

Heat stress at preschool yards

A MIXED-METHOD GEOGRAPHICAL
STUDY IN GOTHENBURG, SWEDEN

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Abstract

As climate change is predicted to generate higher temperature and more frequent heat waves and extreme temperature events in Sweden, issues related to heat will be more accentuated in the future. Children are both vulnerable to heat and spend much of their time outdoors at preschool yards. This thesis has a broad approach to the issue of heat stress at preschool yards, where modelling of T_{mrt} as well as interviews with preschool teachers and planners has been conducted in order to explore how heat is affecting preschool yards in Gothenburg. Previous research has shown that shading and vegetation are key factors in lowering T_{mrt} , and that the urban environment has a great impact in regulating thermal conditions in urban environment. Furthermore, most studies conducted on heat and school environment has been focusing on harmful UV-radiation mitigation or indoor thermal environments.

The study has been modelling T_{mrt} , shading and Sky view factor on 438 preschool yards in SOLWEIG and conducted interviews with 9 preschool teachers and 2 municipal actors involved with planning and preschool yards. The study results indicate that even though heat stress is present at preschool yards in Gothenburg, the issue of heat is mainly seen as an inconvenience rather than a problem and are thus underprioritized to measures of UV-radiation or other problems present at preschools and preschool yards. The study also conclude that shading is the most important factor for keeping low temperature at preschool yards, and that the most important factor of shading is found from trees. Trees and vegetation are also found to hold other desirable factors for preschool yards apart from heat mitigation.

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Oskar Bäcklin

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1 Introduction

1.1 BACKGROUND

The unusually warm and sunny Swedish spring and summer of 2018 raised a lot of questions regarding future thermal conditions in Sweden. Global climate change will affect the Swedish climate with higher summer temperature as well as heat waves such as in 2018 is predicted to occur more frequently in the future (Thorsson et al., 2017). Heat affects diverse groups in society differently, based on many factors including physiological conditions, amount of exposure to sun and heat, physical environment, amount of clothing as well as physiological and behavioural differences (Coccolo, Kämpf, Scartezzini, & Pearlmutter, 2016; Vanos, Herdt, & Lochbaum, 2017). Along with elderly people, children are especially vulnerable to heat (Kim & de Dear, 2018; Vanos et al., 2017; Yun et al., Xu et al., 2012). Children are less aware of their own thermal status, which leads to that others such as preschool teachers, parents and other adults need to ensure that the children stay in comfortable thermal conditions (Yun et al., 2014; Kim & de Dear, 2018). When thermal comfort zone is exceeded, heat stress occurs. Heat stress ranges from feeling too warm, to reaching levels when heat has serious health impact such as overheating and fainting (Oke, Mills, Christen, & Voogt, 2017).

As preschool yards in Sweden are fenced delimited areas where the majority of the outdoor activities are performed at preschool, it is important to ensure healthy environments for the children that is able to mitigate heat stress (Boverket & Movitum, 2013; Vanos et al., 2017). Apart from the measures taken by caretakers of children, the built-up physical environment regulate thermal conditions and thus play a major role in mitigating and affecting extreme heat (Chen, Yu, Yang, & Mayer, 2016; Lindberg, Thorsson, Rayner, & Lau, 2016; Shashua-Bar, Pearlmutter, & Erell, 2009; Vanos et al., 2017). The complex urban form of cities creates local microclimates that may respond to changes in the ambient weather conditions differently. Thus, the design and content of preschool yards are important factors in creating healthy thermal environments.

Previous studies of thermal comfort and sun exposure for preschool children have primarily investigated the indoor environment of classrooms in relation to study performance rather than impact on health (Kim & de Dear, 2018; Nam, Yang, Lee,

Park, & Sohn, 2015; Teli, Bourikas, James, & Bahaj, 2017; Yun et al., 2014). The general increase in cancer from solar exposure has also led to a great awareness for UV-radiation which is greatly influencing the design of preschool yards in Sweden today (Boverket & Movitum, 2015; Hulth, Molnár, Ögren, & Holm, 2016; Lokalförvaltningen, 2018; The Swedish Association of Local Authorities and Regions, 2015, 2018). Even though regulations and strategies in Sweden and Gothenburg assess higher temperatures from climate change as a reality, heat stress are not dealt with in the prevailing guidance and regulating documents, but heat is, if addressed, referred to as a matter of comfort on warm days rather than a possible threat to children's health.

1.2 AIM AND RESEARCH QUESTIONS

Through a mixed-method approach using both modelling of thermal conditions on preschool yards and interviews with preschool teachers and planners, this study aim to conduct a broad examination of heat at preschool yards. The study will investigate how the physical environment affect the thermal conditions at preschool yards using T_{mrt} as indicator of heat. To further expand these findings, the study will also investigate how heat at preschool yards is managed by preschool teachers and planners.

Following research questions will be used to fulfil the aim

- What characteristics and content of preschool yards affect the thermal conditions during warm days?
- What strategies of heat mitigation at preschool yards are present in Gothenburg?

2 Literature Review of Key Themes

2.1 PRESCHOOL CHILDREN AND PRESCHOOLS IN SWEDEN AND GOTHENBURG

In Sweden, all children aged 1 to 6 have legal right according to the Swedish act of education to attend preschool. The aim with preschools is to stimulate the development and learning for children as well as provide safe and proper care. The principal of a preschool owns the responsibility of ensuring that the children's groups are of appropriate composition and size and that the children are offered good and healthy environments (SFS 2018:1368). According to statistics from 2017, 84% of all children aged 1 to 5 years enrolled in preschool in Sweden, whilst for children aged 4-5, 95% were enrolled in preschool. On average for the whole country there are 5.1 children per preschool employee. For private preschools the children per employee ratio is lower, 5.0 while the ratio for public preschools is 5.1 (Ministry for Education and Research, 2017a).

There are about 34 000 children in preschool age in Gothenburg (Statistik och Analys, 2018), where 81% of these children are enrolled in preschool. The average number of children in a preschool class in Gothenburg is in average 15.5. The staffing situation per child are the same as for the entire country, 5.1 children per preschool employee (Ministry for Education and Research, 2017b). In average, preschool children in Sweden spend 31 hours a week in preschool where 5-year olds spend most time, 32 hours a week, and 1-year olds least time, 29 hours a week. (Ministry for Education and Research, 2013).

2.1.1 PRESCHOOL YARDS

This study use the definition from The Swedish Association of Local Authorities and Regions (2015, p. 10) to define preschool yards: *“Preschool yards refers to the outdoor environment that surrounds preschool buildings and lies within the same property¹”*. Thus, this definition does not account nearby green areas, parks or playgrounds as part of the preschool yard area even though it in some cases are treated as such in the day-to-day activities. Henceforth in this report, preschool yards are to be interpreted through this definition.

¹ Authors own translation, the original wording is *“Med skolgård avses den utemiljö som omger grundskolebyggnader inom samma fastighet”*

Preschool yards are in comparison to high school and primary school yards fenced with gates in order to keep children from leaving the property (City Premises Administration, 2018). The preschool yard has multiple functions that should strive to enhance the development through play, movement, exploration, creation and learning. In times of densifying cities with decreasing amount of areas suitable for play in the urban fabric, preschool yards becomes even more important as backbone for movement and play for many children (Boverket & Movitum, 2015; The Swedish Association of Local Authorities and Regions, 2015, 2018). The free open space of preschool yards in Gothenburg should be at least 35m² per enrolled child in order to ensure sufficient amount of space for both play and rest for all children. The preschool yards should be able to mitigate unpleasant and potentially harmful effects from weather such as rain, wind, sun and heat (City Premises Administration, 2019). More than 70% of parents in Sweden feel that the preschool environment in terms of safety and quality to great extent meet their expectations. Private preschools are in general assessed as better than public schools in the comparison of satisfaction with outdoor environments (Ministry for Education and Research, 2013).

The amount of time spent on preschool yard varies dependant on the preschool yard quality, weather, and specific profile of the preschool as well as general interest of being outdoors from preschool teachers. Hence it is difficult to generalise how much time that are actually spent on preschool yards. However, standard for most preschools is to be outside both before and after noon with various lengths (Mårtensson, 2006). Based on two investigations of time spent on preschool yards with in total 241 participating preschools (Fors & Jönsson, 2018; Mårtensson, 2006), an average of 3 hours is spent on preschool yards per day. Even though 3 hours is an average, a much larger portion of preschools spent more than 3 hours outside than fewer than 3 hours, i.e. more preschools spend 3 or more hours on preschool yards than less than 3.

Despite the fact that the preschool is primarily a domain created for the children's well-being, it is also a workplace for the preschool's staff who must satisfy a decent working environment. High quality environments may decrease the amount of stress and work load for preschool personnel, and thus provide both better care of children and well-being of the staff (Persson & Broman, 2019).

2.2 THE URBAN CLIMATE

The complex morphology of urban settlements creates specific climatic conditions at both mesoscale and microscale. The variance in form, materials, activities and vegetation that is found in urban areas makes the climatic conditions shifting and dynamic. The general climate conditions of the urban settlement also affect the urban climate, as well as limitations, possibilities, and problems for both living and planning the city (Oke et al., 2017; Shooshtarian, Rajagopalan, & Sagoo, 2018). The urban fabric holds a great variance of structures such as trees, bushes, vegetation, buildings, wall and roads. How these structures are organised distributed are key features in regulating urban local climate conditions (Lindberg et al., 2016-a; Shashua-Bar et al., 2009; Vanos et al., 2016). A widely used concept in urban climatic studies is the Sky View Factor (Svf). Sky view factor is a ratio 0-1 where 0 means that the sky is totally obstructed, and 1 that the sky is totally unobstructed from a specific point upon a surface (Lindberg et al., 2018). Svf may also give indication on general building density conditions for urban areas, which is useful when doing research in urban areas (Lindberg et al., 2016-a). The Svf are an important factor in radiation studies and calculations as it solar access as well as radiation fluxes to a great extent affect the magnitude of these two parameters (Oke et al., 2017)

The urban geometry thus affects the thermal environment through shading as well as influencing both short and longwave radiation fluxes. As Radiation fluxes in an urban environment is far from uniform due to complex geometries of the urban fabric such as buildings, trees and other vegetation that provide shading, as well as different surface materials emit and reflect various amount of radiation. The thermal conditions of cities thus have high spatial variation even at very short distances (Oke et al., 2017; Lindberg et al., 2016-a). Mean radiant temperature (T_{mrt}) is a meteorological parameter that sums up all incoming and outgoing long and shortwave radiation both direct and indirect that the human body is exposed to (Thorsson et al., 2007). T_{mrt} is in comparison to air temperature (T_a), capable of measure spatial thermal variations, which makes it a useful meteorological parameter in urban climate studies (Ali-Toudert & Mayer, 2007; Chen et al., 2016; Kántor & Unger, 2011; Thorsson et al., 2007). During calm and clear weather conditions, T_{mrt} is the most important meteorological parameter governing human thermal comfort (Kántor & Unger, 2011; Mayer & Höpfe (1987) in Lindberg et al.,

2018; Vanos et al., 2016). At these conditions, differences in temperature may vary more than 30 C° between T_a and T_{mrt} (Ali-Toudert & Mayer, 2007; Chen et al., 2016).

Highest T_{mrt} in urban environments are found at sunlit south-west facing walls, due to high fluxes of both reflected short wave radiation and emitted longwave radiation from the building walls (Lindberg et al., 2016-a). In more general terms, highest levels of T_{mrt} occur past noon with a thermal maxima around 16:00 (Ali-Toudert & Mayer, 2007). As shading is found to be the most efficient way of reducing T_{mrt} , open spaces with high sky view factor could also be considered prone to heat stress at clear calm days (Ali-Toudert & Mayer, 2007). Trees are excellent heat mitigating measures, and are found to be efficient T_{mrt} mitigating objects in areas prone to heat stress (Lindberg et al., 2016-a; Thom, Coutts, Broadbent, & Tapper, 2016; Thorsson et al., 2017). Since trees differ in form and shape, the choice of tree species are important in regard to both wanted and unwanted effects from trees. For heat mitigation in climatic conditions such as Gothenburg, deciduous trees that obstruct the sun in summer, and have relative high emissivity in wintertime is preferred compared to evergreen trees (Thorsson et al., 2017). The shape of tree such as canopy and tree height, as well as placement of trees is also key factors for the efficiency of trees T_{mrt} mitigating efficiency (Lindberg et al., 2016-a; Thorsson et al., 2007). Even though different surface materials on both walls and ground to some extent affect T_{mrt} , the heat reduction is though minor compared to shading due to the fact that the most important factor of T_{mrt} is incoming short-wave radiation (Shashua-Bar et al., 2009; Lindberg et al., 2016-a).

2.2.1 DEFINITION AND DETERMINATION OF T_{MRT}

The definition of T_{mrt} by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE, 2004): "The uniform surface temperature of an imaginary black enclosure in which an occupant would exchange the same amount of radiant heat as in the actual nonuniform space" is widely used in the literature on T_{mrt} (Chen et al., 2016; Lindberg, Holmer, & Thorsson, 2008; Oke et al., 2017; Thorsson et al., 2007, 2014). Even though there are many ways to calculate and determine T_{mrt} , the most accurate way is to use incoming and outgoing long- and shortwave radiation measured from all six directions (north, east, south, west, up and down) (Krüger, Minella, & Matzarakis, 2014; Lindberg et al., 2008; Thorsson

et al., 2007). In order to determine T_{mrt} , the mean radiant flux density of the human body (S_{str}) needs to be known. S_{str} is calculated with following equation (1):

$$S_{str} = \alpha_k \sum_{i=1}^6 K_i F_i + \alpha_l \sum_{i=1}^6 L_i F_i \quad (1)$$

K_i = Short-wave radiation fluxes

L_i = Long-wave radiation fluxes

F_i = Angular factors between person and surrounding surfaces

α_k = absorption coefficient for short-wave radiation

α_l = absorption coefficient for long-wave radiation

Both short-wave K_i and long-wave L_i radiation fluxes is in the equation multiplied by the six angular factors F_i , which depend on the specific position and orientation of the person in question. Standard values for a standing or walking person, F_i is set to 0.22 for the horizontal angular factors, and 0.06 for the vertical angles. Standard values the absorption coefficients are 0.7 for α_k , and 0.97 for α_l (Ali-Toudert & Mayer, 2007; Thorsson et al., 2007).

When S_{str} is known, the Stefan-Boltzmann law can be used to calculate T_{mrt} using following equation (2):

$$T_{mrt} = \sqrt[4]{\left(\frac{S_{str}}{\varepsilon_p \sigma}\right) - 273.15} \quad (2)$$

σ = Stefan-Boltzmann constant ($5.67 * 10^{-8} \text{ Wm}^{-2} \text{ K}^{-4}$)

ε_p = Emissivity coefficient of a human body

2.3 HEAT STRESS

Heat stress occur when the thermal comfort zone of a human is exceeded. Thermal comfort, and consequently heat stress is affected by many factors both physical and psychological as well as internal and external factors. The meteorological parameters of the current environment to which a human being is exposed such as temperature, wind, radiation and humidity are important factors of thermal comfort (Oke et al., 2017; Shooshtarian et al., 2018). Physical personal factors such

as age, gender metabolic rate affect thermal comfort but also psychological factors as attitude towards the current thermal environment and general preferences of heat (Knez, Thorsson, Eliasson, & Lindberg, 2009; Shooshtarian et al., 2018). Furthermore, perceived amount of control over the capability to alter the present thermal environment also affect thermal comfort (Nicol & Humphreys, 2002 in Shooshtarian et al., 2018). Finally, situational factors such as length of exposure to heat, and the type and amount of clothing are important factors affecting thermal comfort (Shooshtarian et al., 2018). Hence as thermal comfort is highly subjective and affected by the physical conditions and context for the present moment of the person in question, there is no clear temperature threshold indicating when heat stress occurs for humans (Coccolo et al., 2016). As climate change is expected increase higher temperatures as well as increase the number of extreme heat events in Gothenburg, the problem of heat stress are assessed to be a bigger problem in the future than it is today (Thorsson et al., 2017).

2.3.1 CHILDREN AND HEAT STRESS

Along with elderly people, small children are especially vulnerable to heat due to both physical, psychological and behavioural factors. (Kim & de Dear, 2018; Thorsson et al., 2017; Vanos et al., 2017; Xu et al., 2012). The body of a child differs from an adult by having a higher surface to body ratio, which makes the body relatively thinner to the surface area compare to an adult. The higher ratio means that the core temperature of a child fluctuate faster and thus are more vulnerable to overheating as well as freezing than adults (Oke et al., 2017; Vanos et al., 2017). Furthermore, the awareness of one thermal situation is found lower for children, where younger children are found to be less aware than elder children (Yun et al., 2014). As extreme heat conditions due to heat waves in many parts of the world do not occur on a yearly basis, extreme heat may to small children be a completely new phenomenon where the child has no perception in how to deal with that kind of heat (Vanos et al., 2017). This means that children are less likely to react and alter their own thermal condition by changing clothes, moving into cooler areas, drink water or change the intensity of the current activity to lower the core body temperature (Yun et al., 2014). Children also suffer from having less efficient sweat production than adults, which means that the evaporative cooling effect from sweat is significantly lower. Therefore, children have more limitations in physically alter their thermal situation (Vanos et al., 2017).

Thus, others such as preschool teachers, parents and adults need to ensure that the children are thermally comfortable and kept at healthy thermal levels as well as keeping them hydrated (Kim & de Dear, 2018). Apart from the measures taken by caretakers of small children, the built-up physical environment plays a major role in mitigating and affecting heat stress in milieus visited by children (Chen et al., 2016a; Lindberg et al., 2016-a; Shashua-Bar et al., 2009; Vanos et al., 2017). Heat conditions for children in school has been studied extensively, but mainly with an approach of how heat affect school performance, rather than whether heat pose a threat to health and wellbeing of the children. Furthermore, as preschool children do not have the same performance focus as elementary school kids, preschools and preschool yards has thus gained less attention in research than elementary schools (Kim & de Dear, 2018; Nam et al., 2015; Teli et al., 2017; Yun et al., 2014). Although there are many different indices and methods for measuring thermal comfort, (Coccolo et al., 2016), these indices are designed for the bodies, behaviour and thermal perception of adults which as has been presented greatly differ from children (Vanos et al., 2017).

