Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Environmental characteristics and school travels made by foot and bicycle

- A case study of four compulsory schools in Sweden

Agnes Landefjord & Marit Ripel

Master Project • 30 credits
Hållbar stadsutveckling – ledning, organisering och förvaltning
Alnarp 2018

Environmental characteristics and school travels made by foot or bicycle - A case study of four compulsory schools in Sweden

Utemiljöers karaktär och skolresor med gång och cykel - En fallstudie av fyra grundskolor i Sverige

Authors: Agnes Landefjord & Marit Ripel

Supervisor: Märit Jansson, SLU, Department of Landscape Architecture, Planning and Management

Co-supervisor: Neil Sang, SLU, Department of Landscape Architecture, Planning and Management

Examiner: Mats Gyllin, SLU, Department of Work Science, Business Economics and Environmental Psychology

Co-examiner: Mark Wales, SLU, Department of Work Science, Business Economics and Environmental Psychology

Credits: 30

Project Level: A2E

Course title: Master Project in Landscape Architecture

Course code: EX0814

Programme: Hållbar stadsutveckling – ledning, organisering och förvaltning

Place of publication: Alnarp

Year of publication: 2018

Cover art: Drawn by Kiami Ripel Frederico

Online publication: http://stud.epsilon.slu.se

Keywords: Children, School transportation, Walking, Cycling, Built environment, Independent mobility, Sustainable mobility, GIS.

SLU, Swedish University of Agricultural Sciences
Faculty of Landscape Architecture, Horticulture and Crop Production Science
Department of Landscape Architecture, Planning and Management

I Abstract

Children's active and independent school travels have in recent decades decreased considerably. What determines the travel mode choice among children is complex, as there are several social and environmental factors impacting how children travel. It is not clear to what extent characteristics of the environment are influencing children's school travel behaviour. This thesis aims to study this relationship by comparing children's travel mode choice at four Swedish compulsory schools, with characteristics of the environment around the schools. The study is based on travel mode data collected by the research project Kidscape II. GIS-based methods were used to map environmental variables around the schools. These were based on Mitra's (2013) conceptual framework of the environment and school travel behaviour. Walking and cycling were studied as two separate travel mode choices.

Differences in travel mode choice was found between the four schools. The mapping of environmental features gave a comprehensive description of the environment around the schools, which contributed to the understanding of travel mode choice at the four schools. The relationship between travel mode choice and environmental variables was tested for correlation with Spearman’s ranked correlation test. The findings from this test indicate a relationship between walking and cycling and the environmental variables *child population density* and *proportion of buildings with an “eyes on the street”-effect*. The indication of a relationship in this data does not demonstrate evidence in a general sense, but shows variables that would be interesting to study on a larger scale, using more spatially detailed travel data

Keywords: *Children, School transportation, Walking, Cycling, Built environment, Independent mobility, Sustainable mobility, GIS.*

II Sammanfattning

Barns aktiva och självständiga skolresor har minskat avsevärt de senaste decennierna. Vad som avgör barns transportmedelsval är komplext, då flera olika sociala och fysiska faktorer påverkar hur barn reser. I vilken utsträckning miljöns karaktär påverkar barns skolresebeteende är oklart. Den här uppsatsen syftar till att studera den här relationen, genom att jämföra barns val av färdmedel till skolan vid fyra svenska grundskolor, med faktorer i miljön kring skolorna. Studien är baserad på resedata som samlats in i forskningsprojektet Kidscape II. GIS-baserade metoder har använts för att kartlägga miljövariabler runt skolorna. Dessa baserades på Mitras (2013) konceptuella ramverk kring miljö och skolresebeteende. Gång och cykel har studerats som två separata färdmedelsval.

Skillnader i färdmedelsval hittades mellan de fyra skolorna. Kartläggningen av miljövariablerna gav en omfattande beskrivning av utemiljön till de fyra skolorna, vilket bidrog till förståelsen för hur barnen i studien valde att resa till skolan. Relationen mellan färdmedelsval och miljövariabler testades för korrelation med Spearmans rangkorrelation. Resultaten från testet indikerar en relation mellan färdmedelsval och miljövariablerna *befolkningsdensitet för barn* och *proportion av byggnader med en "ögon på gatan"-effekt*. De relationer mellan miljö och färdmedel som indikeras i denna studie är inte bevis för en relation i en generell mening, men visar vilka variabler som skulle vara intressanta att studera på en större skala, med mer rumsligt detaljerad resedata.

Nyckelord: *Barn, Skolresor, Gång, Cykel, Byggd miljö, Självständig mobilitet, Hållbar mobilitet, GIS.*

III Preface

The base for this topic is our common interest in research relating to mobility and how cities better can adapt to sustainable mobility solutions. It should be obvious that children are included in the process since values and practices that we want to see in the future, are bridged by the children of today. However, this is not the reality we face as children's reported travel behaviour change from being active to inactive. In an intense and dense built environment, where people and vehicles share the same space, spatial conflicts are arising, which is restricting for children's mobility.

This thesis is the final project of the master programme Sustainable urban management at the Swedish University of Agricultural Sciences, Alnarp. In the programme we have learned that sustainable urban development is about identifying the conflicts and to always keep a holistic view that a sustainability perspective includes. With these perspectives we want to engage in the research of understanding what makes an environment child-friendly and how this relates to children's school travel behaviour.

We share a background in geography but from different departments, physical geography and human geography, which has been useful as we have complemented and learned from each other. The thesis is the result of reflections and work from both of us, as we have worked together throughout the entire process.

We would like to thank the research group of the project Kidscape II for sharing their data with us. We could never have realised this study without their input. We would also like to thank our amazing supervisors at SLU, Märit Jansson and Neil Sang, for encouraging and questioning us in this process. Thanks also to the statisticians at SLU for valuable input on what was possible and not possible to do with our material. And many thanks to Kiami for the beautiful drawing of your school way.

Agnes Landefjord & Marit Ripel
Alnarp, 2018

IV Definitions

Environment: Our definition of the environment refers to the physical environment, but we recognize that social aspects are interconnected.

Mobility: Mobility focuses not only on transport systems but also includes the understanding of how movements affect social aspects and power relations (Koglin, 2013).

Independent mobility: This refers to the freedom children have to move and play in their local neighbourhood, unaccompanied by adults (Shaw et al. 2015).

Geographical data: Data which contains spatial features, e.g. position and shape, and non-spatial features, e.g. street names or speed limits. Geographical data can be processed in a geographical information system (Harrie & Eklundh, 2013).

Geographical information system (GIS): A computerised information system for collection, storing, processing, analysis and visualisation of geographical data (Harrie & Eklundh, 2013).

Geographical reference system: A coordinate based system to establish the position of geographical objects. There are different international, national and regional reference systems (Agren & Hauska, 2013).

SWEREF 99: The official Swedish reference system (Agren & Hauska, 2013).

Orthophoto: An aerial photo which has been adjusted to a geographical reference system (Agren, Eklundh, Olsson, Harrie & Klang, 2013).

For many children growing up today,
the luxury of moving about freely in their
neighbourhood is no longer theirs to enjoy.

(Cele, 2006, p. 39)

Table of contents

1. Introduction

In recent decades, changes in children's travel behaviour have been observed. The change is a shift from traveling predominately by active transport modes such as walking and cycling, towards being inactive and travel by motorized transport modes such as being escorted in private cars (Ahern et al., 2017; Larsen et al., 2009). This trend has been observed in Sweden as well, where an overall decrease in bicycle trips per capita has occurred. The greatest decrease is found among children and young adults. Measured in distance travelled per inhabitant, children aged 6-14, cycled 42 percent shorter in 2014 compared to in 1995 (Trafikanalys, 2015). In more recent years, findings from comparing school journeys in Sweden from 2009 to 2012, show that the amount of children travelling actively to school during summer has declined from 66 to 58 percent, and in winter from 57 to 48 percent (Trafikverket, 2013). As active transport modes have decreased, inactive transport modes have increased (Trafikverket, 2013). Additionally, the percentage of children who live within 2 km from their school has decreased from 71 percent in 2003 to 59 percent in 2012 (Trafikverket, 2013). In 1992 a school reform was carried out, which made it possible for parents to choose another school for their children than the school assigned by the municipality. Children who go to the school they were assigned to, cycle to school to a greater extent (33 %), compared to children who chose to go to a different school (23-24 %) (Niska, et al., 2017).

The change in travel modes has an effect on children's independent mobility (Mitra, 2013). Children's independent mobility has been defined by Shaw et al. (2015) as the freedom children have to move and play in their local neighbourhood, unaccompanied by adults. Why children's independent mobility is important can be summarized in two major perspectives:

1. It is a human right captured by the United Nation Convention on the Rights of the Child, and should therefore be seen as a fundamental value that every child should be able to enjoy. A prerequisite for achieving this is a safe outdoor environment (Shaw et al., 2015).
2. Children's independent mobility is linked to a wider set of issues, and a loss of independent mobility will have consequences and effects on children’s wellbeing, health and personal development (Shaw et al., 2015; Westman, 2017).

The local area around the schools can be seen as the school’s *extended outdoor environment*. It should be planned with a child's perspective in order to facilitate independent mobility among school children of all ages. A more child-friendly design of the extended outdoor environment around the schools might trigger active travel modes, such as walking or cycling. The impact of the built environment on physical activity and health has gained increased attention in research. The significance of the built environment for walking and cycling has been measured by studying e.g. infrastructure, recreational features and land use (Gray, et al., 2012). However, most of the research on active travel behaviour is focused on adults, whereas children have gained little attention (Mitra, 2013). Children use pathways and streets not only for transport, but also to play and explore (Björklid, 2004). Rather than translating the findings from research on adult travel behaviour, there is a need to study the relationship between children's travel behaviour and the built environment (Mitra, 2011). To what extent the infrastructure impacts children's use of active travel modes is unclear (Niska, et al., 2017), but attempts to concretise this has been made in several studies (Broberg & Sarjala, 2015; Ewing, et al., 2004; Larsen, et al., 2012; Mitra & Buliung, 2014; Panter et al., 2010; Schlossberg, et al., 2006; Timperio, et al., 2006).

In this thesis we want to study children's school travel habits, where we focus on walking and cycling, with a comparison of the characteristics found in the extended outdoor environment. Children's school travels are often studied as active travels, in one merged category, rather than studying walking and cycling separately. However, walking and cycling are two fundamentally different travel modes, and the environments that might influence them may differ (Tight & Giovani, 2010). Therefore, we want to study cycling and walking separately.

1.1 Children in sustainable development

In the report *Our common future,* the Brundtland commission has defined sustainable development as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs" (United Nations, 1987). The concept of sustainable development is often criticised for lacking a clear definition and being too vague, and therefore needs to be broken down and concretised (Isaksson, 2006). Children are central in the definition in two ways. Firstly, because of the concern for future generations, as every new generation of children motivates a development that is sustainable. Secondly, the values and practices we want to see in the future, are bridged by the children of today. Consequently, what practices children adapt to is of importance.

There is a consensus in the discourse of sustainable development that sustainability is about balancing economic growth, environmental protection and social justice. Agenda 2030 is an effort to concretise the desired future. In 2015 the world leaders agreed on 17 global goals for a sustainable development, with the aim to end poverty, fight inequality and stop climate change to year 2030 (Global goals, n.d.-a). Goals that are applicable to this study are goal 3, 9 and 11. Goal 3 is about good health and wellbeing, and aims to "ensure healthy life and promote well-being for all at all ages" (Global goals, n.d.-b). Goal 9 is about industry, innovation and infrastructure (Global goals, n.d.-c). Goal 11 is about sustainable cities and communities and aims to "make cities and human settlements inclusive, safe, resilient and sustainable" (Global goals, n.d.-d).

The "planner's triangle" represents the three fundamental priorities of the concept of sustainable development, i.e. economic growth, environmental protection and social justice, but also the three associated conflicts between these priorities (Campbell, 1996). Naming the conflicts in sustainable development has been important. Scott Campbell (2012) wrote "The more it stirs up conflict and sharpens the debate, the more effective the idea of sustainable development will be in the long run" (Campbell, 2012:414). Theoretical perspectives on sustainable urban development, motivates a need for change and reminds us to keep a holistic and long-term perspective. Studies on sustainable mobility provide alternatives to the current car-dependent transportation system (Banister, 2008). Developing a sustainable mobility is seen as central when it comes to creating sustainable cities and environments (Banister, 2008).

1.2 Research project Kidscape II

This study builds upon data from the research project Kidscape II, which collected travel mode data at four compulsory schools in mid/southern Sweden, in 2013. The research project aimed to investigate the significance of the outdoor environment of the compulsory schools and its impact on children's physical activity, sun exposure, sleep and general health. Findings from the previously analysed and published Kidscape II studies show that moderate to vigorous physical activity during outdoor stay was in average 39 minutes per day for the entire school year (Pagels et al., 2014). Further, it was concluded that the school's outdoor environments' design and outdoor play time may be a potential health promoter during school hours as the outdoor environment was found to have an impact on children's physical activity (Pagels et al., 2014). What is yet to be analysed in Kidscape II, is the impact of the schools *extended* outdoor environment and if the local area around schools has an impact on children's daily travel.

1.3 Objective and research questions

The focus of this thesis is on the environment and how it relates to travel mode. Our research objective is to investigate the extended outdoor environment of four compulsory schools in mid/south Sweden and the relationship between the school travel modes walking and cycling. This is studied through the following research questions:

- How are the characteristics of the environment relating to the proportion of children walking and cycling to school?

- What planning conflicts for children's walking and cycling can be found?

1.4 Outline of the thesis

In *chapter 1* we present the background and the objective of the study.
In *chapter 2* we introduce the theoretical framework that gives a background to the context.
In *chapter 3* we explain the used methods and material that is the foundation for our analysis.
In *chapter 4* we present the results from the compiled analysis.
In *chapter 5* we discuss the outputs of the analysis and its strengths and weaknesses.
And lastly, in *chapter 6* we present the final conclusion of this study.

1.5 Description of the schools

In the Kidscape II project, four schools were participating. They will be addressed as School 1, School 2, School 3 and School 4. All of the schools are municipal schools and located in residential neighbourhoods.

School 1 is located in a small town and has around 400 pupils. The neighbourhood around the school consists of residential areas. There is one competing school in the town. The town is surrounded by forest and arable land.

School 2 is located in a rural village approximately 15 kilometres (as the crow flies) from the regional city centre. The school has around 300 pupils. There are no competing schools close to School 2. The direct surroundings of the school consist of residential areas, dominated by single family houses and residential streets. Forest and arable land surrounds the village.

School 3 and 4 are located in the same middle sized city, about 1 kilometre apart. The schools have around 700 and 600 pupils. Even if they are located in a similar environmental context, there are differences in the closest surrounding neighbourhoods. **School 3** is located in a busier neighbourhood, with more traffic and higher population density. **School 4** is located in a neighbourhood dominated by single family houses and low speed residential streets. There are a few competing schools in the surrounding area.

2. Theoretical framework

Common for studies on environments suitable for children is to combine one or more theoretical frameworks, similarly we have adapted an interdisciplinary perspective. To give a background of the context which our study exists within, we will in in this chapter review literature from urban development, sustainable mobility and environmental psychology. We will also review previous research which has studied children's school travel behaviour in relationship to environmental characteristics.

2.1 Child-friendly environments

Over the years, the child perspective has increased in urban planning. The *Convention on the Rights of the Child* (UNCRC), established by the UN in 1989, has had a great impact on raising the child perspective. Three important articles in the convention are Article 3, Article 12 and Article 31. Article 3 states that the best interest of the child should be the primary consideration in decisions affecting children, and applies particularly to budget, policy and law makers. Article 12 states that every child has the right to express their view and the right to be heard. Article 31 states that every child has the right to play (United Nations, 1989). Children's ways of obtaining knowledge can be by independently exploring their own neighbourhood and by means of play (Björklid, 2004). In this sense, when the UNCRC stresses children's right to play it indirectly states children's right to move freely (Björklid, 2004).

The concept of child-friendly cities is a strategy that strive to implement the UNCRC, and can be seen as the response to fast urbanization and the transformation of the city where areas considered safe for children slowly disappears. According to a definition by Chatterjee (2005) the concept of child-friendly cities "embodies a commitment to create better living conditions in cities for all children by upholding their basic human rights" (Chatterjee 2005, p. 2). Both the UNCRC and the concept of child-friendly environments, are initiatives used to encourage local governments to make decisions in the best interest of the children (Haikkola et al. 2007). The planning structure in Sweden gives the municipalities the final decision on how the local environment should be planned (Nyström & Tonell, 2012). Swedish government has established that all authorities must implement the UNCRC in all decisions concerning children (Unicef, 2008). This means that the children's rights are leading the different legislations controlling the municipalities, e.g. the planning and building act legislation. But, when local politicians are the policy makers for the local environment, children's right to the city and independent mobility are not usually their key strategy. In an international comparative study on children's independent mobility, it was found that independent mobility was something desirable, but is not regarded as a right that should be accorded to children (Shaw et al., 2015).

A child-friendly city has to fulfil different needs of the children (Chatterjee, 2005), as children who live in the same environment will have different needs and use the environment in various ways (Cele, 2006). Chatterjee (2005) asks if it is truly possible to make a large area, such as a city, child-friendly, and claims that before we can talk about child-friendly cities we have to narrow the concept down to rather talk about child-friendly places. This is supported by the children themselves, who express that the immediate environment is the most important for them (Horelli, 2007). The local environment is the environment that surrounds places where children spend their time. According to Horelli (2007), the environment means the living environment in its complexity. The environment refers not only to the natural environment but also to the whole physical, psychological, economic, political and cultural environment. Björklid (2004) has a similar understanding of what should be included in an environment when studying children and accessibility.

2.1.1 Environments appreciated by children

In order to clarify the concept of child-friendly environments, Horelli (2007) has come up with ten normative dimensions that define environmental child-friendliness. The ambition with these normative dimensions is to relate children's experiences to something that can be used as analytical or political instruments when planning. The ten normative dimensions are: 1. Housing and dwelling, 2. Basic services 3. Participation, 4. Safety and security, 5. Family, kin, peers and community, 6. Urban and environmental qualities, 7. Resource provision and distribution; poverty reduction, 8. Ecology, 9. Sense of belonging and continuity, and lastly 10. Good governance.

From a study done by Nordström (2010) we can learn how a child-friendly environment is defined by Swedish 12-years-olds living in rural areas, suburban areas and in the inner-city. Their answers on what a child-friendly city is, was interpreted after Horellis ten normative dimensions. Three dimensions counted for the majority of the responses, these are further described below, while the other dimensions received only a few responses.

2. Basic services
The dimension reflects on infrastructures that children want in their environment. Horelli (2007) describes this dimension as services, such as health, education or transportation, that are placed within short distances in areas where children live and help facilitate their everyday life. In a Swedish context, this was the dimension with the highest respondent score from all the children who participated. For the children living in the rural areas, their school was stated as the most interesting public environment. The children living in the inner-city, on the other hand, expressed wishes for better parks to play in and entertainment facilities.

4. Safety and security
The dimension covers the conditions that were found threatening for children's safety and security. Horelli (2007) describes this dimension as a guarantee of physical and physiological safety, such as child welfare and the prevention of violence. It is also described as an environment which is tolerant and pluralistic, and have an in general safe transport system and public places. Examples given by the Swedish children of situations found threatening are mainly about traffic, but also about public places and social situations at the school, in the neighbourhood or at home. Interestingly, children from geographically different places have responded differently on this dimension. For children from the suburban areas, this was the

dimension with the highest scores, while only a few children in the rural areas gave answers responding to the safety and security dimension. Nordström (2010) contemplate that the reason why the children in the suburbs strongly emphasize safety and security, could be an indicator of the children not seeing their environment as safe.

6. Urban and environmental qualities
Horelli (2007) describes this dimension as a local environment with high functional, aesthetic and cultural standards where there is a variety of interesting affordances and arenas for activities. Among the positive environmental qualities, a desire was expressed for more nature such as parks to play in and for more grass in the school yards. Especially the children in the rural area expressed nature as a place to run, swim and have fun. Nordström (2010) explains that this reflects children's interest to be outdoors and to be with other children. Among the negative environmental qualities, there was a concern about littering in the streets, and that there should be less noise. Urban and environmental qualities was a dimension that was found important amongst children in the inner-city and in the rural area, but that few of the children in the suburbs mentioned in their responses.

The normative dimensions also make it possible to compare what children consider to be child-friendly in different countries. When comparing the response of the Swedish children with the dimensions found important by children in Finland and Italy, one can see a broader perspective of what children find to be a child-friendly environment. In the comparative study done by Haikkola et al. (2007) both Finnish and Italian children's responses were concentrated around the dimensions *basic services*, *safety and security*, *family, kin and community* and *urban and environmental qualitie*s. The Finnish children understood *safety and security* as social safety, while the Italian understood it as physical safety. In Finland, children limited their movement because of scary people around the pubs and shopping malls. In Italy, children limited their movement because of traffic and urban decay. Another difference was in the children's autonomy. The Finnish children described their environment as spacious and open, and they appreciated the possibilities to play at the sports field or meet friends at the youth centre, while the Italian children described a longing for places where they could move more freely and have the opportunity to interact with friends (Haikkola et al., 2007).

The dimension *family, kin and community* was important to Finnish and Italian children, but this was not mentioned by the Swedish children. Horelli (2007) describes this as the opportunity for close social relationships with family, kin and friends. In the Swedish study, Nordström (2010) points out that only the children in the rural area expressed a sense of belonging to a community in their responses. This dimension does not necessarily describe an environment, but rather who the children like to spend time with if they had the possibility to freely access the environment.

2.1.2 Child-friendly mobility

Environments differ in the extent to which they can offer opportunities for independent mobility. A growing urbanization and intensified building density have consequences on children's use of the outdoor environment. Rissotto and Giuliani (2006) claim that urban spaces progressively have become dehumanized, as traffic has increased and less open space is left available for the public. Francis and Lorenzo (2006) state that children are increasingly disappearing from the urban scene, as they are not using the public spaces, or only doing so under much greater adult surveillance than earlier generations. Björklid (2004) focuses on what it means for a child to be able to move freely around without an adult's supervision, and claim that:

> "Walking or cycling without adult supervision provides children with an opportunity for direct experience of their environment.[...] Children who are driven to school or other activities, miss out on all this informal learning. The outdoor environment is one of children's most basic developmental environments and must be respected as such."
>
> (Björklid, 2004, p. 61)

Studies from environmental psychology have found that places are fundamental in the developing of a child's self-concept and identity (Spencer & Blades, 2006). Empirical research show that children who walk to school, generally have developed a better spatial cognition than children who are driven to school by bus or private car. As a consequence of a better spatial cognition, children who travel by active transport modes have developed qualities, which they use to experience their local environment (Rissotto & Giuliani, 2006). Spatial information is coupled with social information, and when learning how to experience the environment, the children also learn something about other people and personal involvement. Thus can the children become aware of the range of social, physical and behavioural differences that people in a community represents (Rissotto & Giuliani, 2006).

