Research Step 5: Full Concept

Theme 5: Exploring New Publicness (Miller)
Supervisor: Charlotte Miller

# Proximity to heat stress exposure and its effect on residents' desire to engage in climate adaptation activities in the city of Groningen

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## Summary

This thesis looks into the relationship between proximity to heat stress exposure and its effect on citizens' awareness, knowledge, and resources on engagement in climate adaptation activities in the city of Groningen. Using a cross-sectional design and online surveys, data was collected from a sample of 62 residents. The findings indicate that residents with higher awareness, knowledge, and access to resources are more likely to be exposed to heat stress. Moreover, citizens with greater awareness and resource access show higher levels of engagement in climate-adaptive behaviors. These insights highlight the importance of addressing heat stress exposure and promoting awareness and resource accessibility to create more climate-resilient cities. Future research should explore the effectiveness of interventions aimed at increasing awareness, knowledge, and resources.


*Keywords: heat stress exposure, climate adaptation, awareness, knowledge, resources, Groningen*

# 1. Introduction

## 1.1 Background

Climate change caused by humanity is already affecting every region of the world and we must act quickly to mitigate the effects. If we do not take immediate action to reduce emissions and mitigate the effects, the consequences will become increasingly severe and irreparable (IPCC, 2023). The time to act is now before it is too late.
In the past decades, extreme heatwaves, droughts, and heavy precipitation events have increased in frequency and intensity, which are already causing widespread damage and disruption. (IPCC, 2023). Due to the higher measured and forecast temperatures and, more importantly, the higher frequency of extreme heat waves, the urban heat island effect is becoming increasingly urgent to tackle. The urban heat island effect is caused by a high concentration of buildings, roads, and other infrastructure that absorb and retain heat while the amount of vegetation cover and urban greenery is scarce or often absent (USGCRP, 2017). Because of the increased intensity and frequency of urban heat stress, the corresponding range of adverse health impacts on citizens, especially the vulnerable population such as the elderly and young children, are on the rise. This includes heat exhaustion, dehydration, heat stroke, and worsening pre-existing health conditions such as cardiovascular and respiratory diseases (US Global Change Research Program, 2017). In order to reduce these risks, municipalities can implement many mitigation and adaptation strategies and measurements. The most obvious solution to cool down cities is to add urban greenery since it creates shade, improves evapotranspiration, and absorbs solar radiation (Bowler et al., 2010). Besides the temperature reduction, exposure to urban greenery has a range of positive health outcomes such as increased physical activity, mental and cardiovascular health, and social benefits such as increased social cohesion and community well-being (Lee and Maheswaran, 2010). Aside from adding urban greenery, municipalities can implement several other measures such as water fountains, reflective pavement, green roofs and walls, and other shading structures (Jain et al., 2020). However, municipalities in the Netherlands have limited control because "approximately 60 percent of the Dutch cities is owned by its citizens and thus only 40 percent is in possesion of the municipality" (K. de Goederen, personal communication, December 24, 2021). So in order to create future-proof climate-resilient cities in the Netherlands, citizens will have to do their part as well through active involvement and domestic implementation.
A recent study into the feasibility of green climate adaptive pergolas in the city of Groningen clearly showed that the implementation of such climate adaptive measures has great support from the municipality and government. However, in order to make a major impact, it is necessary to get residents into action themselves, where the bridge between objectives from the municipalities and practical implementation by residents is often missing (Verkooijen et al. 2022). Most citizens in the Netherlands, as well as in the city of Groningen, are willing to engage in climate adaptive measures but a lack of the required awareness, knowledge and resources hinder their involvement (Hegger et al., 2017; A. Holleman, 2023).

## 1.2 Research Problem

The previous section discusses the issue of climate change and its impact on urban areas. In particular, the urban heat island effect, which can lead to adverse health impacts on vulnerable populations, is a pressing issue that requires the involvement of both municipalities and citizens. While municipalities can implement various measures, such as the addition of urban greenery and other shade structures, active citizens' involvement and participation are crucial, especially since the municipality only has partial control over their cities. Also, citizens are more likely to support initiatives in which they have participated, resulting in better acceptance and adoption of climate adaptation measures (Aylett, 2014). In addition, active citizens' engagement and participation in climate adaptation strategies not only strengthen their sense of ownership and responsibility for their community's sustainable future (Twigger-Ross et al., 2015) but also promote more fair decision-making because all stakeholder's needs are considered in building climate-resilient cities (Few et al., 2007). Lastly, active participation can be used as a valuable education tool by raising more awareness about climate change and inspiring sustainable behaviors in the daily lives of citizens (Lorenzoni et al., 2007).

This research aims to identify strategies to enhance citizen participation and promote climate-resilient cities by investigating the relationship between proximity to heat-stress exposure and residents' ability to engage in climate adaptation efforts in the city of Groningen, shedding light on potential barriers to active participation and ways to overcome then. It will do so by trying to answer the following main research question:

*To what extent does proximity to heat-stress exposure affect residents' desire to engage in climate adaptation efforts in the city of Groningen?*

To give a substantiated answer to this question, the following two sub-questions should be covered:

*1) To what extent does proximity to heat-stress exposure affect residents' knowledge, resources, and awareness of climate adaptation efforts in the city of Groningen?*

*2) How willing are residents to engage in climate-adaptive initiatives given they possess knowledge, resources, and awareness of climate adaptation?*

## 1.3 Structure of Thesis

This thesis starts with an introduction that explains the context of climate adaptation activities in Groningen and the importance of addressing heat stress exposure. Thereafter, a broad literature review is presented, outlining key theories and prior research relevant to climate adaptation and heat stress. Subsequently, the methodology section describes the research design and the approach used for data collection and analysis. The research findings and analysis are then discussed, highlighting the relation between proximity to heat stress exposure and residents' climate adaptation engagement. The thesis winds up with a conclusion that describes the collected insights, the implications for urban environments, and suggestions for future research.

# 2. Theoretical Framework

This research aims to examine the relationship between proximity to heat-stress exposure and residents' ability to engage in climate adaptation activities in the city of Groningen. To do this, a theoretical framework that provides the relevant theories and concepts is crucial. This section will discuss the existing literature on the urban heat island effect, citizens' engagement in climate adaptation activities, and proximity to heat-stress exposure.