2.3.2 PRESCHOOL YARDS AND HEAT STRESS

Outdoor environments of preschools needs to be carefully designed in order to create both playful and safe milieus (Boverket & Movitum, 2015; City Premises Administration, 2019). According to The Swedish Association of Local Authorities and Regions (2015), the outdoor preschool environment should ideally be designed to create a balance between sunlit and shaded areas. Structures where children stay for longer periods of time, such as sandboxes, should be strategically placed in shaded areas, or if not possible use temporary shading devices during summer months. The main cause for sunlight reduction is to reduce the exposure to UV radiation on the children's sensitive skin. (City Premises Administration, 2019). Even though UV-radiation reduction is framed as the main reason for ensuring shaded places on preschool yards, the guidelines also highlight that lack of shaded areas may cause temperature to rise to harmful levels (ibid).

A study of sunlight protection, noise levels and air quality on preschool yards in four city districts (Västra Göteborg, Lundby, Centrum, Askim-Frölunda-Högsbo) in Gothenburg, from 2016 showed that 24% of 202 investigated preschools had inadequate sunlight protection, where preschools in central Gothenburg was found to be least vulnerable. Inadequate sun protection meaning lack of vegetation

and shaded areas during the day, and preschool personnel have limited possibilities to steer children's activities to shaded areas (Hulth et al., 2016). The study used an approach of both investigating the physical environment effects on sunlight, but also routines and teachers' possibilities to adapt the preschool activities to warm and sunny days. Adaptation involved staying indoors, applying sunscreen, sun protective hats or clothes or putting up temporary parasol or shade sail (Hulth et al., 2016). Even though shade sails do provide shading, the reduction in temperature are not found to be as efficient as from vegetation or buildings and may even cause the temperature beneath shade sails to increase rather than to decrease (Shashua-Bar et al., 2009). More than half of all investigated schools sought comfort in nearby green areas for protection on hot and sunny days, but since leaving the preschool area is a resource intensive activity, this action was found often not possible. Hulth et al. (2016) thereby concluded that adaptation from teachers can be made to decrease solar exposure, but that outdoor urban design is the most important feature for mitigating harmful amounts of solar exposure. Children's movement pattern and usage of environments differ a lot from adults as they play and physically interact with objects and surfaces of environments to a larger degree than an adult person (Vanos et al., 2016). Thereby, the surface temperature of both ground and other objects with high heat absorbing potential, such as swings and other play equipment, make potent heat conductors, but also prove potentially harmful to sensitive skin and body of a small child on a touch-scale (ibid). Even though the surface and equipment material may mitigate these effects to a certain degree, shading is found to be by far the most efficient way of reducing thermal conditions (Shashua-Bar et al., 2009; Thorsson et al., 2017; Vanos et al., 2016).

Although exceedingly high temperature may be a problem at preschool yards, the temporality of the problem is highly determined by the climatic and geographic context (Vanos et al., 2016). High latitude cities such as Gothenburg endure cold and dark winters which needs to be taken into consideration when planning for more shaded areas (City Premises Administration, 2018; Thorsson et al., 2017; Vanos et al., 2016). Furthermore, the fact that preschool teachers needs to keep the children under supervision also pose a conflict towards more vegetation and shade-providing structures at preschool yards (The Swedish Association of Local Authorities and Regions, 2018).

3 Study Area – A Brief Introduction to Gothenburg

Gothenburg is located on the Swedish West coast (57.708870, 11.974560) (Figure 1). Gothenburg is the second largest city in Sweden with about 572 000 inhabitants (Statistik och Analys, 2018). The city core is located in the centre of the municipality, with decreasingly amount of built-up urban areas decreases further out (Figure 1). Gothenburg is one of the most rapidly urbanising areas of Sweden, where the city is expected to increase to 736 000 inhabitants up until 2040. According to the forecast, an increase of 4 % is expected for preschool children (Statistik och Analys, 2019).

3.1 CLIMATE

The climate of Gothenburg is characterised by having a marine west coast climate with both relative mild winters and summer with a mean air temperature of 16.3 °C between June and August (Thorsson et al., 2017). Due to climate change, T_a is expected to increase for all months (Fredrik Lindberg et al., 2016-a), and extreme heat events is predicted to occur more frequently in the future (Thorsson et al., 2017)

Despite predicted climate change T_{mrt} is not assessed to increase considerably in the future. This is due to that the increase in air temperature to some extent are

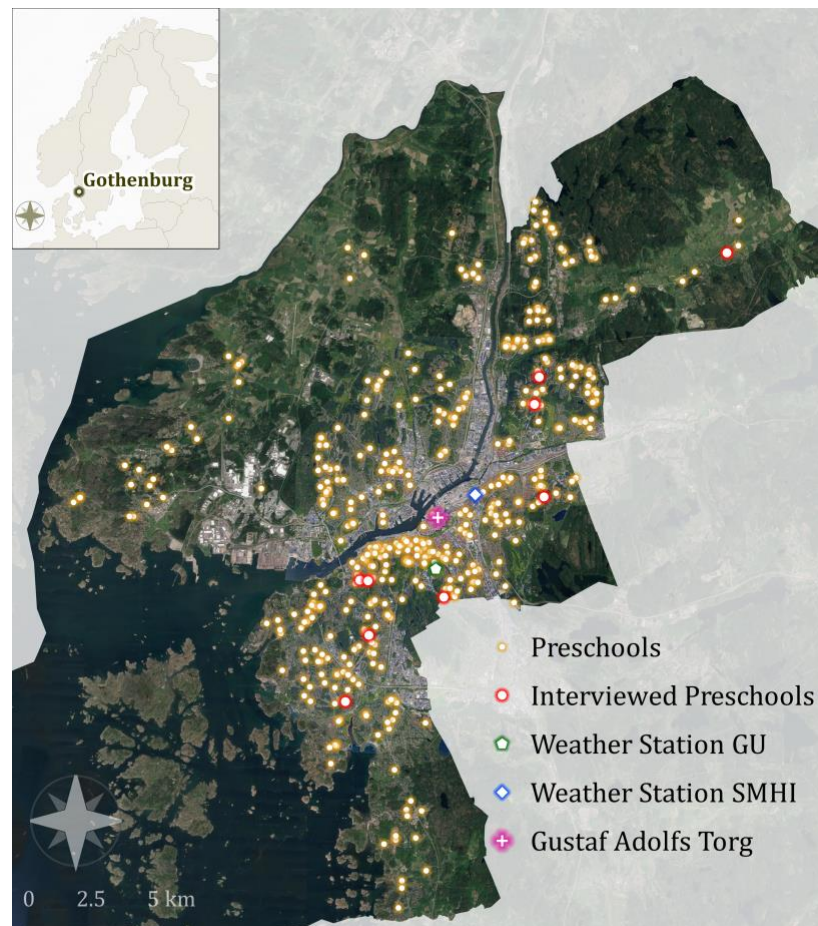


Figure 1. Map of Municipality of Gothenburg including Preschools and Weather Stations used in the study where interviewed preschools are distinguished as being red and location of Gustav Adolfs Torg. Basemap: Google Satellite.

mitigated by increasing cloudiness and hence reduced incoming radiation from the sun (Lindberg et al., 2016-a; Thorsson et al., 2017).

3.2 PRESCHOOLS IN GOTHENBURG

Today (2019), there are 705 preschools in Gothenburg including all forms of preschools (Preschool, Daytime-Carers and Open-Preschools) where 493 are public and 212 are private. The preschools are distributed throughout all populated areas of the municipality, with increasingly amount of schools closer to the city centre (Figure 1).

4 Method and Material

The following section cover the methodological part of the study. The section is structured with a brief description of the research design, followed by methods used in the Quantitative part of the study and finally, methods used for Qualitative part.

4.1 RESEARCH DESIGN

This study uses a mixed method approach including both a GIS-based quantitative part, and a qualitative interview part. The study has so some extent elements of sequential design, where the interview sample is based on the results from the quantitative part (see Denscombe, 2018). The mixed method design has an enhancement approach that aims to make the quantitative and qualitative parts of the study enrich and help explain each other in order to present a more complete picture of the subject in question and deepening the analysis (see Bryman, 2012). Hence the aim of having a mixed method design is not to confirm or validate the results from either part, but rather to provide better basis for interpreting the results by introducing additional points of view (see Cope & Elwood, 2010; Elwood, 2010; Pain, MacFarlane, Turner, & Gill, 2006).

4.2 QUANTITATIVE METHODS

4.2.1 SOLAR AND LONGWAVE ENVIRONMENTAL IRRADIANCE GEOMETRY MODEL (SOLWEIG)

SOLWEIG is a raster radiation model that simulate spatial and temporal radiation fluxes, T_{mrt} , shading patterns and S_{vf} in outdoor environments. The SOLWEIG model is included in the UMEP (Urban Multi-scale Environment Predictor) service tool, designed for spatial climate simulations (Lindberg et al., 2018). The model uses different digital surface models DSM to simulate complex urban morphology including buildings, terrain and vegetation, as well as meteorological parameters: air temperature (T_a), Relative Humidity (RH) and K_{direct} , $K_{Ddiffuse}$ and K_{global} . SOLWEIG uses an approach of calculating T_{mrt} as presented in Equation(1) and Equation (2) in 2.2.1, where the three dimensional radiation fluxes calculated for a standing person (Lindberg et al., 2008). More detailed information regarding how SOLWEIG process the input data can be found in Lindberg & Grimmond (2011) and Lindberg et al. (2018, 2008).

This study has used version v2019a of SOLWEIG. This model considers the diffuse incoming shortwave radiation of the sky as anisotropic instead of isotropic as in previous versions. The anisotropic sky is more accurate at modelling the spatial variation found at facets facing the horizon towards where the sun is at present moment. This makes the SOLWEIG output reflect reality to a higher degree than previous versions (see Wallenberg, 2018).

Research on T_{mrt} and spatial variations in thermal conditions using SOLWEIG has been conducted around the world with various climatic, seasonal conditions as well as different urban forms (Lindberg et al., 2018). Evaluation of SOLWEIG has shown good agreement between the SOLWEIG-modelled outputs and in-situ measurements (Chen et al., 2016; Chen, Lin, & Matzarakis, 2014; Lindberg et al., 2008; Thom, Coutts, Broadbent, & Tapper, 2016). SOLWEIG has been found to produce slight errors in the spatial variation on early mornings and late evenings when sun altitudes are low (Chen et al., 2016; Lindberg et al., 2008; Thom et al., 2016), but to be very accurate at modelling T_{mrt} when the sun is located at high altitudes between 10:00-16:00 (Thom et al., 2016). Since the time of interest in this study mainly lies in the time span of 11:00-15:00, and a time of the year in Sweden where sun altitude is generally high, there is reason to believe that the modelled T_{mrt} has high reliability.

4.2.2 USING SOLWEIG IN THIS STUDY

SOLWEIG v.2019a has been used with QGIS 3 in the python IDE PyCharm 2018.3.5. Figure 2 show a schematic image of how SOLWEIG, the type of data and processors has been used. Table 1 present the settings used in the SOLWEIG model.

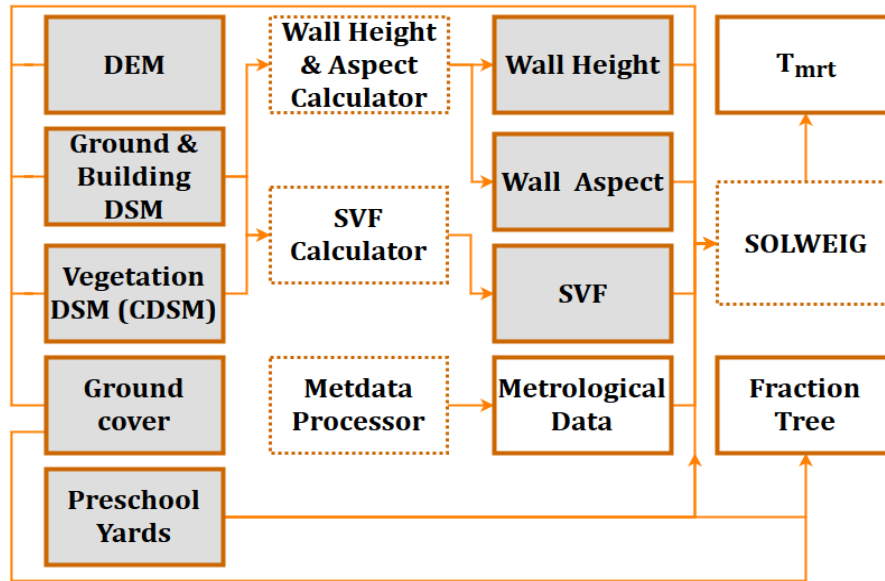


Figure 2. Flowchart for SOLWEIG used in the study. Adapted and modified from (Lindberg et al., 2018). Bold grey boxes marks geodata while white bold boxes indicate other type of data. Dotted boxes are processors within the UMEP-toolbox.

Table 1
Settings used in SOLWEIG model.

	Parameter	Value
	Temporal Resolution	30 min
Environmental Parameters	Albedo ground	As Lindberg et al. (2016-b)
	Albedo building walls	0.20
	Albedo building roofs	0.18
	Angular radiation fluxes (N,E,S,W)	0.22
	Angular radiation fluxes(up, down)	0.06
	Emissivity building walls	0.90
	Emissivity building roofs	0.95
	Emissivity ground	As Lindberg et al. (2016-b)
	Radiation transmissivity through vegetation	0.03
Human Parameters	Body longwave absorption	0.97
	Body shortwave absorption	0.70
	Body as cylinder	Yes
	Posture	Standing
	Centre of gravity standing person	0.66 (m)

The albedo and emissivity for building walls was set according to Oke (1987 in Thorsson et al., 2017). The body long and shortwave absorption and angular radiation fluxes was set according to (Ali-Toudert & Mayer, 2007; Lindberg et al., 2016-a). Transmissivity through vegetation was set according to Konarska, Lindberg, Larsson, Thorsson, and Holmer (2014). This study used the SOLWEIG ground cover scheme, which gives different groundcover classes emissivity and albedo values in accordance with (Lindberg et al., 2016-b).

The value for centre of gravity is calculated using rule of thumb by Oke et al. (2017), where the centre of gravity of a human is found at approximately two thirds of the body height, of standing person (ibid). Mean height of all children in Sweden from age 1-6 is 99.2 cm (Wikland, Luo, Niklasson, & Karlberg, 2007), which means that centre of gravity for Swedish children is found at approximately 66 cm. The SOLWEIG built-in function of considering the human body as a cylinder according to Holmer, Lindberg, Thorsson and Rayner (2015) was used in the modelling.

In order to include shading and radiation from nearby urban elements, a buffer of 100m from the schoolyard extent was used for all preschool yards. The data used for calculation of S_{vf} , T_{mrt} , shading and fraction trees, that are presented in the Result chapter was conducted using only values from within the school yard perimeters.

4.2.3 SPATIAL GROUND DATA

The SOLWEIG-model uses four input raster as ground data (Figure 2); Digital Elevation Model (DEM), Digital Surface Model (DSM), Canopy Digital Surface Model (CDSM) and Ground cover. All raster has a 1m resolution and are derived from LiDAR-data from 2010, from City Planning Authority of Gothenburg. Further information regarding how the LiDAR-data was processed into the different raster can be found in Johansson (2018).

The Ground cover raster is classified into 7 classes; Water, Bare soil, Paved, Buildings, Evergreen Trees, Deciduous Trees and Grass. As T_{mrt} through SOLWEIG is calculated on ground pixels, it would be unfit to use tree as ground cover since it is rather a description of what is above the ground. Therefore, pixels with Evergreen and Deciduous Trees were reclassified as bare soil when modelling

in SOLWEIG. Thus, it is reasonable to assume that certain areas on the schoolyards is not accurately classified underneath trees. But since there is most likely grass, paved or bare soil underneath trees, to classify as bare soil was assessed to be a fairly good compromise in accordance to actual conditions.

4.2.4 PRESCHOOLS AND PRESCHOOL YARDS

Data for preschools was collected from the city planning authority of Gothenburg, which is point data from 2019. The preschool data is categorised into three different forms of preschools; Daytime-Carer where day care workers provide preschool educational care in their home (City of Gothenburg, n.d.-a), Open-Preschool where children are not required to be enrolled and parents are required to participate (City of Gothenburg, n.d.-b), and lastly Preschools. Due to that Daytime-Carers do not have specified preschool yards, this category was removed. The Open-Preschools were removed due to lack of Geodata for preschool yards as well as the difference in the role of preschool teachers was considered too different from the more continuous work with preschool children from the other two forms of preschools. Since the spatial data used in the SOLWEIG model as described in 4.2.3 are from 2010, all schools newer than that year were removed to remove the risk of modelling a school that is not present in the DEM's and Ground Cover data. Preschools located in the archipelago of Gothenburg were also removed since the spatial Ground Data does not cover the area.

The used geodata for preschool yards was compiled and processed using different steps. Geodata for preschool yards from 2015 was acquired from the Environmental Administration of Gothenburg. The data was compared with the up-to-date point preschool data from the City Planning Authority of Gothenburg, and preschools that are no longer active were removed. The preschools that were missing in the dataset were digitalized using ocular interpretation of Google Earth images from June 2018, Google-street view images as well as information, pictures from the preschool's webpages and geodata of preschool properties in Gothenburg provided from the city planning authority of Gothenburg. The point-data of preschool yards from the City Planning Authority of Gothenburg was used to give the location of the preschool. This method was used by Statistics Sweden (2018) when mapping schoolyards in Sweden, and was found efficient when mapping in urban areas. However, the method has problems with diffuse boundaries that are not visible from above, such as forests, colocation with other activities such as other

schools or playgrounds but also when shading from nearby objects that makes it impossible to distinguish the preschool yard boundary when looking at a remotely taken image (Statistics Sweden, 2018). Preschool yards that were considered too difficult to distinguish was not digitalized and thus not part of the study. However, preschool yards in Sweden are often easily distinguishable since they are surrounded by fences which eased the process of digitalization.

In total 438 Preschools-yards were used in the study. Appendix 1 present more detailed information of all Schools that was used in the study.

The size of preschool yard varies greatly from around 50 m² to 15 000 m². From investigating the interquartile range of the distribution of preschool yard areas, most preschool yards are found in between 1000 m² and 3500. The distribution is clearly skewed to the lower values of the distribution (Figure 3).