In an international comparison Sweden has a high degree of independent mobility (Shaw et al., 2015). However, as the everyday lives of children are increasingly institutionalized, they spend most part of their day in schools, day-care and leisure activities. Therefore children spend more time commuting between different places and less time in their local neighbourhood, even in Sweden (Cele, 2015). There is a strong trend of increasing mobility, as technological development has decreased the cost of travel (Banister, 2008). At the same time, children's active and independent mobility has significantly decreased. Whitzman et al. (2010) write that: "Increasing mobility for adults [...] has been bought at the cost of reducing children's mobility" (Whitzman et al., 2010:474). Promoting the use of active transport at an early age may encourage continued patterns of active mobility later in life (Mitra, Buliung & Roorda, 2010). In a recently published national strategy to promote cycling, children's right to independent mobility is stated (Regeringskansliet, 2017). Still, a child's independent travel is a gradual accomplishment that includes showing of routes or accompaniment by component peers (Cornell & Hill, 2006). In order to increase cycling among children it is stated that efforts in traffic education should be combined with measures in the physical environment (Regeringskansliet, 2017).

Walking and cycling has until recently been given little attention in transport planning, but with the understanding of the need for sustainable mobility, walking and cycling has received an increasing interest (Tight & Giovani, 2010). An increase of active modes of transportation at the cost of private cars, would have positive impacts on environment and health, e.g. in form of decreased emissions, less noise and more physical activity (Banister, 2008). However, there are difficulties with improving the conditions for walking and cycling, in order to make them real alternatives to the car. Private car use has become an essential part of modern lifestyles, as it enables people to live complex lives where time is precious (Tight & Giovani, 2010). If walking and cycling takes more time, in order to save time, parents are likely to drive their children to school (Anund, et al., 2013).

Transport and land-use are highly interconnected processes and land-use patterns are essential for the understanding of travel behaviour. The location of homes, schools, work and other activities affects how people travel (Wee, et al., 2013; Mitra, 2013). Transportation development has enabled a greater individualisation, in the form of single-family dwellings and urban sprawl (Essebo & Baeten, 2012). This embedded car-dependence in many existing urban structures is difficult to reverse and has made cycling, walking and public transport less attractive modes of transportation (Banister, 2008). By a conscious land-use and transport planning, the distance between activities can decrease and therefore also the need for transportation. Sustainable mobility can this way be built into the urban layout (Banister, 2008).

2.2 Categorizing the environment

One of the first attempts to create a framework of how the environment impacts children's travel mode choice was made by McMillan (2005). This contribution showed the need to re-conceptualize the built environment to a child perspective, instead of transferring knowledge from adult behaviour (Mitra, 2013). McMillan (2005) argue that children's travel behaviour is a product of parent's perceptions and decision making. The environment has only an indirect link to children's active transportation, as the environment contribute to the parent's decision process. Based on the perception of the environment, the parents decide whether children are allowed to walk or cycle to school. Mitra (2013) argue that since the framework does not emphasize a child's role in the travel mode decision, it is more applicable for young children with less independency (Mitra, 2013).

Panter et al. (2008) criticise McMillan for not integrating the varied components of the environment that had been shown to influence the parents. Therefore, in their study the focus is on introducing an ecological approach to understand children's travel behaviour, and they identify four domains which could influence active school travel. These domains include individual factors, such as attitudes, perceptions and socio-demographic factors; the built environment, such as neighbourhood or travel route; external domains, such as weather or travel cost; and main moderators, such as age, gender or distance. Panter et al. (2008) hypothesized that the parents *and* the children participate in the process of deciding on a travel mode, and booth's perceptions are important. Mitra (2013) argues that the framework is an extensive summary of factors which correlate with active travel modes, but it is less clear in explaining the behavioural processes which make these factors interesting.

Mitra (2013) saw the need of a behavioural model that explains children's travels from both a social and an ecological perspective. The conceptual framework he suggests therefore consists of a behavioural model that combines major theoretical approaches from transportation, urban planning health and environmental psychology. The model has also adapted a multi-level approach, as the travel outcome of a child is based on the influence of the urban environment, the household and personal characteristics of a child. In the framework, the social-ecological environment is categorised as five domains which can be seen as the intervening causal factors for school travel outcome. These are; proximity to school, traffic and personal safety, street connectivity, comfort and attractiveness and the opportunity to produce and maintain social capital. Pointed out by Mitra (2013) is that the hypothesized relationship of these domains should be tested by designing empirical research based on the model.

2.3 Previous research

Several efforts have been made to quantify the effect of different environmental factors on active school transportation by objective measures of the environment (Broberg & Sarjala, 2015; Ewing, et al., 2004; Larsen, et al., 2012; Mitra & Buliung, 2014; Panter et al., 2010; Schlossberg, et al., 2006; Timperio, et al., 2006). Some of these studies have used GIS-based methods to collect and analyse data.

Ewing, et al. (2004) have tested the relationship between active school travel and a number of built environmental factors. The study was compiled in an American context and studied travel time, school size, presence of sidewalks, and land-use factors such as density and land-use mix. Factors which proved to have a significant relationship with walking and cycling to school were *travel time to school* and the *presence of sidewalks*. They conclude that the relationship between the built environment and school travel mode choice still remains an issue, since their findings are partially inconsistent with previous findings.

Schlossberg, et al. (2006) have studied the effects of urban form and distance on active school travel, in an American context. They found that *distance* had a strong association with both walking and cycling. For walking they found associations between *street intersection density*, where high intersection density was associated with a higher probability of walking. However, no association was found with presence of major roads and railroads. They conclude that measures that can predict walking to school are not the same as measures that can predict cycling. They point out that their study only can establish associations and not causality.

Timperio et al. (2006) have studied this relationship using questionnaires to children and parents about perceptions of the environment, and using GIS to study the objective physical environment. The study was compiled in an Australian context. Negative associations were found between active school travel and parental perceptions about *lack of street lights*, *lack of signalised crossings* and *no other children in the neighbourhood*. Negative associations were also found with *busy road barriers*, *good connectivity* and *steep incline*. *Shorter distances* had a positive correlation with active school travels.

Panter, et al. (2010) have studied characteristics of the built environment which might influence walking and cycling, in England, using GIS to assess environmental attributes. A *high density of roads* was positively associated with probability of walking and a *high density of streetlights* was negatively associated with probability of cycling.

Larsen et al. (2012) have studied the relationship using GIS-linked surveys and statistical tests. The study is compiled in a Canadian context and studies the relationship between active travel modes and the built environment. They found positive associations between the likelihood of using active school travel modes and *shorter distances*, *higher land use mix* and *presence of street trees*. They also found that boys were more active than girls. They conclude that environmental characteristics are associated with travel mode choice and suggest that these factors are taken into consideration in the planning process.

Mitra and Buliung (2014) have studied the effect of neighbourhood environment on school travel behaviour, in a Canadian context. Their findings indicate that the environment both around the school and around the home were associated with the probability of walking to school. Environmental factors related to *safety* and *aesthetics* were associated with mode choice. The findings were however not generalizable to all neighbourhoods and were more accurate in some types of neighbourhoods. Therefore the authors emphasize the importance of studying this relationship at a local level.

Broberg and Sarjala (2015) have used Mitra's (2013) conceptual framework and the five domains of the socio-ecological environment, to study the relationship of environmental characteristics and active school travel. The study was compiled in Helsinki, Finland and used GIS-methods to collect and analyse data of the environmental variables. A number of different factors, compiled from previous research, were categorised under Mitra's five domains. The presence of these factors in children's school routes and home environments, were then tested for correlation with school travel data. *Proximity*, *connectivity* and *traffic safety* seemed to be the most relevant domains. The findings were partially contrasting with findings from previous research, which the authors discuss could be explained by different geographical contexts.

The used methods have also been criticized. Wong et al., (2011) have reviewed 14 studies which use GIS to measure the relationship between active school transportation and built environment features, and critically discussed the methods used. Most of the reviewed studies were compiled in an American context. They conclude that distance is the only factor where the findings are consistently associated with active school transportation. For land-use mix, residential density and intersection density, the findings are inconsistent. Factors such as busy road crossings and greenery has not been as frequently studied, but the current findings are inconsistent. Despite the inconsistency, they argue that objective measures of the built environment still can be relevant to understand active school transportation. However, there are methodological challenges. How the built environment influence active school transportation may differ from place to place. There are also a lot of inconsistencies in the methods used, when it comes to buffer zones, quality of data and estimation of school routes. They argue that it is also important to compare parents' and children's perceptions of the built environment, with objective measures of the built environment.

3. Material and methods

In this chapter we describe the methods for how the analyses were performed and what material we used. Since the thesis builds upon data from the research project Kidscape II, the selection of study targets and geographical locations follow their research design. The objective with the analysis, is to study if the environment can help explain why the children chose to travel as they did in the Kidscape II measurement. The method aims to compare the travel mode data with the extended outdoor environment of the four schools, by mapping different environmental variables around the schools. When we studied the extended outdoor environment of the schools, the study area had to be within a reasonable distance and travel time from the school, for children to walk and cycle. Therefore, the first part of the GIS-based method is focused on mapping accessible areas based on travel time. The second part builds upon the results from part 1, and focuses on mapping environmental characteristics.

3.1 Data from Kidscape II

The collected data from Kidscape II consists of measurements of transportation mode to school. Target for the Kidscape II study were children in 2nd and 5th grade. Data was collected during four consecutive school days at two occasions, in March 2013 and in May 2013. In March 159 pupils (2nd graders = 74, 5th graders = 85) participated in the study, while in May 156 pupils (2nd graders = 74, 5th graders = 82) were participating. In general, the same pupils participated in the two measurements.

Information of children's travel habits was collected with a questionnaire that the children filled in at arrival to school. A questionnaire has similarities with a personal interview but different from an interview the respondent answer the questions without the interviewer to be able to follow up (Trost & Hultåker, 2016). The advantage of a questionnaire is the possibility to reach out to a large group of respondents, however it comes with a risk of blank answers or the respondent not fully understanding the questions (Trost & Hultåker, 2016). The questionnaire form was designed by the research group of Kidscape II. The children were asked about their mood and alertness and how they had travelled to school this day. They could select between the transport modes; walked, cycled, travelled by bus, travelled by car and other.

From the questionnaires we have found 871 travels to be valid for further analysis, compromising 69 percent of all measured travels. One travel is equal to one measurement day and the transportation mode used on that specific school journey. Of the valid travels, 440 (girls = 211, boys = 229) were made by 2nd graders and 431 (girls = 227, boys = 204) were made by 5th graders. The gender distribution at the four schools can be seen in Table 1. As there were little or no data on travel mode for School 3 and 4 in May, we have decided to not look at seasonal variation in travel mode choice.

Table 1: Number of pupils participating at each school

	Number of pupils
School 1	**191**
Girls	103
Boys	88
School 2	**235**
Girls	113
Boys	122
School 3	**224**
Girls	86
Boys	138
School 4	**221**
Girls	136
Boys	85

Weather conditions were observed and collected every morning at the four schools, see Table 2. The weather conditions were classified according to the National Oceanic and Atmospheric Administration (NOAA) and follows the index: 1 = cloudless, 2 = partly cloudy, 3 = white cloudiness, 4 = grey cloudiness, 5 = precipitation.

Table 2: Weather during time of measurements. 1 = cloudless, 2 = partly cloudy, 3 = white cloudiness, 4 = grey cloudiness, 5 = precipitation, na =no data

	Weather in March				Weather in May			
	day 1	day 2	day 3	day 4	day 1	day 2	day 3	day 4
School 1	3	5	3	2	4	1	2	2
School 2	2	3	1	1	2	3	2	na
School 3	3	1	3	2	3	3	2	5
School 4	3	1	3	2	3	3	2	5

3.2 Geographical data - a general overview

Geographical data describes the surrounding world and contains spatial features, e.g. position, shape, length or area. The aim of geographical data is to give a foundation for a good description of reality. As reality is too complicated to be able to fully reconstruct, the geographical data has to represent selective properties (Harrie & Eklundh, 2013). Consequently, all maps should be seen as a generalisation of reality, which can be more or less accurate. Geographical data also contains non-spatial data, which is linked to the geographical object. The non-spatial data is called *attribute* and can contain information like street names or speed limits (Harrie & Eklundh, 2013). Geographical data can be stored in a vector structure, which is used for separate geometrical objects, or in a raster structure, which is a grid of cells with numerical values (Eklundh & Pilesjö, 2013).

The data we have used to describe the environment around the four schools are the selective properties of roads, footpaths and cycle paths, buildings and land use cover as this was found relevant for the purpose of the used method. The used geographical data has been supplemented with attribute data from the Central Bureau of Statistics (SCB). In the process we have worked with both vector data and raster data. The mapping was done with ArcMap 10.5. All geographical data was downloaded from Swedish administrative authorities, with the reference system SWEREF 99.

3.3 Part 1: Distance modelling

The aim with this analysis was to determine areas from the school that, most likely, are reachable for a child that travels by foot or bicycle. As the travel mode data from Kidscape II did not contain information about the children’s travel route to school, the method aimed to model areas that could be seen as potential school ways at the four schools. The approach used to model distances from the schools, is the GIS-analysis tool *Cost distance*. This method will soon be described in more detail.

For each of the schools, a cost distance analysis was performed twice. The first analysis was based on average walking speed and the second was based on average cycling speed. This gave two distance models for further use, one showing the accessible areas when walking and the other showing accessible areas when cycling. For the continued analysis in part 2, the distance modelling gave a foundation for determining areas to be mapped.

3.3.1 Cost distance analysis

A cost distance model have many similarities with the function "route planner" that can be found on different navigator apps. Here, the concept is to find the best route between two given positions, e.g. a children's road from home to school. The advantage with a cost distance model is that only one known position is needed. This was useful since we only knew the position of the schools but not the children's homes.

From the known position, distances are calculated based on the costs given as travel time. Cost is not a price in SEK, but should be understood as a cost in travel time. For example, in the more advanced navigator apps, the user can choose between different transports modes such as car, bus or walking, these travel modes can be said to have different "cost" in travel time. Similarly, we have given two different costs to our models, the cost of walking and the cost of cycling. As walking takes longer travel time than cycling, walking have a higher cost than cycling. A workflow chart of the steps performed in the cost distance calculation, is shown in Figure 1.

Input data needed for the distance modelling, were estimations of average travel speed and geographical data describing roads for walking and cycling. The reliability of a geographical analysis is dependent on the quality of the data and the models used to perform it. Errors in the input data can reproduce in the further analysis and flaws in the model will have impact on the quality of the result. There will always be more or less weaknesses in a spatial analysis, since a model cannot reflect the complexity of reality (Wasström, Lönnberg & Harrie, 2013).

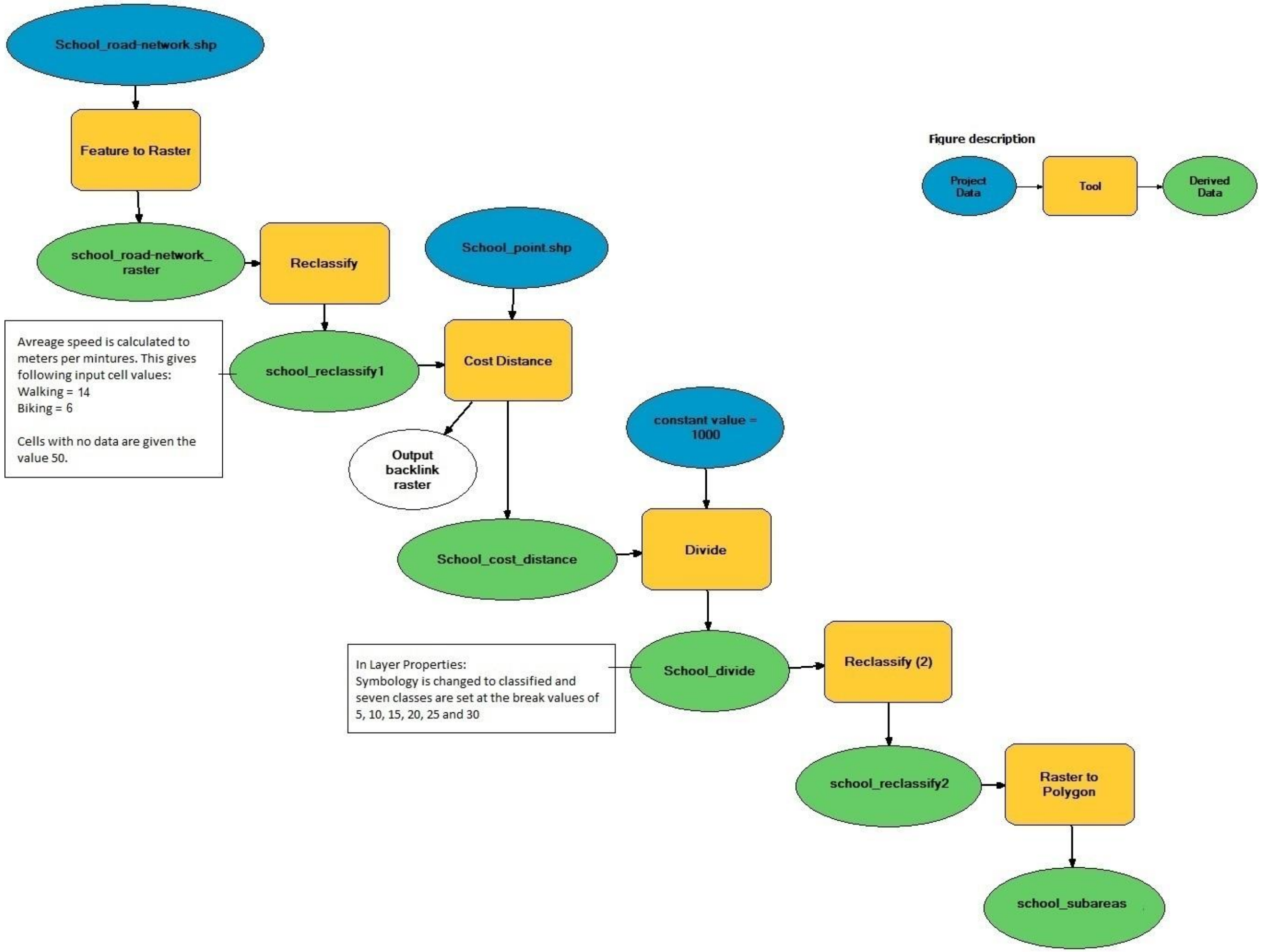

Figure 1: Workflow over part 1 of the GIS method. The chart shows that the school-road-network and placement of the school are used as input data in the model.

3.3.1.1 Defining a school-road-network

A major part of the analysis was to create a road-network of potential schoolways. Geographical data of road networks comes from the National road database (NVDB) and was downloaded from the online service *Lastkajen* from the Swedish Transport Administration (Trafikverket). NVDB contains data on all the roads and streets in Sweden and is also comprehensive for footpaths, moped and cycle paths (Trafikverket, 2018). When it comes to securing quality of the geographical data, ISO (International Organization of Standardization) has developed general quality standards for geographical data (Wasström, Lönnberg & Harrie, 2013) and the NVDB-data is guaranteed to have the quality of *SS ISO 19157 Data Quality* (Trafikverket, 2018). From NVDB we used road data with speed limits, footpaths and cycle paths.

Based on the NVDB-data we created our own road-network of connected paths and roads, which will hereafter be referred to as *school-road-network*. An important part of the connectivity was to map logical ways for children to travel, including shortcuts and informal connections in the network. Since the cost distance analysis is performed as raster layer we had to convert the school-road-network from vector to raster. It is possible to convert between vector data and raster data, but there will always be some information that is lost in the conversion (Eklundh & Pilesjö, 2013). To avoid problems where geometrical objects are lost due to placement in the same raster cell, the cell size can be scaled down to a lower size (Eklundh & Pilesjö, 2013). We used a raster cell size of 2 x 2 meters. In the process of categorizing a road-network we studied orthophotos from year 2014-2015 with a resolution of 0.25 meters and the function *Street View* in Google Maps with images from year 2010-2011. In combination with geographical data, e.g. buildings and land use, this gave us a good overview and local knowledge of the areas.

The school-road-network was classified after the categories shown in Table 3. These are the categories we have found essential to create a safe and connected road-network. What can be considered safe is subjective, but increased traffic has been stated a major factor for why children's independent mobility has decreased (Mitra, 2013). When we created the school-road-network, traffic safety was based on the prevalence of sidewalks, foot- and cycle paths and road speed limits. Roads that was not corresponding to any of these categories, or did not have a function for the connectivity, were excluded from the network. It is possible that some of the roads we excluded might be used by children. The school-road-network should therefore be seen as a generalisation of potential school ways.

Table 3: Categories used to create the school-road-network

Class	Category	Description
1	Footpaths, cycle paths and sidewalks	Non-motorised traffic, like walking and cycling, often have to share the same paths. Therefore we classified paths for walking and cycling, which are separated from motor traffic, in the same class. Sidewalks are also in this category. Bikeways were included in the network only when they were in low speed traffic.
2	Bikeway (separated lane in motor traffic)	
3	Zebra crossing	Zebra crossings were included in the NVDB-data, but additional zebra crossings were identified, from orthophotos and Google Maps Street View. Crossings without marking were identified and included in the network if they were important for the connectivity and if they crossed low speed roads.
4	Crossing without zebra marking	
5	Separated crossing, flyover, tunnel crossing	
6	Green open space	New line segments were added if we found that links were missing, such as shortcuts visible in orthophotos and Google Maps Street View.
7	Shortcut	
8	Residential street with sidewalk	Residential roads with low speed traffic and sidewalks were included in the network. Larger roads with higher speed limits were included if they had sidewalks. Some rural roads were included if they connected residential areas to the rest of the network, and had little traffic.
9	Less safe (but bikeable) road with sidewalk	
10	Country road, rural road	

3.3.1.2 Defining average travel speed

Finding an average travel speed for children that was directly applicable to our study was difficult. Thompson, et al. (1997) suggest that the average cycling speed, for recreational cycling among children aged 3 to 13, is 8.9 mph (14 km/h). The settings for their study was a street that was closed for traffic where cyclists could ride freely, in Seattle. Since they studied recreational cycling and the setting was different from our case we argue that it is not directly applicable to our study. Another study suggests 13.5 km/h as the average cycling speed for 10-12-year-olds, in an environment that encourage cycling in Scandinavia (Raustorp, Boldemann & Mårtensson, 2013). We decided to base the analysis on the speed 10 km/h, which is lower than the literature suggests. However, we find that this speed is more likely to represent the cycling speed for younger children and cycling in an environment that is not necessarily cycling friendly.

The walking speed we used for the calculation was 4.3 km/h, which according to Colclough & Owens (2010) is the average walking speed for an assisted child between 5 and 9 years old. This is slightly younger than the children in our study. This article also suggests 5 km/h as an average walking speed for children under 15 years old (Colclough & Owens, 2010).