## 2.1 Urban heat island effect

The urban heat island (UHI) effect refers to the situation in which urban areas experience significantly higher temperatures compared to nearby rural areas. This is mainly because heat is absorbed and retained by buildings, roads, and other infrastructures (Oke, 1982). Consequently, these higher temperatures in urban areas can lead to heat stress, which occurs when the body is unable to regulate its temperature effectively due to excessive heat exposure or inability to dissipate heat. This can result in a variety of heat-related health issues such as heat exhaustion, heatstroke, and dehydration which present significant risks to human health, especially among vulnerable population groups (Centers for Disease Control and Prevention [CDC], 2019). To fight the UHI effect and reduce heat stress, climate adaptation strategies, and measures are put into action. Examples of these tactics include the introduction of urban greenery, the use of reflective pavement, and the development of green roofs and walls and other shade-creating structures (Bowler et al., 2010; Santamouris, 2014). Cities that effectively implement the previously mentioned strategies can mitigate the negative impacts of climate change on urban populations and better cope with heat stress incidents (Rosenzweig et al. 2011). Thus, the UHI effect causes health risks due to higher temperatures in urban areas, highlighting the need for climate adaptation strategies. Since municipalities can not succeed without the citizens, their engagement in climate adaptation activities is of high importance.

## 2.2 Citizens' Engagement in climate adaptation activities

To create future-proof, resilient communities that are capable of sustaining and recovering from negative impacts caused by climate change, the engagement of citizens in climate adaptation activities is of crucial importance (Neil Adger et al., 2005; Hegger et al., 2017). It can lead to more effective, equitable, and sustainable outcomes (Moser and Ekstrom, 2010). However, even though the majority of people are willing to engage in climate adaptation activities, many lack the required awareness, knowledge, and resources to do so (Hegger et al., Holleman, 2023).

The theory of planned behavior (Ajzen, 1991) and the socio-ecological model (McLeroy, 1988) are often used to explain the factors that influence citizens' engagement in climate adaptation activities. The theory of planned behavior states that attitude, social norms, and behavior control determine a person's intention to engage in climate-adaptive behavior. The social-ecological model states that individuals' behavior is influenced by various factors at different levels,

consisting of individual, social, environmental, and policy factors.
Previous research has shown that knowledge and awareness of climate change can affect citizens' engagement in climate adaptation activities (Hegger et al., 2017). Also, socio-demographic factors like age, gender, and education level play an important role (Lwasa et al., 2014). Both social factors, such as social norms and social support, and environmental factors, such as access to resources and infrastructure, play an important role in engagement. However, there is still much to learn about the factors that influence citizens' engagement, especially in metropolitan areas (Hegger et al., 2017)

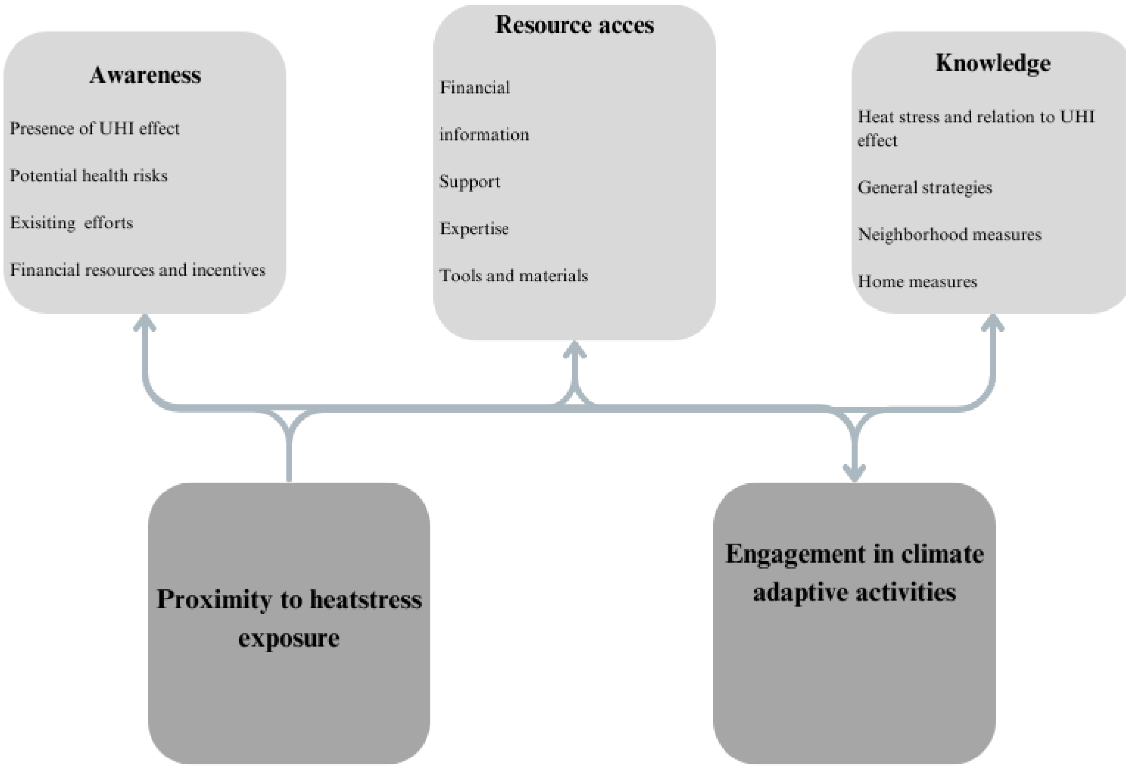
### 2.3 Proximity to Urban Heat-Stress

The concept of proximity to urban heat stress refers to the spatial relationship between citizens' homes and areas that experience higher temperatures due to the UHI effect (Harlan et al. 2006). Previous research has found that residents that are living in areas with a higher level of urban heat stress are more likely to perceive climate change as a pressing issue and are more willing to engage in climate-adaptive behaviors such as planting trees and creating shade (Kabisch et al., 2016). Another research found that people who live in areas with higher levels of urban heat stress have a higher risk of heat-related illness and mortality (Reid et al., 2009). It also found significant evidence that, regardless of their proximity to heat-stressed areas, demographic and socio-economic factors such as age, income, and education level can influence residents' ability to participate in climate adaptation activities. Thus, proximity to heat-stress areas influences residents' climate adaptation behaviors and health risks, where socio-economic factors play an important role. Therefore it would be interesting to explore if proximity to heat stress also influences citizens' engagement in climate adaptation activities and how it affects residents' knowledge, awareness, and resources on climate adaptation.
Since this research focuses on answering these questions, it adds to the existing literature and leads to a deeper understanding of how to ease the way toward actual engagement in climate-adaptive activities