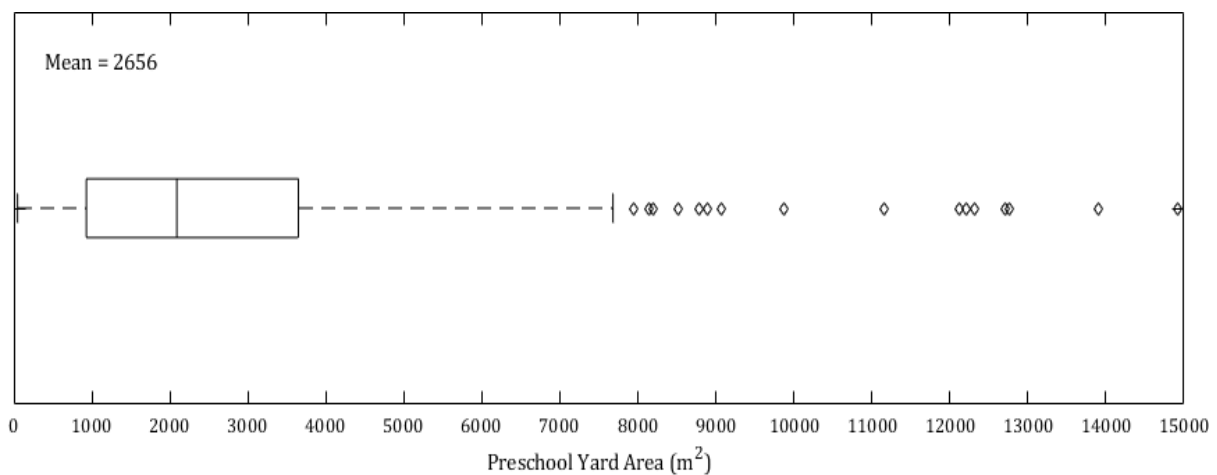


Figure 3. Boxplot of preschool yard size of used preschool yards in the study.

4.2.5 METEOROLOGICAL DATA AND WEATHER CONDITIONS

The meteorological conditions for June 1, 2018 in Gothenburg were characterized by being a clear and sunny day with low winds. The day thus has the characteristics where the thermal conditions are highly influenced by T_{mrt} (Mayer & Höppe, 1987 in Lindberg et al., 2018; Vanos et al., 2016) The meteorological data for the simulation is from 1st of June 2018, and was collected from Swedish Meteorological and Hydrological Institute (SMHI) station in Gothenburg, and from Gothenburg University (GU) 's own weather station at the Department of Geosciences (Table 2). Both located in central Gothenburg (Figure 1).

Table 2

Data sources for meteorological data used as input in SOLWEIG model.

Data	Time resolution	Station	Unit	UTC
Air-temperature	1-hour	SMHI	°C	0
Relative humidity	10-minute	GU	%	+1
K_{diffuse}	10-minute	GU	w/m ²	+1
K_{global}	10-minute	GU	w/m ²	+1

In order to get similar time resolution for all data, the raw data was interpolated. The data with 1-hour time resolution was interpolated using linear interpolation.

The data with 10-minute resolution was prepared by calculating a mean value from the three values found in each half-hour i.e. the value of 13:00 is then the average of the measures of 12:40, 12:50 and 13:00.

Due to shading from a nearby building, the values of incoming shortwave radiation were distorted around 06:00-06:30. The same distortion is also found in Konarska et al. 2014, p. 369 Fig.4) which uses data from the same source. In order to remove this disturbance, the values for this time was interpolated using linear interpolation. However, the deviation is assessed to be of minor importance since the specific time is not within the time span of interest in this study. The different time series was then compiled and translated into the same time zone (UTC+1).

K_{direct} was not available from any of the weather data sources but was instead calculated using SOLWEIG built in function of calculating K_{direct} . Further information on how this calculation is done can be found in Lindberg & Grimmond, 2011. A detailed table of all meteorological for entire day is found in Appendix 2.

4.2.6 ANALYSIS OF THE DATA

The output of the model was categorised into 9 Bins based on mean T_{mrt} of the schoolyard in the time between 11:00-15:00. 11:00-15:00 is the timespan used as the time when public preschool yards in Gothenburg is in need of protection from sun during April-September in order to reduce UV-radiation and heat stress according to the City Premises Administration (2019). The timespan was therefore assessed to be a relevant temporal delimitation. (Table 3).

Table 3
Categorisation of preschool yards used in the analysis.

Bin	Mean T_{mrt} (°C) at preschool yards 11:00-15:00	n
1	< 35	14
2	35 - 37.5	31
3	37.5 – 40	38
4	40 – 42.5	66
5	42.5 – 45	91
6	45 – 47.5	63
7	47.5 – 50	77
8	50 - 52.5	40
9	> 52.5	18

The categorisation of Bins is divided with intervals of 2.5 T_{mrt} (°C) in order to base the division on thermal conditions that indicate cooler and warmer preschool yards. The sample size for each Bin is not equal but is although rather normally distributed with a slight skewness towards the higher Bins. As the same categorisation is used throughout the study, patterns of covariation of different aspects that affect T_{mrt} on preschool yards is easier to detect. The presented categorisation of Bins will be used as basis for the analysis in the study. Henceforth when referring to Bins in this study, the presented categorisation in Table 3 is what being referred to.

Distance to city centre

Distance to city centre was calculated in order to statistically investigate the correlation between proximity to urban centre is affecting the thermal conditions and preschool yards content. The distance was calculated using a point of reference at Gustaf Adolfs Torg which lies in central Gothenburg (Latitude: N 55° 36.1663' Longitude: E 13° 0.0168') (Figure 1). Euclidian distance from centre of all schoolyards to the point of reference was then calculated using simple distance matrix in QGIS3.

4.3 QUALITATIVE METHODS

4.3.1 SAMPLING STRATEGY

The selection of interviewees for the study were different for interviews with preschool personnel and municipality actors. In total 2 interviews were carried out for municipality actors and 9 interviews was conducted with preschool teachers.

Preschools

The sampling strategy for interviews with preschool personnel was conducted through mixture of convenience and critical sampling where respondents was selected mainly due to availability factors but also with intention of obtaining a variation of warm and cool preschool (see Bryman, 2012).

Based on the Bin scheme as presented in 4.2.6 preschools from each Bin were randomly selected and offered to participate in the study. Even though all Bins are not represented, the sample however include both warmer and cooler preschool yards, as well as being widely distributed throughout the city (Figure 1).

Table 4.

Interviewed preschools with bin and organisation type.

Preschool	Type	Bin
Dr Allards Gata Förskola	Public	-
Förstamajgatan 1 Förskola	Public	2
Bankebergsgatan 5 Förskola	Public	3
Bronsåldersgatan 27 Förskola	Public	4
Studiegången 1 Förskola	Public	5
Förskolan Valen	Private	5
Kalendervägen 15-17 Förskola	Public	6
Saras Väg 5 Förskola	Public	8
Förskolan Ladan	Private	9

Dr Allards Gata Förskola has not been fit into a Bin. This is due to that a mismatch of actual conditions and the spatial data. Thus from the modelled results, this preschool provided lower T_{mrt} then what it would do if the spatial data would have been more in accordance to actual conditions. The school was removed from the modelling, but the interview was already made, therefore the Bin of this preschool is unknown. However, the preschool yard of this school lies in south facing position

with very little vegetation and trees with clear unobstructed view to south all day long. Therefore, it is reasonable to believe that the bin on this school to be somewhere on the upper half of the Bin scale.

Municipality actors

The sampling strategy for municipality actors was a purposive snowball sample where a sample frame of actors of interest to the study was identified and contacted by e-mail (see Bryman, 2012). Thereafter an e-mail-based correspondence of being directed to relevant representatives for the administration of interest was carried out.

The final actors that were selected that had possibilities of participating in the study was the City Premises Administration (Lokalförvaltningen) and the City Planning Authority (Stadsbyggnadskontoret).

The City Premises Administration is responsible for maintenance and manage of premises and houses run and owned by the municipality of Gothenburg. The City Planning Authority are the main planning authority of Gothenburg, with responsibility of comprehensive and detailed development planning as well as development of other strategic documents.

4.3.2 INTERVIEWS

The interviews were conducted as semi-structured, where an interview guide was used as basis for the interview but with a great portion of flexibility regarding following-up questions and availability to go deeper into interesting topics that arise during the interview (see Bryman, 2012). The purpose for using a flexible interview approach is therefore as expressed by McDowell (2010): *“The purpose is to explore and understand actions within specific settings, to examine human relationships and discover as much as possible about why people feel or act in the ways they do (McDowell, 2010, p. 158)”*. This approach entails a more open form of interviewing, where the interviewees are free to speak their mind unbound by strict boundaries of interview guides (Bryman, 2012). This study adopted this type of interview style. The interviews were centred on preschool teacher’s experiences of preschools during heat waves both as in how it affects preschools and what could and should be done about it. The interviews with municipal actors focused on how the city work with thermal conditions at preschool yards. Interview guide for

preschools are found in Appendix 3 and an interview guide for municipality actors are found in Appendix 4.

Each interview lasted between 25-45 minutes. The interviews were recorded with permission of the respondent when it was possible, and transcribed. 2 interviews were not recorded due to that the respondent for different reasons were unable to leave the preschool children during the interview. During these interviews, notes were taken which then were compiled quickly afterwards. The interviews with preschool teachers were held at the preschool of interest, except for one that was conducted at the University of Gothenburg. The interviews with municipality actors was conducted at the office of the specific administration.

4.3.3 THEMATIC ANALYSIS

In order to avoid that the analysis of qualitative data is based on unstructured interpretations of the empirical material with high level of subjectivity, it is necessary to attain a certain level of systematics (Bryman, 2012). Thematic analysis is a standard well used analysis method of qualitative data, which forms the foundation to many other types of analysis methods and can easily be fitted to any kind of qualitative data (Braun & Clarke, 2006; Bryman, 2012). Another key feature of thematic analysis is that it does not require a theoretical framework in order to proper analyse the material (Braun & Clarke, 2006). Since this study does not have an analytic framework for interpreting the qualitative results and has mainly an inductive approach, thematic analysis is assessed to be a reasonable analytic method for the qualitative data.

The aim with thematic analysis is to find themes within the empirical material. The themes should be distinct and recurring throughout the material, but not overlapping each other (Braun & Clarke, 2006). This study followed the 6 steps of thematic analysis proposed by Braun & Clarke (2006);

1. Familiarising yourself with the data
2. Generating initial codes
3. Searching for themes
4. Reviewing themes
5. Defining and naming the themes
6. Producing report

Even though a systematic analysis method such as this is conducted in a systematic manner with specific rules and frames, the researcher doing the analysis should always be considered an active creator of the themes rather than an objective discoverer of general truths (Braun & Clarke, 2006; McDowell, 2010). Thus, the thematic analysis results are therefore more of a structured subjective interpretation of raw data than discovered facts (Braun & Clarke, 2006). The themes with associated sub-themes are briefly presented in Table 5, and thoroughly presented in 5.2.

Table 5
Themes from thematic analysis with associated sub-themes

Theme	Sub-themes
Awareness and perception of heat	Joy of summer Problem or inconvenience Heatwave experience Regulations and requirements Forgetfulness of warm conditions
Temperature effects on preschools	Effects on children Physical outdoor environment Behavioural changes Working environment
Actions of heat mitigation	Preventive and active measures Experience based actions Water Shading Planning for heat
Responsibility	Division of responsibilities Actors of heat Mandate and capacity Conflicting interests

5 Results

The following chapter will first present the results from the quantitative part of the study in 5.1, followed by the results of the qualitative part of the study in 5.2.

5.1 T_{MRT} AT PRESCHOOL YARDS IN GOTHENBURG

5.1.1 SPATIAL PATTERNS OF T_{MRT} AT PRESCHOOL YARDS THROUGHOUT GOTHENBURG

The modelled output shows some spatial patterns of difference in mean T_{mrt} in Gothenburg. The spatial distribution of preschool yards with high and low mean T_{mrt} is to a large degree scattered throughout the entire study area. A pattern of centrality is visible where the foremost cold preschool yards are found in more central parts of Gothenburg (Figure 4).

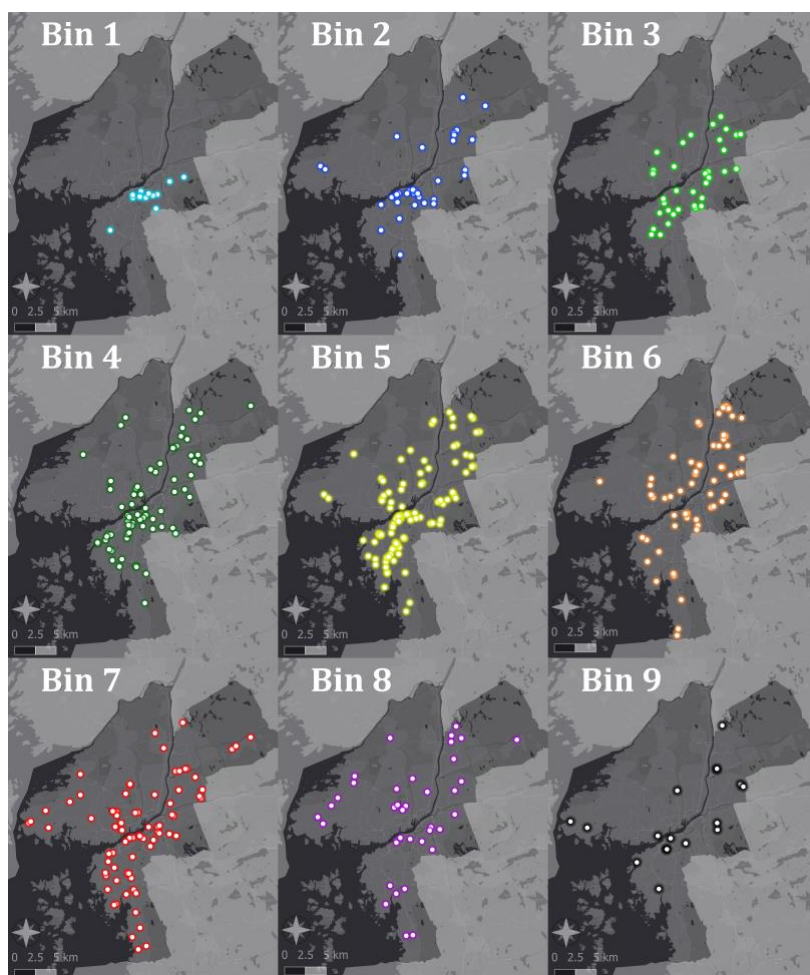


Figure 4. Spatial distribution of difference in mean T_{mrt} T_{mrt} 11:00-15:00 at preschool yards divided into Bins. Base map: Esri Gray (dark)

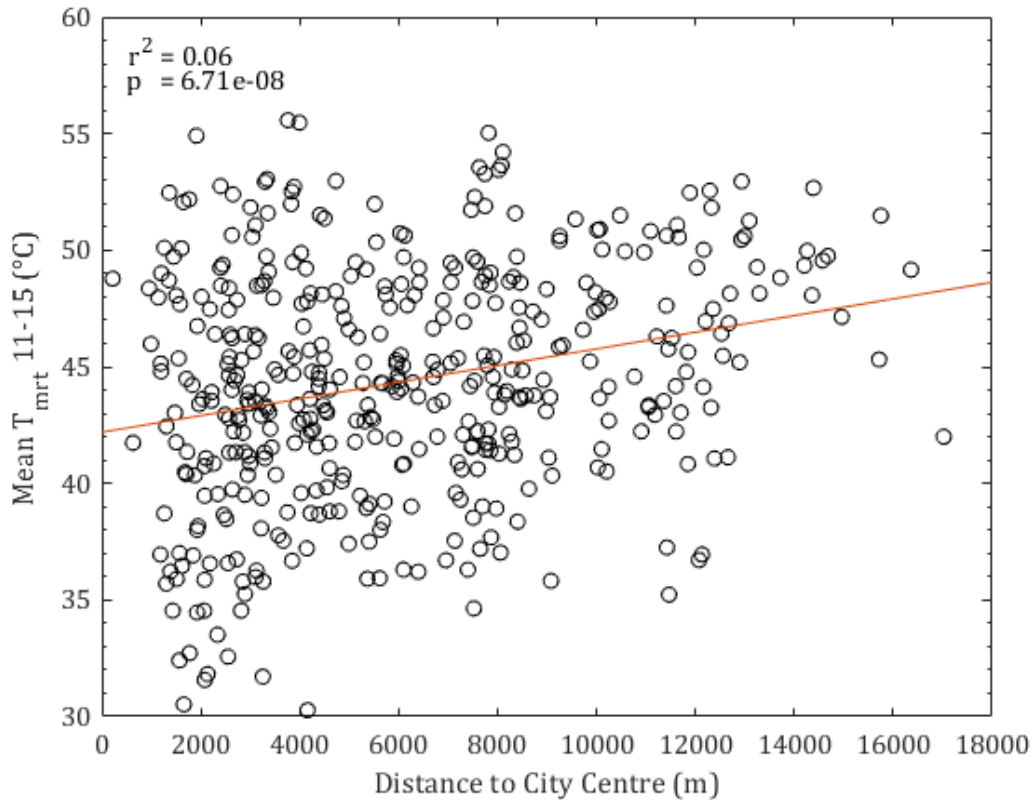


Figure 5. Correlation of distance to city centre and mean T_{mrt} 11:00-15:00.

Even though the correlation of mean T_{mrt} and distance to the city does not indicate a correlation between the two variables, the distribution is sort of cone shaped, where the proximity to city centre indicate higher variance in mean T_{mrt} than further away. The pattern implies that T_{mrt} on preschool yards is to a greater extent dependent on the local or microscale variation than the geographic location within a city, and that preschools further from the city centre are more likely to be in the uppermost Bins (Figure 5).

5.1.2 VARIANCE OF T_{MRT} AT PRESCHOOL YARDS

As mean T_{mrt} alone is not sufficient to indicate the variance of T_{mrt} at the different schoolyards, a boxplot-diagram is used to examine to the distribution of T_{mrt} in the different Bins (Figure 6).