Calculations with higher average speeds (walking speed of 5 km/h and cycling speed of 13.5 km/h) were performed, but in the end the lower speeds were used. The children in our study are of two different age groups. The younger children are around eight years old and the older children are around eleven years old. We chose to base the calculations on a minimum average speed, rather than a maximum average speed, in order to cover an area that is accessible for more children. Furthermore, children's movements involve play (Björklid, 2004), which lowers the average speed for the whole trip. In the model we have focused on the whole journey, which includes play, rather than just the average speed of the movements.

The model use average travel speed, given in meter per minute, as input data. As the average speeds above are given in kilometres per hour, we had to recalculate the travel speed to fit the cost distance analysis tool. The calculation for cycling speed was done as following: 10 km/h = 10 000 m/h = 167 m/min = 0.00599 min/m. As the value has to be an integer number we multiplied 0.00599 with 1000 ≈ 6. The calculations for walking speed was done as following: 4.3 km/h = 4300 m/h = 71.7 m/min = 0.0139 min/m. Multiplied with 1000 ≈ 14. This gave the input values 14 for walking speed and 6 for cycling speed.

3.3.2 Maps of the distance models

The output from the cost distance model generated subareas representing travel time from the school. These can be seen in the maps in Figure 2-5. The maps do not show specific travel routes used by the children, but they should be understood as areas accessible for children that walk or cycle in the speed defined in the map. We chose to classify the travel time in intervals of 5 minutes, and make each time interval an independent subarea. The study areas for walking consists of six subareas, showing the accessible areas 0 to 30 minutes from the schools. While the study areas for cycling consists of three subareas, showing the accessible areas 0 to 15 minutes from the schools.

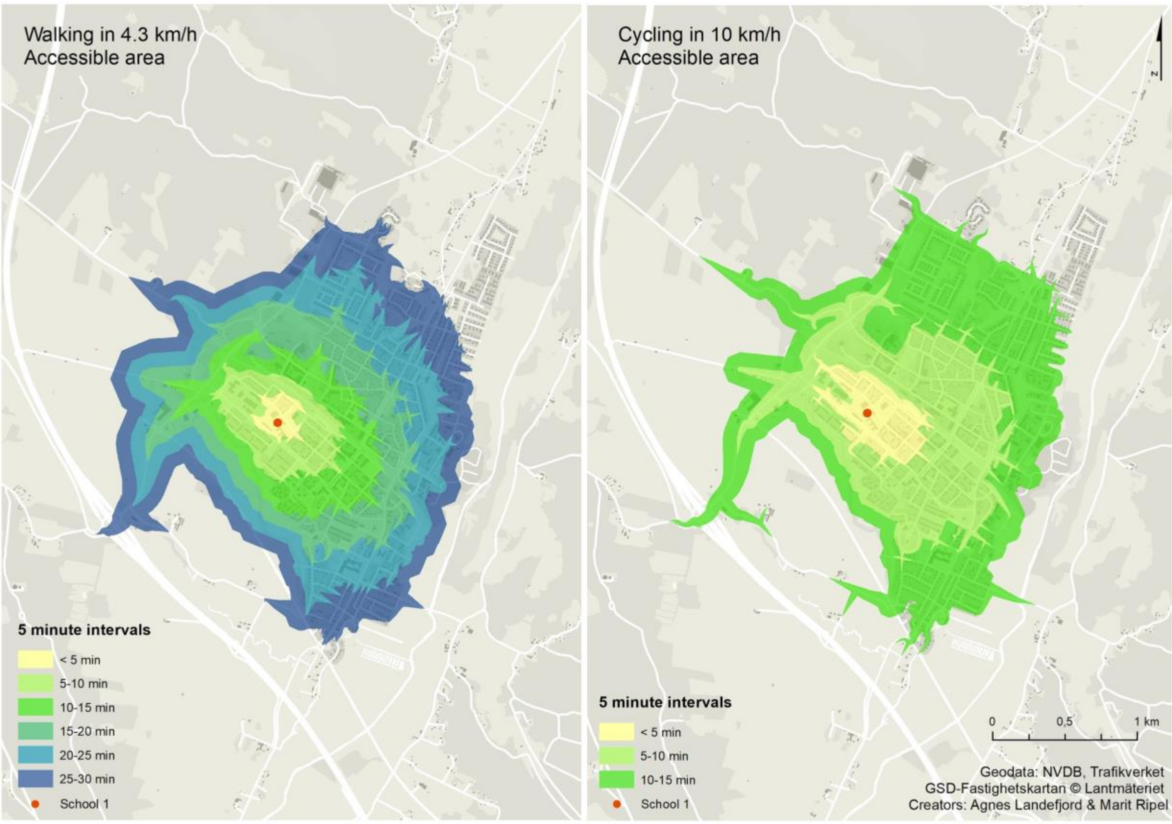

Figure 2: Maps of accessible area from School 1, in an average walking speed of 4.3 km/h and an average cycling speed of 10 km/h.

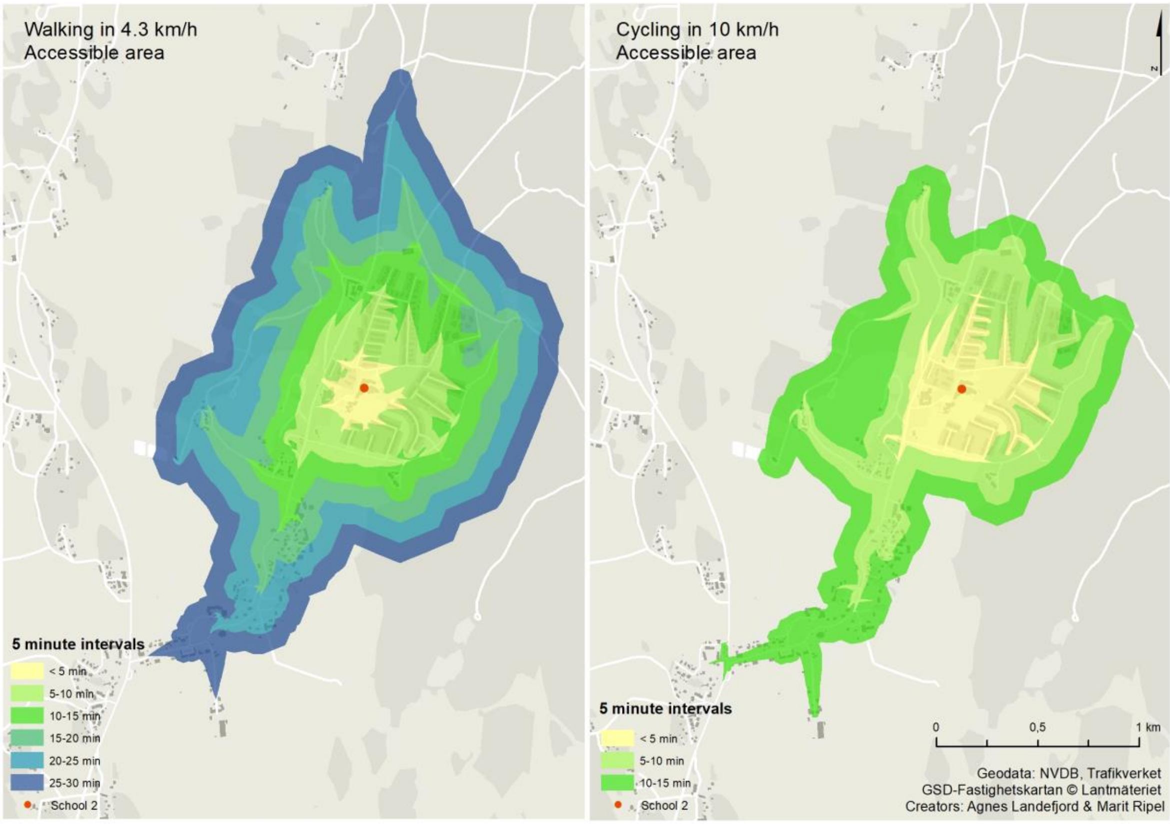

Figure 3: Accessible area from School 2, in an average walking speed of 4.3 km/h and an average cycling speed of 10 km/h.

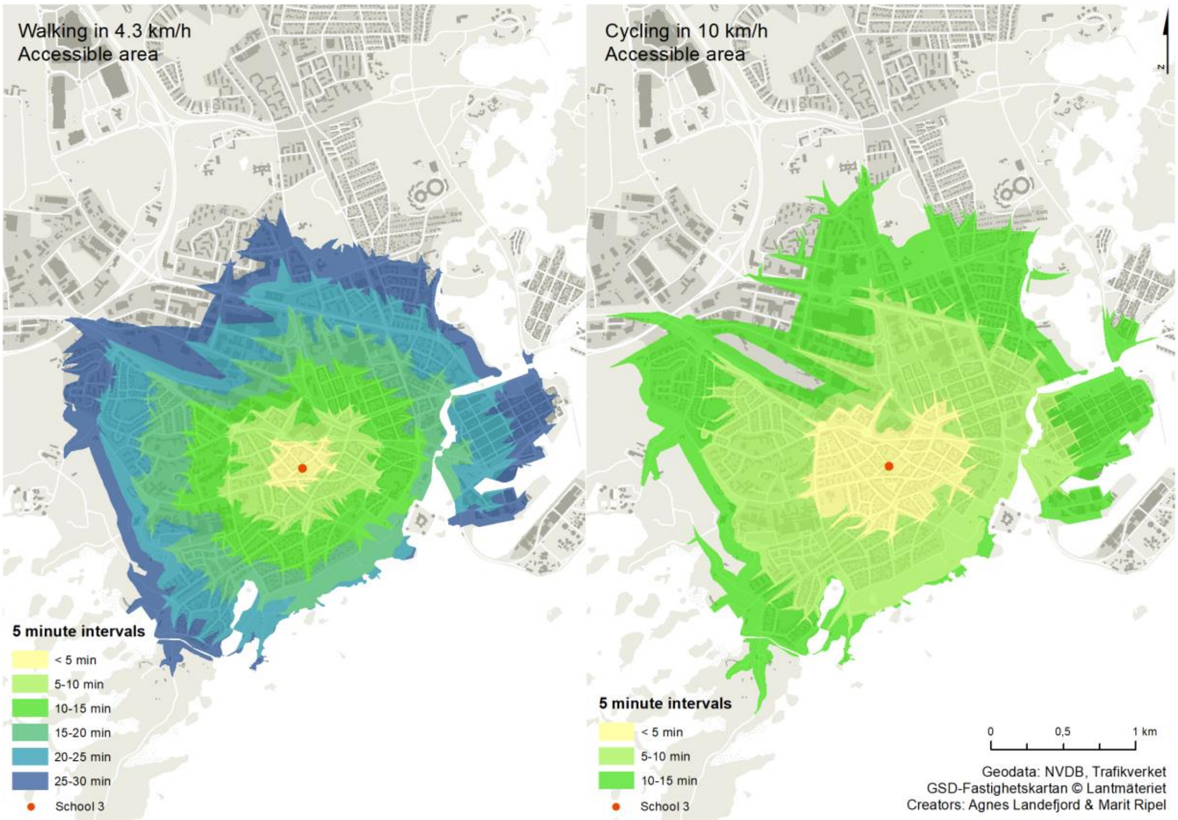

Figure 4: Accessible area from School 3, in an average walking speed of 4.3 km/h and an average cycling speed of 10 km/h.

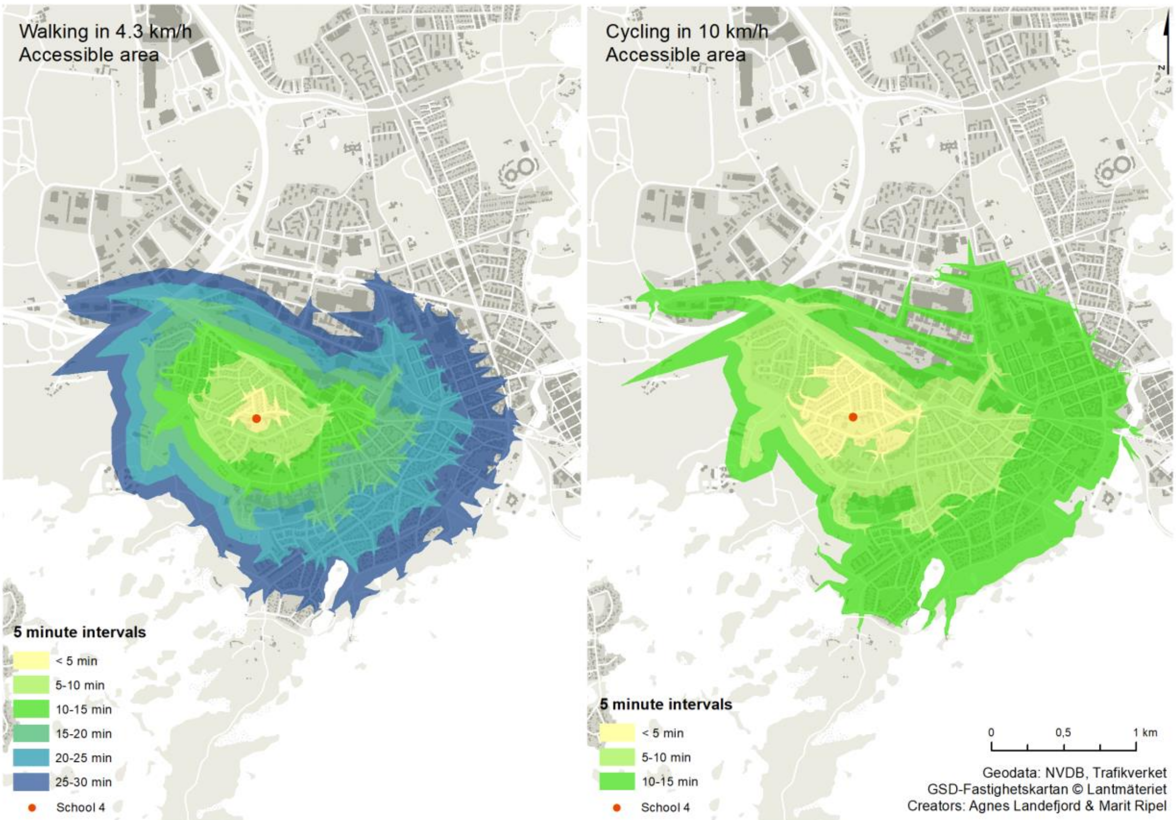

Figure 5: Accessible area from School 4, in an average walking speed of 4.3 km/h and an average cycling speed of 10 km/h.

Sizewise the total area of the subareas for walking and cycling are fairly equal, but cycling covers a bit larger area than walking. In Table 4 the total accessible area in the study areas for walking and cycling are compared. For School 1, 3 and 4 the study area for cycling is the biggest, while in School 2 the study area for walking is bigger.

Table 4: Difference in total area between the subareas

	Walking		Cykling		Difference
School 1	323	ha	334	ha	3%
School 2	139	ha	132	ha	-5%
School 3	511	ha	568	ha	10%
School 4	353	ha	399	ha	12%

3.4 Part 2: Mapping the environment

The aim with this part of the analysis was to determine and map the selective environmental variables that could explain children's walking or cycling behaviour. Later these variables will be tested for correlation with the travel mode data from Kidscape II.

A number of previous studies have looked at environmental characteristics of children's school routes and neighbourhoods, in order to help explain children's travel habits (Broberg & Sarjala, 2015; Ewing, et al., 2004; Larsen, et al., 2012; Mitra, 2013; Mitra & Buliung, 2014; Panter, 2008; Panter, et al., 2010; Schlossberg, et al., 2006; Timperio, et al., 2006). Broberg & Sarjala (2015) have studied this in a Scandinavian context, by looking at characteristics of the built environment and school travel mode choice in Helsinki, Finland. The environmental variables chosen for our study are based on a conceptualization of neighbourhood environment and school travel by Mitra (2013) and a categorization outlined by Broberg and Sarjala (2015). They use the five main categories 1. Proximity to school, 2. Traffic and personal safety, 3. Connectivity, 4. Comfort and attractiveness and 5. Opportunity to produce and maintain social capital. Table 5 is an overview of the studied variables. Since we wanted to compare the different environments, the variables were measured mainly as proportion or density.

Table 5: Overview of studied variables and data sources.

Variable	Description	Data source
I. Proximity to school		
Distribution of child population	Child population number within each of the different subareas.	Central Bureau of Statistics *SCB: Befolkning vektor*
II. Traffic and personal safety		
Traffic safety		
Proportion of major roads	Major road defined as *NVDB: Funktionell vägklass*, classes 0-5. Measured as length of major roads divided by length of all roads.	Swedish Transport Administration *Trafikverket: NVDB*

Presence of railroad	Intersecting railway = 1 No intersecting railway = 0	Swedish Land Survey *Lantmäteriet: Fastighetskartan kommunikation*
Traffic accident density	Accidents involving pedestrian or cyclist, +/- 5 years from 2013. Measured as accidents per hectare.	Swedish Transport Administration *Trafikverket: STRADA*
Proportion of safe intersections	Number of marked crossings (zebra crossings or signalized crossings) divided by total number of crossings included in the school-road-network.	Swedish Transport Administration *Trafikverket: NVDB*
Proportion of car parks	Manual digitizing from orthophoto. Area of car parks divided by total subarea.	Swedish Land Survey *Lantmäteriet: Ortofoto raster IR 0,25 m mosaik*
Proportion of footpaths and cycle paths	Length of footpaths and cycle paths divided by total length of the school-road-network.	Swedish Transport Administration *Trafikverket: NVDB*
Personal safety, land use mix		
Proportion of buildings with "eyes on the street"-effect*	Area of land covered by buildings with "eyes on the street"-effect divided by total subarea..	Swedish Land Survey *Lantmäteriet: Fastighetskartan bebyggelse*
Proportion of industrial area	Industrial area divided by study area.	Swedish Land Survey *Lantmäteriet: Fastighetskartan bebyggelse/markdata*
Proportion of high-rise buildings and employment districts	Area of high-rise buildings and employment districts divided by total subarea.	Swedish Land Survey *Lantmäteriet: Fastighetskartan bebyggelse*
III. Connectivity		
Intersection density	Number of all intersections in school-road-network divided by total subarea.	Swedish Transport Administration *Trafikverket: NVDB*
IV. Comfort and attractiveness		
Proportion of parks and green open spaces	Manual digitizing from orthophoto. Area of parks and green open spaces divided by total subarea.	Swedish Land Survey *Lantmäteriet: Ortofoto raster IR 0,25 m mosaik*
Proportion of forests	Area of forest divided by total subarea.	Swedish Land Survey *Lantmäteriet: Fastighetskartan markdata*
Proportion of land covered by single family houses	Area of land covered by single family houses divided by total subarea.	Swedish Land Survey *Lantmäteriet: Fastighetskartan bebyggelse*

V. Opportunity to produce and maintain social capital		
Population density	Number of residents per hectare. Population data from 2013.	Central Bureau of Statistics *SCB: Befolkning vektor*
Child population density	Number of child residents (7-15 years old) per hectare. Population data from 2013.	Central Bureau of Statistics *SCB: Befolkning vektor*

* *Explained below*

3.4.1 Study area for the environmental variable analysis

The area within which to study the different environmental variables, was determined by the output of the cost distance modelling in part 1. Here we modelled accessible areas from schools that we separated into subareas based on five minute time intervals (3.3.2). Each of the environmental variables were studied within each of the subareas. Most likely do the environment in the subareas closer to the schools have a greater influence on the travel behaviour than the subareas further away from the school. But since we do not know where the children lived, this was not assumed in the model. However, by averaging the mean of each subarea we removed some of the bias of the inner and outer subarea. Accessible areas when walking or cycling were studied separately, but the same variables were used in both analyses. A workflow chart of the steps performed in the environmental variable analysis, is shown in Figure 6.

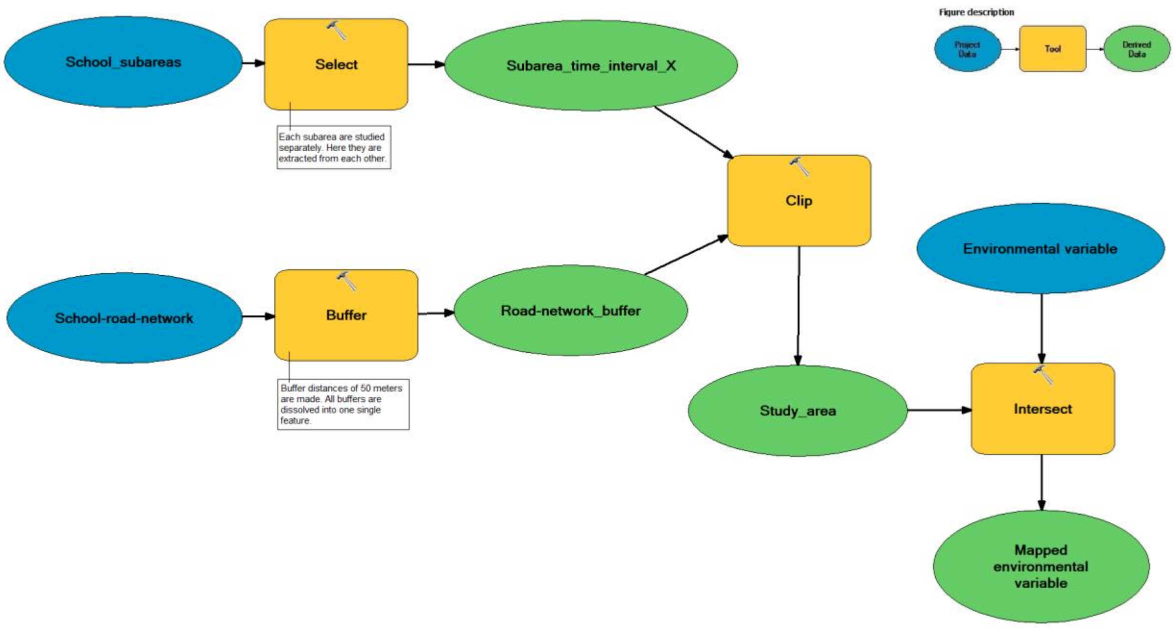

Figure 6: Workflow chart over part 2 of the GIS method. The chart show that the subareas combined with the school-road-network is used to create a study area. This is than used with an intersect operation on each environmental variable.

Since it was only relevant to study the features around the potential school ways, a buffer zone of 50 meters was created around the school-road-network. This generated a study area with a total width of 100 meters around the road-network, for which the density and proportion of the environmental variables were calculated. This resembles Broberg and Sarjala's (2015) buffer zones that was calculated within 100 m of the road. All environmental variables were overlaid (intersected) with the buffer-study-areas. Overlay operations are used to study geometrical objects which overlap each other (Pilesjö & Eklundh, 2013).