### 2.4 Awareness, Knowledge, and Resources

There are three main factors that play significant roles in shaping citizens' ability to engage in climate adaptation and mitigation activities. First of all, citizens that possess knowledge of climate change, its implications, and adaptation strategies, are more likely to make conscious decisions about implementing relevant measures, such as planting trees or installing green roofs (Adger et al., 2005). Resources, including financial possibilities, time, material availability, and community support can be essential determinants of such engagement. For example, when installing a green roof, you need a substantial investment, access to certain materials, and possibly professional assistance (Moser and Ekstrom, 2010). Furthermore, being aware of climate change, its local impacts, and the necessity for adaptation can stimulate individuals toward action. This awareness can be specifically important in areas with higher urban heat stress levels, where the effects of climate change are more immediate and tangible (Lorenzoni et al., 2007; Harlan et al., 2006). In short, citizens' engagement in climate adaptation activities is influenced by their knowledge, resources, and awareness of climate change, which are especially critical in areas that face urban heat stress.

### 2.5 Conceptual Model




The conceptual model above is an abstract representation of the key concepts and expected relationships that will be tested in this research.

### 2.6 Hypotheses

Residents of Groningen who live closer to areas with higher levels of urban heat stress are more aware of climate adaptation efforts, possess more knowledge on the topic, and have greater access to resources to engage in climate adaptation activities. Therefore, they are more likely to engage in climate adaptation activities compared to citizens who live further away from areas with urban heat stress exposure.

# 3. Methodology

### 3.1 Data collection and sample

Since this research has limited time, it is impossible to take a longitudinal approach. Therefore, the methodology of this research will contain an online questionnaire with a cross-sectional design. This means that quantitative data will be collected at a single point in time to get a snapshot of the relationship between proximity to heat-stress exposure and citizens' ability to engage in climate adaptation activities. The online survey will be shared primarily on social media platforms, such as Instagram, Facebook, LinkedIn, and WhatsApp, to reach as many respondents that live in the city of Groningen as possible. In addition, since the sole use of social media might lead to a somewhat biased sample group in terms of age, a QR-code on a physical paper (see appendix 1) that leads to the survey will be delivered to mailboxes and public buildings such as the university library and supermarkets.

Participants will be selected through a non-probability convenience sampling technique. This means that participants will be chosen based on their availability and willingness to participate in the study. Because the survey will be shared online and physically this will be done automatically since the people that are willing to participate will do so. In this way, a large and diverse sample of respondents will be gathered. The target population will be residents of the city of Groningen who are 18 years or older. To ensure that there is enough statistical power to test the research question, the goal is to have a sample size of at least 500 participants.

The questionnaire will have three sections. Firstly, personal data such as location, age, gender, educational level, etc. will be gathered. The locations together with existing knowledge on heat stress in Groningen will be put in a Geographic Information System (GIS) to determine the proximity to heat stress exposure. Thereafter a map (see image below) is created in order for participants to be able to identify what type of heat stress exposure is present in their homes. Then, participants' awareness, knowledge, and resources related to climate adaptation activities will be measured. By creating a couple of question on each of these factors three variables can be made that indicates the level of awareness, knowledge, and resources. Lastly, engagement in climate adaptation activities will be measured. Here the focus lies on urban heat island adaptation and mitigation such as using shade structures.

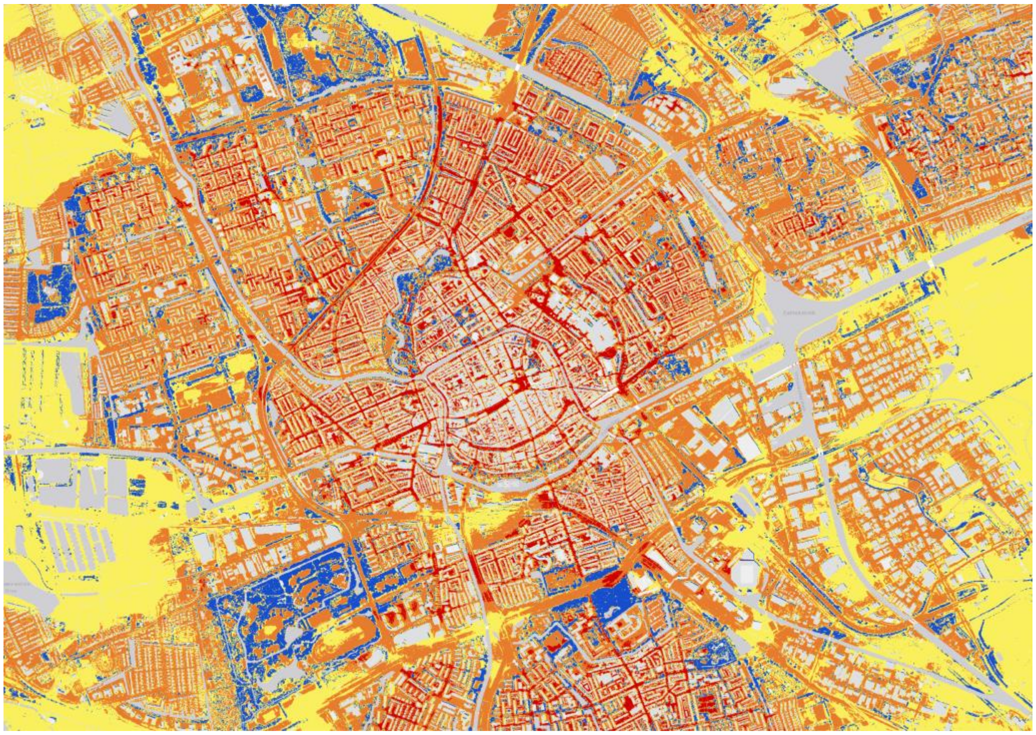


**Image 1:** A map of Groningen that shows the different levels of heat stress exposure were Blue = Very low exposure, Yellow = LOW exposure, Orange = High exposure, and Red = Very High exposure.