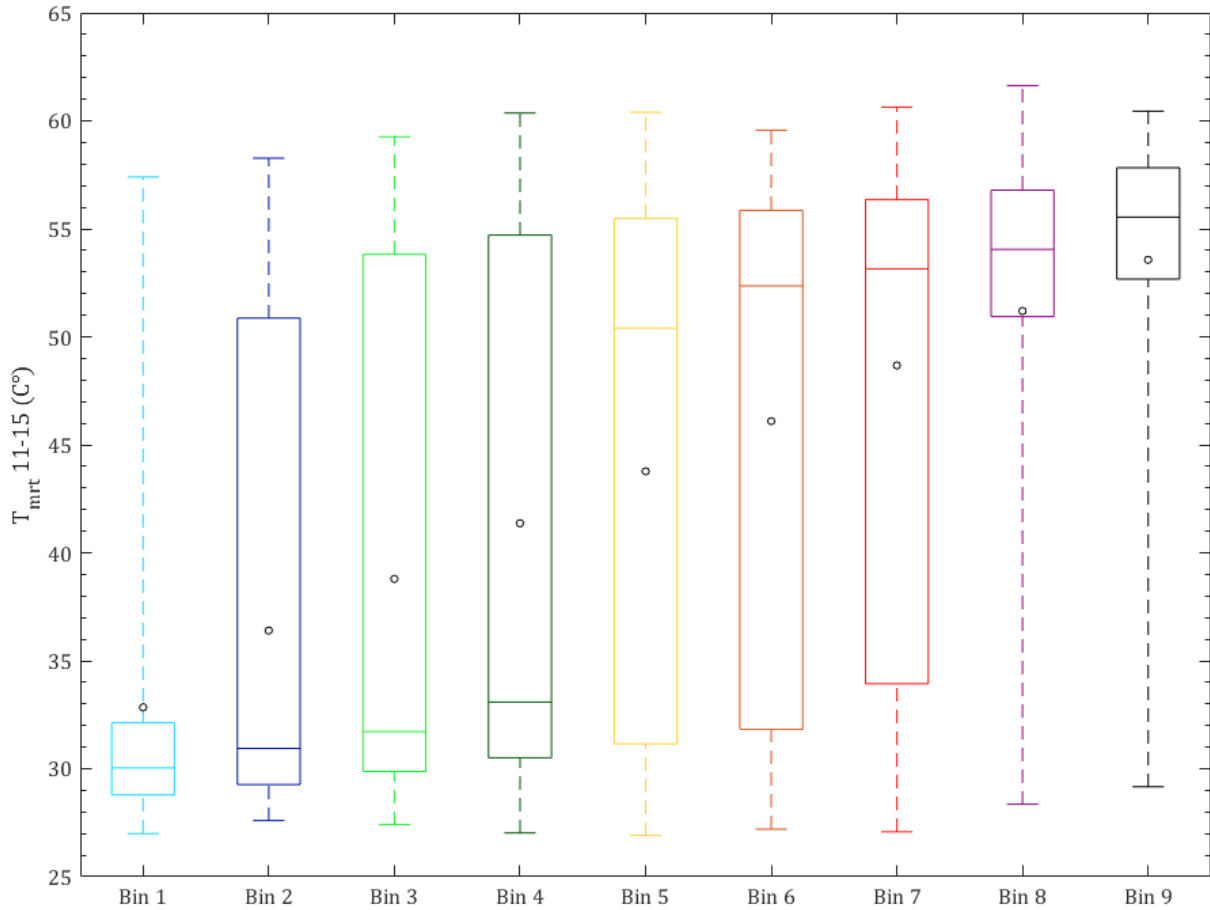


Figure 6. Distribution of T_{mrt} on preschool yards between 11:00-15:00 in Bins.

A clear pattern of increasing mean T_{mrt} at higher Bins is visible in Figure 6. The 5th and 95th percentiles for all Bins indicate that all schools to some extent has some areas of high and low T_{mrt} . The major difference is thus found in the interquartile range (IQR), where Bin 1 stands out with having 75% of the preschool yard area below 32 T_{mrt} (°C) and Bin 8 and 9 having 75 % of preschool yard area above 51 T_{mrt} (°C). The other bins have more similar range of IQR, where a clear shift of median value is found between Bin 4 and 5. Thus the results in Figure 6 indicate an increase in mean T_{mrt} for each Bin, as well as considerable increasing amount of preschool yard area are experiencing higher T_{mrt} for the higher Bins (Figure 6).

Examination of descriptive statistics of T_{mrt} for all modelled preschool yards indicate that the schoolyards has similar min and max values. It is thereby reasonable to believe that the majority of preschool yards has some areas on the schoolyards both completely shaded and sunlit where T_{mrt} are similar for all

examined schoolyards. Thereby, the min and max values are not considered that important in further analysis as they do not differ to a considerable importance.

5.1.3 TEMPORAL CHANGES ON MEAN T_{MRT} AT PRESCHOOL YARDS

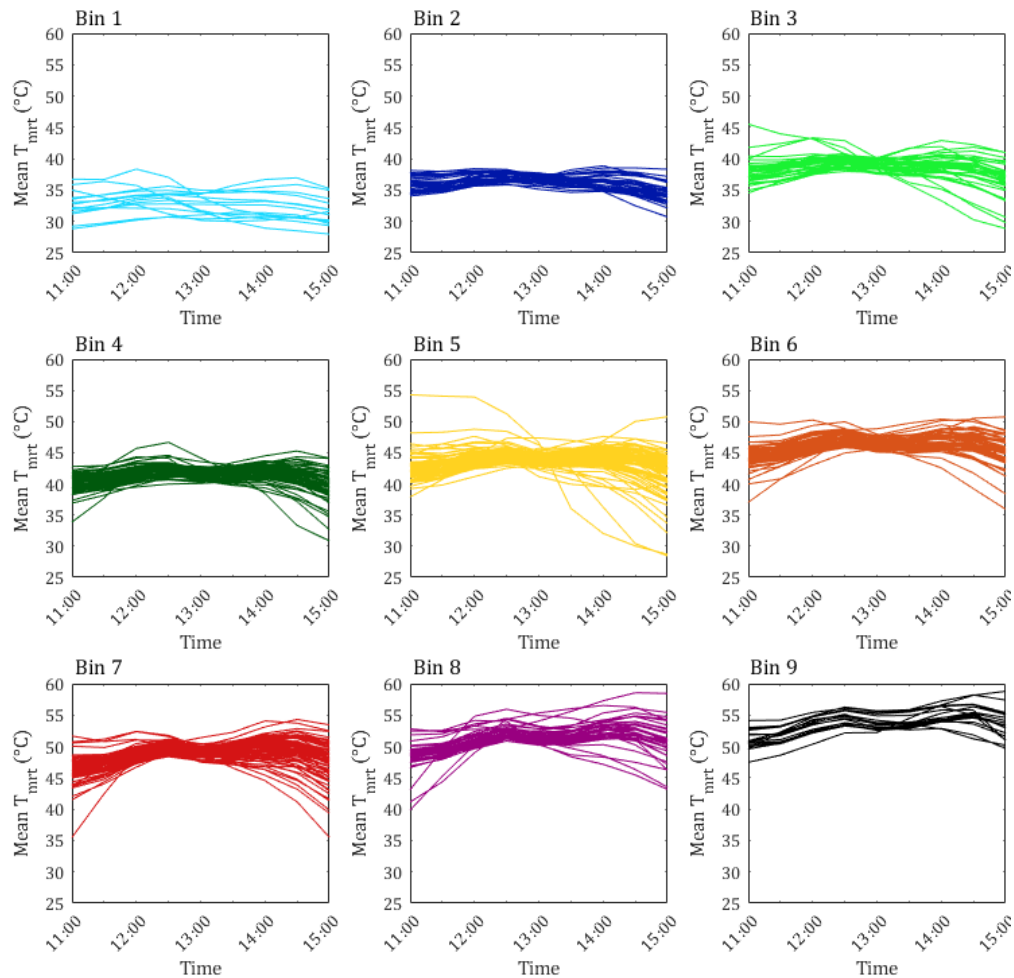


Figure 7. Temporal variation of mean T_{mrt} for preschool yards throughout the investigated time span divided into Bins.

Figure 7 show a clear pattern of the Mean T_{mrt} for the schoolyards change relative to the other Bins, i.e. the warmest preschool yards are generally warmest throughout the examined time span, and the coldest are in relation to the warmer always cooler. Thus, it is reasonable to believe that using a mean value for the entire time span is a valid indicator of describing the general T_{mrt} conditions for the investigated period of time.

Deviations in the prevailing pattern occur such as is visible in Figure 7 Bin 5. The reason for the major shifts in T_{mrt} is due to an east or westerly location of the school

yard in relation to surrounding urban structures such as buildings or forests, thus varies greatly in shading. However, the majority of all preschool yards lies mainly in a south facing position and are thereby sunlit most of the day which explain the pattern of relative increase and decrease of T_{mrt} between Bins throughout the examined period of time.

5.1.4 EFFECT OF SHADING ON MEAN T_{MRT}

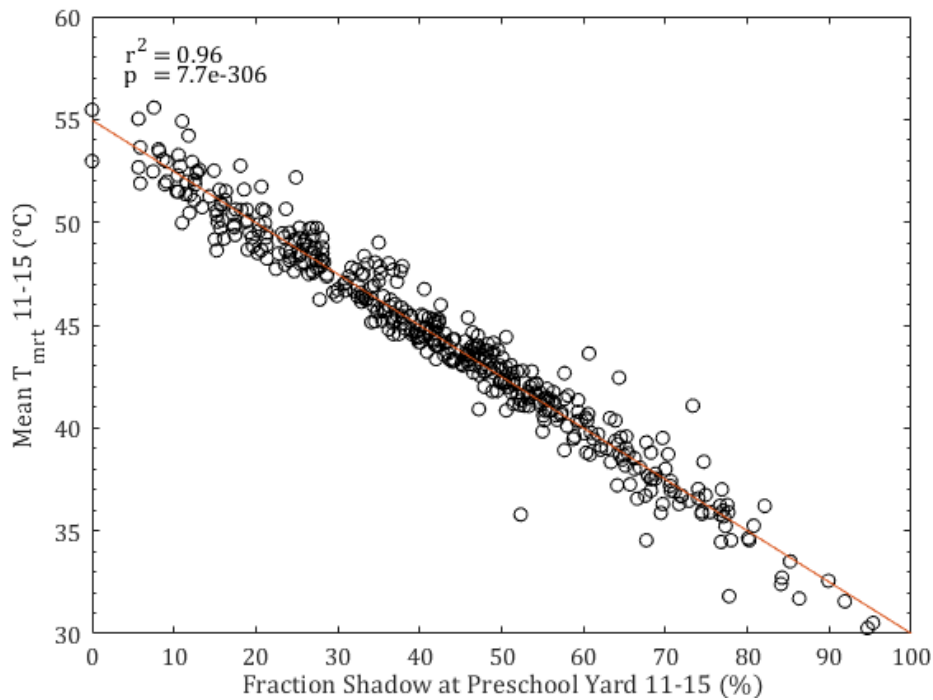


Figure 8. Correlation of mean fraction shadow 11:00-15:00 and mean T_{mrt} .

A strong statistically significant correlation between mean T_{mrt} and fraction shadow on preschool yards is presented in Figure 8, where the figure indicates 96% of the variance in mean T_{mrt} could be explained by fraction of shading at preschool yards.

5.1.5 AMOUNT OF SHADED AREA FOR PRESCHOOL YARDS

Based on that preschool yards in Gothenburg should be dimensioned for at least $35m^2$ per child, and that an average preschool class in Gothenburg consist of 15.5 children, $543m^2$ is needed in order to meet the requirement of sufficient amount of space for one preschool class.

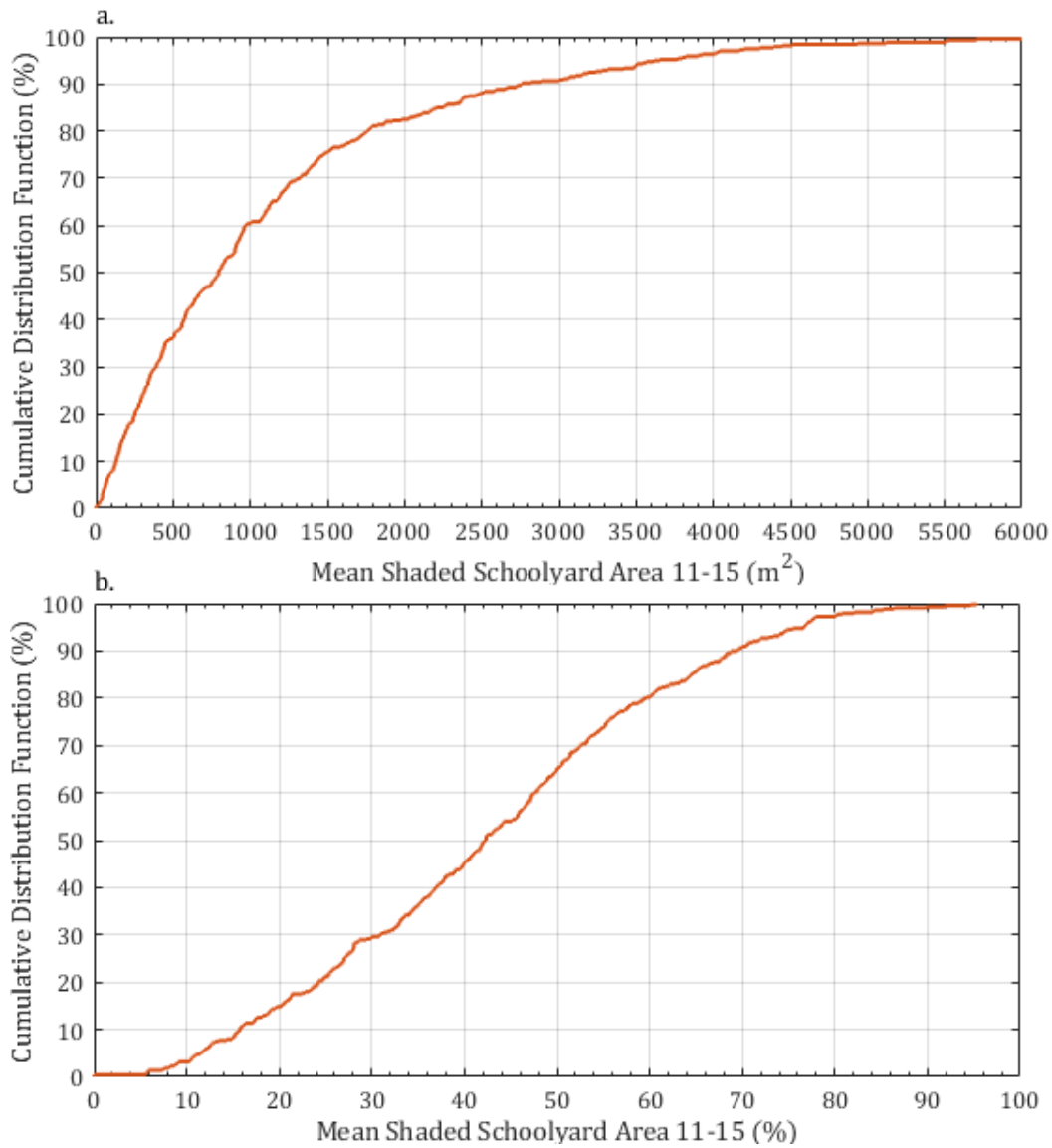


Figure 9. Cumulative Frequency plots of shaded area of Preschool yards. a. mean shaded schoolyard area in m² for the time of 11:00-15:00. 2 preschools with more than 6000 m² is not visible in this graph in order to make the differences where most of the distribution is found easier to examine. b. Mean shaded schoolyard area in % for the time of 11:00-15:00. All preschools included.

With an assumption of that all preschools have at least one preschool class, 38% of the investigated preschool yards has less shaded areas needed to fit one preschool class based on the assumption that every child needs 35 m² space. 62% does not have enough space to fit two preschool classes in their yard, assuming that everyone is outside at the same time (Figure 9, a.). Furthermore, 50% of all investigated preschool yards have, based on mean shaded area in the investigated time span, less than 65% of the preschool yard area shaded (figure 9, b.).

Hence, during conditions such as the day used in this study, a large number of preschool yards provide significantly less available area per children than is deemed sufficient according to the guidelines from the City Premises administration.

5.1.6 SKY VIEW FACTOR INFLUENCE ON MEAN T_{MRT}

The total Sv_f for preschool yards is found to have a strong and statistically significant correlation to the mean T_{mrt} of preschool yards where higher total Sv_f of preschool yards generate higher mean T_{mrt} (Figure 10).