3.4.2 Defining and mapping of environmental variables

I. Proximity to school

Distance is the variable which is most frequently reported as a determinant of children's active travels (Broberg & Sarjala, 2015; Ewing, et al., 2006; Larsen, et al., 2012; Mitra, 2013; Schlossberg, et al., 2006; Timperio et al., 2006; Wong et al., 2011). Independent travels are also more likely within short distances (Mitra, 2013). Since we did not know the home addresses of the children, we looked at proximity to school in a more general sense. An overlay analysis with **child population** data from was performed, in order to see tendencies in where children live around the four schools. This way, we estimated how many children, aged 7 to 15 years old, who lived within each of the subareas. For this we used population grids from the Central Bureau of Statistics (SCB), from 2013. Due to integrity reasons, the population data was available in grids of 250x250 meters in densely populated areas and 1000x1000 meters in sparsely populated areas. This gave an estimation of the population and not an exact number.

II. Traffic and personal safety

Traffic safety

Broberg and Sarjala (2015) measure traffic safety and personal safety by a number of different variables. In this study, traffic safety is measured as proportion of major roads, presence of railroads, traffic accident density, proportion of safe intersections, proportion of car parking and proportion of footpaths and cycle paths.

Home and school environments without the presence of **major roads** are associated with higher rates of walking among school children (Mitra & Buliung, 2014). When Björklid (2004) compared children in an inner-city area and a suburban area, she found that less children were allowed to cycle in the inner-city than in suburban areas, since children and parents perceived heavy traffic and a lack of consideration among drivers in the inner city as a threat. In this study, the presence of major roads was measured as the proportion to the length of all roads. When defining a major road, we used the layer *Funktionell vägklass* (Functional road class) in NVDB. This is a classification from the Swedish Transport Administration (Trafikverket) where all roads are classified by their importance for the connectivity of the road network, and aims to point out where to lead the traffic. All the roads are classified in the classes 0-10, where 0 is most important roads and 10 the least important roads (Trafikverket, 2017). We defined the classes 0-5 as major roads, which also corresponded with higher speed limits. The length of the major roads was normalized by the length of the total road network.

If the school journey intersects with a **railroad** it could potentially have a negative effect on active transport (Schlossberg et al., 2006). If the subareas contained a railroad it was given the number 1 and if not it was given the number 0. The mean of the whole study area was then calculated.

Another traffic safety variable which might affect school travel is **traffic accidents** (Panter, et al., 2010), which was measured as density of traffic accidents. The density of traffic accidents have to be understood in two ways. A high number of accidents involving children might indicate an unsafe traffic environment, but on the other hand could a reduction of traffic accidents be seen as a consequence of reduction of children's mobility (Björklid, 2004). We used geographical data from STRADA (Swedish Traffic Accident Data Acquisition), provided by the Swedish Transport Administration. STRADA is an information system for data of all traffic accidents where a person was injured (Transportstyrelsen, n.d.). We only looked at accidents which involved pedestrians or cyclists and that had occurred between 2008 and 2017. We chose to not only look at accidents from 2013, since previous and later accidents can give an indication of the traffic environment. Traffic accidents were measured as density and normalized by the area of the subareas.

Broberg and Sarjala (2015) measure proportion of **signalized crossings**. In our case we found it more relevant to measure the proportion of both zebra crossings and signalized crossings, to the total number of crossings we had included in the school-road-network. In the school-road-network we included street crossings which were not marked, but were logical passages and important connections. Safe crossings were measured as proportion and normalized by total number of crossings.

Car parks has been reported by children as an issue when walking or cycling to school (Björklid, 2004). This was measured as proportion of car parking area to the total study area. Car parks were manually mapped from an orthophoto with a resolution of 0.25 meters, and from Google Maps Street View.

We also studied the proportion of **footpaths and cycle paths**, to the total school-road-network. This was also studied by Broberg and Sarjala (2015).

Personal safety

In previous studies personal safety has been measured as different types of land uses, since land use potentially could have an effect on personal safety and active travel modes. Pedestrian safety is according to Mitra (2013) increased by smaller residential blocks and smaller retail, as it places eyes on the street. Larger retail centres and employment districts have the opposite effect (Mitra et al., 2013; Mitra & Buliung, 2014). Broberg and Sarjala (2015) look at residential density as summed floor space of buildings, which they assume discourage active transportation. We have used three different categories of land use as measures of personal safety.

Larger retail centres, **employment districts and high-rise building** areas, were classified in the same category, since they lack what Mitra (2013) describes as "eyes on the street"-effect and discourage walking. The geographical data from the Swedish Land Survey (Lantmäteriet) contained classifications of land use and buildings. These classifications were somewhat modified to fit the study. We assumed that **industrial areas** would have a similar effect, and therefore measured this as a separate variable. We have also made **"eyes on the street"-effect** as a variable on its own where we included areas with smaller residential blocks, single family houses and districts with smaller retail.

III: Connectivity

Street connectivity has been defined by Mecredy et al. (2011) as a measurement of how well streets are connected to one another, directness of links and the density of intersections. When a road is highly connected the street has many short links and numerous intersections which could make it easier to walk or cycle from one place to another (Mecredy et al., 2011). Whether street connectivity can encourage or discourage active school travels among children is debated. Among adults a well-developed street connectivity can encourage more to travel by active transport modes (Ewing & Cervero, 2010). Yet, there are conflicting results from studies compiled on this relationship for children. As high connectivity corresponds with high traffic, it might have a negative influence on children's active travels (Mecredy et al., 2011). Mecredy et al. (2011) and Panter et al. (2010) have found that youths living in areas with low street connectivity were more likely to be physically active than youths living in areas with higher street connectivity (Mecredy et al., 2011; Panter et al., 2010).

Intersection density is used as a measure of connectivity in a number of studies (Broberg & Sarjala, 2015; Panter et al, 2010; Schlossberg et al. 2006). We have studied connectivity as the number of three- and four-way intersections in the school-road-network. The density was then calculated by dividing the number of nodes with the total area of the subarea.

IV: Comfort and attractiveness

An attractive and comfortable environment can enhance active travels (Mitra, 2013). This can be measured as presence of green open space, parks, trees (Ding et al., 2011) or smaller neighbourhood blocks (Mitra, 2013). Similar to Broberg and Sarajala (2015), we have studied comfort and attractiveness as the proportion of parks and recreational areas, forests and land covered by single family houses.

Parks and green open spaces were digitized from orthophotos with a resolution of 0.25 meters, and from Google Maps Street View. Data on **forestry** cover was extracted from the land use layer from the Swedish Land Survey. Data on **single family houses** was extracted from the building layer from the Swedish Land Survey. The variables were normalized by the total area of the subarea.

V: Produce and maintain social capital

Mitra (2013) argue that the opportunity to produce and maintain social capital is an important dominator for active travels, but is often poorly understood in research. Previous research in Finland have shown that population density around children's meaningful places increases the odds for active transportation (Broberg et al. 2013). Pointed out by Björklid (2004), children's travelling is a combination of movement and play, and motivational elements for travel mode choice can be passing by a friend's house, a shop or parks to play (Panter et al., 2008). Broberg and Sarjala (2015) used population density as a variable for producing and maintaining social capital. We have looked at the total **population density**, but also narrowed it down to **child population density**, of children aged 7-15 year old. The population data used was from 2013 and was provided by the Central Bureau of Statistics (SCB). Similar methods were used as described under *I. Proximity to school*, but the density was calculated by dividing the population numbers with the area of the subareas.

3.5 Testing of environmental variables to transport data

The aim with this part of the analysis was to study if the environmental variables can help explain why the children chose to travel as they did in the Kidscape II measurement. Since we did not know the home addresses of the children and what route they had travelled, we could only test this using mean values of the transport data and mean values of the study areas for each school. The mean value of the environmental variables was calculated by averaging the mean of the subareas. This gave us four values for walking and four values for cycling.

We have used *Spearman's rank correlation* to test the relationship between the environment and children's travel mode choice. This is a nonparametric correlation test, which can be used to measure the relationship between two ranked series of observations. The differences between the ranks are obtained with this test (Puri & Mullen, 1980). This can be used as a nonparametric alternative to regression (McDonald, 2014). The output is an r-value between -1 and 1. Where, 1 indicates strong positive correlation and -1 indicates strong negative correlation. 0 indicates no correlation (Puri & Mullen, 1980). When the order of rankings are similar or opposites the correlation effect is strong.

We tested each of the environmental variables to the proportion of travels made by walking and the proportion of travels made by cycling, at the four different schools. The travel mode proportions were ranked from 1 to 4, from lowest to highest proportion. The mean of the environmental variables were ranked the same way. The Spearman's correlation test was then performed, for one variable at a time, and for both walking and cycling.

We also made scatter plots from the travel data and the environmental variables. Each scatter plot matrix represents the relationship between the proportion of travels made by walking or proportion of travels made by cycling, and the mean value of one of the environmental variables. The scatter plot matrix were then arranged according to their r-value. With only four data points it is not possible to find a statistically significant relationship. However, we could see tendencies in how the data correlates in these four cases, which could give an indication of what variables might be interesting to study further.

3.6 Uncertainties with used methods

In order to perform this method we had to assume some general factors. Every time an assumption is made the quality of the output weakens, since there will be a higher degree of uncertainty. The major limitation in our study is that we do not know the routes or how far the children have travelled. To overcome this gap, we have assumed that all footpaths, cycle paths and roads in the school-road-network are potential school ways for the children in the measurement. The cost distance model gave a result that is specific to our interpretation and definitions of the input data. A redefinition of the school-road-network or the average travel speed would also change the output of the cost distance model. Empirical data on the average walking and cycling speed of the children who participated in this measurement could have given more accurate distance models.

The SCB child population data from 2013 shows approximately were the children live around the four schools. This could have been used to weight the different subareas based on population distribution, but on the other hand, this would be putting more assumptions into the model. The SCB child population data cover a larger age group than the children in our study and due to the free choice of school we cannot know which school these children attend. Instead, we chose to assume an equal population distribution within each sub area and that the children attend the school closest to their home.

We have no local knowledge as we have not visited any of the studied areas. Since the geographical data available was of good quality, we argue that this gave us a good enough foundation to perform the analysis. The project Kidscape II collected the data in 2013, therefore visiting the study areas five years later is an assumption as much as studying orthophotos from 2014-2015 and Google Street View from 2010-2011.

Using no assumption would have been ideal and given us more accurate results. However, we believe that the outcomes from this study can be used as an argument for which environmental variables that are interesting for further research.

4. Results

In this chapter the results from the analyses are presented. First the results from the Kidscape II measurements are presented as travel mode distribution at the four schools. Then the results from the mapping of the environmental variables are presented. Lastly we present the results from the relationship tests.

4.1 Travel mode distribution

The measurements of daily travels compiled at the four schools in March and May 2013 give a representation of how school journeys are made in the four case schools. The pie charts in Figure 7 show the travel mode distribution at the four schools.

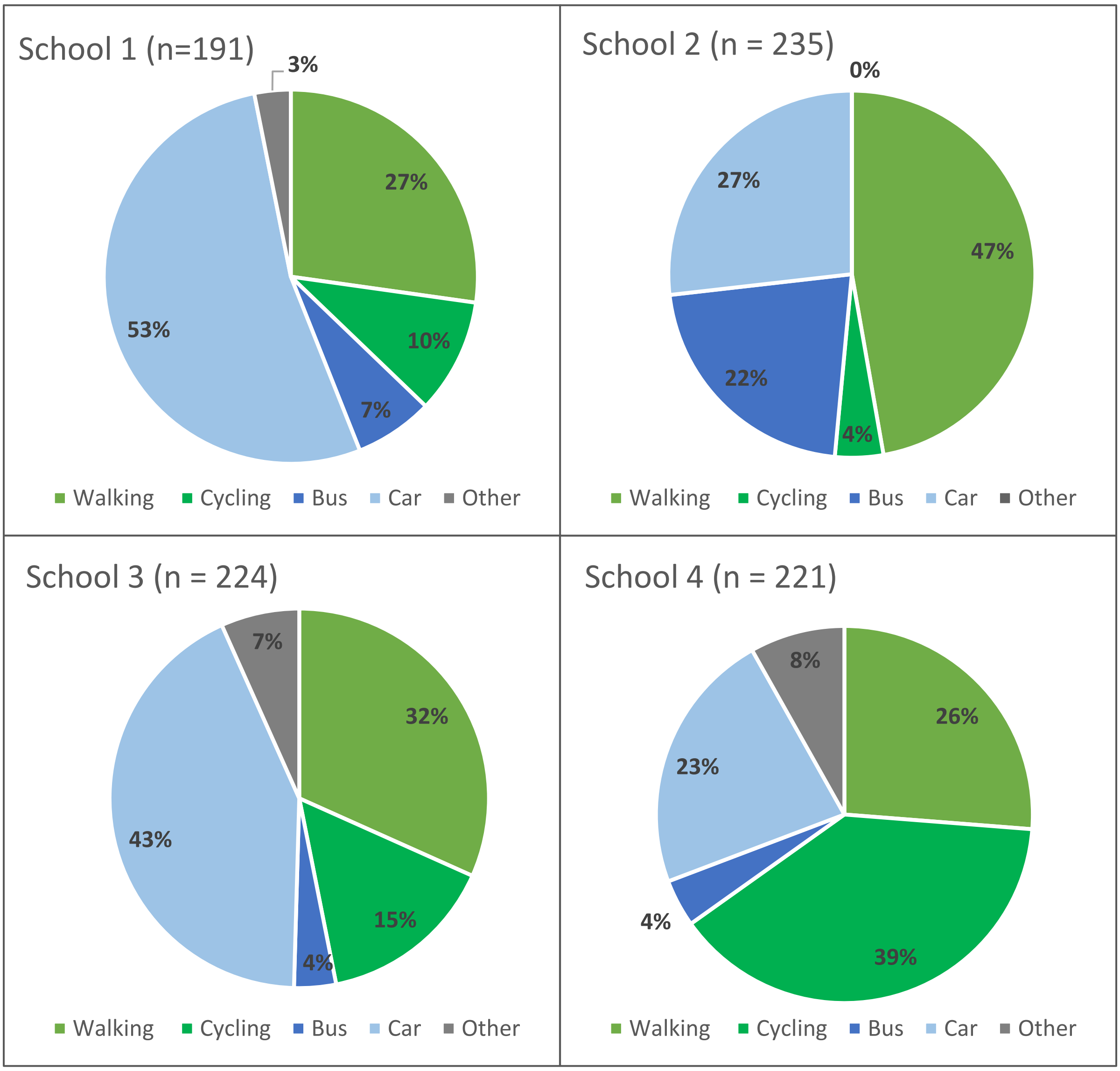

Figure 7: The pie charts show the distribution of all travels made by children in 2nd and 5th grade during the two measurement periods at the four schools.

At **School 1** the most common transport mode was being escorted in private car, with 53 percent of the reported travels. The second most common transport mode was walking, with 27 percent. Cycling to school was the third most common transport mode choice, with 10 percent of the travels. Overall, School 1 was the least active school and had the highest share of travels made by car.

At **School 2** the most common transport mode was walking, with 47 percent of all the travels. The second most common choice of transport mode were travels made by car. Cycling was the least popular transport mode, with only four percent of the school travels done by bicycle. Of all the schools, School 2 had the highest share of children who reported that they walked to school.

At **School 3** the most common transport mode was travelling by car, with 43 percent of the reported travels. The second most common transport mode was walking with 32 percent. Cycling was the third most common transport mode, with 15 percent of reported travels.

At **School 4** the most common transport mode was to travel by bicycle, with 39 percent of the reported travels. The second most common transport mode was walking at 26 percent. Travels made by car was the third most common transport mode choice, with 23 percent of all travels. Of all the schools, School 4 was by far the most active.

For the further study we were interested in the share of travels made by walking and cycling at each school. In Table 6 we have ranked the schools from highest to lowest when it comes to the number of travels done by either walking or cycling (n). The share is calculated from the total number of travels made at each school (n tot).

Table 6: The schools ranked after share of travels made walking and cycling.

Walking				**Cycling**			
Rank	School	Share of travels	n / tot n	Rank	School	Share of travels	n / tot n
1	School 2	47%	111 / 235	1	School 4	39%	86 / 221
2	School 3	32%	71 / 224	2	School 3	15%	34 / 224
3	School 1	27%	52 /191	3	School 1	10%	19 / 191
4	School 4	26%	58 / 221	4	School 2	4%	10 / 235

Seen in Table 6 is that School 2 and 4 shift between being ranked as the most active and least active school. Even if School 4 is ranked last in the share of children who walks, the gap to School 1 is at only one percent difference. School 3 has a steady second place in both of the rankings.

4.1.1 Differences in travel mode and grades

In the following figures we have looked into differences between travel mode distribution at 2nd grade and 5th grade.

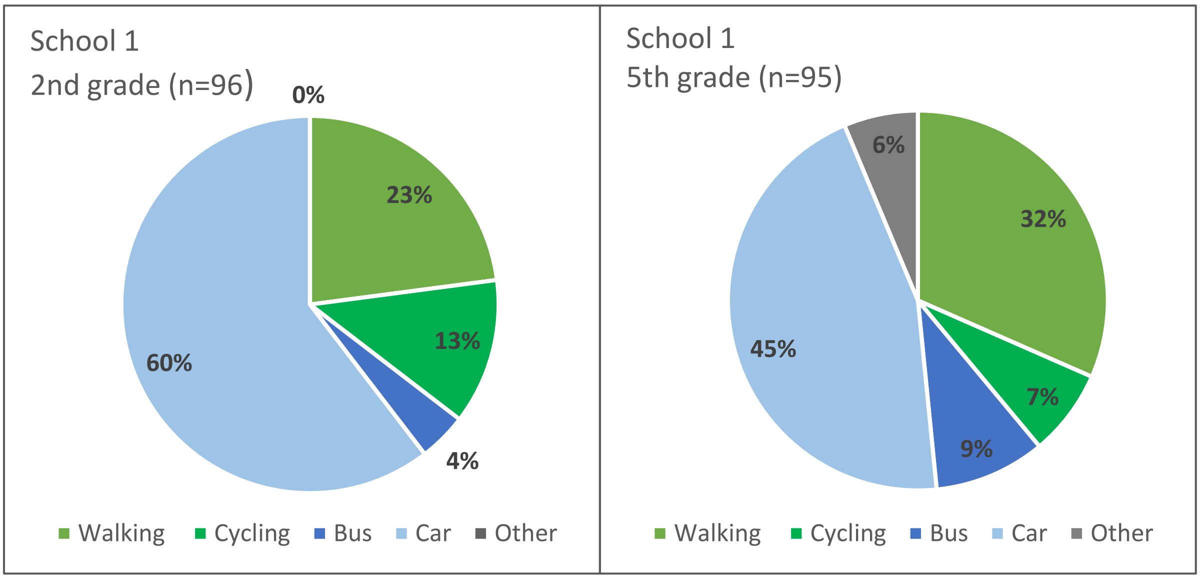

Figure 8: The pie charts show the difference in travel mode distribution between 2nd grade and 5th grade at School 1.

Seen in figure 8, the most common transport mode at **School 1** was car, in both 2nd and 5th grade. Overall, there were little change in the total amount of travels made by walking or cycling. But more children in 2nd grade reported that they cycled to school than in 5th grade.

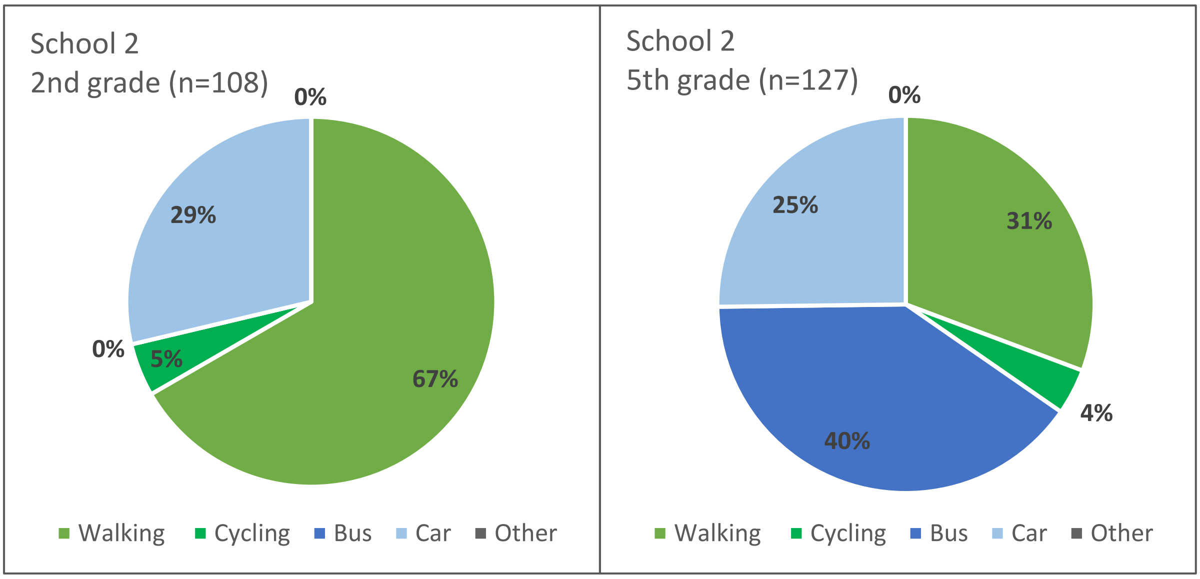

Figure 9: The pie charts show the difference in travel mode distribution between 2nd grade and 5th grade at School 2.

Seen in figure 9, there was one major change in travel mode distribution at **School 2**. In 2nd grade a majority of the children reported that they walked to school, while in 5th grade most children reported that they travelled to school by bus.

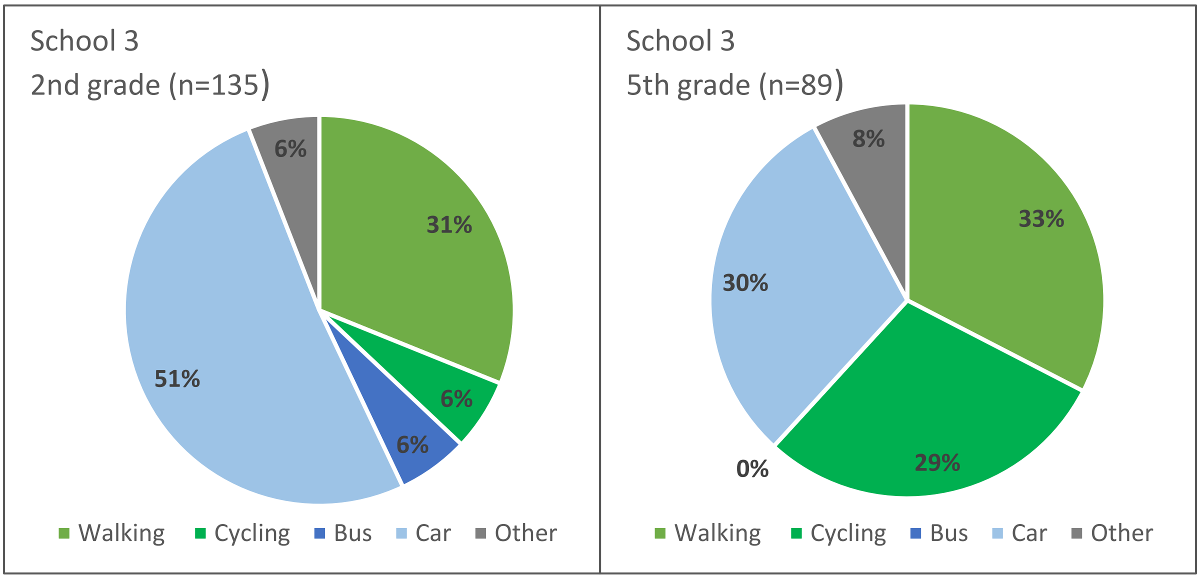

Figure 10: The pie charts show the difference in travel mode distribution between 2nd grade and 5th grade at School 3.