The questionnaire was initially shared through Instagram and WhatsApp. This resulted in 36 participants after two weeks. Since this is far from enough, additional steps were taken to enlarge the sample size. A poster with a QR code (Appendix 1) to the survey was distributed in the University library, and the questionnaire was also shared on Linkedin. This led to the final sample which consists of 65 respondents without any missing values.

Descriptive statistics will be used to describe the demographic characteristics of the sample group and participants' engagement in climate adaptation activities. Thereafter the hypothesis will be tested through a multiple regression model.

### 3.2 Dependent variable

The first dependent ordinal variable is *PROX_HS* which represents the resident's proximity to heat stress exposure. Participants were shown a map of Groningen with the current highest perceived temperature within a year where they had to identify in which color their home location is. It is measured by an ordinal scale from 1 to 4, where 1 = blue < 30 °C, 2 = yellow = 30 - 34 °C, 3 = orange = 34 - 39 °C and 4 = red > 39 °C.

The second, continuous, dependent variable, *ENG*, refers to citizens' implementation of climate adaptation activities. It is measured by the average score computed out of the five ordinal variables that represent the ranked score of the corresponding answers that the participants in the questionnaire provided. This results in the following formula:

*ENG = (IMPL_HOME + IMPL_NEIGH + PART_LOCAL + ACTION_GRON + HIRE_EXP) / 5*

Where *IMPL_HOME* is the ordinal dependent variable that measures the likelihood a participant will implement a climate adaptive measure in or around their home. The numeric scale is represented on a scale of 1 to 5 and it is the same for all other variables that are included in the dependent variable. 1 = very unlikely, 2 = unlikely, 3 = neutral, 4 = likely, 5 = very likely. Followed by four variables that include *IMPL_NEIGH*, the likelihood of implementing climate adaptive measures in the neighborhood. *PART_LOCAL*, the probability that an individual will participate in local climate adaptation efforts, programs, or initiatives. *ACTION_GRON*, illustrating the probability that an individual will take action toward making the city of Groningen more climate adaptive. And lastly, *HIRE_EXP* portrays the likelihood a person will hire an expert or company with the purpose of taking domestic climate adaptive action. The average score of the combined abovementioned variables creates an adequate estimator for the likelihood that a person will engage in climate adaptive activities.

**3.3 Independent variables**

The first ordinal independent variable is *AWAR*, which illustrates the extent to which an individual is aware of the presence of the UHI effect in Groningen (*AWAR_UHI)*, the potential health risks associated with it (*AWAR_HR*), the existence of climate adaptational programs, organizations or initiatives (*AWAR_EPOI)* and the availability of financial resources and incentives for climate adaptive measures (*AWAR_AFI)*. This estimator is calculated as follows:

*AWAR = (AWAR_UHI + AWAR_HR + AWAR_EPOI + AWAR_AFI) / 4*

The second independent variable *KNOW*, estimates the amount of knowledge participants possess on five different but climate adaptation-related variables. The estimator is calculated as follows:

*KNOW = (KNOW_UHI + KNOW_S + KNOW_NH + KNOW_D + KNOW_EG) / 5*

Where *KNOW_UHI*, estimates the amount of knowledge a participant possesses about heat stress and its relation to the urban heat island effect. *KNOW_S* illustrates the amount of knowledge an individual possesses about climate adaptation strategies. *KNOW_NH* shows how much the participant knows about the specific measures that can be taken to reduce heat stress in the neighborhood. *KNOW_D* describes the amount of knowledge individuals have on the measures one can take to reduce domestic heat stress exposure. And lastly, *KNOW_EG* represents the amount of knowledge the individual knows about the effects of green spaces and vegetation in reducing heat stress.

The third independent variable *RES_A*, estimates the participants' ability to access resources required for climate adaptational activities. This includes access to financial resources *(RES_A_F)* such as subsidies or incentives for climate adaptation, informational resources (*RES_A_I)* meaning necessary information to know how to implement climate adaptational activities, supportive resources (*RES_A_S)*, such as support from local organizations, municipalities or community groups, ability to access expertise and guidance required to implement climate adaptation measures (*RES_A_EG)*, and the ability to access tools and materials for climate adaptation efforts (*RES_A_TM)*. Results in the following formula that calculates the estimator:

*RES_A = (RES_A_F + RES_A_I + RES_A_S + RES_A_EG + RES_A_TM) / 5*

Lastly, *PROX_HS* will also serve as an independent variable in estimating the effects of residents' proximity to heat stress exposure, as explained above, on the likelihood of engaging in climate adaptive activities.

**3.4 Control variables**

Several control variables are added in order to isolate the effect and reduce the risk of confusing influences on the independent variable. The control variable age *(AGE)* has responses between 18 and 70 years. Therefore the variable was added into four categories: 1. Young adults (18–24), 2. Adults (25-39), 3. Middle age adults (40-59), and 4. Elderly (60+). The other control variables include gender *(GENDER)*, the highest level of completed education *(EDUCATION)*, and annual household income *(INCOME)*.

In order to test the hypothesis and the sub-questions, two multiple estimation models should be examined. The first estimation model tests the effect of residents' knowledge, resources, and awareness of climate adaptation on proximity to heat stress. It consists of three regression models in order to separately test the effects of the predictor's *AWAR*, *KNOW*, and *RES_A* of climate adaptation on the dependent variable *PROX_HS:*

**1A.** $PROX\_HS = \beta 0 + \beta 1 AWAR + \beta 2 AGE + \beta 3 GENDER + \beta 4 EDUCATION + \beta 5 INCOME + \varepsilon$

**1B.** $PROX\_HS = \beta 0 + \beta 2 KNOW + \beta 3 AGE + \beta 4 GENDER + \beta 5 EDUCATION + \beta 6 INCOME + \varepsilon$

**1C.** $PROX\_HS = \beta 0 + \beta 1 RES\_A + \beta 2 AGE + \beta 3 GENDER + \beta 4 EDUCATION + \beta 5 INCOME + \varepsilon$

The second estimation model tests the effect of the independent variables *AWAR*, *KNOW*, and *RES_* of climate adaption on *ENG.* Also, *PROX_HS* is added as a predictor in order to control for its direct effects on *ENG,* which leads to the following regression model:

$$ENG = \beta 0 + \beta 1 AWAR + \beta 2 KNOW + \beta 3 RES\_A + \beta 4 AGE + \beta 5 PROX\_HS\ \beta 6 GENDER + \beta 7 EDUCATION + \beta 8 INCOME + \varepsilon$$

# 4. RESULTS

### 4.1 Descriptive statistics

Summary of the key measures: number of observations, mean, standard deviation, range, skewness, and kurtosis.

