gaan voor korte reizen (minder dan 5 km).
9. Proactief kiezen voor ‘groene’ elektriciteitsproducten en services.

[Zou ik zeker niet doen, Zou ik waarschijnlijk niet doen, Zou ik waarschijnlijk bereid zijn te doen, Zou ik zeker bereid zijn te doen, Doe ik al]

Cronbachs α for this measure was 0.75 for the total sample of N=76 (pre-test) and 0.71 (pre-test) and 0.69 (post-test) for the sample of N=34 only including participants that participated in both the pre- and post-test. Cronbachs α for the delayed post-test was 0.56 (N=11). The total scale score was computed by summing all items in the scale.

[**Willingness to adapt**]

1. De tuin vergroenen.
2. Regenwater afkoppelen (laat het water naar een sloot, vijver of groenstrook lopen in plaats van naar het riool).
3. Helpen met aanleg of onderhoud van groen in de straat.
4. Regenwater hergebruiken.
5. Een groene gevel of groendak aanleggen.

[Zou ik zeker niet doen, Zou ik waarschijnlijk niet doen, Zou ik waarschijnlijk bereid zijn te doen, Zou ik zeker bereid zijn te doen, Doe ik al]

Cronbachs α for this measure was 0.73 for the total sample of N=76 (pre-test) and 0.80 (pre-test) and 0.85 (post-test) for the sample of N=34 only including participants that participated in both the pre and post-test. Cronbachs α for the delayed post-test was 0.58 (N=11). The total scale score was computed by summing all items in the scale.

Uw motivatie

Het kan zijn, dat u sommige van de hiervoor genoemde acties al kende en al uit had willen voeren, maar dat iets u in de weg heeft gezeten. Ik zou graag willen weten of dit het geval is en wat voor u de belangrijkste reden(en) is/zijn.

1. Als geld geen probleem zou zijn, zou u dan één of meer van de genoemde acties uit willen voeren?
2. Als tijd geen probleem zou zijn, zou u dan één of meer van de genoemde acties uit willen voeren?

[Zeker niet, Waarschijnlijk niet, Waarschijnlijk wel, Zeker wel]

Zijn er nog overige zaken die u ervan weerhouden één of meer van de genoemde acties uit te voeren? Probeer ze dan zo kort mogelijk hieronder te noemen.

[open]

Tot slot

Heeft u nog op- of aanmerkingen over de vragenlijst of wilt u nog iets kwijt dat niet in de vragenlijst genoemd is?

[open]

Naast deze vragenlijst, zou ik graag een paar mensen kort (maximaal 20 minuten) willen spreken over de interactieve tool. Zou ik u hiervoor eventueel mogen benaderen? Vul in dat geval hieronder uw email adres in, of beantwoord de email die u hierover heeft ontvangen.

Ook dit gesprek zal geanonimiseerd verwerkt worden en u mag altijd weigeren of het gesprek stopzetten, zonder reden op te geven.

[open]