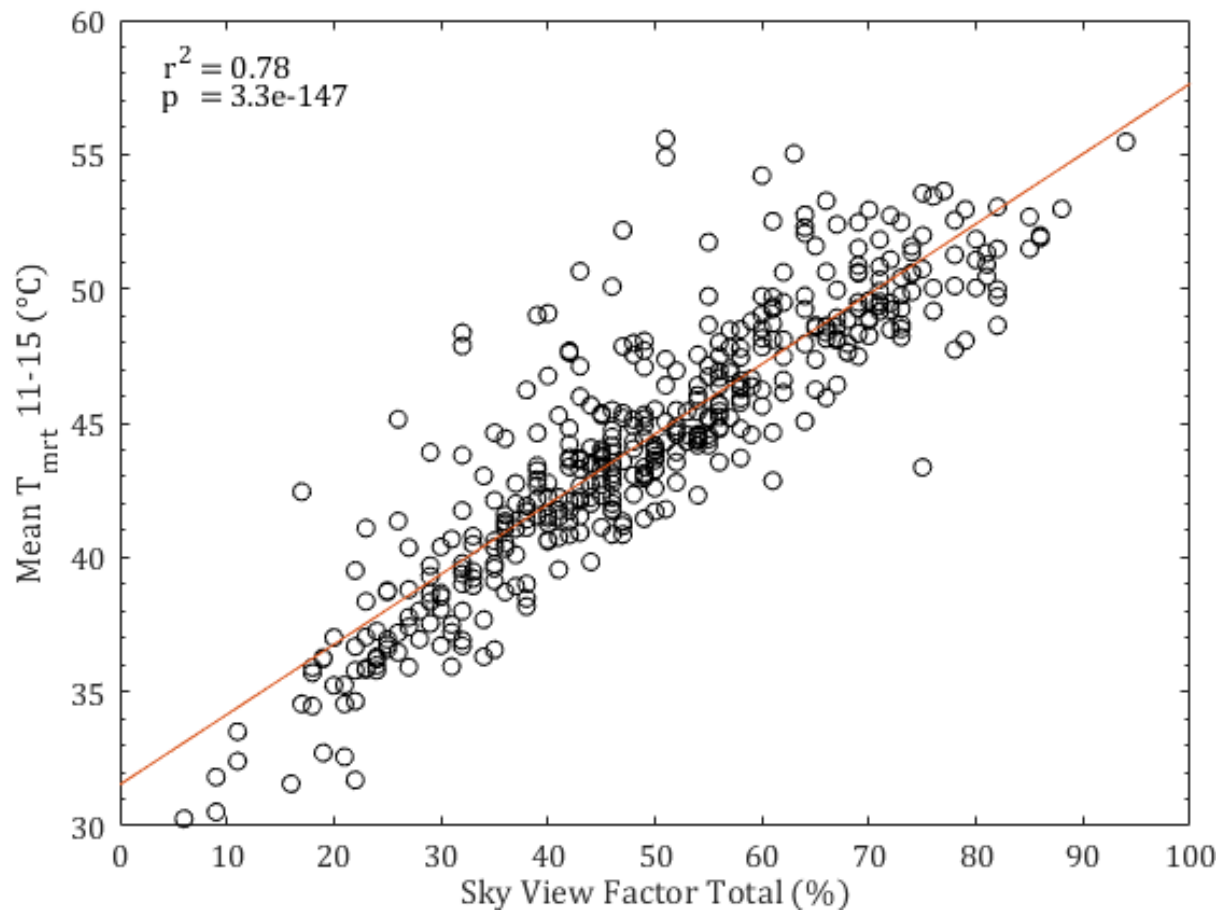


Figure 10. Correlation of mean T_{mrt} 11:00-15:00 and total Sv_f

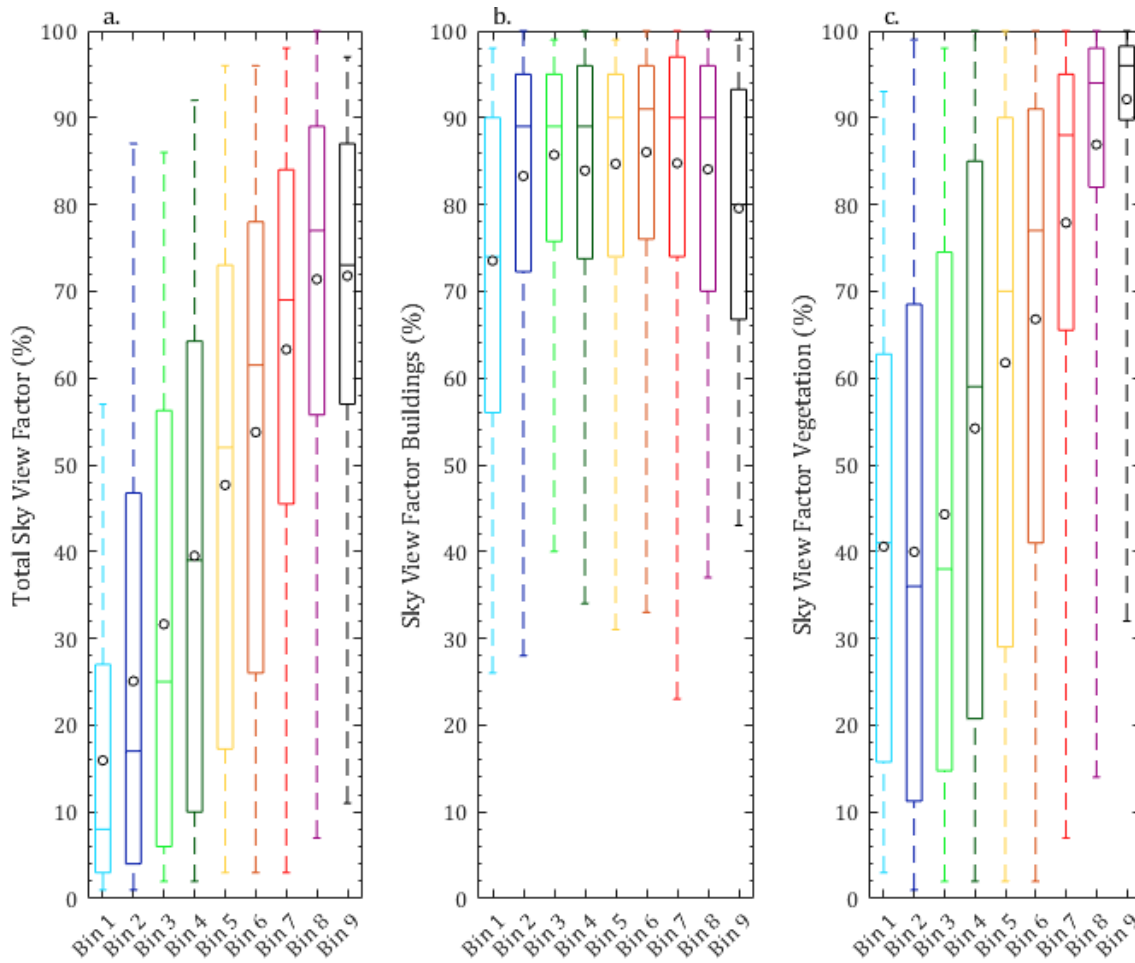


Figure 11. Boxplots of calculated Svf at preschool yards divided into Bins. a. total Svf including both buildings and vegetation. b. Svf from buildings. c. Svf from vegetation.

By dividing Svf into total Svf, Svf from vegetation and Svf from buildings, it becomes clear that the most important Svf factor for T_{mrt} is vegetation (Figure 11). Total Svf show an increase from Bin 1 to Bin 8, and then decline in Bin 9 (Figure 11, a.). The decline is explained by the lower Svf from buildings in Bin 9. (Figure 11, b.). Bin 1 and 9 stand out from the general pattern of Svf from buildings. Since the preschool yards of Bin 1, as presented in Figure 4 shows a pattern of urbanity, the low Svf from buildings is to be expected. Even though Bin 9 do not indicate as strong urban pattern as Bin 1, many preschools in this bin are located in between or in the centre of high-rise buildings that are found throughout Gothenburg. However, the significance of Svf from buildings is from the modelled results minor in comparison to Svf from vegetation. The rate of importance is visible from the similarity of patterns between total Svf and Svf from vegetation (Figure 11, a. & c.).

5.1.7 TREE INFLUENCE ON MEAN T_{MRT} AT PRESCHOOL YARDS

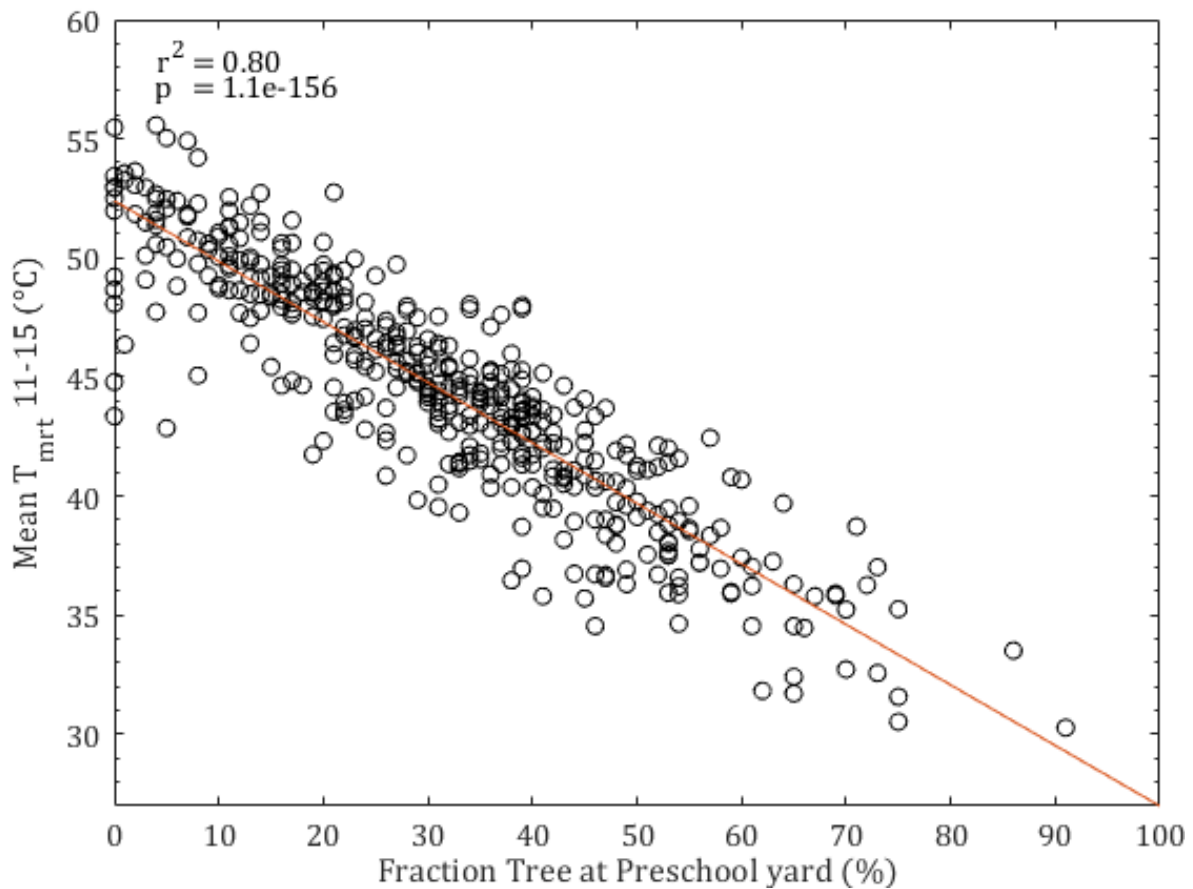


Figure 12. Correlation of mean T_{mrt} between 11:00 and 15:00 and fraction tree at preschool yard.

Figure 12 indicate a strong statistically significant correlation between fraction trees at schoolyards and mean T_{mrt} , where higher fraction trees generate lower mean T_{mrt} at preschool yards. In comparison to S_{vf} , this correlation does not consider objects outside the yard perimeter which thus indicate that amount of schoolyard area covered trees within the preschool yard area affect T_{mrt} to a great extent.

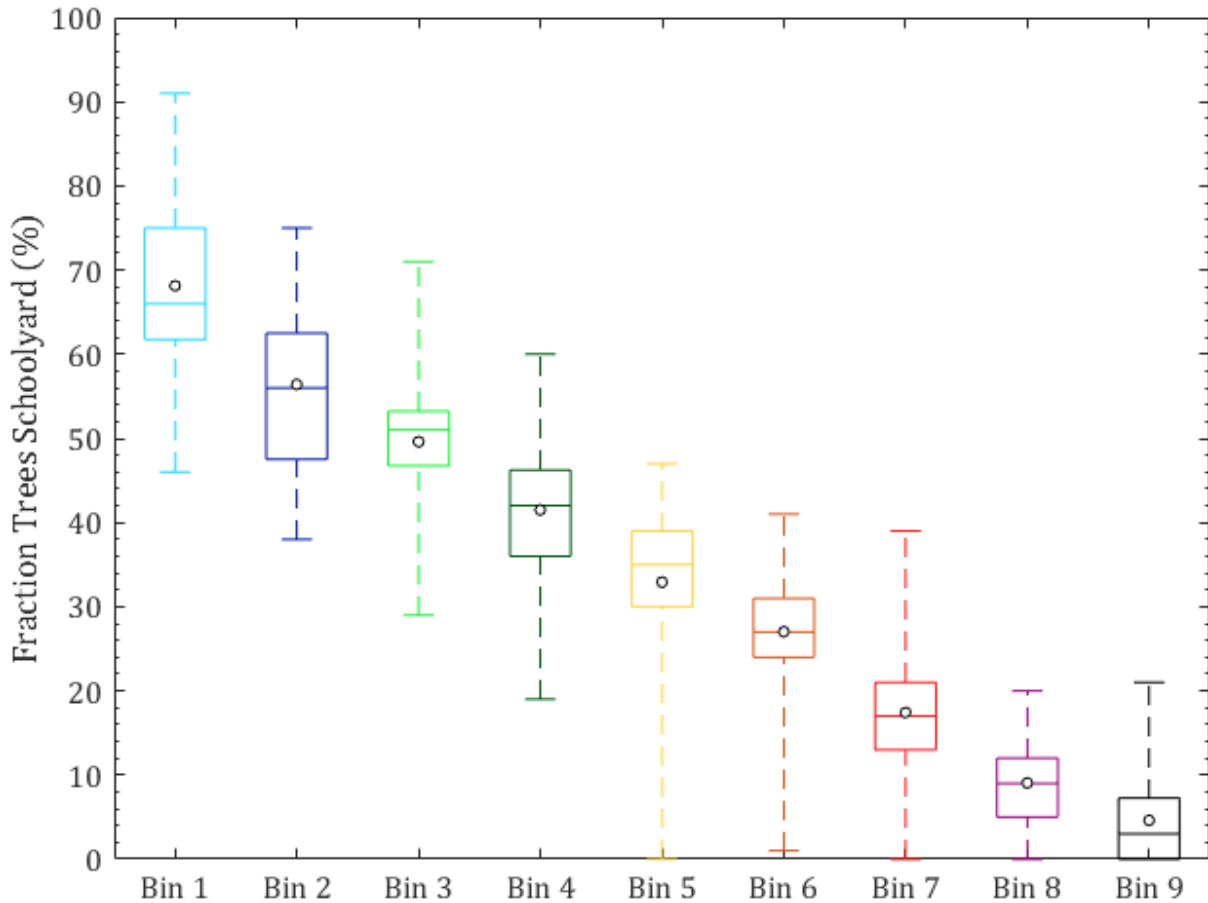


Figure 13. Boxplot of fraction trees at schoolyards divided into Bins indicate higher fraction trees for cooler preschool yards.

Investigating fraction tree divided into Bins also stress the importance of trees on preschool yards on T_{mrt} where drastic changes in both mean fraction tree and variance in fraction tree for each Bins are visible (Figure 13). No evidence of proximity to the city centre as an important parameter for the fraction of trees has been found. Thus, the result indicates that surrounding area and objects outside preschool yards are less important to T_{mrt} on preschool yards than the objects found inside the preschool yard (Figure 13).

5.2 THEMATIC ANALYSIS

The following section cover the results from the interview through the themes that was created from the thematic analysis. Although the interviews were held in Swedish, all quotes have been translated into English. Quotes are distinguishable from the rest of the text as being italics within quotation marks. In some quotes,

comments are inserted to ease understanding of intents or similar. These comments are found inside square brackets [].

The themes will be presented in following order

- Awareness and perception of heat
- Temperature effects on preschools and preschool yards
- Actions of heat mitigation
- Responsibilities

5.2.1 AWARENESS AND PERCEPTION OF HEAT

The theme Awareness and perception of heat covers how the respondents viewed and reflected on heat. In comparison to 5.2.2. This theme does not deal with the actual effects of heat, but rather heat is perceived in different ways. To some extent, some actual effects and routines may be discussed, but the core is in awareness and perception of heat, rather than the actions and effects.

Heat and high temperature are mainly perceived as positive to preschools. Since inconveniences that follows from bad and cold weather such as rain clothes, cold and wet clothes and children disappear when heat is present, there is a high level of acceptance to hot conditions amongst the interviewed teachers. Both children and teachers enjoy being able to spend time outdoors which characterises the summer periods of preschool. Although heat is longed for at preschools, the view of heat as entirely positive show signs of to some extent being altered by the hot summer of 2018. Even though the preschools per se has not made any significant changes in terms of heat mitigation, many preschool teachers hint that their personal apprehension and awareness of how heat and sunlight affect preschool children as well as themselves had changed due to last year's heat wave. The increased awareness did to some extent involve negative effects such as overheating and dehydration that may follow from heat, but the discussions did mainly concern worries for increased exposure to sunlight in relation to skin problems.

The heat wave of 2018 was also seen as an extreme case that one was to be looked upon as beyond what is normal even in the future. As one preschool teacher noted *“we are still of the opinion that it [summer 2018] was an exceptional summer. We do not prepare for it to be standard from now on”*. However, to a certain degree, the summer of 2018 has shed light on the importance of the physical environment

of the preschool yard regarding shading and heat. The City premises administration has worked with sun protection at preschool yards for some time but has from the hot summer gained more understanding for the importance of their work, and thus been given more funding to mitigate harmful sun exposure. However, the awareness of heat as a problem on preschool yards is mainly limited to the administrative officers involved in the matter, as well as mainly being focused on UV protection rather than heat mitigation.

Since there is no specific regulations or directives either in preschools or in planning and maintenance of school yard concerning heat, there is a state of powerlessness for both preschool personnel and planners. From a planning point of view, lack of regulations allows for bypassing or skip the heat issue when planning preschools but also the city as a whole. Real change would according to the interviewed municipal representatives require some kind of judicial trial of a plan or from a supervision that could set legal praxis for how the city deal with heat. Similar opinion is also found amongst teachers. Many of the interviewed preschool teachers had many years of work experience and thus to some extent viewed heat as something that they have to deal with and have always done. As described by a teacher *"we have no cases where heat has made it impossible for the preschool to be open. We have managed it. It has rather been tiresome than impossible, but where to draw the line for what is considered acceptable?"*. This highlight the ambivalence of whether heat is a problem that needs to be addressed, or an inconvenience that the preschool has to adapt to with the means present at the school. The interviews indicated that interviewed preschools in the lower Bins (2-5), perceived heat at school yards to be a minor problem compared to the schools in the higher Bins. However, the small number of interviews and deficiency of randomness in the sample, makes it unreliable to say whether it may be due to personal variation rather than a consequence from the thermal conditions of each specific preschool yard.

Another important feature in the perception of heat is how fast one forgets. As one teacher phrased it, *"I have to think back how was it actually last summer? Right now, I'm just thinking of everything positive with everything that is with a summer period that the kids are super happy to get out"*. Even though this study was carried out in the spring that followed the unusually hot summer of 2018,

many teachers had difficulties in remembering how the preschool was affected by the heatwave.

Although the previous summer was in many ways problematic, there is always a more present problems and situations of higher significance to the preschool that requires attention and intervention. To a great extent, heat issues is viewed upon in relation to other interests, but also budget. The municipality and preschools have a limited budget where priorities often fall on other more pressing problems than the rather diffuse issue of heat.

5.2.2 TEMPERATURE EFFECTS ON PRESCHOOLS AND PRESCHOOL YARDS

The theme Temperature effects on preschools and preschool yards focuses on the direct effects and implications that heat has on preschool yards, children and teachers.

The most recurring implication from heat that has been described in the interviews is that the preschool children gets tired and drowsy at hot days. Children who are normally energetic is drained of energy due to intense heat. Some teachers also had experience of more critical situations where children have been on the verge of fainting due to overheating. Apart from being less energetic, warm children are also more easily irritated and prone to end up creating conflicts with each other. As noted by one teacher, the amount of shaded areas in relation to the number of children may affect this negative, *”As I said, it is a bit crowded when everyone has to seek shade at the same place on a hot day. All children are clustered in a too small area. And when this is hot, it the mood easily gets low, and children are so warm that they feel bad. Thus, many small disputes and conflicts arise”*. At preschools, the amount of space for each child is important in order for the children to have adequate amount of free space to play and relax. At many school yards, the amount of space is found not sufficient during hot days, where much of the schoolyard is sunlit and thus too hot to use.