Seen in figure 10, the children at **School 3** reported to be travelling to school by different modes depending on grade. In 2nd grade a majority of the children reported that they were escorted by private car, while in 5th grade a majority of the children reported that they either walked or cycled to school.

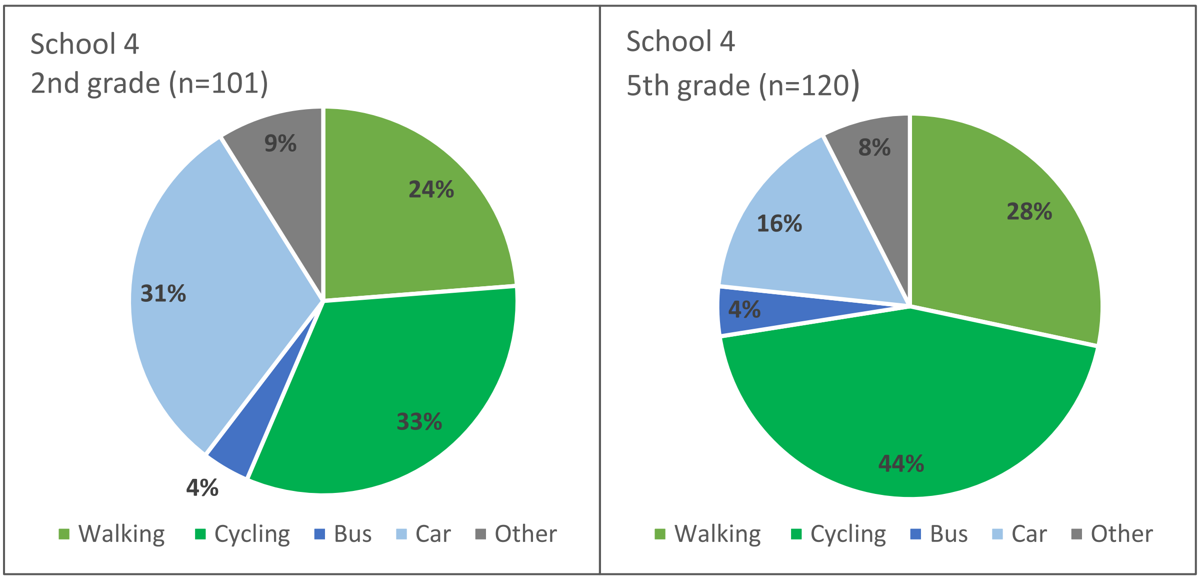

Figure 11. The pie charts show the difference in travel mode distribution between 2nd grade and 5th grade at School 4.

Seen in figure 11, a majority of pupils in both 2nd grade and 5th grade at **School 4** reported that they travel to school by foot or bicycle. More children in 2nd grade report that they are escorted to school in private car.

Since School 3 and 4 are placed in the same city it is interesting to compare these two schools with each other. In 5th grade, both schools were quite active. The biggest difference was found at 2nd grade, where School 4 is active both when it comes to walking and cycling, while at School 3 a majority of the children travelled with motorized transport modes and only a small share of the children cycled to school.

4.2 Results from mapping

4.2.1 Proximity to school

The child population overlay gave an overview of how children's homes are distributed around the four schools. We have looked at the child population within a 30 minute walking distance and a 15 minute cycling distance from the school.

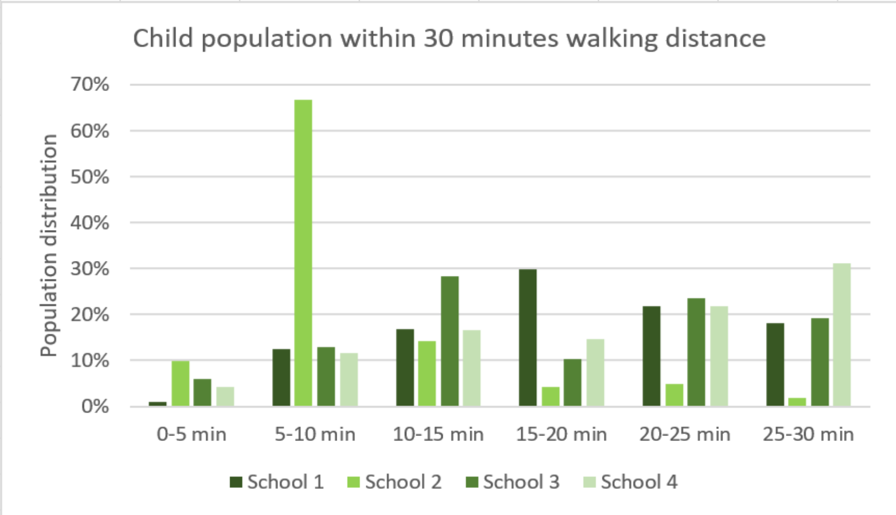

Figure 12: Percentage of all children living within 30 minutes walking distance from school that live within each of the subareas.

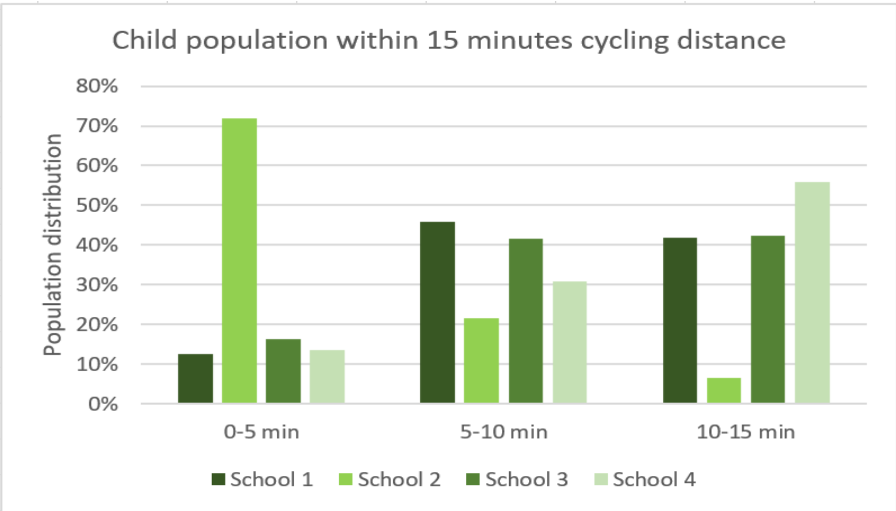

Figure 13: Percentage of all children living in 15 minutes cycling distance from school that live within each of the subareas.

Figure 12 and 13 show how the child population is distributed between the subareas, as the percentage of all children living within the studied area. The results are similar for walking and cycling. Seen here is that School 2 stands out, as the majority of children live within a 5-10 minutes walking distance or 0-5 minutes cycling distance. School 1 and 3 have a similar distribution, where the population numbers go down slightly far away from the school. Since the area of the subareas in general increases the further away from the school they are (see 3.3.2), the population numbers would increase with travel time, if the population were to be evenly distributed over the study area. This is seen at School 4, which has a relatively even distribution of child population.

4.2.2 Mapped environmental variables

The following figures show the spread in the mean values for each environmental variable that was mapped. The points in the figure represent a mean value for the subareas of each school (for definition of subareas, see 3.3.2 and 3.4.1). The green figures show the values for walking and blue figures show the values for cycling. The schools are separated by different symbols (School 1 = Δ, School 2 = ○, School 3 = ◊, School 4 = □). On the x-axis, every subarea is represented as a point in the figure and should be read as travel time from the school in order from the left (0-30 minutes for walking and 0-15 minutes for cycling). On the y-axis are the values for the environmental variable.

4.2.3 Traffic and personal safety

4.2.3.1 Proportion of major roads

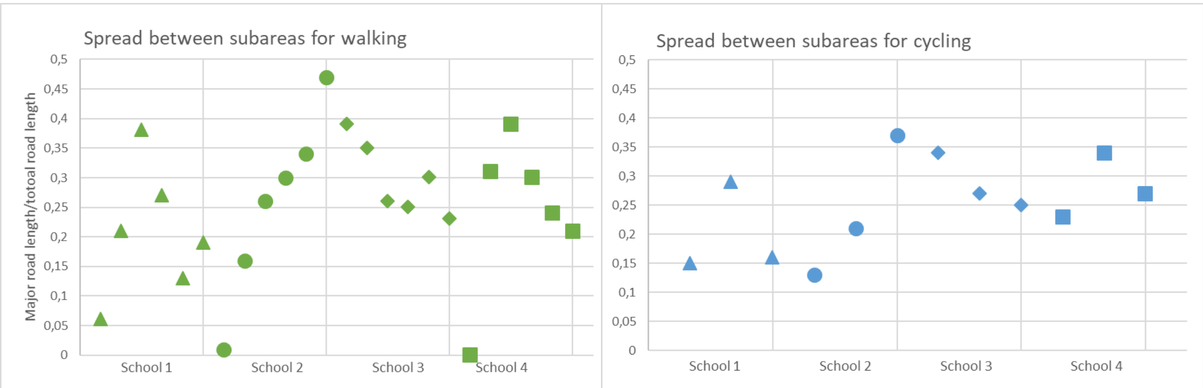

Figure 14: The diagrams show the value spread for the environmental variable proportion of major roads. On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** there were less major roads in the inner and outer subarea. A proportion peak were found around 10-15 minutes from the school. At **School 2** there were a clear trend that the proportion of major roads increases with distance. At **School 3** the proportion were found highest in the inner subarea and to decrease with distance. **School 4** had a low proportion in the inner subarea, with distance the proportion increased and peaked around 10-15 minutes from the school.

When comparing the schools, School 1 and School 4 have similar tendencies when it comes to the spread of mean values. Both have a peak of major roads around 10-15 minutes from the school. School 2 and School 3 are each other's opposites. School 2 also has the greatest spread in mean between the subareas.

4.2.3.2 Railroad presence

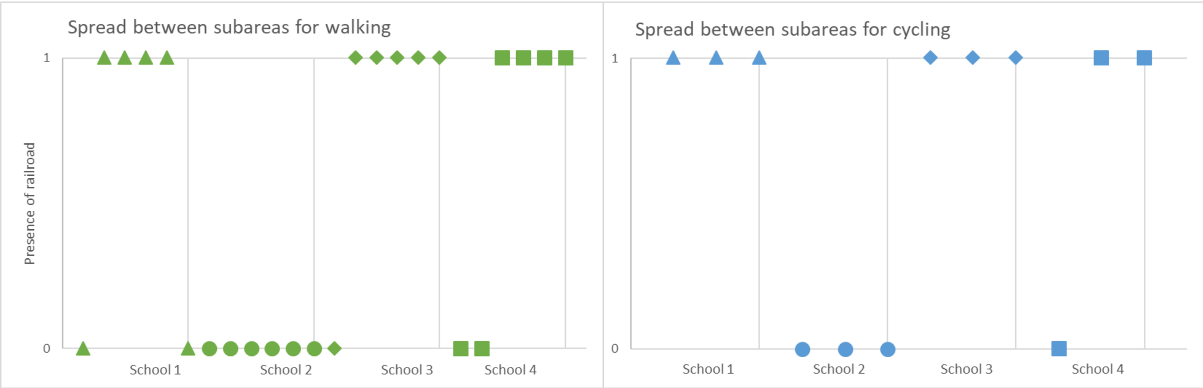

Figure 15: The diagrams show the value spread for the environmental variable presence of railroad. On the x-axis the points represent a sub area, and the y-axis show the presence of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** a railroad was crossing the subareas for walking at the subareas from 5-25 minutes. No railroad was crossing the subarea close to the school and no railroad was crossing in the subarea further away from the school. In the study area for cycling, the railroad was crossing all the subareas. At **School 2** there was no railroad presence. At **School 3** the railroad was crossing all the subareas for cycling. In the study area for walking, no railroad was crossing the subarea closest to the school, but it crosses all other subareas. At **School 4** the railroad was not crossing the subareas closest to the school, for either walking or cycling. It crosses all other subareas.

When comparing the presence of the railroads between the schools, School 2 stands out since it has no railroad presence in any of the subareas. School 1 and School 3 have similar presence of railroad, as both have a railroad intersecting 5-10 minutes from the school. School 4 also has a railroad presence but it does not intersect with the subareas near the school.

4.2.2.3 Traffic accident density

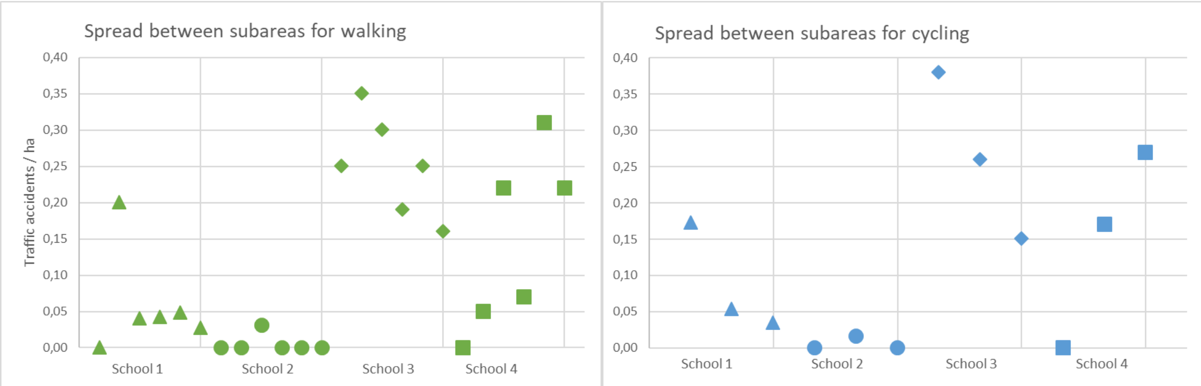

Figure 16: The diagrams show the value spread for the environmental variable traffic accident density. On the x-axis the points represent a sub area, and the y-axis show the density of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** there was peak in density 5-10 minutes from the school for walking and cycling. At **School 2** there was an overall low density rate both for walking and cycling. At **School 3** the highest density rate was found close to the school for both walking and cycling. At **School 4** the density rate increases with distance from the school, both for the walking and cycling subareas.

When comparing the schools, School 1 and School 2 stands out with the overall lowest accident density rate. Both School 1 and School 3 have a higher density rate in the subareas close to the school. School 4 had an opposite trend of more accidents further away from the school. School 3 had the highest overall accident density rate.

4.2.3.4 Proportion of safe intersections

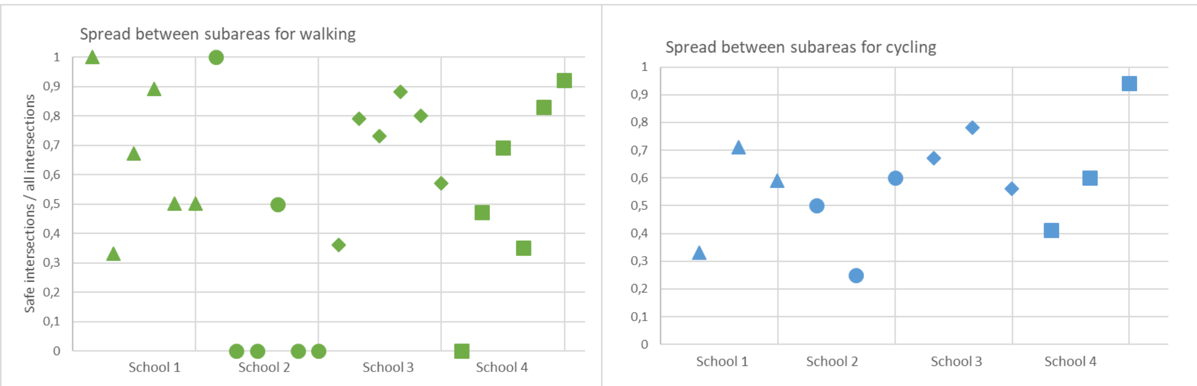

Figure 17: The diagrams show the value spread for the environmental proportion of safe intersections. On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** there were more safe intersections close to the school in the study area for walking, this was not the case for cycling. At **School 2** there was a high proportion close to the school, but the proportions decreases with distance. For cycling the highest proportion was found in the outer subarea. At **School 3** and **School 4** the proportions were found at its lowest in the subarea closest to the school both for the walking and cycling subarea

When it comes to the differences between the schools, School 2 has the overall lowest proportion of safe intersections and School 3 and 4 have the overall highest proportion. Both School 3 and 4 have a higher proportion of safe intersections further away from the schools, while School 1 and 2 have the highest proportion of safe intersections close to the school.

4.2.3.5 Proportion of car parks

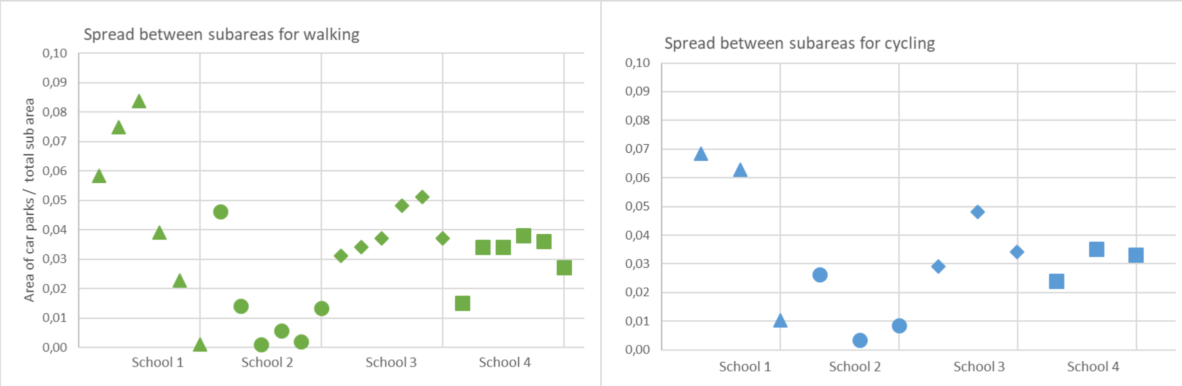

Figure 18: The diagrams show the value spread for the environmental proportion of car parks. On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** there was a higher proportion of car park areas close to the school, than further away. The same tendencies was found at **School 2**. At **School 3** the proportion of car parks were lower close to the school, both for the walking and cycling study area. The same tendencies was seen at **School 4**. When comparing the schools, all are found to have low rates of car parks (less than 10%).

4.2.3.6 Proportion of footpaths and cycle paths

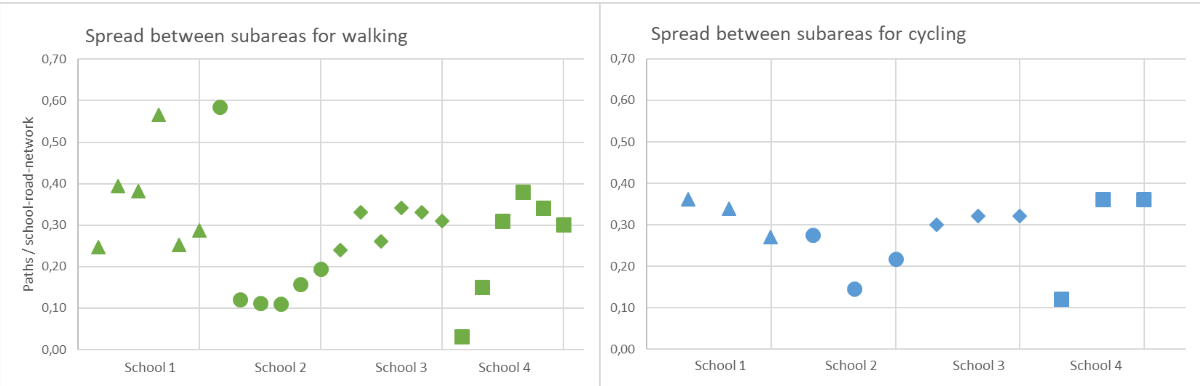

Figure 19: The diagrams show the value spread for the environmental proportion footpaths and cycle paths. On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1**, the proportion of footpaths and cycle paths peaked 15-20 minutes from the school. This tendency was not seen in the subareas for cycling. At **School 2**, the subarea closest to the school has a remarkably higher proportion of footpaths and cycle paths than the rest of the study area, which has relatively low proportions. At **School 3** there was little change in proportion of footpaths and cycle paths between the subareas. There was however a tendency of lower proportions in the areas closer to the school. **School 4** has a low proportion of footpaths and cycle paths in the subareas close to school. The proportion increased with distance.

When comparing the schools, there is a lot of variation in tendencies between the four schools. School 2 has a lower proportion of footpaths and cycle paths compared to the other schools, apart from the area closest to the school. School 4 stands out as it has a very low proportion of footpaths and cycle paths in the areas closest to the school.

4.2.3.7 Proportion of buildings with "eyes on the street"-effect

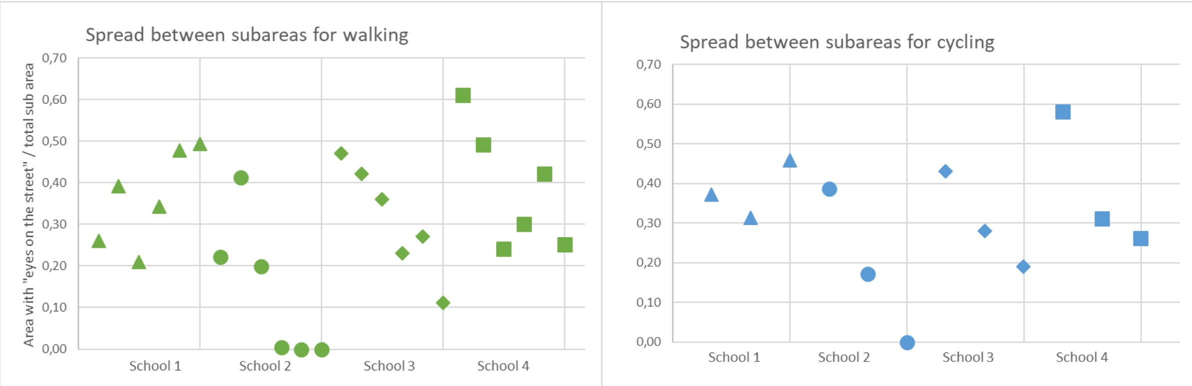

Figure 20: The diagrams show the value spread for the environmental proportion of buildings with "eyes on the street"-effect. On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** the proportion of buildings with "eyes on the street"-effect was higher in the subareas far away from the school. At **School 2** the proportion were higher in the subareas close to the school. The same tendencies can be seen for **School 3** and **School 4**.