Appendix II - Adaptation measures

Measure	Function	Suitable in gardens	Suitable on building level	Suitable in badly permeable soil	Suitable on existing buildings
Buildings					
(flexible) awnings/blinds	heat reduction	-	yes	-	-
(extensive/intensive) green roof	water retention/storage, cooling, biodiversity, air quality	-	yes	-	if roof is strong enough
green facades	heat reduction (inside & outside), insulation	-	yes	yes	yes
water roof/blue roof	water buffering, cooling	-	yes	-	on almost any flat strong roof
Material choice					
high albedo (facades, roofs, paving…)	cooling	yes	yes	-	-
low density surfacing (e.g. board walk)	heat reduction	yes	-	-	-
Objects/constructions					
canopies/louvres (built canopy)	heat reduction, protection from rain	yes	yes	-	yes
demarcation elements (built)	reduce heat (shading), wind protection	yes	-	-	-
demarcation elements (green)	reduce heat (shading), wind protection	yes	-	-	-
pergola (green canopy)	cooling	yes	-	-	-
wind screen	protection from wind	yes	-	-	-
porous/permeable paving/groundcover (wood pulp, gravel…)	let water infiltrate, filtering of water, cooling, biodiversity	yes	-	yes	-
pond for use of precipitation	reuse & retention of rainwater, cooling, biodiversity (closed retainment reservoir often more advisable)	yes	-	yes	-
(open) gutter	above ground drainage	yes	-	yes	-
rainwater (retention/buffer) pond/ basin	water purification & buffering, cooling, biodiversity		-	yes	-
Rain barrel/rainwater tank/in fence (regenwaterschutting)	extra storage of rainwater	yes	-	yes	-
downspout disconnect	relieve pressure on sewage system, efficient use of water	yes	yes	yes	-
height differentiation	water buffering/infiltration/guidance, biodiversity	yes	-	-	-
cover soil (mulch, leaves or groundcover)	limit moisture loss in soil, reduce heat	yes	-	yes	-
Planting					
plant (espalier/street) trees	improve infiltration capacity, cooling, biodiversity, air quality	yes	-	yes	-
planted screen elements	reduce heat, wind protection	yes	-	-	-
green demarcation elements	reduce heat (shading), wind protection	yes	-	-	-
add vegetation (low/middle/high/ climber)(edible, water loving)	increase absorbtion capacity soil, cooling (evaporation & shadow), biodiversity, air quality	yes	-	yes	-
depaving	water infiltration, cooling, biodiversity	yes	-	yes	-
windbreak (hedge, dense trees, fence)	protection from wind	yes	-	-	-
helophyte filters (vertical, aerated, horizontal)	water infiltration & purification, heat reduction, biodiversity	yes	-	yes	-

(Aquaflow, 2016; Colt International, 2011; Dreelin, Fowler & Caroll, 2006; Hiemstra, de Vries & Spijker, 2017; Huisjeboompjebeter, n.d.; Lenzholzer, 2015; Urban Green Blue Grids, n.d.; Voskamp & Van de Ven, 2015)

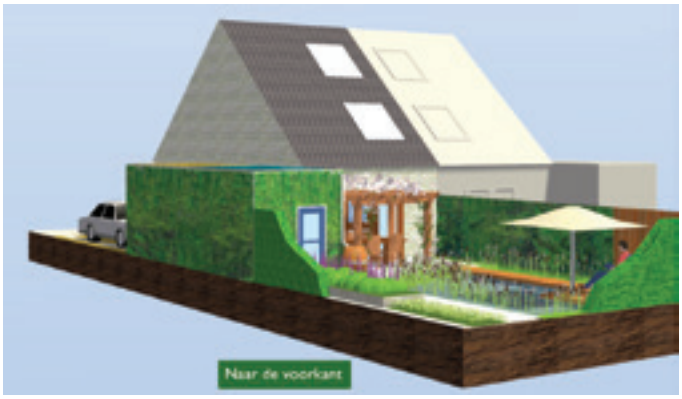
Appendix III - Environments

Row house environment with back garden on the South, back garden perspective

Row house environment with back garden on the South, front garden perspective

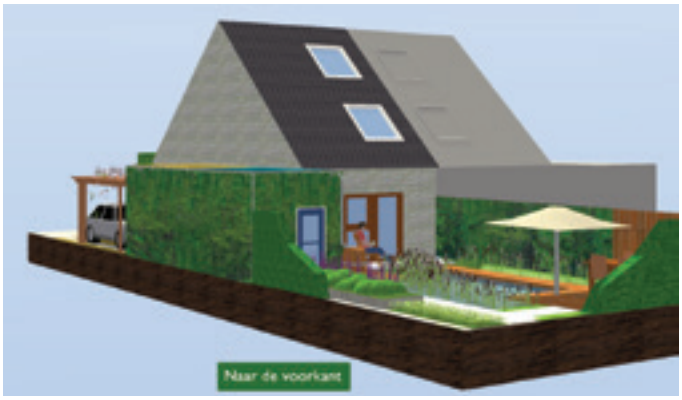
Row house environment with back garden on the North, back garden perspective

Row house environment with back garden on the North, front garden perspective



Semi-detached house environment with back garden on the South, back garden perspective

Semi-detached house environment with back garden on the South, front garden perspective



Semi-detached house environment with back garden on the North, back garden perspective

Semi-detached house environment with back garden on the North, front garden perspective

The above images show an overview of the different environments. Only two housing types are shown, as the focus is on the garden environments. As described in 2.1.3. Spatial typologies, 8 housing types in total were selected and represented in the tools.