The heat also affects the preschool personnel, whom also experience tiredness and a general feeling of being slower and less alert. Shading is assessed to be an important component for teachers as well during warm and sunny periods, however most concern from teachers is derived from being exposed to high levels of UV radiation rather than from heat. This is mainly due to that the teachers are aware of their own thermal comfort compared to the children as well as having

experience from how to deal with heat, and thus be more capable of modifying their thermal situation. Younger children is perceived to be more sensitive to heat than older, as a teacher phrased it, *“I think it was very hard for many children actually. I work with the youngest children, 1-3 years and they cannot really understand heat, and why it is so hot. If a small child wants to sit in the sandbox then it sits there even though it is very hot and does not think about moving, while older children react more when being too hot”*. Lack of awareness of own thermal status of the children mean that the preschool personnel needs to pay extra attention to the behaviour and body signals of the children in order to detect signs of overheating or dehydration. The children per teacher ratio is an important factor in this, where preschools with higher staffing have better possibilities supervise the thermal conditions for the children at schoolyards.

The decisive factor for how heat affects preschool yards is found to be the content and design of the schoolyard. It sets the limit to how usable the schoolyard is during warm sunny days. Schoolyards with lots of trees have been thankful for them being there, and school without or with few trees have been longing for more. As described by a teacher from one of interviewed warmer preschools, *“There are not many areas where you can get away from the sun. Especially in the afternoon, the sun shine directly onto the yard. So, we are quite trapped by the sun, and we have no trees or anything that blocks it”*. The placement and type of trees has from the interviews been frequently discussed in the interviews. Many teachers describe that trees have been planted at their yard that shade areas not used by children, or that the trees are slim and thus not provide any shading. Some trees are also experienced to have too much branches and leaves close to the ground which obstructs the line of sight of preschool teaches. Many bushes that are put on preschool yards also possess this problem. A viewed shared by both teachers and planners are that much vegetation on preschool yards both in term of selection of vegetation type and placement are chosen based on aesthetical purposes rather than with intention of be functional.

Besides trees, groundcover material and the openness of the yard is major factors in experienced heat situations. A common referred to expression is “Asphalt deserts” which is used to characterize unbearably hot schoolyards without shading. Large areas of asphalt and other impermeable surfaces is experienced to accentuate the effect and feeling of the heat to a large extent. Similar stance

towards natural impermeable surfaces as rock has not been found, but more viewed upon as desirable elements that do not affect the heat situation. Regarding the paved and impermeable surfaces, the City Premises Administration mean that there are problems connected to maintenance and wear and tear of grass and permeable surfaces, where increased use of these surfaces intensifies the wear and thus lead to more paved or artificial surfaces due to worn out grass plots.

The surrounding neighbourhood and urban form is regarded to be of some importance to the heat conditions on the schoolyard. At some schools the surrounding area provided lush places to seek shelter from sun, at some schools the urban geometry caused feeling of being trapped in a cauldron that kept heat and prevent wind to bring fresh air onto the yard. However, the preschool could also be completely different from its surroundings, as noted by a teacher in one of the cooler preschool yards located in a highly urban area of the city, *“All day before this interview, I have thought of heat here at our schoolyard. And how lucky we should consider ourselves to have such a lush and green schoolyard. Yes, I really thought that to myself. It is an Oasis in an otherwise concrete milieu “*. This highlight that preschool yards may be a place where natural elements that may be missing in highly urban areas could be allowed to exist.

5.2.3 ACTIONS OF HEAT MITIGATION

The theme Actions of heat mitigation present strategies for heat mitigation carried out or are desirable at preschool yards. Associated problems opportunities and experiences of these actions are also presented. Many more measures of heat mitigation than presented in this theme has been discussed throughout the interviews. However, since the aim of this study is not to explore all possible actions and strategies used in preschools, the actions are presented in a more general way where the presented strategies are to be seen as examples rather than exhaustive list.

As preschools are not forced to be outdoors, seeking shelter from the sun indoors is a measure of heat mitigation practiced by all interviewed preschools. To some extent, the daily routines on preschools where the children take a nap around noon provide a natural break from the sun during mid-day. But during hot days, such as most of the summer of 2018, many preschools spent more time than usual indoors due to intolerable outdoor conditions. Although taking shelter from sun indoors may not be an efficient strategy, as the indoor thermal conditions are not

always better than outdoors. Poor ventilation and lack of fans makes indoor air to be of low quality. Opening windows and using blinds or jalousies are common, but only efficient to a certain degree, and the high outdoor temperature means that the fresh air from outside do not really cool the indoor environment. One teacher described that all the rooms used by children had south or west facing windows, which meant that it quickly became hot in the areas where the children resided. And even though the outdoor environment of the school did not offer much shade, it was still assessed to be better than indoors. As the teacher described it, *“when it’s warm, we go out. No matter if it is hot without any wind, there is fresh air compared to inside”*. However, schools that do not have problems with high indoor temperature view staying indoors to a much higher extent as heat mitigating strategy than schools with hot indoor environment. Since preschools, unlike elementary schools are not to same extent perceived linked to performance, there is less incitement and regulations towards indoor environments of preschools than elementary schools, or other municipality owned facilitates. As described by a municipal interviewee, *“Indoor climate have been discussed for long, and we have demanded how warm it should be inside and so [In elementary schools], and we know that it affects study results. And we know that more people die at a certain temperature at retirement homes. But at preschools and preschool yards, we don’t have such things. And I believe that understanding is greater when we talk about shading than temperature reduction”*. Thus, when planning new areas and preschools, temperature is not properly taken into account. As described by the respondent from the City Planning Administration when discussing the awareness of heat stress in the administration, *“There are some planners that have some interest and awareness of it [Heat stress], whom has some knowledge. But in general, awareness is rather low. So, I think it depends on the interest and previous knowledge one may have stumbled upon before coming here”*.

The measures and actions taken by preschool teachers to mitigate effects of heat stress are based almost exclusively on experience. Since there are no guidelines apart from some vague idea to stay indoors during the hottest hours of the day, the measures taken are almost exclusively experience based. As described by a teacher who worked in a team consisting of teachers with long experience, *“we were a bit more attentive to the youngest kids, for instance if the diapers were dry, well then we had to drink more. That may be something that we just do based on work experience, or instinct rather than something we speak of”*.

Apart from staying inside, seeking shelter in shaded areas are a common strategy of heat mitigation, where teachers initiate activities or create opportunities for children in shaded areas in order to reduce sun exposure. The more areas of shade there is on the yard, the easier this gets. The preschools also adapt the daily activities to fit the prevailing temperature conditions by arranging calmer activities for the children, as well as moving out typical indoors activities to shaded areas of the yard. Thus, the preschool yard can be both a relief from heat as well as too warm to use.

Water in various forms are also a major heat mitigation strategy for all investigated schools. The awareness of that children easily gets dehydrated and needs much water is high in preschools, and teachers highlighted the importance of drinking water throughout the interviews. Besides drinking, water is used in playing, splashing and showering the children at hot days. Some schools also spray water at the asphalt of their schoolyard with purpose of cooling down the hot surface. Even though the actual thermal effect was uncertain, any actions compared to doing nothing at least brought a feeling of coolness. Even though the summer of 2018 also brought public recommendations for saving water, most preschool teachers did see preschools as somewhat excluded from these restrictions. As one teacher said, *“Yes, of course we should not be wasteful with our water. But I think it is mainly for shutting our taps and such. I think we should be able to prioritise the well-being of children and be allowed to use water to cool them even during water restrictions”*.

As complement to shading from the physical environment of preschool yards and its surrounding objects, temporary shading devices such as shade sails and parasols are to a large extent used at many schools. Although the devices to some extent provide some shade, they are not perceived as a sufficient substitute from trees or fixed structures such as pergolas. Apart from providing very little shading, the temperature underneath the shade sails are not perceived as cool as in the shade from a tree or a building. The shade sails and parasols are in comparison to trees or pergolas not assessed to provide additional values to the yard. Vegetation do bring both aesthetic and pedagogical values to the schoolyard that shading devices do not. Shade sails are also criticized for being difficult to handle and maintain, which means that they either break, or that they steal time from the teachers that need to handle the devices. They also tend to be ripped apart during

rain as water are accumulated in the sails until they break. As noticed by the City Premises Administration, *"Many preschools have ordered sun sails that we have installed. But we have noticed that they do not lower the temperature, but only shade the small area underneath. Nor do the sails provide any additional values except shadow, and they are easily broken."* Although the sails are not fully appreciated from planners or teachers, it is perceived as a necessary action to mitigate heat and lowering sun exposure, but trees are still from both seen as the desired option.

To seek shelter from sun and heat in nearby shaded areas such as forests, parks or other playgrounds is for some preschools a measure of heat mitigation. Proximity to these areas are of high importance, as described by a teacher in one of the warmer preschools, which is also located rather isolated with large open areas nearby, *"there are some areas we would love to visit on warm days, but since the road that leads to the forest are completely sunlit it is too warm for small children to walk"*. Excursions are also dependant on the amount of children per teacher, where larger child groups are harder to supervise and consequently are the teachers for larger groups less likely to arrange excursions. The experience factor and interest of individual teachers also influence the likelihood of an excursion, as described by one teacher, *"The team I work in, we chose to work together due to our common interest in doing excursions to the woods and outside the schoolyard. One of my colleagues is educated outdoor teacher, and the rest of us is just passionate driving forces regarding being outdoors, so I think we are better equipped with know-how in excursions that other teacher lack"*

5.2.4 RESPONSIBILITY

The theme Responsibility concerns the different responsibilities, opportunities, restrictions of different actors relevant to heat situations at preschool yards. The responsible actors discussed in the interviews are visible in Figure 14.

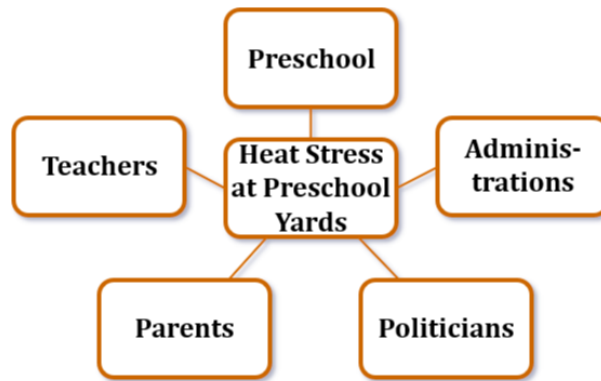


Figure 14. Responsible actors of heat stress at preschool yards according to interviews.

Although the assessed responsibilities for each actor has not been consistent throughout the interviews, some signs of consensus have been found. The different actors will be presented individually, but some overlapping will be made where it is deemed reasonable for the sake of the subject being discussed. The figure and order of presentation of actors should not be seen as a ranking from greater or lesser responsibility.

The responsibility for parents is that of bringing relevant clothing for the children. Long thin clothing for sun protection and sunhats or caps is desirable, from teachers' point of view. The interviews indicated that parents are rather good at providing clothes that are suited for their children, and that the dialogue between parents and preschools often are satisfactory in terms of clothing. The awareness of harmful effects of sun from both teachers and parents also means that much of the discussions on parental responsibilities is focused on whom should apply sun lotion, and other UV-protective measures rather than heat. The interview provided some indications of that parents are better at equipping their children with winter clothing than clothes suited for extreme heat. There seems to be less experience of heat than winter conditions, and consequently more variation in the summer clothing are found for children than during wintertime. Concerning clothing, times when children for some reasons do not have adequate clothing as for instance no sunhat or mittens, the preschools generally do not have clothes for borrow. This is due to that in the procurement procedure in the municipality of Gothenburg, different administrations are allowed to buy only from selected shops and categories of purchases, where clothing is not available for preschools. This of course is not a problem present at private schools, whom possess greater abilities for swift adaptation such as buying sun hats, sun sails and parasols.

Politicians are assessed responsible in a sense that they set the limits for budgets for both schools and administrations, which affect the limitations and possibilities both have in working with heat stress. But since politicians also are the decision-making authority for how the city are planned and designed, they are assessed to be greatly responsible for ensuring that new preschools have sufficient amount as well as high quality areas for preschool yards. In politics, making room for preschools per se is a problem, and consequently, heat issues of preschool yards even less noticed.

The administrations that have been regarded most responsible for the thermal environment of schoolyards are the City Premises Administration and the City Planning Authority. As the City Premises Administration maintain, build and plan the outdoor environments (of public preschools), their responsibility is assessed to be greatest. The interview with this administration indicated that heat mitigation is rising in importance in their work with preschool yards. However, the main focus is although for UV-protection rather than heat. The administration is reshaping their working methods and measures taken by for instance planting bigger and more expensive trees at preschool yards to ensure trees provide shading already from the time it has been planted. Furthermore, they now set harder directives to landscape planners that design preschool yards to pay less attention to the aesthetic features of trees and vegetation and instead focus on the actual values they can contribute to preschool yards. As described by the respondent from City Premises administration, *“It has been more focus on making sure that trees have nice colours during the fall than providing something to the preschool yard, and sun and shading aspects has not been a priority when looking back at the build preschools the last decade”*. The City Premises Authority however only have mandate to take action within the perimeter of preschool areas, which mean that they only can influence the environment inside the preschool yard fences. Outside the fences are the City Planning Administration responsible for making sure that preschool yards are located on suitable areas, which often seems to be outweighed by other interests, as discussed by the City Premises administration, *“we have quite tough demands on the type of plot we want to be allocated on [when building a new preschool], but these plots often ends up being residential grounds. Since schools, and preschool yards are not attractive income-generating activities they tend to be of low priority when develop our city”*. And even if the detail development plans design for more trees or vegetation designed to mitigate heat,

there is no assurance that it will be realized. As discussed by the respondent at the City Planning Authority whom once had investigated differences in the plans and actual implementation of it, *“it [the detailed plan] clearly stated that this area would be vegetation and trees, but in reality, it had become parking spaces. I asked our juridical adviser who compared to the possibilities of to some extent depart from roof or floor height when building a house. You don’t have to follow the detail development plans to the letter”*. Consequently, the planning tools owned by the planning office are also limited into what they can do regarding heat. However, the municipality is by the Swedish Environmental Code compelled to use land in such a way that it creates healthy and sustainable environments. Although this requirement may provide cause for ensuring healthy thermal conditions at preschool yards as well as in other parts of the city, it is currently powerless since ambient heat is not assessed as a problem that the municipality needs to solve.

Even though there are many responsible actors regarding thermal conditions on preschool yards, the preschool itself do have lot of responsibility. As a teacher described it when discussing responsibility, *“Well, the main responsibility is not ours [Preschool teachers], it is higher up, politicians and executives. But regardless of whoever has the main responsibility, we are the ones who have to deal with the current situation which somehow makes it our responsibility”*. But there is no clear consensus in this matter. Another teacher described it as, *“it is our responsibility as a preschool to create healthy safe environments for all children, and I guess that it includes heat as well”*. However, it is from the empirical material collected from the interviews hard to distinguish what different respondents include in “we”, “preschool”, “us” or similar, where some refers to it as only teachers, some to the preschool including principals or even the municipality as such. For private schools the responsibility division is much easier, as it is always the preschool. This complex multitude of views of responsibility however makes it difficult for preschool teachers to know what is expected from them as well as what they can expect from other actors. As one teacher described, *“indoors we have protective covers on our radiators, and limitations in how hot the tap water is in order to make sure the children are safe from harm. I don’t know. The yard is as much a part of the preschool as taps and radiators, so maybe it is our responsibility as well. But I actually don’t know if those things [protective covers on our radiators and limitations in tap water] are our responsibility or someone else’s”*. Despite many responsible actors, the preschool teachers, regardless of whom actually bears the responsibility, do end up with ensuring that the children at preschool yards stay healthy and safe. Thus, the teachers in the interviews described themselves forced of having main responsibility at a day to day basis.

6 Discussion

6.1 HEAT STRESS EFFECTS ON PRESCHOOL CHILDREN AND TEACHERS

Preschool children has as argued by Xu et al. (2012) in this study been found to be more sensitive to heat than adults, where younger children are more affected than older. Even though the study does not provide guidance to at what T_{mrt} level heat stress occur for children, the interview results indicate that the threshold of exceeding thermal comfort and thus experiencing heat stress is significantly lower for children than adults. However, the interviews revealed that the preschool teachers found sunlit areas in summer time too warm for both children and themselves to spend longer times, thus the amount of sunlit area could be used as indication of which preschools that are more prone to heat stress than others.

The study also confirm the findings of Vanos et al. (2017) and Yun et al. (2014), that smaller children are less aware of temperature both ambient and own body heat, and that lack of conception of heat makes them less prone to act in order to lower their thermal status by for instance move to shading, or lower their activity level. The responsibility of preschool teachers thus is high in order to ensuring that the children stays healthy and safe. The result indicates that work experience and staffing levels impact preschools ability to handle heat stress to a great extent.

Since the preschool yard is delimited with fences and thus has a limited accessible area at its disposal, the interview results suggest that a sense of having no way to seek shelter is present at preschool yards. Shooshtarian et al. (2018) argue that perceived control of capacity to alter the thermal environment affect the thermal comfort and consequently also heat stress. Hence the result from this study indicate that limitations of shaded and cool places to seek shelter may also influence the heat stress situation at preschools. In addition to the outdoor environment, the indoor environment may also be important for the same reason, as heat on schoolyard could be perceived more acceptable if indoors offer a cool place. Thus, although the division of preschool yard and indoors as two separate units made in this study is not necessarily inappropriate, the indoor environment effect of the perceived thermal conditions of preschool yards should not be disregarded.

6.2 THE PHYSICAL ENVIRONMENT OF PRESCHOOL YARDS AND HEAT STRESS

The results from this study has clearly shown that the physical environment of preschool yards have high impact on both modelled T_{mrt} and the perceived and experienced thermal conditions on preschool yards as was argued by Hulth et al. (2016) and Vanos et al. (2017, 2016). Preschool yards with low amount of shading, high amount of openness as high S_{vf} are in accordance with Ali-Toudert and Mayer (2007), Lindberg et al. (2016-a) and Thorsson et al. (2017) found to have highest T_{mrt} . Openness was although found to be to some extent desirable from a teachers point of view in order to easily supervise the children at preschool yards, which was also argued by The Swedish Association of Local Authorities and Regions (2018). However, the results do not suggest that visual openness and sun obstructing features on schoolyards necessarily have a contradictory relation, but rather that good planning is needed to ensure preschool yards to have both. Thus, the role of appropriate selection of trees to ensure lower T_{mrt} without negative externalities as proposed by Thorsson et al. (2017) and Thom et al. (2016) are found valid also for preschool yards. This study in addition also emphasize the importance of line of sight underneath trees, and thus advocate trees with high trunk height as suitable for preschool yards.