*Table 1:* **Descriptive statistics**

| Variables | Obs | Mean | Std. Dev. | Min | Max | Skew. | Kurt. |
|---|---|---|---|---|---|---|---|
| *PROX_HS* | 63 | **3.46** | 0.113 | 1.00 | 4.00 | **-1.760** | **2.292** |
| *ENG* | 63 | **3.089** | 0.122 | 1.00 | 5.00 | 0.028 | -0.657 |
| *AWAR* | 63 | **3.067** | 0.126 | 1.00 | 4.75 | -0.207 | -0.742 |
| *KNOW* | 63 | **3.108** | 0.124 | 1.00 | 5.00 | 0.080 | -0.586 |
| *RES* | 63 | **2.591** | 0.113 | 1.20 | 4.60 | 0.364 | -0.701 |
| *AGE* | 63 | **1.651** | 0.116 | 1.00 | 4.00 | 1.150 | 0.131 |
| *GENDER* | 63 | **1.37** | 0.065 | 1.00 | 3.00 | 0.932 | -0.355 |
| *EDUCATION* | 63 | **2.83** | 0.156 | 1.00 | 6.00 | 0.028 | -0.539 |
| *INCOME* | 63 | **2.48** | 0.205 | 1.00 | 6.00 | 1.022 | -0.056 |

Table 1 shows the descriptive statistics, which provide some insights into the variables used in the sample. Several noticeable values are shown, which will be discussed. First of all, *PROX_HS* has a mean of 3.46, which indicates that the majority of the residents' homes are located between the orange (34 °C – 39 °C) and red (>39°C) zones on the heat stress map of Groningen. This means that most participants experience significant exposure to heat stress at peak moments. It is also shown by the skewness of -1.760, which suggests that the distribution is skewed towards higher values. The kurtosis of 2.292 indicates relatively high peaks in the distribution of *PROX_HS*. In addition, the mean of *ENG* is 3.089, which indicates that on average residents show moderate engagement in climate adaptation activities. This suggests a general willingness to participate in efforts to address heat stress and climate change. Residents also display moderate awareness of climate adaptation efforts and climate change effects (mean of *AWAR* = 3.067), which suggests that they have some awareness of the UHI effect, associated health risks, and available programs and initiatives. Similarly, residents possess a moderate level of knowledge (mean of *KNOW* = 3.108) about climate adaptation strategies, including the reduction of heat stress in their homes, neighborhoods, and the role of green spaces. Furthermore, the access to resources for climate adaptation is at a moderate level (mean of *RES* = 2.591), which implies that there is room for improvement in terms of available financial, informational, supportive, expertise, and material resources. The average age of the participants is relatively young, between 18 – 39 years old (mean of *AGE* = 1.651), suggesting that either young individuals are more likely to participate in the study or engage in climate adaptation activities, or both. There are slightly more men (41) in the sample group compared to women (29). The average education level is 2.83, which corresponds to a Bachelor's degree. Lastly, the mean of *INCOME* of 2.48 suggests that the average household income of the participants is around €30.000.

### 4.2 Correlation Matrix

*Table 2*: **Correlation Matrix (coefficients)**

| | PROX_HS | ENG | AWAR | KNOW | RES |
|---|---|---|---|---|---|
| *PROX_HS* | 1.00 | | | | |
| *ENG* | **0.397**** | 1.00 | | | |
| *AWAR* | 0.245 | **0.664**** | 1.00 | | |
| *KNOW* | 0.232 | **0.527**** | **0.742**** | 1.00 | |
| *RES* | **0.363**** | **0.682**** | **0.656**** | **0.582**** | 1.00 |

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

*** p<.01, **p<.05, *p<.1

Table 2 shows the correlation matrix for the coefficients of the dependent and independent variables used in the regression models. First of all, from this, it can be observed that multicollinearity is apparently absent in the model since the highest correlation coefficient between *KNOW* and *AWAR* is 0.742 at a 1% significance level. Multicollinearity becomes an issue when the correlation coefficients between two independent variables exceed 0.8, which is not the case here. Some other values are noticeable such as the positive correlation coefficient between *ENG* and *PROX_HS* of 0.397 at a 1% significance level, suggesting that individuals that have closer proximity to heat stress are associated with greater engagement in climate adaptive activities. Also, *ENG* shows a strong positive relation with *AWAR (0.664), KNOW(0.527),* and *RES(0.682)* at a 5% significance level. This indicates that a higher level of awareness, knowledge, and resources are associated with greater engagement in climate adaptive activities. Also, *AWAR, KNOW,* and *RES* are positively correlated with each other, indicating that individuals with higher awareness are likely to have more knowledge and resources related to climate adaptation. However, it is important to note that these correlation coefficients give insights into the strength and direction of the linear relationship between the variables, but they do not imply causation. Therefore further regression models and analysis will be conducted in order to understand the specific relationships and potential causal effects between the variables.