When comparing the schools, School 4 has the overall highest proportion. School 1 have less spread in the proportion values, compared to the other schools. The only school where the proportion values were 0, was at School 2, in the subareas far away from the school.

4.2.3.8 Proportion of industrial areas

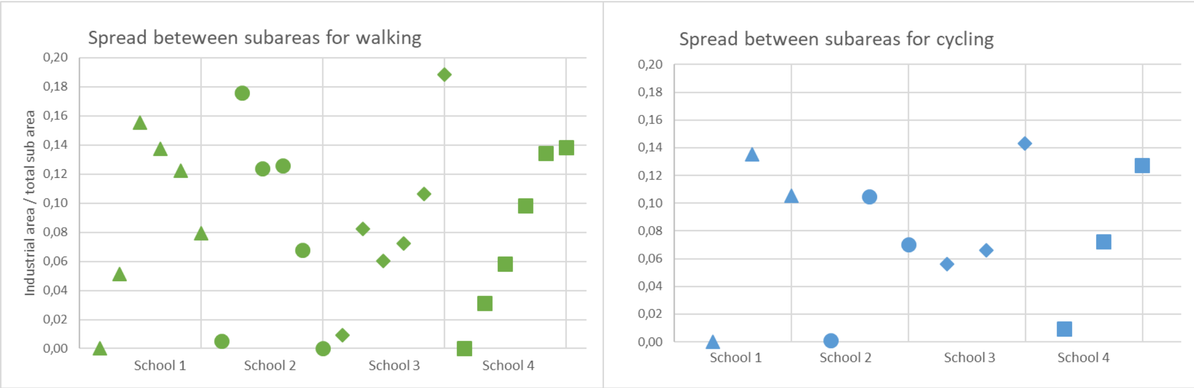

Figure 21: The diagrams show the value spread for the environmental proportion of industrial area. On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** the proportion of industrial area increased with distance from the school before it peaks and sinks again. There was a similar tendency at **School 2**, where it peaks around 5-15 minutes from the school. At **School 3** the proportion industrial area increased with distance from the school. The same tendency was seen at **School 4**.

When comparing the schools with each other, they all have a little or no industrial area in the environment closest to the school. Yet, both School 1 and 2 have a peak in industrial areas within 15 minutes from the school for walking. At School 3 and 4 the proportion of industrial areas increased with distance from the school. School 3 however stands out, as it has a higher proportion in the area close to the school (5-10 min walking and 0-5 min cycling).

4.2.3.9 Proportion of high-rise buildings and employment districts

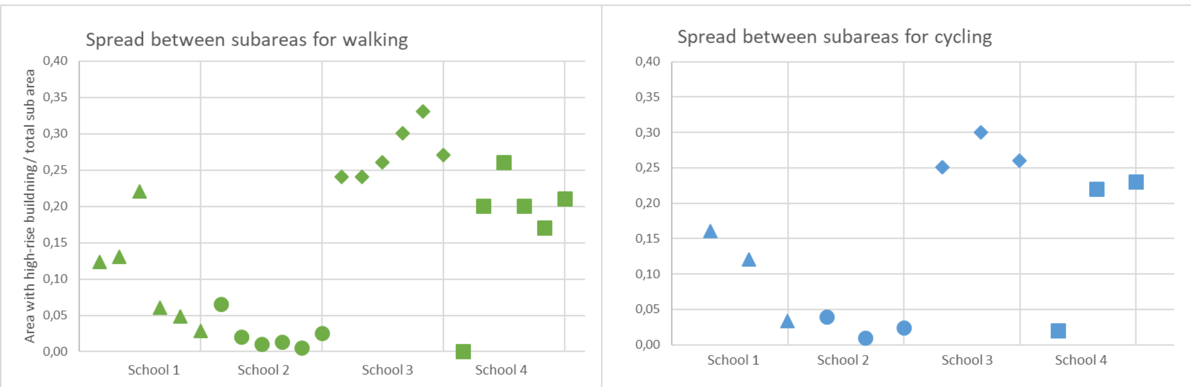

Figure 22: The diagrams show the value spread for the environmental proportion of high-rise buildings and employment districts. On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols

At **School 1** the proportion of high-rise buildings and employment districts gradually decreased with distance from the school. At **School 2** there was an overall low proportion of high-rise buildings and employments districts. The highest proportion was found in the subarea closest to the school. At **School 3** the proportion if high-rise buildings and employment districts show a tendency to increase with distance from the school. There was an overall high proportion. At **School 4** proportion if high-rise buildings and employment districts showed a tendency to increase with distance from the school. In the area closest to the school, the proportion was low.

When comparing the schools, School 1 and 2 the proportion gradually decreased with distance, while at School 3 and 4 the proportion increased with distance. School 2 has notably lower values than the rest of the schools. School 3 has the highest proportion values, also in the subarea closest to the school.

4.2.4 Connectivity

4.2.4.1 Network intersection density

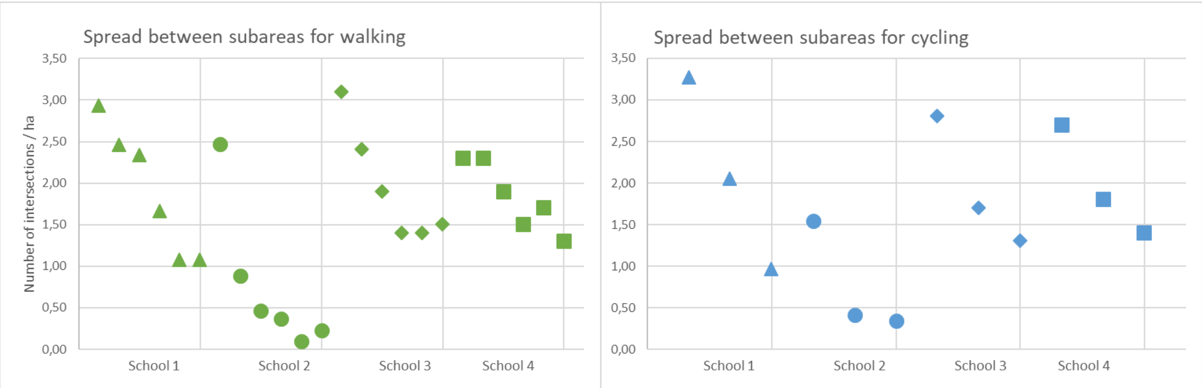

Figure 23: The diagrams show the value spread for the environmental intersection density. On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

School 1 has a higher density of network intersections in the subareas close to the school. There is a strong trend of lower intersection density further from the school. The same tendency can be seen at **School 2, 3 and 4.**

There are very similar tendencies at each of the schools, where the intersection density decreases with distance. School 2 stands out, as it has a lower intersection density than the rest of the schools. It also has a remarkably high intersection density in the area closest to the school, compared to the rest of the study area.

4.2.5 Comfort and attractiveness

4.2.5.1 Proportion of parks and green open spaces

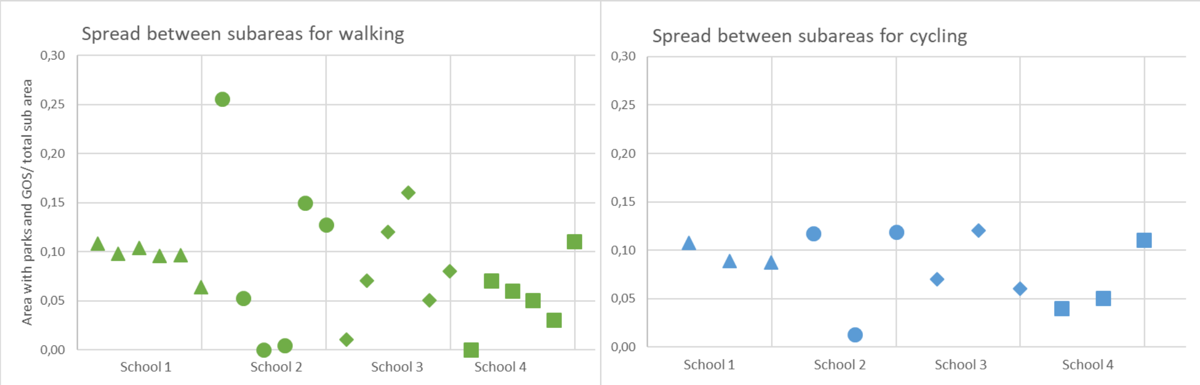

Figure 24: The diagrams show the value spread for the environmental proportion of parks and green open spaces (GOS). On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** there was very little variation in the proportion of parks and green spaces between the subareas. At **School 2** the inner subarea has a remarkably high proportion of parks, for walking. The same tendency was not seen in the study area for cycling. At **School 3 and 4** the proportion of parks were unevenly distributed between the subareas.

When comparing the schools, all have quite small proportions. School 2 stands out as it has a high proportion of parks in the subarea close to the school, but also in subareas far away from the school.

4.2.5.2 Proportion of forest

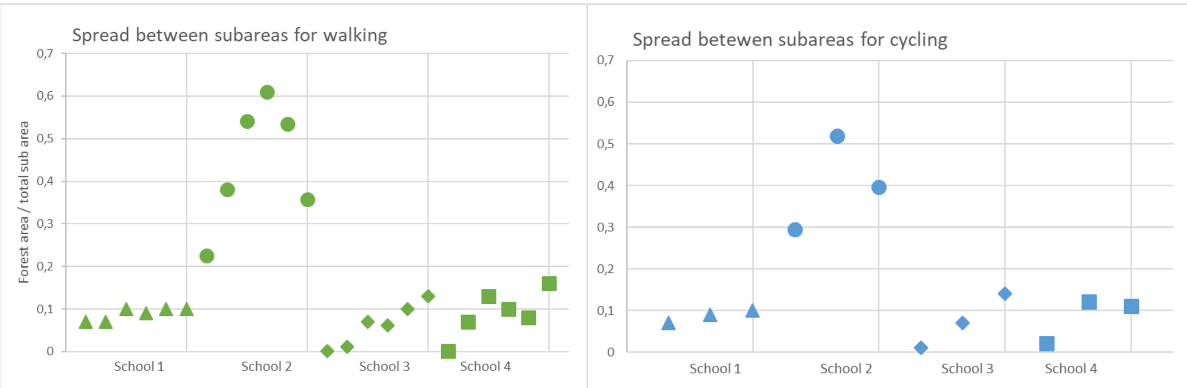

Figure 25: The diagrams show the value spread for the environmental proportion of forest. On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

School 1 has a very evenly distributed proportion of forest, yet the numbers are very small. **School 2** has a high proportion of forest in 10-25 minutes from the school for walking. While, **School 3** has a very low proportion of forest in the areas close to the school. The proportion increases further away from the school. The same tendency can be seen at **School 4**.

When comparing the schools, School 2 stands out as it has a considerably larger proportion of forest than the rest of the schools. School 3 and 4 have a larger proportion of forest further from the school.

4.2.5.3 Proportion of single family houses

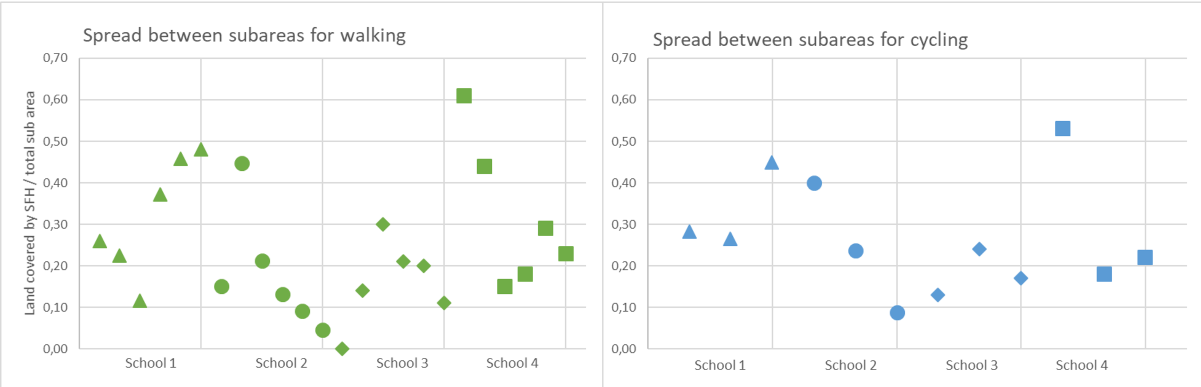

Figure 26: The diagrams show the value spread for the environmental proportion single family houses. On the x-axis the points represent a sub area, and the y-axis show the proportion of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** there was a tendency of higher proportion further away from the school, but the proportion drops 10-15 minutes from the school in the subareas for walking. At **School 2** there was a high proportion of single family houses close to the school, which decreased with distance. At **School 3** the proportion of single family houses was lowest in the inner and outer subareas. At **School 4** there was a high proportion of single family houses in the inner subareas.

When comparing the schools, School 2 and 4 stands out as they have high proportion of single family houses close to the school.

4.2.6 Opportunity to produce and maintain social capital

4.2.6.1 Population density

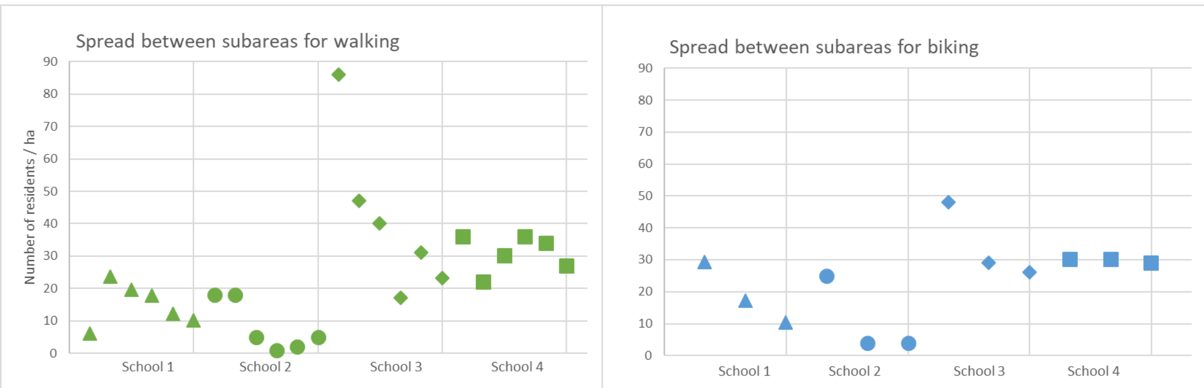

Figure 27: The diagrams show the value spread for the environmental population density. On the x-axis the points represent a sub area, and the y-axis show the density of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** the population density peaked 5-10 minutes from the school, but gradually decreased with distance. At **School 2** the population density was highest in the inner subareas, from here it decreased. At **School 3** the population density was highest in the inner subarea, and from here it gradually decreased. At **School 4** there was little change in population density between the subareas.

When comparing the schools, School 1 and 2 have the lowest population densities. School 3 stands out as it has a remarkably higher value in the area closest to the school. All the schools share the tendency of a decreasing population density with distance from the school.

4.2.6.2 Child population density

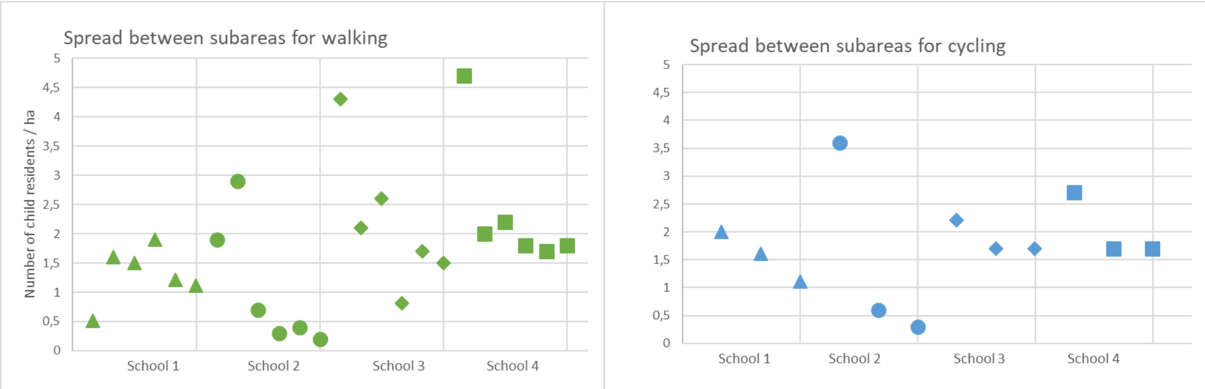

Figure 28: The diagrams show the value spread for the environmental proportion child population density. On the x-axis the points represent a sub area, and the y-axis show the density of the named environmental variable. The diagrams are separates by subareas for walking (green figure) and cycling (blue figure), and the schools are differentiated by symbols.

At **School 1** the child population density was at its lowest in the inner subarea. This tendency was not seen in the study area for cycling, where the density was highest close to the school and decreased with distance. At **School 2** the density was highest close to the school and decreased with distance. This tendency can also be seen at **School 3 and 4**.

When comparing the schools with each other, School 2, 3 and 4 have the highest child population in the inner subarea, but at School 1 the population peak was in the subarea 15-20 minutes from the school. However, this changed in the study area for cycling.

4.3 Testing of relationships

The relationship between the travel modes and the environment has been tested with Spearman's rank correlation. In the Table 7 the correlation results are listed and in Figure 29 we have arranged the scatter plots for each variable in a matrix. The correlations are strong when the order of the rankings are similar or opposite, where 1 equals a perfect match in rank order, and -1 equals a negative match in rank order. This indicates the strength of correlation between the explanatory variable and children's travel behaviour. The relationship should be considered in combination with the scatter plots since with only four schools to compare, an outlier can affect the appearance of a trend in these plots.

Table 7: Overview of Spearman's correlation. Expected relationship, based on the literature, is marked - or +. Colour codes indicate if the result corresponds with expectation.

		Spearman's ranked correlation			
	Environmental variable	*Walking*	*Expected relationship*	*Cycling*	*Expected relationship*
Traffic safety	Proportion of major roads	0,6	-	0,6	-
	Railroad presence in subareas	-0,1	-	-0,3	-
	Traffic accident density	-0,4	-/+	0,8	-/+
	Proportion of safe intersections	-0,2	+	0,8	+
	Proportion of car parks	-0,4	-	0,2	-
	Proportion of footpaths and cycle paths	-0,4	+	0,2	+
Personal safety	Proportion of buildings with "eyes on the street"-effect	-1	+	0,8	+
	Proportion of industrial area	0,2	-	0,4	-
	Proportion of high-rise buildings and employment districts	-0,4	-	0,8	-
Connec-tivity	Intersection density	-0,2	-	0,4	-
Comfort and attractiveness	Proportion of parks and green open spaces	0,8	+	-0,4	+
	Proportion of forest	0,2	+	-0,8	+
	Proportion of single family houses	-0,6	+	0	+
Social capital	Population density	-0,4	+	0,8	+
	Child population density	-0,8	+	1	+

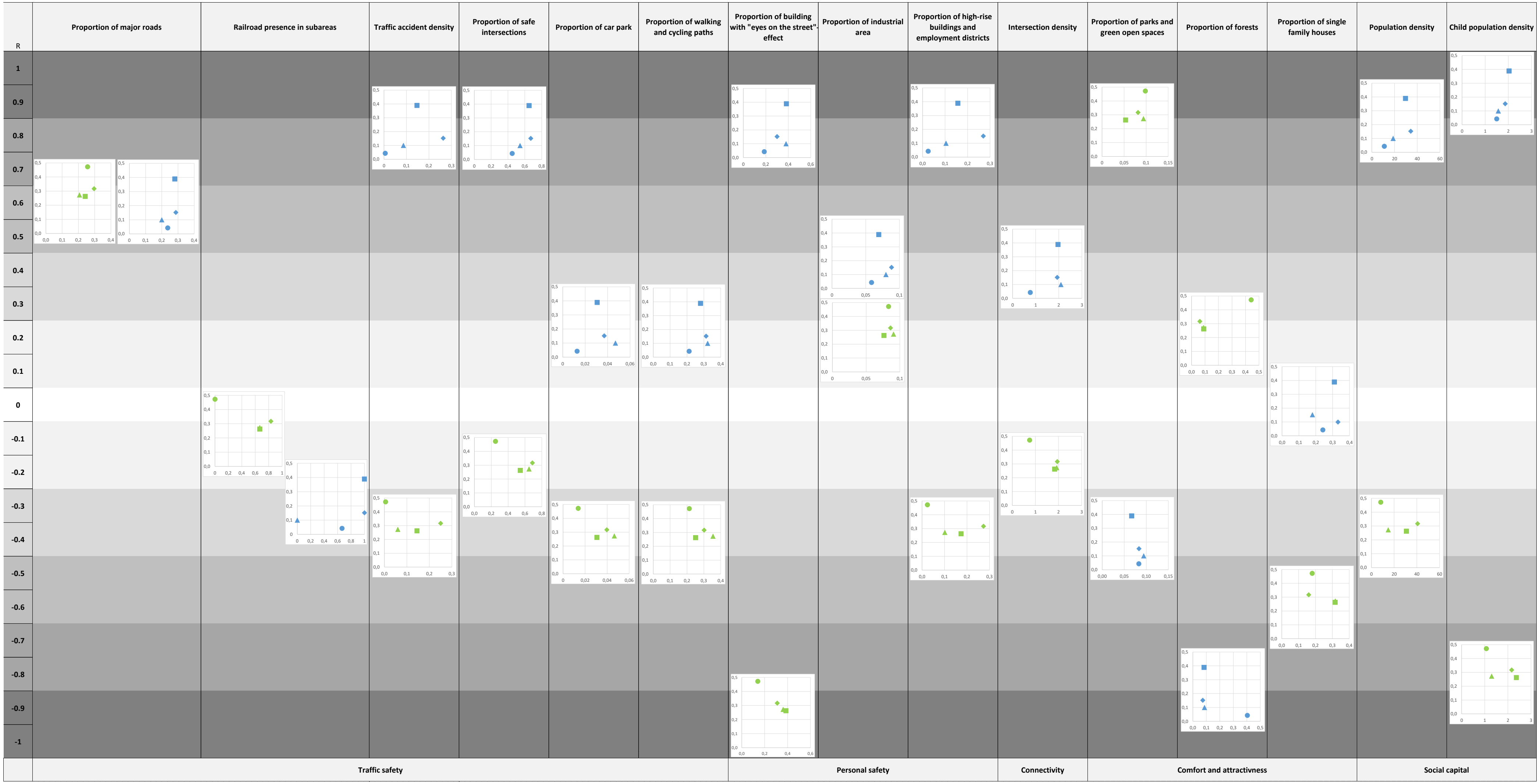

Figure 29. The matrix show the scatter plots for the environmental variables and the travel mode distribution for walking (green plots) and cycling (blue plots). The scatter plots are placed according to their Spearman´s ranked correlation value (-1 to 1) shown at the y-axis, and the environmental variable category shown at the x-axis. The schools are differentiated by symbols (School 1 = Δ, School 2 = ○, School 3 = ◊, School 4 = □).