Even though the results from the modelling, in accordance with Shashua-Bar et al. (2009) indicate that surface characteristics are of lesser importance to T_{mrt} than shading, the results from interviews shows that surface material may affect the thermal perception of preschool yards of teachers. As thermal comfort is both affected by physiological and psychological factors (Knez et al., 2009; Oke et al., 2017; Shooshtarian et al., 2018), the surface material as well as other materials found on the schoolyards may affect heat stress at preschool yards. Since the interviews was conducted with the teachers, the study does not imply that this view is shared by the children. However as teachers also are affected by heat stress, the effect on their working environment should also be taken into consideration (Persson & Broman, 2019). Problems with overheated surfaces and play equipment found by Vanos et al. (2016) was in this study not found to be an issue at the examined preschool yards.

6.3 PRESCHOOL YARD SPACE AND LOCATION

The study has shown that great differences in mean T_{mrt} on preschool yards at short distances, as was argued by Lindberg et al. (2016-a) and Oke et al. (2017). Hence, the specific physical characteristics on micro and local scale are found to be more important to T_{mrt} than the location within the city. However, the results of the study do indicate that the preschool yards with foremost low mean T_{mrt} is found in the city centre. Hulth et al. (2016), concluded that a larger fraction of preschool yards in central Gothenburg had better sun protection than yards further out from the city centre. This study to some extent indicate that similar patterns were found concerning mean T_{mrt} , but it also show that the variance of mean T_{mrt} is found much higher closer to the city centre. Thus, preschool yards with high mean T_{mrt} is also found in the centre. The result in this study also show that the characteristics of preschool yard of a preschool yard may differ greatly from its surrounding milieu, and consequently work as a form of lush and cool oasis in an area otherwise characterised by low vegetation and high temperature. As the study also has shown that the amount of trees found inside the preschool yard perimeter are highly efficient in altering T_{mrt} conditions, the result indicate that heat mitigating objects such as trees on preschool yards, are efficient even if the area outside the schoolyard do not contribute significantly to heat mitigation at the preschool yard

The result from this study indicate that half of all investigated preschool yards in general during the time period of 11:00-15:00 have less than 65% of the schoolyard area shaded. As both results from both interviews and the modelling indicate that much of the non-shaded area is too hot to use, the study highlight that the 35m² free space recommended per children at preschool yards according to the City Premises Administration (2019) is not available at many schools on clear warm days. Hulth et al. (2016) concluded that 24% of the investigated preschool yards had inadequate sun protection that included low amount of shading and lack of opportunities for preschool teachers to steer the children into shaded areas. The results from this study suggest that based on the same assumptions inadequacy, the amount of schoolyards with inadequate heat protection is far greater than 24%. As 38 % of all investigated preschool yards had less shaded area that is needed to fit one average size preschool class, it seems reasonable to assume that much more than 24% of the investigated preschools in the study lack sufficient

amount of shaded areas. Thus, the study indicate that measures taken to reduce UV-radiation does not necessarily mitigate high temperature.

The reduction in usable area has been found to affect the children as conflicts tend to emerge more often when children gets clustered in smaller areas as well as possibilities for physically active activities decreases. The lowered usable area during sunny days also increase wear of the shaded areas, which increases the degradation of the schoolyard, as well as increasing costs for maintenance.

6.4 HEAT MITIGATION AT PRESCHOOL YARDS AND PLANNING FOR HEAT

The adaptive measures taken from preschool teachers to mitigate heat stress found in this study are in accordance to what was found by Hulth et al. (2016). Measures of sun exposure reduction such as staying indoors, adapting activities to match the current thermal conditions, initiate activities on shaded areas on the preschool yard was found practiced at preschool yards by this study. The results to some extent also confirm that seeking shelter in nearby parks or green areas, is a plausible heat stress mitigating strategy for preschool teachers. However, this study also stresses the importance of experience and interest of preschool teachers for being able to leave the preschool yard, as well as thermal conditions on the road to the nearby green area as crucial in the feasibility of seeking shelter in nearby parks. The study showed that water activities as well as drinking water has been found to be a frequently used heat mitigating strategy for all interviewed preschools.

The study has shown that temporal shading devices such as shade sails and parasols are frequently used on preschool yards in Gothenburg. However, they are not assessed to be a substitute for shading from trees or other fixed shading objects. However, shade sails are perceived as being a valid complement to use until permanent solutions are in place, but it is not found to be a long-term solution as they do not generate adequate amount of shading, are difficult to handle and maintain and also expensive. The study results also indicate that the thermal conditions underneath temporary shading devices are not significantly lower than the surrounding area, which was also found by Shashua-Bar et al. (2009). Thus, the study indicate that temporal devices are more efficient in UV-reduction than in mitigating heat stress at preschool yards.

Most of the measures to mitigate heat at preschool yards is also found based at experience of the preschool teachers and not from guidelines, recommendations or directives from principals or other higher instances. The lack of guidelines and awareness of heat stress is not found to be a problem for preschool teachers, but to some extent it does affect how the question is dealt with at a planning level. Since thermal conditions are not required aspect to include in planning, the level of inclusion in planning is mainly dependant on the interest and knowledge of the individual planner. And as temperatures and heat stress are not required aspects in planning, other interests are considered to be of more importance, and thus making it hard to demand for better thermal conditions. However, the study indicates that the summer of 2018 to some degree increased the awareness of heat stress at preschool yards, which consequently has led to some changes in strategies for sun and heat mitigating long-term strategies of the administrations of Gothenburg. A shift in planning from aesthetically appealing preschool yards, towards a greater focus on usability is indicated in the study.

As summer and heat is welcomed at preschool, the acceptance of high temperature at preschool yards is found to be high. The results in the study indicate that heat stress is a problem for preschool children at preschool yards in Gothenburg. However, heat stress is not to same extent perceived as a problem by both teachers and planners, but rather as an inconvenience. Protection from harmful UV radiation from excessive solar exposure is found to be more important for both planners and teachers.

6.5 DISCUSSION OF METHODS AND STUDY DESIGN

6.5.1 *MIXED METHOD APPROACH*

Through the mixed method research design of this study, more perspectives as well as a broader understanding of the study subject of heat stress at preschool yards has been obtained. However, the width of the study has also affected the depth and possibilities of defining the aim and orientation of the research conducted. Thus, the study could have been conducted with a purely quantitative or qualitative approach and consequently been able to do more focused in-depth research (See Bryman, 2012). However, the results and insights learned from both study parts has enabled a richer understanding of the situation of heat stress at preschool yards.

6.5.2 LIMITATIONS IN GEOSPATIAL DATA AND MODELLING

As all type of modelling are based on assumptions of actual condition, the results from the SOLWEIG model should not be seen as a perfect copy of the real world. Although the spatial DSM's used in the modelling are assessed to be of high quality, some errors are expected to exist in the data, and thus some shading patterns or ground cover may not be correct. However, as the study has large sample of preschool yards, these flaws are assessed to be of minor importance.

Furthermore, as only ground data from 2010 was available, the changes in the urban fabric of the latest nine years has of course not been taken into account in this study. However, the aim with the study is not to provide a situational analysis of the current T_{mrt} situation at the preschools in Gothenburg. The analysis and conclusions drawn on the results still are valid since the correlations and patterns found aim at explaining rather than presenting current T_{mrt} status of preschool yards in Gothenburg.

The spatial data for preschool yards could also have distorted the results to some extent, where the method of digitalising the preschool yards probably could have been done more in detail from in-situ observations than the ocular interpretation of aerial photography used in the study. Also, as many of the preschool yards with indistinct borders were not included in the study often was found to be excluded due to obscuring forests or trees, the sample could have been distorted to not include preschool yards with more vegetation on the yard. Furthermore, the spatial data of buildings used in the modelling do consider buildings as "boxes" where eaves or arcades are nor present in the data. Thus, more shading from buildings is probably present at the preschool yards than presented here. Although, the amount of shaded area in relation to the size of preschool yards is rather small. Therefore, the lack of this shading in the modelling is assessed to be minor in the study. Furthermore, temporal shading devices such as shade sails and parasols are not present in the data.

6.5.3 SPATIAL VARIATION OF METEOROLOGICAL DATA

As this study has used metrological data from stations in the city centre, is reasonable to believe that the spatial meteorological variance within the study area has not been captured in the modelling of T_{mrt} . T_{mrt} is not that sensitive to relative humidity (Onomura, Grimmond, Lindberg, Holmer, & Thorsson, 2015),

hence the variance in that parameter that can be found in the study area is assessed to be minor. Variation in T_a affect T_{mrt} to a higher degree than humidity, where changes in T_a covaries with T_{mrt} to a slightly less degree, where a 10°C increase of T_a results in about 8°C higher T_{mrt} , with similar decrease in T_a ratio. Thus, T_{mrt} at preschool yards in areas that could have been experiencing lower T_a the modelled day may be slightly overestimated. However, the aim with this study is not to provide the most accurate situational analysis of T_{mrt} conditions for all preschools in Gothenburg but to analyse T_{mrt} in relation to other parameters found on and nearby preschool yards. Therefore, it is reasonable to assume that the conclusions drawn from the results are valid regardless if the spatial variance of T_a is present or not.

6.5.4 ANALYSIS METHODS FOR THE QUANTITATIVE RESULTS

The distance to city centre and mean T_{mrt} correlation analysis did as presented in the study show some interesting results. However, the results are based on an assumption that the city centre is the most urbanised and built-up area, and that the level of urbanity decreases evenly at all directions. This is of course not how reality looks like, and another way of investigating could be to use some level of urbanity instead of Euclidian distance as variable. This does not imply that the method used in this study is negligible, but rather that there is potential for improvement.

The Binning categorization done in the studies may also have influenced the results. Another categorisation done for instance to have equal amount of samples in each Bin could be used to increase reliability of the conclusions drawn from the results. However, since the conclusions drawn from the presented results that used Bin method based on mean T_{mrt} was not used in any statistical analysis than only visual interpretation of patterns that distinguishes preschools with lower or higher mean T_{mrt} , the results are assessed to be of significance.

Another factor that could have affected the results is the used time span of 11:00-15:00. As this time span is based on recommendations of sun exposure, they may not be the most suitable timespan for investigating changes in T_{mrt} . A different time span could then provide other results. However, the mixed method approach of the study did set limits on what was possible to analyse in the scope of a master's thesis, and therefore some limitations had to be made. If this study was a pure

quantitative GIS based study, more periods of time, or longer periods of time could have been studied more extensively.

6.5.5 *INTERVIEW SAMPLE*

The original sampling strategy of interviews was to conduct critical case sampling, where permits the researcher base the sample with intention of being investigate a specific phenomenon of interest for the study (see Bryman, 2012). The phenomenon of interest for sample was in this study preschool yards with variance in mean T_{mrt} that was used as indication of warm and cool preschool yards. However, this strategy to some extent failed due to difficulties in getting into contact with preschool staff, both principals, teachers and other personnel. But also due to lack of interest and time for participating in an interview. There were also ambiguities as to whether a student was allowed to conduct research at preschools which mainly ended up in vague commitments of escalating the question to a higher instance which did not end in any returning answers.

In order to get a valid number of interviews in a reasonable time in the scope of the study, a more convenience sample approach was adopted where a larger amount of preschools were contacted and, the interested preschools that was able to participate was selected. The convenience sampling in this way could create a sampling bias, where the respondents in the sample did chose to participate due to that they find the subject or question, in this case heat stress at preschool yards, important. Thus giving a sample that to a higher extent see heat stress as a problem (See Bryman, 2018). However, this effect was assessed to be of minor importance next to having no samples at all. With this said, in order to provide a more representative picture, more studies with a more random sample as well as having a larger sample should be conducted in order to provide more valid results.

6.6 FURTHER RESEARCH

The study has resulted in many loose ends that should be further studied. Some indications that the warmer interviewed preschools perceive heat as a problem to a greater extent than what cooler preschools do has been found by the study. However, with the low number of interviews it is hard to evaluate the validity of the correlation. Hence studies with higher amount of respondents would be useful in order to validate the connection.

As this study has been focusing on variation of T_{mrt} as well as other parameters on a large scale, it has not captured the effects on micro scale at the actual preschool yards. Further research could adopt a case study approach to investigate few preschool yards in depth, with perhaps more of observational methods along with detailed studied investigation of T_{mrt} at the actual preschool yard.

Furthermore, similar modelling could be done with newer DSM data and thus investigate how the increased densification and urbanisation has affected T_{mrt} of preschool yards, as well as having a time approach to investigate differences in preschool yard environments from both newer and older preschools.

7 Conclusions

The study has concluded that heat stress on preschool yards do affect preschool children negatively, where younger children are more prone to heat stress than older, and that the physical environment of the preschool yard are more important than adaptation from teachers to mitigate heat stress. However, the study has also shown that heat stress today is mainly perceived as a complicating factor or an inconvenience that preschools need to deal with, rather than a problem that needs to be taken into consideration in higher instances such as planning and politics. The main issue related to clear and sunny days from both planners and teachers are still sun exposure and harmful UV-radiation, rather than high temperatures.

The study has through both interviews and modelling of T_{mrt} concluded that shading is the most important heat stress reducing factor at preschool yards. Children on preschool yards with low amount of shaded areas are thus more likely to experience heat stress than children on more shaded preschool yards. Results indicate that many of the investigated preschool yards have insufficient amount of shaded areas in order to ensure adequate space for each child at clear and warm days. The study has also shown that shading from trees are found to be the most important shading objects at preschool yards, as well as providing other desirable values to the preschool yard for both children and teachers.

Even though temporal shading devices such as shade sails and parasols may be useful in mitigating high temperatures and sun exposure, these devices are both found more costly economically and workload, and less efficient and attractive than trees.

8 References

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Appendix 1 – List of Preschools in Modelling

ABC / All about children
Albotorget 5 förskola
Algebraförskolan
Allmänna Vägen 40 förskola
Amhults Byväg 10 förskola
Amiralitetsgatan 19 B förskola
Aniaragatan 5 förskola
Annandagsgatan 1 förskola
Apelsingatan 15 förskola
Arken Tynnereds Kyrka
Askims Domarringsväg 103 förskola
Astris Gata 7 förskola
Backa Kyrkogata 3 förskola
Backa Kyrkogata 7 förskola
Backa Kyrkogata 9 förskola
Backa Västergård
Baldersplatsen 2 förskola
Bankebergsgatan 5 förskola
Barnens Hus
Barnens Hus Montessoriförskola i Hagen
Barytongatan 2 förskola
Bergaborgen
Bergsgårdsgärdet 39 förskola
Bergsgårdsgärdet 46 förskola
Bergsgårdsgärdet 54 förskola
Bergsgårdsgärdet 93 förskola
Beryllgatan 1 förskola
Bild & Form
Bildradiogatan 38 förskola
Billdals Kyrkväg 3 förskola
Birger Jarlsgatan 1 förskola
Björlanda Strand 5 förskola
Björnsareds Genväg 1B förskola Bergums framtid
Blåsippan
Blåsvädersgatan 2 förskola
Bollplansgatan 2 förskola
Bondegärdet 18 B förskola
Borgaregatan 5 förskola
Brandströmska förskolan Livskraft
Bredfjällsgatan 72 förskola
Bronsåldersgatan 27 förskola
Bronsåldersgatan 82 förskola
Brunstorpsvägen 41 förskola
Bräcke Östergårds Väg 15 förskola
Brämaregatan 2D förskola
Brännekullavägen 5 förskola
Brännemysten 6 förskola
Bygatan 13 C förskola
Båtsman Grås Gata 2 förskola
Bärbyvägen 24 förskola
Carl Grimbergsgatan 5 förskola
Carl Johans Församlings Förskola
Cassiopeja
Ceresgatan 16 förskola
Child Activity Center
Con Brio
Creative Kids Lotsgatan Förskola/Preschool
Creative Kids Älvsborgsgatan Förskola/Preschool
Daniel Petterssons Gata 6 förskola
Djungeln
Djurgårdsgatan 29 förskola
Doktor Håléns Gata 11 förskola
Doktor Sydows Gata 44 förskola
DoReMi - Medborgarskolans musikförskola
Draget
Dragonörtsgatan 1 förskola
Eckragatan 36 förskola
Edwin Ahlqvists väg 55 förskola
Ekedalsgatan 24 förskola
Eketrägatan 13A förskola
Emelie Lejmans Väg 5 förskola
Eriksbo Västergärde 12 förskola
Eriksbo Västergärde 35 förskola
Eriksbo Östergärde 3 förskola
Explorama
Falkgatan 5 förskola
Fanjunkarens Lycka 7 förskola
Fiolgatan 20 förskola
Fjällblomman 5, förskola
Fjällbo Park 13 förskola
Fjällkåpan 2 förskola
Fjällstugan