### 4.3 Regression models

*Table 3:* **Regression Table**

| *PROX_HS* | Model 1A | Model 1B | Model 1C |
|---|---|---|---|
| *AWAR* | 0.170 (0.112) | | |
| *KNOW* | | 0.156 (0.116) | |
| *RES* | | | 0.329 (0.120)*** |
| *AGE* | -0.290 (0.112) | -0.333 (0.200) | -0.286 (0.189) |
| *GENDER* | -0.311 (0.220) | -0.277 (0.231) | -0.220 (0.214) |
| *EDUCATION* | -0.012 (0.106) | 0.011 (0.104) | -0.011 (0.100) |
| *INCOME* | 0.005 (0.114) | 0.016 ( 0.115) | -0.014 (0.109) |
| *Constant* | 3.866 (0.530)*** | 3.832 (0.587)*** | 3.445 (0.508)*** |
| *R-squared* | 0.205 | 0.980 | 0.205 |
| *F-ratio* | 2.937 ** | 4.205*** | 2.816** |
| *N* | 62 | 62 | 62 |

*** p<.01, **p<.05, *p<.1

Table 3 provides the regression table of the three regression models that all include the control variables but each regresses the independent variables separately on the dependent variable *PROX_HS.*

Model 1A has an F-ratio of 2.937, which is statistically significant at a 5% level, suggesting that the model as a whole is statistically significant. The R-squared of 0.205 shows that approximately 20.5% of the variance in the dependent variable (*PROX_HS)* is explained by the independent variables. However, the coefficient of the independent variable of 0.170 is statistically insignificant. This means that there is insufficient evidence to reject the null hypothesis and thus the null hypothesis of no relationship or association between the independent variables and dependent variables, is accepted. In other words, there is not enough evidence for

a significant relationship between *AWAR* and *PROX_HS.*
Model 1B as a whole is statistically significant at a 1% significance level with the corresponding f-ratio of 4.205. The very high R-squared value of 0.980 indicates that approximately 98% of the variance in the dependent variable is explained by the independent variables. This suggests that the model is likely overfitting the data or there may be issues of multicollinearity. In addition, the coefficient for the variable *KNOW* is 0.156 and was found not to be statistically significant (p>0.1). Therefore there is insufficient evidence the reject the null hypothesis, meaning the null hypothesis of no relationship is accepted. Thus, there is no statistically significant relationship between *KNOW* and *PROX_HS.*
Model 1C is also statistically significant as a whole because the F-ratio of 2.816 is significant at a 5% level. The R-squared of 0.205 illustrates that roughly 20.5% of the variance in the dependent variable is explained by the independent variables. The coefficient of 0.329 for the independent variable *RES* is statistically significant at a 1% level. There is enough evidence to support the alternative hypothesis of a relationship between the independent variable and the dependent variable. Thus, this indicates a relationship between *RES* and *PROX_HS,* where for every one-unit increase in *RES, PROX_HS* is expected to increase by 0.329, assuming all other factors remain constant. In other words, participants that pose higher levels of access to resources required for climate adaptational activities, have closer proximity to heat stress exposure.
In all models (1A, 1B and 1C) the control variables *AGE*, *GENDER*, *EDUCATION*, and *INCOME* do not have statistically significant coefficients. This means that there is no evidence to suggest a significant relationship between the control variables and the dependent variable (*PROX_HS).* The main reason for this is the weak associations the control variables have with the dependent variable. The influence of participants' age, gender, education, and income on the proximity to heat stress exposure is negligible. Whether you are a man or a woman, young or old, high or low educated, and a high or low earner, you have virtually no or little influence on the amount of heat stress exposure your resident faces when living in a city such as Groningen. That is also the main reason that the control variables were removed whereafter the three models were run again.

*Table 4:* **Regression Table** (without control variables)

| *PROX_HS* | Model 2A | Model 2B | Model 2C |
|---|---|---|---|
| *AWAR* | 0.220 (0.112)* | | |
| *KNOW* | | 0.210 (0.113)* | |
| *RES* | | | 0.362 (0.119)*** |
| *Constant* | 2.785 (0.359)*** | 2.806 (0.368)*** | 2.523 (0.326)*** |
| *R-squared* | 0.060 | 0.054 | 0.132 |
| *F-ratio* | 3.897* | 3.460* | 9.255*** |
| *N* | 62 | 62 | 62 |

*** p<.01, **p<.05, *p<.1

Table 4 shows the regression table where the control variables have been removed. This allows to examine the relationship between the independent variables (*AWAR, KNOW, RES)* and the dependent variable *(PROX_HS)* without the potential influence of the control variables.
Firstly, the R-squared values of 0.06, 0.054, and 0.132 show that the independent variables explain approximately 6% *(AWAR)*, 5.4% *(KNOW),* and 13.2% *(RES)* of the variation in the dependent variable *(PROX_HS).* The first two values suggest that the model's ability to explain variation in *PROX_HS* is relatively low. Therefore, there may be other factors not accounted for in Model 2A and Model 2B. However, the low R-squared scores do not necessarily invalidate the outcomes of the coefficients. The coefficients still provide information on the relationship between the dependent variable and the independent variables, but the models may not capture a significant portion of the overall variability in *PROX_HS.*
Secondly, the F-ratios of 3.897, 3.460 for *AWAR* and *KNOW* are statistically significant at a 10% level while the F-ratio of 9.255 for *RES* is statistically significant at a 1% level. This indicates that the models are statistically significant and provide a better fit to the data than models without the independent variables. The lower significance level of the F-ratio for Model 2C implies a higher level of statistical significance compared to Model 2A and 2B.
When analyzing the coefficients of the three models several interesting results occur. Firstly, the coefficient of 0.220 for *AWAR* is statistically significant at the 10% level. This indicates that there is a positive relationship between *AWAR* and *PROX_HS.* Thus, for every unit increase in *AWAR, PROX_HS* is expected to increase by 0.220, holding other variables constant. In other words, on average, the higher the levels of awareness of the presence of the UHI effect in Groningen, potential health risks associated with it, existing climate adaptational programs, organizations, or initiatives, and the availability of financial resources and incentives for climate adaptive measures, the closer proximity to heat stress exposure is for participants.
Secondly, the coefficient of 0.210 for *KNOW* is statistically significant at the 10% level, suggesting a positive relationship between *KNOW* and *PROX_HS.* For every unit increase in *KNOW, PROX_HS* increases by 0.210, assuming other variables remain constant. Therefore, on average, the higher the amount of knowledge participants poses on heat stress and its relation to the UHI effect, climate adaptation strategies, neighborhood-specific measures to reduce stress, domestic heat stress reduction measures, and the effects of green spaces and vegetation in reducing heat stress, the closer the proximity of residents' homes to heat stress exposure.
Lastly, the coefficient of 0.362 for *RES* is statistically significant at the 1% level, showing a positive relationship between *RES* and *PROX_HS.* For every unit increase in *RES, PROX_HS* increases by 0.362, holding other variables constant. Thus, on average, the higher the level of participants' ability to access multiple resources required for climate adaptational activities, including financial resources, informational resources, supportive resources, expertise and guidance, tools and materials, the closer the proximity to heat stress exposure.