The environmental variables with a strong positive or negative correlation are described below. Three of these variables were looked at further, with walking and cycling proportion calculated on only active transport modes. This is because we wanted to see if the relationship changed when excluding inactive travel modes. The variables that were tested again are marked with an asterisk (*).

Proportion of major roads* have a positive correlation for both walking (0.6) and cycling (0.6) on the environmental variable proportion of major roads. Seen in the scatter plot is that the mean values do not differ much, but School 2 stands out in the y-axis in the plot for walking and School 4 stands out on the y-axis in the plot for cycling. From the literature we expected the variable to have a negative influence on walking and cycling. The relationships do not correspond with what we expected from the literature.

In the new relationship test, walking got a correlation of 0 and cycling kept a correlation of 0.6. They are not each mirror images as the rank order of School 2 and 4 changes between walking and cycling. Seen in both of their scatter-plots are a low spread on the x-axis and higher spread on the y-axis due to the difference between School 2 and 4.

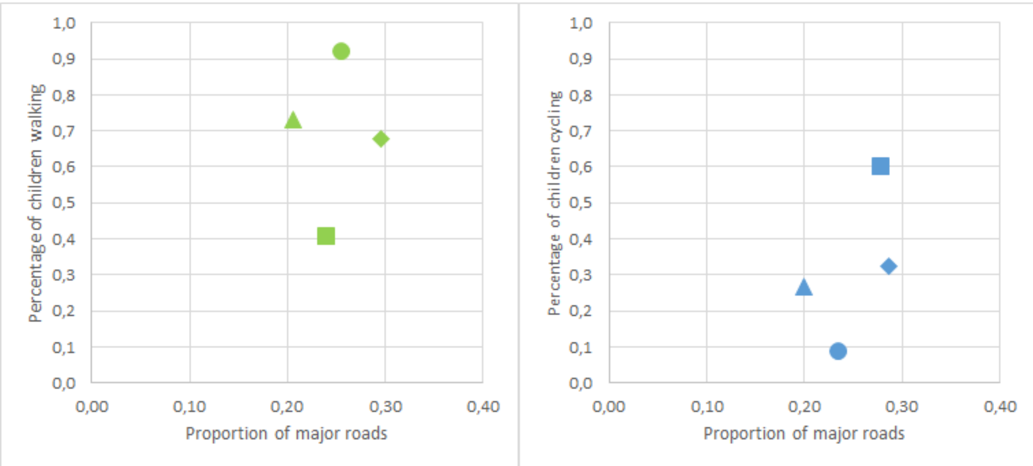

Figure 30. The scatter-plots show the relationship between the environmental variable proportion of major roads and proportion of children walking and cycling calculated from active travels.

Traffic accident density has a positive correlation for cycling (0.8). Seen in the scatter-plot for cycling is that the means are spread on both the x-axis and the y-axis, even though the correlation is high. The relationship between the environmental variable and walking gave no interesting relation (0.4). From the literature we expected a high negative effect of a high accident density, on the other hand no traffic accidents is also corresponding to less traffic. We therefore choose not indicate positive or negative corresponding.

Proportion of safe intersections has a positive correlation with cycling (0.8) but no interesting correlation with walking (-0.2). Seen in the scatter-plot for cycling is that the means are quite similar on the x-axis but School 4 stands out on the y-axis. The high correlation for cycling corresponds to School 4, that have a high ranking both the x- and the y-axis. From the literature we expected this variable to have a positive effect on both walking and cycling. In our results only cycling is found to be corresponding the literature.

Proportion of buildings with "eyes on the street"-effect* has a strong negative correlation with walking (-1) and a strong positive correlation with cycling (0.8). Seen in the scatter-plot is near to a linear relation for walking, and a fairly near to a linear relation for cycling. In the plot for cycling it is School 1 that stands out from the line, having a high rank on the x-axis but a low rank on the y-axis. From the literature we expected this variable to have a positive effect on both walking and cycling. In our results only cycling is found to be corresponding with the literature.

In the new relationship test walking got a correlation of -0.8 and cycling kept a correlation of 0.8. Seen in new scatter-plots are spread on both x-axis and the y-axis. School 1 stands out from the line at both walking and cycling. The strong linear relation found in the first test is no longer as strong. Also seen is that they become each other's mirror image.

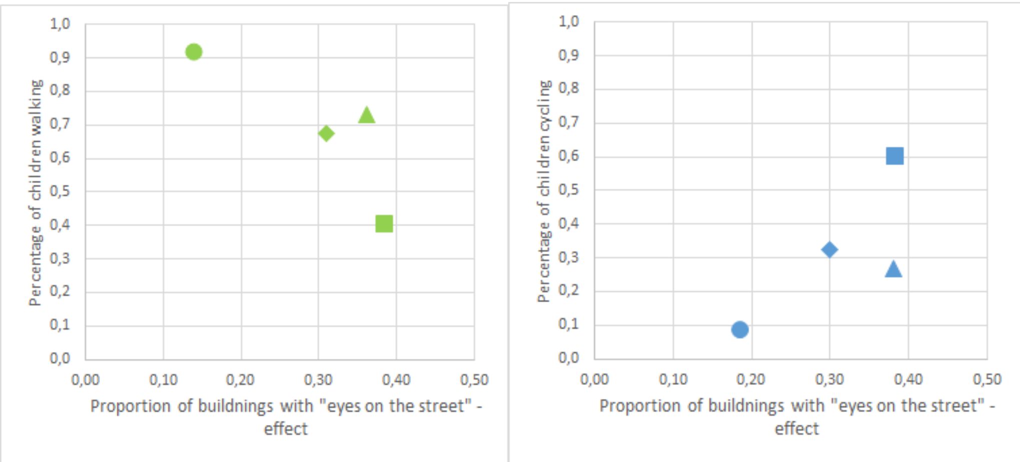

Figure 31. The scatter-plots show the relationship between the environmental variable proportion of buildings with "eyes on the street"-effect and proportion of children walking and cycling calculated from active travels.

Proportion of high-rise buildings and employment districts has a strong positive correlation with cycling (0.8). Seen in the scatter-plot for cycling is that the means are spread on both the x-axis and the y-axis, even though the correlation is high. This indicates that the actual likely travel environment of the children at each school is highly dependent on where they are in the catchment, thus the mean is likely to not be a good representation of their experienced environment, i.e. high-rise buildings may be prevalent in number but spatially clustered in an area few children pass. The relationship for walking is found to be not interesting (-0.4). From the literature we expect that this variable have a negative influence on both walking and cycling. Our results contradict the literature with a positive relation for cycling.

Proportion of parks and green open spaces has a strong positive correlation with walking (0.8) and no interesting relation with cycling (-0.4). Seen in the scatter-plot for walking is that the means are quite similar on the y-axis but School 2 stands out. The high correlation for walking corresponds to School 2, that have a high ranking both on the x- and the y-axis. From the literature we expected this variable to have a positive influence on both walking and cycling. In our results only walking is found to be corresponding with the literature.

The proportion of forests have a strong negative correlation with cycling (-0.8) and no interesting relation with walking (0.2). Seen in the scatter-plot for cycling is that the means are spread on both the x-axis and the y-axis, even though the correlation is high. From the literature we expected this variable to have a positive influence on walking and cycling. Our results contradict the literature with a negative relation with cycling, again, this may be an effect of an unrepresentative mean.

Population density has a strong positive relationship with cycling (0.8) and a no interesting relation with walking (-0.4). Seen in the scatter-plot for cycling is that the means are spread on both the x-axis and the y-axis, even though the correlation is high. From the literature we expected this variable to have a positive influence on walking and cycling. Our results corresponds with the literature for cycling, but the high variance in the density metric around the mean for each school indicates a need for caution in that conclusion.

Child population density* has a strong negative relationship with walking (-0.8) and a strong positive relationship with cycling (1). Seen in the scatter-plot is near to a linear relation for cycling, and a fairly near to linear relation for walking. In the plot for walking School 1 stands out from the line, having the lowest rank on the x-axis and the y-axis. From the literature we expected this variable to have a positive influence on walking and cycling. Our results corresponds with the literature for cycling but contradicts the literature for walking.

In the new relationship test, walking got a correlation of -1 and cycling kept a correlation of 1. Seen in both of their scatter-plots are near linear relation between the variable and travel mode. In the plot for walking the spread on the x-axis is found to be bigger than for cycling. This may be an effect of the mean being less representative for walking.

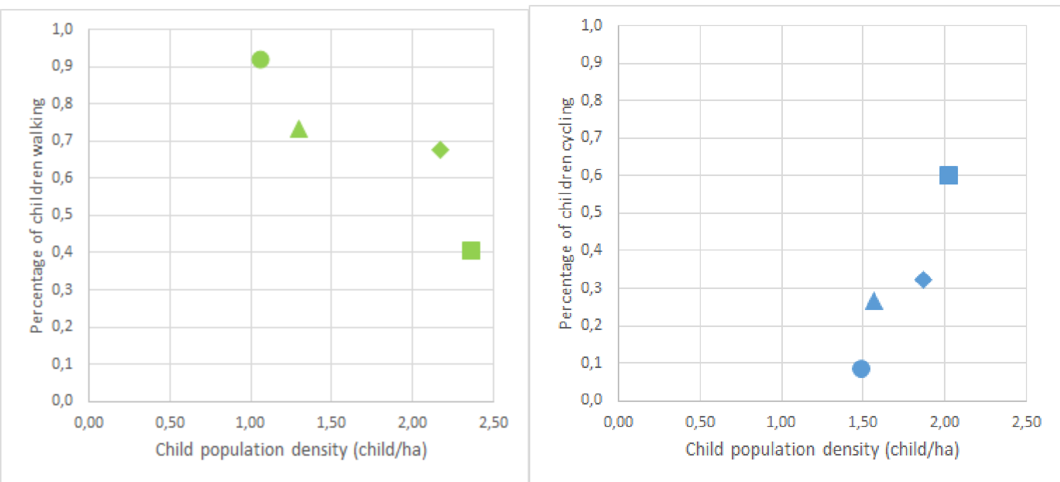

Figure 32. The scatter-plots show the relationship between the environmental variable child population density and proportion of children walking and cycling calculated from active travels.

5. Discussion

In this chapter we discuss our results in relation to the theoretical framework. The objective of this thesis has been to investigate the extended outdoor environments of four compulsory schools in mid/south Sweden in relation to the schools' travel mode distribution. We asked two research questions. The first research question was about how characteristics of the environment are related to the proportion of children walking and cycling to school. The second research question was about what planning conflicts that can be found for children's walking and cycling.

5.1 Environmental characteristics and school travel mode

5.1.1 Travel mode distribution at the schools

With the analysed data on travel mode distribution we can get an insight into the children's current travel habits at the four compulsory schools. The four schools differed in many ways in travel mode distribution. **School 4** stood out as the most active school, with a high rate of the travels made by bicycle. None of the other schools were close to having a similar share of cycling. Also the rate of children who reported that they walked to school was high, with a similar walking percentage as School 1 and 3. **School 2** had the highest share of children who reported that they walked to school. None of the other schools were close to reaching the same share of walking. **School 1** was found to be the overall least active school. Here the most common transport mode was being escorted by car. Also at **School 3**, the majority of the reported travels were made by car.

Factors other than the environment, which could have influenced the travel mode distribution of the reported school travels are age, gender and the weather on the days of the measurements. There is a tendency that older children are more active than younger children. This was a clear trend at School 3 and 4. At School 1 there was no interesting difference between the younger and the older children. At School 2 there was a clear opposite trend. The travel mode distribution changed from being dominated by walking in 2nd grade to being dominated by travelling by bus. An explanation for this shift could be that the school might have a bigger catchment area in 5th grade, and therefore children from surrounding areas travelled by bus. Assuming this, a high number of the younger children probably lived close to the school, which could help explain the high rate of walking.

It is difficult to say how gender affects school travel mode choice in this case. The unequal distribution of gender of the participants at School 3 and 4 could have influenced the distribution of travel modes, but it has probably not affected the results considerably. In previous findings boys were more active than girls (Larsen, et al., 2012), but School 4 had the highest proportion of girls, and yet was the most active school.

Weather can be seen as an external influencer on children's travel behaviour (Panter et al., 2008). Data of the weather conditions was collected for every measurement day at the four schools. School 1, 3 and 4 had one out of eight measurement days with precipitation. The other measurement days varied with different grades of cloudiness. The relationship between the weather and children's travel mode was not tested for significance. However, we judge that in this analysis, the weather is not a major variable to explain the children's travel behaviour.

5.1.2 Mapped characteristics of the extended outdoor environment

Based on Mitras (2013) conceptual framework, a total of 15 environmental variables were used to describe the infrastructure, land-use, connectivity and socio-material aspects in the extended outdoor environments of the schools. In this part we discuss how the variation between the subareas differed between the schools. The conclusions drawn about how this relates to travel mode are based on tendencies we have seen in the environment, and not on statistically tested relationships.

I. Proximity

Living closer to the school has been found to reduce the travel cost and encourage active and independent travels (Broberg & Sarjala, 2015; Ewing, et al., 2006; Larsen, et al., 2012; Mitra, 2013; Schlossberg, et al., 2006; Timperio et al., 2006; Wong et al., 2011). In this study we have measured a generalized travel cost of travel time, rather than measuring distance in meters. Together with child population data of children aged 7-15 years old, we got an overview of how the child population was distributed regarding travel time from the school. We found that School 2 had a very high share of child population close to the school, which indicates that many of the children in our travel data could live close to the school. This might also explain why so many children walked to School 2. This is based on the assumption that the residency of the children in the study, corresponds with the tendencies seen in the population distribution. The child population around the other schools were more evenly distributed, even though some tendencies can be seen. Around School 1 and 3 there are more children living closer to the school, than at School 4. However, these tendencies are not as strong as in the case of School 2 and it would be far-fetched to draw conclusions about the children in our study from this.

When children were asked, a child-friendly city should have basic services, such as schools, in the near proximity to places where they live (Nordstöm, 2010). Yet, in Sweden, children's distance to school has increased (Trafikverket, 2013) which could partially be explained by the free choice of school (Niska, et al., 2017). If these are the tendencies in the schools participating in our study, is not something we can conclude from the data we have. But from the literature we know that children tend to spend more time commuting than in their local neighbourhood (Cele, 2015). As planners we believe in land-use planning as a way to decrease distances and promote sustainable mobility. This however becomes a less powerful incentive when the children do not attend the school closest to their home and are becoming more mobile with motorized transportation. In our study, School 2 was the only school without any nearby competing schools. School 2 was also the school where we assume most children lived in near proximity to their school.

II. Traffic and personal safety

Previous studies have given us a good insight of what children perceive as safe. From a child perspective safety and security was found important when children expressed their views of what a child-friendly environment is. Both the physical and social environment can be threatening for children and perceptions of safety differs between the geographical location in which the children live (Horelli, 2007; Nordström, 2010). Traffic safety was also found to have a relationship with walking and cycling to school by Broberg and Sarjala (2015) and Mitra and Buliung (2014).

In our study, one variable where the schools differed was in the density of traffic accidents. Found here was that School 1 and 2 had a low accident density. While School 3 and 4 had a higher accident density, which also corresponded with the variable proportion of major roads being high at these schools. School 4 had a lower traffic accident density in the subarea closer to the school, compared to School 3. This could say something about the differences between the two schools. The number of accidents could indicate the degree of how safe the traffic environment is. On the other hand, a reduction of traffic accidents might also be explained by a reduction of children's mobility (Björklid, 2004). The fact that School 1 had a low number of traffic accidents could be understood as an outcome of general low rates of walking and cycling.

When comparing School 3 and 4, School 4 had a higher rate of cycling and very similar rate of walking, yet a lower traffic accident density. The exposure to traffic is probably lower at School 4, as this corresponded with the proportion of major roads. The best way to understand traffic safety, traffic accidents and active school travels is probably that they are interconnected processes with a complex relationship. However, since we did not measure children involved in traffic accidents, these conclusions are based on a general tendency of exposure to an unsafe traffic environment.

Mitra and Buliung (2013) found that a school environment without the presence of major roads is associated with higher rates of walking. In our study, School 2 fits this description as there are both high rates of walking and a low proportion of major roads close to the school. School 4 could also fit the description, only with a high rate of children that cycle. Similarly to School 2, the proportion of major roads is very low in the subarea closest to the school.

To measure personal safety we have studied different land-use variables. Mitra (2013) discuss that low scale urban development which places eyes on the street can encourage walking among children by providing a safer environment. When we studied this variable we saw a tendency at all the schools of higher proportions of "eyes on the street"- buildings in the subareas closer to the schools. This can probably be explained by the fact that all of the schools are placed in residential neighbourhoods.

A safe traffic and social environment has an in general safe transport system and public places (Horelli, 2007). Even though this is a very universal statement, it can be understood as the presence of a footpath, safe intersection or a residential house is enough to give a perception of safety that can encourage children to walk or cycle. Therefore, when analysing these variables, presence or absence of these variables within each subarea might be more important than their proportions. In our analysis, all of the studied variables that could increase children's mobility, such as safe intersections or existence of footpaths and cycle paths could be said to be general safe at the four schools. It would however be interesting to combine our results with studying what the participating children perceive as safe.

III. Connectivity

The results from previous research on connectivity are very inconsistent (Mitra, 2013; Wong et al., 2011). The results from the mapping of connectivity are similar for the four schools and it is difficult to see any tendencies that could be influencing travel mode. Connectivity could be influencing school travel behaviour, but the relationship seems to be very complex. Connectivity has been reported as important for adult's active mobility, but since a high connectivity can indicate high traffic it might have the opposite effect for children (Mitra, 2013). At School 2 the connectivity is lower than at the other schools. This could indicate that low connectivity can encourage walking. However, School 2 represents a non-urban environment where connectivity also could be claimed to be less relevant.

IV. Comfort and attractiveness

In our analysis, School 2 stood out from the others when it came to these environmental variables. For the variables proportion of parks and green open spaces and proportion of forests, there were little variation between School 1, 3 and 4. However, School 2 stands out with a proportion parks and green open spaces close to the school and it also had a considerably higher proportion forest than the other schools. The main reason why School 2 have more nature is because of its rural character. The findings on the effect of greenery for active travels are somewhat inconsistent (Wong, et al., 2011), however Larsen et al. (2012) found a positive association with presence of street trees and Mitra and Buliung (2014) found that environmental aesthetics were related to active school travel. When children are asked, accessible nature is important for a child-friendly environment (Horelli, 2007; Nordström, 2010). This could be one possible explanatory factor for the high rate of walking children at School 2, which would indicate that greenery is influencing walking more than cycling.

V. Produce and maintain social capital

Opportunity to produce and maintain social capital is often forgotten in the understanding of children's active travels (Mitra, 2013). The opportunity to more easily interact with friends was named important by children who did not have this freedom (Haikkola et al., 2007). Timperio et al. (2006) found that parents were more likely to let their children walk and cycle if they had the perception there were other children in the neighbourhood. As travelling for children is a combination of movement and play, being able to travel to school with friends, can be seen as a motivator for walking or cycling instead of being escorted in private cars (Björklid, 2004). At School 2, 3 and 4, there is a tendency of a higher child population density in the area closest to the school. This tendency is not as clear at School 1, which could possibly be an influencer of the low rates of walking and cycling there.

5.1.3 Correlation test with environmental variables and travel mode

We used Spearman's rank correlation to test the relationship between the environmental variables and school travel mode. This test did not include a measure of statistical significance, only the correlation effect. Our aim was to find which variables could be interesting for further studies, based on the indication of a relationship *in this data*, rather than to demonstrate evidence of this in the general sense. Nevertheless, there are some variables from the correlation test which are interesting to discuss.

The variable *Proportion of major roads* gave an unexpected result in two ways. It differed from the other variables in the sense that walking and cycling had the same correlation. Also, we expected this variable to have a negative correlation. Why they got the same correlation value could be because School 1 and 3 are ranked to have the lowest and highest proportions of major roads. In the ranking of other variables, either School 2 or School 4 were found ranking highest or lowest, but for this variable they were neutrally placed in the middle. It is crucial when interpreting the correlation test not to confuse a high correlation with a strong effect. The mean values for major roads, which the ranking was based on, were very similar for the four schools but this is not shown in the ranking. Since the correlation shifted to 0 in the second test with just active travel modes, it indicates that the effect is very weak. As shown in 4.2.2.1 there was a lot of variation within each school, these variations were lost when the mean value was calculated. For this variable it might be more relevant to study the variations between the subareas, to understand how it is related to school travel modes.

Another unexpected result was *proportion of footpaths and cycle paths*, which had a very weak correlation. This is something we expected to have a positive impact on walking and cycling. The existence of footpaths and cycle paths are fundamental for children's movement, and especially when it comes to children who cycle. However, the correlation test gave no strong relationship for either walking or cycling. A reason why we got so bad outputs could be because of averaging the subareas, as the average do not state anything of the existence of footpaths and cycle paths between the subareas. Similarly as major roads, for this variable it would have been useful to study each subarea separately.

Proportion of buildings with "eyes on the street"-effect, had high correlation which was mirrored for walking and cycling. The variable had a positive correlation for cycling and a negative correlation for walking. The same effect was seen for the variable *child population density*. The literature indicates that both "eyes on the street"-effect and child population density would have a positive influence on walking (Mitra, 2013). School 2 and School 4 become each other's opposites, both in the environmental ranking and the transport mode ranking. Therefore, their strong positive or strong negative correlation is a mathematical consequence of a data set where the majority of responses choose one or other of these two travel modes. A further explanation of the negative correlation for walking can be explained by the fact that School 2 had the highest proportion of walking children, and is placed in a more rural environment. Because of its rural character, it had an overall low proportion of buildings and low child population density. Here it is important to discuss the weakness in the method, since we do not know where the children live. With so many interactive explanatory variables, a much larger survey with more detailed spatial resolution is needed to resolve this picture. As we have discussed previously, it is reasonable to assume that many of the children who walk at School 2 live very close to the school. With this said, we still believe that these variables could be interesting to study further, since the results from the correlation test and the scatter plot combined indicate a relationship. We would like to see if these relationships also can be found on a greater scale.

Variables we find odd because they contradict the literature are the variables *proportion of high-rise buildings and employment districts, proportion of forest* and *proportion of single family houses.* As previously mentioned, we suspect the reason why they contradict the literature is because School 2 and 4 are connected and become each other's opposites both when it comes to environment and travel modes. For example, for cycling the variable *proportion of high-rise buildings and employment districts* has a strong positive relationship. This does not necessarily mean that the variable has a positive influence on cycling, but the ranking relationship is strong since School 3 and 4 have the highest proportion of this variable and the highest proportions of children who cycle. We believe that the correlation would have become weaker if there were more schools participating in the study. Similar explanations could be given for the two other variables.