Fjärde Långgatan 19 förskola
 Flotten
 Flygvädersgatan 13 förskola
 Folke Bernadottes Gata 4 förskola
 Framnäsgratan 16 förskola
 Franska förskolan
 Fredagstomten 23 förskola
 Friarelyckan 53 förskola
 Frida förskola
 Fridhemsgatan 11 A förskola
 Fridhemsgatan 33 förskola
 Friggagatan 3b förskola
 Fräntorpsgratan 57 förskola
 Fyrmästaregången 6-8 förskola
 Färgaregatan 7 förskola
 Författaregatan 11 förskola
 Förskolan Båten
 Förskolan Emilia
 Förskolan Fyren
 Förskolan Jätten
 Förskolan Ljuset
 Förskolan Pärlan
 Förskolan Rymden
 Förskolan Selma
 Förskolan Solgården Aurinkopiha Ek.Förening
 Förskolan St. Jörgen
 Förskolan Tindra Eriksberg
 Förskolan Torkelsgratan (Solveigs förskolor AB)
 Förskolan Valen
 Förskolan Villa Ramnebacken
 Förstamajgatan 28 förskola
 Föräldrakooperativa förskolan Vildingen
 Föräldrakooperativet Balsaminen
 Föräldrakooperativet Kottarna
 Föräldrakooperativet Lekstugan
 Föräldrakooperativet Linbråkan
 Föräldrakooperativet Lönner
 Föräldrakooperativet Nallarna
 Föräldrakooperativet Skattkammaren
 Föräldrakooperativet Snipan
 Galaxgatan 1 förskola
 Gamla Tumlehedsvägen 100-104 förskola
 Gibraltargatan 29 förskola
 Giraffen
 Gitarrgatan 5 förskola
 Gjutegården 7A förskola
 Glasmästaregatan 2 förskola
 Glasmästaregatan 6 E förskola
 Glöstorpsvägen 26 förskola
 Gnistgatan 3 förskola
 Gothenburgs Preschool Krukmakaregatan
 Grenens förskola
 Grinnekullegatan 250 förskola
 Gropens gård 36 förskola
 Gryningen
 Gunnilse Skolväg 3 förskola
 Gångglåten 31 Dygnet-runt förskola
 Hackspettsgatan 1-7 förskola
 Haga Nygata 17 förskola
 Hagens Kapellväg 4 förskola
 Hagkroksvägen 1 förskola
 Hagvidson Fyreviken
 Hakefjordsgatan 119 förskola
 Hallandsgatan 7 förskola
 Hammarkroken 1 förskola
 Hammarkullegatan 3 förskola
 Hammarvägen 2 förskola
 Hammarvägen 4 förskola
 Hemmansägaregatan 11 förskola
 Hjällbogärdet 29 förskola
 Hyltevägen 1 förskola
 Hyltevägen 51 förskola
 Hällskriftsgatan 1A förskola
 Höstvädersgatan 51-57 förskola
 Höstvädersgatan 73 förskola
 Igelkotten
 International Preschool Guldheden
 International Preschool Älvsborg
 Januarigatan 5 förskola
 Julianska gatan 8 förskola
 Jungmansgatan 28 förskola
 Jungmansgatan 45 B förskola
 Jungmansgatan 55 B förskola
 Junibackens förskola, personalkooperativ
 Just like hemma
 Kalendervägen 103 förskola
 Kalendervägen 15-17 förskola
 Kanngjutaregatan 1 förskola
 Kapellgången 8-10 förskola
 Kaponjärgatan 9 förskola

Karduansmakaregatan 44 förskola
 Karneolgatan 79 förskola
 Kastanjen
 Kastvindsgatan 3 förskola
 Katolska skolans förskola
 Klåvavägen 77 förskola
 Klåveskärsgratan 1 förskola
 Knivsmedsgatan 2 förskola
 Kobergsgatan 32 förskola
 Kometgatan 2 förskola
 Kompassgatan 11 förskola
 Konvaljegatan 8 förskola
 Korsåsliden 29 förskola
 Kristinaskolans förskola
 Krumeluren 6 förskola
 Kullegatan 4 förskola
 Kuminggatan 126 förskola
 Kuminggatan 128-130 förskola
 Kuminggatan 132 förskola
 Kvadrantgatan 1 förskola
 Kvinnofolkshögskolans förskola
 Kyrkans förskola
 Kålhagen 3-7 förskola
 Kärralundsgatan 19 förskola
 Körvelgatan 2 förskola
 Ladan
 Landala förskola
 Landerigatan 17 A förskola
 Landsväggsgatan 7 förskola
 Lantmätaregatan 21 förskola
 Lars Kaggsgratan 35 förskola
 Lasarettsgatan 7A förskola
 Lejonsparres väg 3 förskola
 Lennart Torstenssonsgatan 11 förskola
 Lerumsvägen 31 förskola
 Levgrensvägen 3 förskola
 Liljan
 Lill-Martina
 Lilla Grevegårdsvägen 6 förskola
 Lilla Hällsviksvägen 25 förskola - tillhör Skutehagens förskola
 Lilla Montessori
 Lilla Samskolan
 Lilla Skintebovägen 8 förskola
 Lilla Solstrålegatan 10 förskola
 Lilla Sörredsvägen 2 förskola
 Lilleby Kronogård 70 förskola
 Lillebyvägen 9 förskola
 Lillekärr Norra 130 förskola
 Lillekärr Södra 53 förskola
 Lillhagsparken 14 förskola
 Lillängsgatan 6 förskola
 Lindebovägen 1 förskola
 Lingonet, Grevegårdens Kyrka
 Lisa Sass Gata 11 förskola
 Little Kids förskola
 Ljusstöparegatan 1A förskola
 Lonsegårdsvägen 39 förskola
 Låkebergsgatan 10 förskola
 Långströmsgatan 32-34 förskola
 Låssbyvägen 55 förskola
 Länkhavsgatan 3 förskola
 Lär & Lek förskola
 Makrillen
 Malmstengsgatan 6 förskola
 Mariebergsgatan 7 förskola
 Marklandsgatan 21 förskola
 Marklandsgatan 41 förskola
 Melongatan 3 förskola
 Merkuriusgatan 75 förskola
 Meteorgatan 52 förskola
 Mildvädersgatan 3 förskola
 Mildvädersgatan 7 förskola
 Minutgatan 4 förskola
 Molinsgatan 23 förskola
 Montessoriföreningen Askim
 Montessoriföreningen Kaprifolen
 Montessoriföreningen Maria
 Montessoriförskolan Lyckan
 Montessoriförskolan Mumin
 Montessoriförskolan Polstjärnan
 Montessoriförskolan Trädet
 Montessoriförskolan Villa Villekulla
 Montessoriskolan Casa
 Morgonsol
 Mörkögatan 9 och 18 förskola
 Myrekärrsvägen 45 förskola
 Måns Bryntessonsgatan 10-12 förskola
 Måsen
 Mölndalsvägen 29 förskola
 Mölnesjögratan 165-166 förskola

Natur och lek i Ur och Skur
 Nedre Kvarnbergsgatan 17 förskola
 Noaks Ark
 Nolehultsvägen 15 förskola
 Nolviksvägen 3 förskola
 Nolviksvägen 40 Förskola
 Nordostpassagen 17 förskola
 Norra Flundregatan 23 förskola
 Nya Skogomevägen 1 förskola
 Nymilsgatan 6-8 förskola
 Nymånen
 Okay
 Omvägen 2 F förskola
 Opalgatan 100 förskola
 Orkestergatan 35 förskola
 Ostindiegatan 24 förskola
 Oxelgatan 6 förskola
 Oxeödsgatan 1 förskola
 Persiljegatan 1 förskola
 Pilegården 9 förskola
 Plantagegatan 8-10 förskola
 Plåtslagaregatan 19 förskola
 Polarna
 Prebendegatan 2 förskola
 Prilyckegatan 147 förskola
 Prilyckegatan 315 förskola
 Prästgårdsgatan 44 B förskola
 Prästgårdsängen 2-6 förskola
 Prästkragsgatan 2 förskola
 Prästvågen 6 förskola
 Pärlan, Näsetkyrkans förskola
 Ramnebacken 40A förskola
 Rangströmsliden 3 förskola
 Redegatan 15 förskola
 Rimmaregatan 7 förskola (Bällskärs specialförskola)
 Risåsgatan 7 förskola
 Rosengatan 6 förskola
 Rudedammsgatan 6B förskola
 Röda Stråket 10 förskola
 Rödluvans förskola
 Römosseförskolan
 Saffransgatan 80 förskola
 Sagolunden
 Salviagatan 2 förskola
 Salviagatan 56 förskola
 Sanatoriegatan 90 förskola
 Sandeslättsgatan 3 förskola
 Saras Väg 5 förskola
 Seglaregatan 17 Förskola
 Seglaregatan 5 förskola
 Seminariegatan 7 förskola
 Senapskornet
 Siriusgatan 4-10 förskola
 Sjupundsgatan 10 förskola
 Sjöelefant
 Sjöhästens förskola
 Skanstorget 17 förskola
 Skattegårdsvägen 100 förskola
 Skepparegången 1 förskola
 Skillnadsgatan 36 förskola
 Skogshyddegatan 23 förskola
 Skogsängsvägen 14 förskola
 Skolspåret 2 förskola
 Skolspåret 61 förskola
 Skolspåret 77 förskola
 Skutehagen 102 förskola
 Skånegatan 18 förskola
 Slottsskogsgatan 90 förskola
 Smaragdsgatan 28B förskola
 Smithska Vägen 14B förskola
 Smultronvägen 7 förskola
 Småfröna
 Småtrollen
 Smörgatan 80 förskola
 Smörslottsgatan 22 förskola
 Smörslottsgatan 69 förskola
 Snäckskalet
 Sockenvägen 26 förskola
 Solgläntan
 Solhagagatan 136 förskola
 Solrosens förskola Kortedala
 Solveigs förskolor, Flygledarevägen 3
 Solventilsgatan 10 förskola
 Solvädersbyn 60 förskola
 Spannlandsgatan 1 förskola
 Spekebergsgatan 3 förskola
 Standargatan 10-12 förskola
 Stengetsgatan 22 förskola
 Stenskärsgatan 2 förskola
 Stjärnbildsgatan 3 förskola

Stjärnbåtsgatan 7 förskola
 Stomvägen 1 förskola
 Stora Björn förskola
 Stortoppsgatan 2 förskola
 Studiegången 1 förskola
 Styrmansgatan 13 förskola
 Styrmansgatan 21A förskola
 Svalebogatan 52 B förskola
 Svaleboskogen 3 förskola
 Svaleboskogen 7 förskola
 Sveagatan 17 förskola
 Svenska kyrkans förskola Fisken
 Svenska kyrkans förskola Lammet
 Svenska kyrkans förskola Tufvan
 Svensksundsgatan 2 förskola
 Svetsaregatan 101 förskola
 Såggatan 73 förskola
 Säl dammsbacken 11 förskola
 Sälen
 Södra Särövägen 80 förskola
 Taklöksvägen 1 förskola
 Talattan
 Tandkullegatan 7 förskola
 Teleskopgatan 3 förskola
 Tellgrensgatan 7 förskola
 Tellusgatan 4 förskola
 Temperaturgatan 70 förskola
 Temperaturgatan 93 förskola
 Temperaturgatan 95 förskola
 The International Preschool AB
 Theresias Katolska Montessoriförskola
 Tideräkningsgatan 4C förskola
 Timjansgatan 52 förskola
 Titteridammstigen 2 förskola
 Toleredsgatan 12 förskola
 Topasgatan 1 förskola
 Torpagatan 20 A förskola
 Torpagatan 32 förskola
 Torpagatan 38 förskola
 Torslanda Hästeviks Väg 10 förskola
 Torslanda Torg 8 förskola
 Transistorgatan 2 förskola
 Trollstugan
 Trondheimsgatan 15 förskola
 Trädet
 Trädgårdsgärdet 124 förskola
 Tunlandsgatan 3 förskola
 Turkosgatan 1 förskola
 Tuvegranen
 Tångenvägen 11 förskola
 Tärneskärgatan 4 förskola
 Uddevallagatan 16 förskola
 Uggledalsvägen 31 förskola
 Universumsgatan 2 förskola
 Utbyvägen 111 förskola
 Valhallagatan 4 förskola
 Vallareleden 24 förskola
 Valthornsgatan 3 förskola
 Varnhemsgatan 2 förskola
 Vasa Kyrkogata 7 förskola
 Vasa Neon
 Vidkärrs montessoriförskola
 Vildrosen
 Virginsgatan 19 förskola
 Vitsippan
 Våglängdsgatan 7 förskola
 Väderbodarna 1B förskola
 Världens Blomma Förskolan
 Västra Tuvevägen 50 förskola
 Wadköpingsgatan 157 förskola
 Welandergatan 37 A förskola
 Wieselgrensgatan 11 förskola
 Zenitgatan 24 förskola
 Åkereds Skolväg 16 förskola
 Åkereds Skolväg 20 förskola
 Årekärrsvägen 1 förskola
 Änghagsdalen 16 förskola
 Änghagsvägen 4 förskola
 Änglagård
 Änglagården Svenska kyrkans förskola
 Ängåsgatan 21 förskola
 Äringsgatan 4A förskola
 Örlogsvägen 20
 Östra Keillersgatan 3 förskola
 Östra Palmgrensgatan 38 förskola
 Övralidsgatan 2 förskola

Appendix 2– Meteorological Conditions

Meteorological Data used in the study

<i>Time</i>	T _a (C°)	Wind-speed (m/s)	RH (%)	K _{down} (w/m ²)	K _{Diff} (w/m ²)	K _{Dir} (w/m ²)
00:00	20.05	3.42	44.33	6.44	5.28	0
00:30	20.05	3.42	44.33	6.44	5.28	0
01:00	19.5	2.74	47.2	6.45	5.31	0
01:30	18.85	2.8	49.77	6.13	4.96	0
02:00	18.2	2.38	52.13	6.19	5.04	0
02:30	17.7	2.28	54.33	6.26	5.11	0
03:00	17.2	2.34	56.77	6.72	5.5	0
03:30	17	1.86	59.37	9.59	8.44	0
04:00	16.8	1.9	61.07	19.12	15.41	302.32
04:30	16.9	1.59	62.3	45.94	24.12	199.99
05:00	17	1.54	62.4	85.6	30.25	250.04
05:30	17.55	1.43	61.4	140.63	34.75	353.34
06:00	18.1	1.31	60.37	198.63	40.22	417.54
06:30	18.6	1.31	58.43	261.33	39.66	474.46
07:00	19.1	1.58	55.97	339.87	48.52	581.26
07:30	20	1.82	53.3	411.63	60.02	639.91
08:00	20.9	1.46	51.13	477.33	63.22	669.5
08:30	21.95	1.18	48.23	532.67	63.61	669.42
09:00	23	1.03	43.57	599.27	68.17	717.97
09:30	23.8	1.35	41.53	669.03	79.54	782.31
10:00	24.6	1.61	38.8	722.43	77.22	812.04
10:30	25.05	1.76	38.4	765.5	79.8	827.04
11:00	25.5	1.99	36.13	794.77	88.73	827.48
11:30	25.8	2.55	37.03	800.3	82.73	784.98
12:00	26.1	1.7	36	812.33	83.3	786.05
12:30	26.1	1.38	34.1	833.33	93.6	833.94
13:00	26.1	2.93	37.77	834	103.9	848.43
13:30	26.15	4.38	40.77	803.77	97.47	807.26
14:00	26.2	4.29	38.87	774.07	99.03	795.81
14:30	26.2	3.97	38.3	749.9	104.73	820.79

<i>15:00</i>	26.2	3.57	39.73	712.23	109.23	828.87
<i>15:30</i>	26.3	3.52	38.63	654.7	100.07	799.98
<i>16:00</i>	26.4	3.75	39.37	595.37	92.23	778.25
<i>16:30</i>	26.45	3.66	40.57	529.7	90.63	745.88
<i>17:00</i>	26.5	3.55	39.37	465.33	88.97	727.86
<i>17:30</i>	26.15	3.82	39.87	401.43	87.1	713.32
<i>18:00</i>	25.8	2.99	40.07	336.63	82.8	695.1
<i>18:30</i>	25.35	3.24	40.97	266.9	75.34	638.26

Appendix 3 – Interview Guide Preschool Teacher

1. HUR SKULLE DU BESKRIVA KVALITETEN AV UTEMILJÖN PÅ ER FÖRSKOLA?
 - Hur upplever du den generella temperaturförhållanden på förskolans utemiljö?
 - Upplever du att temperaturförhållanden på din förskola är mer eller mindre lämpad för vissa årstider eller vädersituationer än andra?

2. VÅREN OCH SOMMAREN 2018 VAR OVANLIGT VARM OCH SOLIG, HUR PÅVERKADE DET FÖRSKOLAN?
 - HUR PÅVERKADES
 - BARNEN?
 - PERSONALEN?
 - VERKSAMHETEN SOM HELHET?

3. HUR STOR PÅVERKAN ANSER DU ATT FÖRSKOLEGÅRDENS UTEMILJÖ HAR FÖR DIG SOM LÄRARE/BARNSKÖTARE/REKTOR Etc. FÖR ATT SE TILL ATT BARNEN MÅR BRA UNDER VARMA DAGAR?

4. KAN DU BESKRIVA VILKET ANSVAR OLIKA AKTÖRER HAR GÄLLANDE VÄRMESTRESS?

5. VILKA ÅTGÄRDER KAN FÖRSKOLAN(PERSONALEN) GÖRA FÖR ATT MINSKA VÄRMESTRESS PÅ FÖRSKOLEGÅRDEN?

6. UPPLEVER DU ATT VÄRMESTRESS PÅ FÖRSKOLEGÅRDAR ÄR ETT PROBLEM?

7. HAR SOMMAREN 2018 PÅVERKAT DIN OCH FÖRSKOLANS SYN OCH MEDVETENHET OM VÄRMESTRESS OCH HUR MAN SKA HANTERA VÄRMEBÖLJOR?

8. VILKA KRAV OCH RIKTLINJER FINNS SOM REGLERAR HUR NI SOM FÖRSKOLEÄRARE SKA AGERA VID RIKTIGT VARMA DAGAR?
 - Varifrån kommer dessa ev. riktlinjer och krav?

Appendix 4 – Interview Guide Municipal Actor

1. I VILKEN UTSTRÄCKNING SKULLE DU BEDÖMA ATT MEDVETENHETEN KRING VÄRMESTRESS, SAMT VÄRMESTRESS I RELATION TILL FÖRSKOLOR, ÄR I STADEN IDAG?
 2. HUR ARBETAR NI (SOM FÖRVALTNING) STRATEGISKT INFÖR ATT MÖTA ETT FRAMTIDA VARMARE KLIMAT NÄR DET GÄLLER FÖRSKOLOR?
 3. VILKA MÖJLIGHETER FINNS DET FÖR ER ATT PÅVERKA VÄRMEFÖRHÅLLANDEN PÅ FÖRSKOLEGÅRDAR I GÖTEBORG? (alltså ungefär vad kan ni i er position göra?) OCH VAD GÖR NI?
 4. HAR DEN VARMA VÅREN OCH SOMMAREN 2018 FÖRÄNDRAT MEDVETENHETEN KRING FRÅGOR OM VÄRMESTRESS
 5. VILKET ANSVAR HAR STADEN/FÖRVALTNINGEN/(NI?) FÖR ATT SE TILL ATT DET SKAPAS HÄLSOSAMMA VÄRMEFÖRHÅLLANDEN PÅ FÖRSKOLEGÅRDAR?
 - Hur bedömer man vad som är lämpliga värmeförhållanden?
 6. VAD KAN PERSONALEN PÅ FÖRSKOLOR GÖRA FÖR ATT MINSKA PÅ VÄRMESTRESSEN?
 7. SER DU NÅGRA MOTSÄTTNINGAR FRÅN ANDRA INTRESSEN ELLER MÅL SOM STADEN ARBETAR MED SOM KAN STÅ I KONFLIKT MED ATT MINSKA VÄRMESTRESS PÅ FÖRSKOLEGÅRDAR?
 - Vad får det för konsekvenser?
-