*Table 5:* **Regression Table**

| *ENG* | Model 3A | Model 3B |
|---|---|---|
| *PROX_HS* | 0.114 (0.105) | 0.182 (0.099)* |
| *AWAR* | 0.309 (0.136)** | 0.379 (0.136)*** |
| *KNOW* | 0.032 (0.130) | -0.021 (0.127) |
| *RES* | 0.463 (0.128)*** | 0.404 (0.129)*** |
| *AGE* | -0.172 (0.156) | |
| *GENDER* | 0.147 (0.177) | |
| *EDUCATION* | 0.127 (0.081) | |
| *INCOME* | -0.090 (0.088) | |
| *Constant* | 0.393 (0.585) | 0.313 (0.387) |
| *R-squared* | 0.628 | 0.573 |
| *F-ratio* | 11.396*** | 19.434*** |
| *N* | 62 | 62 |

*** p<.01, **p<.05, *p<.1

Overall, Model 3A and 3B, as represented in Table 5, show a relatively strong relationship between the independent variables and the dependent variable *ENG*, based on the relatively high R-squared values of 0.628 and 0.573 respectively. Both models provide a statistically significant fit since the F-ratios of 11.396 and 19,434 are both statistically significant at the 1% level.
The model with the control variables included, Model 3A, shows a statistically, at the 5% level, significant coefficient of 0.309 for *AWAR*, and a statistically, at the 1% level, significant coefficient of 0.463 for *RES*. This shows a positive correlation between *AWAR* and *RES* on *ENG*. Firstly, this indicates that the higher the levels of awareness of the presence of the UHI effect in Groningen, potential health risks associated with it, existing climate adaptational programs, organizations, or initiatives, and the availability of financial resources and incentives for climate adaptive measures, the higher the likelihood of a participant engaging in climate adaptive activities related to implementing measures in their home, neighborhood, participating in local initiatives, taking action to make the city more climate adaptive, and considering hiring experts for climate adaptive actions. Secondly, the greater the participant's access to various resources, such as finance, information, support, expertise, and materials, the more likely they are to engage in climate adaptive activities in their homes, neighborhoods, and city. The second model (3B) without control variable shows statistically significant coefficients of 0.379 and 0.404 for *AWAR* and *RES* respectively at a 1% significance level on *ENG*. Also, the coefficient of *PROX_HS* has a statistically significant coefficient of 0.182 at a 10% level on *ENG*. This means that there are positive relationships between *AWAR*, *RES*, and *PROX_HS* on *ENG*. The first two remain unchanged by removing the control variable, however, the positive relationship between *PROX_HS* and *ENG* was absent with the control variables included. Thus, the closer participants are to areas with heat stress exposure, the more likely they are to engage in climate adaptive activities in their homes, neighborhoods, and city, and consider hiring experts for such actions.

## 5. Conclusion

This research examined the relationship between proximity to heat stress exposure and citizens' ability to engage in climate adaptation activities in the city of Groningen. The study provides insights into the factors that impact residents' awareness, knowledge, resources, and engagement in climate adaptive behaviors. Significant statistical evidence was found that citizens with higher awareness, knowledge, and access to resources are more likely to be exposed to heat stress. Also, citizens that have higher levels of awareness and access to resources required for climate-adaptive activities, are more likely to engage in climate-adaptive behaviors.

Personally, I have experienced this research as a great opportunity to dive into a subject that interests me a lot. While I had some struggles in choosing the right angle and deciding on the most suitable methods, I think on average the research came out quite well. It has shown me once more, how research can serve as a tool to find a way of exploring and understanding difficult and broad topics related to climate change. It also taught me that this topic is far from fully explored and that no research is without flaws.

Overall, this research contributes to the broader theoretical framework of climate adaptation in cities and stresses the importance of addressing heat stress exposure in urban environments. From the results, it can be concluded that there is a need for increased residents' awareness and knowledge of climate adaptation strategies and to facilitate better access to resources.

While this research provides valuable insights, it is not without limitations. The sample size was relatively small and the study was focused on a single city, which limits the generalizability of the findings. Also, the data was gathered at a single point in time and thus future research could benefit from longitudinal data to examine the influences and dynamics of the relationships over time. Besides, it would be interesting to examine the effectiveness of specific interventions aimed at increasing residents' awareness, knowledge, and resources related to climate adaptation in order to create effective policies.

In short, this research shows the importance of awareness, knowledge, and resources in stimulating citizens' engagement in climate adaptation activities and their proximity to heat stress exposure. Cities and municipalities can improve climate resilience by addressing these factors

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# 7. Appendix

**Appendix 1**

Picture 1: An A4 poster that has been spread out in order to increase survey responses.

**Appendix 2**

**Questionnaire**

Start of Block: Default Question Block

Q1 What is your age?

________________________________________________________________

Q2 What is your gender?

- ◯ Male (1)
- ◯ Female (2)
- ◯ Non-binary / third gender (3)
- ◯ Prefer not to say (4)

Q3 What is the highest level of education completed?

- ◯ High school diploma (1)
- ◯ Bachelor Propedeuse (2)
- ◯ Bachelor's Degree (3)
- ◯ Master's Degree (4)
- ◯ Doctorate (PHD) (5)
- ◯ Other (6)

Page Break

Q4 What is your approximate annual household income?

- (1)
- €10.000 - €30.000 (2)
- €31.000 - €50.000 (3)
- €51.000 - €70.000 (4)
- €71.000 - €100.000 (5)
- >€100.000 (6)

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Q5 What is your postcode? (e.g.: 9711AA)

________________________________________________________________

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Q12 **Please take a look at the map of Groningen.**
**What color is present at your home?**

- **Blue** (1)
- **Yellow** (2)
- **Orange** (3)
- **Red** (4)

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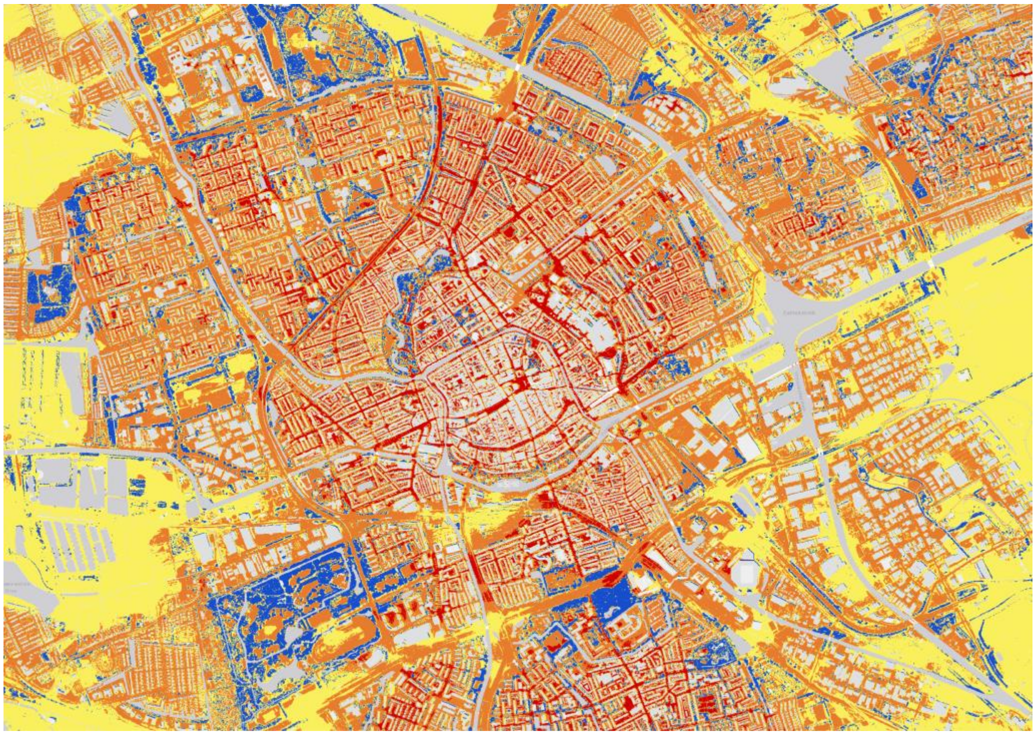

Q8 *Awareness*
Please answer the following questions: On a scale of 1 to 5, how aware are you of...?

| | 1. Completely unaware (1) | 2. Somewhat unaware (2) | 3. Neutral/unsure (3) | 4. Somewhat aware (4) | 5. Completely aware (5) |
|---|---|---|---|---|---|
| The presence of the urban heat island effect in Groningen? (1) | ○ | ○ | ○ | ○ | ○ |
| The potential health risks associated with heat stress? (2) | ○ | ○ | ○ | ○ | ○ |
| The existence of climate adaptation efforts, programs, organizations or initiatives in the city of Groningen? (3) | ○ | ○ | ○ | ○ | ○ |
| The financial resources or incentives available to implement climate adaptation measures in your home or neighborhood? (Examples: Tax incentives for solar panels, grants or funding for water conservation measures etc.) (4) | ○ | ○ | ○ | ○ | ○ |

Q9 *Knowledge*

Urban heat stress refers to the increased heat levels in urban areas compared to surrounding rural areas due to human activities such as transportation, buildings, and industry. It can lead to higher temperatures and lower air quality, which can be harmful to human health and the environment.

Please answer the following questions: On a scale from 1 to 5, how much do you know about...?

| | 1. Nothing at all (1) | 2. A little (2) | 3. A moderate amount (3) | 4. A lot (4) | 5. A great deal (5) |
|---|---|---|---|---|---|
| Heat stress and its relation to the urban heat-island effect? (1) | ○ | ○ | ○ | ○ | ○ |
| Climate adaptation strategies? (2) | ○ | ○ | ○ | ○ | ○ |
| The specific measures that can be taken to reduce heat stress in your neighborhood? (3) | ○ | ○ | ○ | ○ | ○ |
| The specific things you can do to make your home more resilient to heat stress? (4) | ○ | ○ | ○ | ○ | ○ |
| The effect of green spaces and vegetation in mitigating heat stress? (5) | ○ | ○ | ○ | ○ | ○ |

Q10 *Resources*
Please answer the following questions: On a scale of 1 to 5, how confident are you in your

ability to access...?

| | 1. Not at all confident (1) | 2. A bit confident (2) | 3. Moderately confident (3) | 4. Very confident (4) | 5. Completely confident (5) |
|---|---|---|---|---|---|
| Financial resources or incentives to implement climate adaptation measures in your home or neighborhood? (1) | ○ | ○ | ○ | ○ | ○ |
| Information on climate adaptation measures? (2) | ○ | ○ | ○ | ○ | ○ |
| Support from local organizations, municipalities or community groups for climate adaptation efforts? (3) | ○ | ○ | ○ | ○ | ○ |
| Expertise or guidance on implementing climate adaptation measures? (4) | ○ | ○ | ○ | ○ | ○ |
| The necessary tools or materials for climate adaptation efforts? (5) | ○ | ○ | ○ | ○ | ○ |

Q11 *Engagement in climate adaptation activities*
Please answer the following questions: On a scale from 1 to 5, how likely are you to...?

| | 1. Very unlikely (1) | 2. Unlikely (2) | 3. Neutral (3) | 4. Likely (4) | 5. Very likely (5) |
|---|---|---|---|---|---|
| Implement climate adaptation measures in your home? (1) | o | o | o | o | o |
| Implement climate adaptation measures in your neighborhood? (2) | o | o | o | o | o |
| Participate in local climate adaptation efforts, programs, or initiatives? (3) | o | o | o | o | o |
| Take action towards making Groningen more climate adaptive? (4) | o | o | o | o | o |
| Hire an expert or company to take domestic climate adaptation measures ? (solar panels, isolation, green roof etc.) (5) | o | o | o | o | o |