In this study we have found that the environmental variables *proportion of buildings with "eyes on the street"-effect* and *child population density* distinguish themselves from the other environmental variables, and the fact that their scatter-plots show an almost linear relationship with transport mode makes them interesting. To test if these relationships still will be found at a greater scale could be interesting for further studies. But we do acknowledge that the relationship could be more complex, as a strong correlation is not necessarily a causal relationship. These relationships are difficult to reconstruct in models. It is therefore important to keep a holistic perspective rather than studying each variable individually, however establishing *degree* of contribution co-variances in a multi-linear regression would require a larger sample of schools.

5.2 Planning conflicts for children´s walking and cycling

It has been pointed that children are central in a definition of sustainable development and when adapting more sustainable transport systems a child perspective is important. Values and practices that we want future generations to have, should be encouraged for younger generations. Promoting active mobility for children can encourage continued patterns of active mobility (Mitra, et al., 2010). On a policy level it has been stated that children's active and independent mobility is important to care for (Regeringskansliet, 2017). From the UNCRC and the Global goals, it can be motivated that children's active and independent mobility should be accounted for in the urban planning process (Björklid, 2004; Global goals, n.d.-a; Unicef, 2008; United nations, 1989). Yet, children's active and independent mobility decreases. Naming the conflicts is a helpful tool to better define sustainability (Campbell, 2012). By pointing out the planning conflicts which can restrict children's active and independent mobility, we want to reintroduce a holistic perspective to our analysis.

An environment that promotes active transportation for adults is not necessarily the same as an environment that promotes active transportation for children. Rather, the research shows that adults' and children's travel behaviour differ in many ways (Mitra, 2011; Björklid, 2004), which can be seen as a planning conflict. It is therefore relevant to discuss what environment that was found at the two most active schools for walking and cycling, School 2 and School 4, even though we cannot claim a relationship between environment and travel mode. Assuming that the environment has impacted travel mode distribution at the studied schools, in our study, School 4 seemed to have the most cycle-friendly environment, while School 2 seems to have the most walking-friendly environment. The different variables mapped have provided a general idea of the environments of each school. The differences seen in the environment closest to the school and in travel mode choice between School 3 and School 4, indicate that Chatterjee's (2005) ideas about child-friendly places are more important than the concept of child-friendly cities. As these two schools are located in the same city, it is interesting that there were tendencies of more child-friendly characteristics, such as lower proportions of major road and traffic accidents and higher proportions of low scale development, in the closest environment of School 4. Coming back to the conflict, that adults and children are not equally mobile in the same environment, it can be argued that the environment of School 4 is characterised by an overall lower degree of mobility for adults. This highlights the conflict Whitzman et al. (2010) discuss, where children's mobility is conflicting with adults' mobility. Environments that enable children's independent mobility might therefore have to restrict adults' mobility e.g. in form of car use. In an environment for sustainable mobility we therefore argue that there should exist footpaths and cycling paths for people traveling at different speeds. Children should not be expected to adapt to adults grade of mobility, but there need to be places and roads that allows pedestrians/cyclists to be slow movers as well.

How walking-friendly and cycling-friendly an environment is for children varies in different geographical contexts. Mitra (2013) points to a tendency of more use of active travel modes among children in urban areas than in non-urban or rural areas. School 1 has a lower degree of urbanity, as it is placed in a small town, and has the lowest share of active travels. If this is seen as a non-urban environment, it corresponds with the tendency that Mitra (2013) highlights. On the other hand, this does not explain the high rate of walking at School 2, which also is placed in a non-urban environment. When Björklid (2004) compared children in an inner-city area and a suburban area, she found that less children were allowed to cycle in the inner-city than in suburban areas, since children and parents perceived heavy traffic and a lack of consideration among drivers in the inner city as a threat. It can be argued that School 3 is placed in a neighbourhood with a higher degree of urbanity, whereas School 4 is placed in a more suburban-like environment. This could be an explanation for the higher rate of cycling at School 4. These tendencies has to be considered in relation to the planning conflict that distances are growing and people are expected to be more mobile.

The increasing school travels with motorized travel modes indicates a trend where children are becoming more mobile, but less active and independent in their mobility. We don't know if the travels reported by the children in our study were made independently or not. However we can hypothesize that the children who walk or cycle to school are given a higher grade of freedom than the children who are escorted in private cars. As there are clear differences in how active the children are at the four schools, we can assume that there are differences in how independent they are. We think that the children at School 4 were given a greater independent mobility than the children at School 1. In an international comparison, Sweden is ranked one of the top countries when it comes to children's independent mobility (Shaw, et al., 2015) claiming that School 2 and 4 have a high degree of independent mobility is therefore a reasonable assumption. In relation to our study it is interesting that the two variables that had a strong correlation between travel mode and the environmental characteristics are the variables *proportion of buildings with "eyes on the street"-effect* and *child population density*. We know that independent mobility is a gradual process that has to be taught (Cornell & Hill, 2006) and for parents to give their children a higher degree of freedom, the presence of both of these variables could be important.

5.3 Limitations of this study

Mitra's (2013) conceptual framework has been helpful when it comes to defining what environmental variables that are important when studying children's travel behaviour. The framework is very extensive and theoretically covers this complex relationship. However, in practice it is a challenge to adapt this multi-level approach that includes the urban environment, the household and personal characteristics of a child. Household and personal characteristics are variables we have not been able to include in this study. The five environmental domains have been guiding in describing the environmental characteristics of the schools, but since they are open, they also become somewhat vague and difficult to concretise.

The data from the Kidscape II research project was collected with several aims. The objectives of this study fit the purpose of Kidscape II, but the data and methods used on the data are not fully compatible. The method we ended up using is based on several assumptions. With more specific data, such as knowing the children's travel routes, it would have been possible to test the relationship between travel mode and environment with advanced statistical tests. From this we have learned the importance of customized research design, as it is difficult adapt existing data after a method. Though, we believe that the cost distance analysis made for this study has made the results stronger. Using travel time to measure accessible areas rather than just distance has made the results more accurate, even though the output of the model is specific to the input data that we have defined. Estimating what areas that are accessible for children is an interesting result in itself.

The correlation test gave high correlation for some of the variables, and more often there was found to be a strong positive relationship between the environment and the travel mode cycling, than between the environment and the travel mode walking. That walking and cycling become each other's opposites was weakness of the ranking test, and that we had to use the proportional travel mode distribution in the calculation. Further, it is important to acknowledge that a high correlation is not the same as a strong effect, since many of variables with a high ranking were not close to having a linear relation in the scatter-plots.

This thesis has been a learning process where we have gained a lot of important knowledge along the way. Yet, major decisions on methods and research design were made when the knowledge was the lowest. We are very grateful that Kidscape II shared their data with us. We could not possibly have collected all this data ourselves, with respect to the time we had available.

5.3.1 Limitations of previous research

Our method is inspired by methods from previous research. Though we have learned in the process that this method is complicated, as the relationships between the environmental factors and school travel behaviour is very complex. Previous studies have not given consistent results (Wong et al. 2011). It is therefore not necessary that redoing this study with the information about children's travel routes would have given much better results. One major limitation with the previous findings, which is brought up by Schlossberg et al. (2006), is the fact that correlation is not the same as causality. Since the relationships are so complex, the correlating relationships found in previous research does not necessarily have a causal relationship.

Wong et al. (2011) discuss that the inconsistency in the findings from previous research could be explained by inconsistency in the methods. There is not a standardized method to measure the environment in an objective way. This would probably be a good idea for further studies. Yet, the environment is not objective. Features of the environment could have different meaning in different places. It is also discussed whether the different geographical contexts in the studies is an explanation for the inconsistency, which Broberg and Sarjala (2015) also argue for. This is something we have thought about in our process. A lot of the previous research is from an American context, which differs a lot from the Swedish context. The fact that children's independent mobility is higher in Scandinavia (Shaw, et al. 2015) indicates that the environment is also more child-friendly. Mitra and Buliung (2014) discuss that their findings are not generalizable to all neighbourhoods. This indicates that it is more complex than just differences at an international level. The inconsistency in the results may be explained by the fact that it is very difficult to generalize which environmental factors that influence children's school travel. Maybe every environment has to be understood in its own context. Wong et al. (2011) suggests that future research should study the relationship between parents' and children's perceptions about the environment, with objective measures of what the environment actually looks like. This is something we agree would be interesting to study further.

5.4 Further studies

For further studies we recommend that more data is collected and that this data includes information about the route children travel, or at least how far from their school they live. It would also be interesting to compare schools which are placed in a more similar geographical context, e.g. compare schools located in the same city. Our results have indicated that there can be a lot of variation between schools located in the same city.

We also believe that the causality of the different variables should be counted for. In combination of studying what environments are related to active travel modes it is equally important to understand what limits children’s mobility. These limitations are not necessarily the environment itself but could also be the perceptions of different environments. Further studies should therefore consist of both quantitative and qualitative information of children's travel habits. Studying perceptions of the environment could indicate causality to a greater extent than just studying the environment quantitatively.

It would also be interesting to study changes in the environment over time, since the school travel behaviour has changed significantly in the recent decades. It might me more difficult to objectively measure changes in the environment over longer time periods, but this could be studied with more qualitative methods. Changes over time in perceptions of the environment could also be of interest for further studies. Studies like this, which set our current travel habits in a broader perspective, are relevant because we tend to adapt to the environment we live in (Björklid, 2004).

6. Conclusion

The mapping has given a wide understanding of what the environments looks like around the four schools, which has helped explain why the travel mode shares are different at the different schools. The main findings from this study was that School 4 had the highest rate of children who cycled and the school was located in an urban environment. Also, the area of the inner subareas had a high degree of child-friendly characteristics. Similarly School 2 had the highest rate of children who walked. Located in a rural environment, School 2 also had a high degree of child-friendly characteristics in the inner subareas. Further, children's proximity to the school, is something we assume can explain the rates of walking at School 2.

However, it was found difficult to test the relationship between the environmental variables and travel mode choice. Two variables, *proportion of buildings with "eyes on the street"-effect* and *child population density,* had the better linear relation and are therefore named interesting for further studies on a greater scale. But we do acknowledge the relationship could be more complex, as a strong correlation is not necessarily a causal relationship. The results of this study should therefore be considered suggestive. We also conclude that research design is essential when studying this relationship, and that more extensive travel data could give better results.

The relation between the environment and travel modes are difficult to reconstruct in models. It could therefore be important to keep a holistic perspective rather than studying each variable by itself. In the study we named longer distances and different preferences in environments among adults and children as planning conflicts for children's walking and cycling to school. Taking these conflicts into consideration could provide a more child-friendly urban planning and allow more children to become independently mobile.

References

Agren, J., Eklundh, L., Olsson, H., Harrie, L., & Klang, D. (2013). Insamling av geografiska data [Collection of geographical data]. In L. Harrie (Eds), *Geografisk informationsbehandling: teori, metoder och tillämpningar* (6 ed., p.103-138). Lund: Studentlitteratur

Agren, J. & Hauska, H. (2013). Referenssystem och kartprojektioner [Reference systems and map projections]. In L. Harrie (Eds), *Geografisk informationsbehandling: teori, metoder och tillämpningar* (6 ed., p.79-101). Lund: Studentlitteratur

Ahern, S. M., Arnott, B., Chatterton, T., de Nazelle, A., Kellar, I., & McEachan, R. R. C. (2017). Understanding parents' school travel choices: A qualitative study using the Theoretical Domains Framework. Journal of Transport and Health, 4, 278-293.

Anund, A., Forsberg, I. & Larsson, L. (2013). Varför skjutsar föräldrarna barnen till skolan? [Why do parents drive children to school?]. Stockholm: Sveriges kommuner och landsting.

Banister, D. (2008). The sustainable mobility paradigm. *Transport policy*, *15*(2), 73-80.

Björklid, P. (2004). Children's independent mobility and relationship with open space–studies of 12-year-olds' outdoor environment in different residential areas. *Revista Psihologie Aplicta*, *3*.

Broberg, A., Kyttä, M., Fagerholm, N., (2013). Child-friendly urban structures: Bullerby revisited. J. Environ. Psychol. 35,110–120.

Broberg, A., & Sarjala, S. (2015). School travel mode choice and the characteristics of the urban built environment: the case of Helsinki, Finland. *Transport policy*, *37*, 1-10.

Campbell, S. (1996). Green cities, growing cities, just cities?: Urban planning and the contradictions of sustainable development. *Journal of the American Planning Association*, *62*(3), 296-312.

Campbell, S. (2012). Green Cities, Growing Cities, Just Cities?. *Readings in Planning Theory, Third Edition*, 413-438.

Cele, S. (2006). *Communicating place: methods for understanding children's experience of place.* Stockholm Studies in Human Geography No. 16, Stockholm University.

Cele, S. (2015). Childhood in a Neoliberal Utopia: Planning Rhetoric and Parental Conceptions in Contemporary Stockholm. *Geografiska Annaler: Series B, Human Geography*, 97(3), 233–247.

Chatterjee, S. (2005). Children's Friendship with Place: A Conceptual Inquiry. *Children, Youth and Environments 15*(1): 1-26. Retrieved from http://www.colorado.edu/journals/cye/.

Colclough, J. G., & Owens, E. (2010). Mapping pedestrian journey times using a network-based GIS model. *Journal of Maps*, *6*(1), 230-239.

Cornell, E., & Hill, K.A. (2006). The problem with lost children. In Spencer, C., & Blades, M, *Children and their environments: Learning, using and designing spaces* (p. 26-41). Cambridge: Cambridge university press

Ding, D., Sallis, J. F., Kerr, J., Lee, S., & Rosenberg, D. E. (2011). Neighborhood environment and physical activity among youth: a review. *American journal of preventive medicine*, *41*(4), 442-455.

Eklund, L., & Pilesjö, P. (2013). Rumsliga datastrukturer [Spatial data structures]. In L. Harrie (Eds), *Geografisk informationsbehandling: teori, metoder och tillämpningar* (6 ed., p.139-160). Lund: Studentlitteratur

Essebo, M., & Baeten, G. (2012). Contradictions of 'Sustainable Mobility'–The illogic of growth and the logic of myth. *Tijdschrift voor economische en sociale geografie*, *103*(5), 555-565.

Ewing, R., Schroeer, W., & Greene, W. (2004). School location and student travel analysis of factors affecting mode choice. *Transportation Research Record: Journal of the Transportation Research Board*, (1895), 55-63.

Ewing, R., & Cervero, R. (2010). Travel and the built environment. Journal of the American Planning Association, 76(3), 1–30.

Francis, M. & Lorenzo, R. (2006). Children and city design: Proactive process and the 'renewal' of childhood. In Spencer, C., & Blades, M, *Children and their environments: Learning, using and designing spaces* (p. 217- 237). Cambridge: Cambridge university press

Global goals (n.d.-a). *The 17 goals*. Retrieved from: https://www.globalgoals.org/ [2018-02-12].

Global goals (n.d.-b). *Goal 3: Good health and well-being*. Retrieved from: https://www.globalgoals.org/3-good-health-and-well-being [2018-02-12].

Global goals (n.d.-c). *Goal 9: Industry innovation and infrastructure*. Retrieved from: https://www.globalgoals.org/9-industry-innovation-and-infrastructure [2018-02-12].

Global goals (n.d.-d). *Goal 11: Sustainable cities and communities.* Retrieved from: https://www.globalgoals.org/11-sustainable-cities-and-communities [2018-02-12].

Gray, J. A., Zimmerman, J. L., & Rimmer, J. H. (2012). Built environment instruments for walkability, bikeability, and recreation: disability and universal design relevant?. *Disability and health journal*, *5*(2), 87-101.

Haikkola, L., Pacilli, M. G., Horelli, L. and Prezza, M. (2007). Interpretations of urban child-friendliness: a comparative study of two neigh-bourhoods in Helsinki and Rome, *Children, Youth and Environments*, 17(4), 319–351.

Harrie, L., & Eklundh, L. (2013). Introduktion till geografisk informationsbehandling [Introduction to geographical information processing]. In L. Harrie (Eds), *Geografisk informationsbehandling; teori, metoder och tillämpningar* (6 ed., p.19-35). Lund: Studentlitteratur

Horelli, L. (2007). Constructing a theoretical framework for environmental child-friendliness, *Children, Youth and Environments 17*(4), 267–292.

Isaksson, K. (2006). Fernissa eller förändring [Varnish or change]. *Blücher and Graninger (eds) Planering med nya förutsättningar*, 107-121.

Koglin, T. (2013). Vélomobility-A critical analysis of planning and space. *Bulletin 284*.

Larsen, K., Gilliland, J., Hess, P., Tucker, P., Irwin, J., & He, M. (2009). The influence of the physical environment and socio-demographic characteristics on children's mode of travel to and from school. *American Journal of Public Health*, 99(3), 520-526.

Larsen, K., Gilliland, J., & Hess, P.M. (2012). Route-based analysis to capture the environmental influences on a child's mode of travel between home and school. Annals of the Association of American Geographers, 102, 1–18.'

McDonald, J. (2014). Spearman rank correlation. Handbook of biological statistics. Retrieved from: http://www.biostathandbook.com/spearman.html [2018-05-08]

McMillan, T. E. (2005). Urban form and a child's trip to school: the current literature and a framework for future research. *Journal of Planning Literature*, *19*(4), 440-456.

Mecredy, G., Pickett, W., & Janssen I. (2011). Street connectivity is negatively associated with physical activity in Canadian youth. Int. J. Environ. Res. Public Health 2011, 8, 3333-3350; doi:10.3390/ijerph8083333

Mitra, R. (2011). *School Travel Mode Choice Behaviour in Toronto, Canada* (Doctoral dissertation).

Mitra, R. (2013). Independent mobility and mode choice for school transportation: a review and framework for future research. *Transport reviews*, *33*(1), 21-43.

Mitra, R., & Buliung, R. N. (2014). The influence of neighborhood environment and household travel interactions on school travel behavior: an exploration using geographically-weighted models. *Journal of Transport Geography*, *36*, 69-78.

Mitra, R., Buliung, R., & Roorda, M. (2010). Built environment and school travel mode choice in Toronto, Canada. *Transportation Research Record: Journal of the Transportation Research Board*, (2156), 150-159.

Niska, A., Henriksson, M., Anund, A., Eriksson, J., Ihlström, J., Svedberg, W., Wallén Warner, H., Wehtje, P. (2017). Cykling bland barn och unga. En kunskapssammanställning. [Cycling among children and youth. A compilation of knowledge.]. VTI rapport 958. Statens väg- och transportforskningsinstitut, Linköping.

Nordström, M. (2010). Children's view on child-friendly environments in different geographical, cultural and social neighbourhoods. *Urban studies 47*(3). 414-528. DOI: 10.1177/0042098009349771

Nyström, J., & Tonell, L. (2012). *Planeringens grunder: En översikt* (3. ed.). Lund: Studentlitteratur.

Pagels, P., Raustorp, A., De Leon, A. P., Mårtensson, F., Kylin, M., & Boldemann, C. (2014). A repeated measurement study investigating the impact of school outdoor environment upon physical activity across ages and seasons in Swedish second, fifth and eighth graders. *BMC Public Health*, *14*(1), 803.

Panter, J . R., Jones, A. P., van Sluijs, E. M. F. (2008). Environmental determinants of active travel in youth: a review and framework for future research. Int. J. Behav. Nutr. Phys. Act.5(34).

Panter, J. R., Jones, A. P., Van Sluijs, E. M., & Griffin, S. J. (2010). Neighborhood, route, and school environments and children's active commuting. *American journal of preventive medicine*, *38*(3), 268-278.

Pilesjö, P. & Eklundh, E. (2013). Analys av geografiska data [Analysis of geographical data]. In L. Harrie (Eds), *Geografisk informationsbehandling; teori, metoder och tillämpningar* (6 ed., p.211-262). Lund: Studentlitteratur

Puri, S.C. & Mullen, K. (1980). Applied statistics for food and agricultural scientists. Boston, Mass.: G.K. Hall Medical Publ..

Raustorp, A., Boldemann, C., Mårtensson, F., Sternudd, C., & Johansson, M. (2013). Translation of children's cycling into steps: the share of cycling in 10-year-olds' physical activity. *International journal of adolescent medicine and health*, *25*(2), 171-176.

Regeringskansliet (2017). En nationell cykelstrategi för ökad och säker cykling [A national cycling strategy for more and safer cycling]. Retrieved from: http://www.regeringen.se/498ee9/contentassets/de846550ff4d4127b43009eb285932d3/20170426_cykelstrategi_webb.pdf [2018-05-04]

Rissotto, A. & Giulani, M.V., (2006). Learning neighbourhood environments: the loss of experience in a modern world. In Spencer, C., & Blades, M, *Children and their environments: Learning, using and designing spaces* (p. 75-90). Cambridge: Cambridge university press

Schlossberg, M., Greene, J., Phillips, P. P., Johnson, B., & Parker, B. (2006). School trips: effects of urban form and distance on travel mode. *Journal of the American Planning Association*, *72*(3), 337-346.

Shaw, B., Bicket, M., Elliott, B., Fagan-Watson, B., Mocca, E., & Hillman, M. (2015). Children's Independent Mobility: an international comparison and recommendations for action.

Spencer, C., & Blades, M. (Eds.). (2006). *Children and their environments: Learning, using and designing spaces*. Cambridge University Press.

Thompson, D. C., Rebolledo, V., Thompson, R. S., Kaufman, A., & Rivara, F. P. (1997). Bike speed measurements in a recreational population: validity of self reported speed. *Injury Prevention*, *3*(1), 43-45.

Tight, M. & Givoni, M. (2010). The role of walking and cycling in advancing healthy and sustainable urban areas. *Built Environment*, *36*(4), 461-473

Timperio, A., Ball, K., Salmon, J., Roberts, R., Giles-Corti, B., Simmons, D., ... & Crawford, D. (2006). Personal, family, social, and environmental correlates of active commuting to school. *American journal of preventive medicine*, *30*(1), 45-51.

Trafikanalys (2015). *Cyklandets utveckling i Sverige 1995 - 2014 - en analys av de nationella resvaneundersökningarna* (2015:14) [The development of cycling in Sweden 1995-2014 - an analysis of the national travel behaviour surveys (2015:14)]. Retrieved from: https://www.trafa.se/globalassets/rapporter/2010-2015/2015/rapport-2015_14-cyklandets-utveckling-i-sverige-1995-2014.pdf [2018-05-04]

Trafikverket (2013). *Barns skolvägar 2012* (2013:006) [Children's school ways 2012 (2013:006)]. Retrieved from: https://trafikverket.ineko.se/Files/sv-SE/11519/RelatedFiles/2013_006_Barns_skolvagar_2012.pdf [2018-05-04]

Trafikverket (2017). Dataproduktspecifikation – Funktionell vägklass. Version 3.0. [Data product specification – functional road class. Version 3.0].

Trafikverket (2018). *Översikt vägdata 4.0* [Overview road data 4.0]. Retrieved from: https://www.trafikverket.se/TrvSeFiler/Foretag/Bygga_och_underhalla/Vag/Dataproduktspecifikationer/Oversikt_vagdata/Oversikt_vagdata_v4.0.pdf [2018-05-04]

Transportstyrelsen (n d). Strada informationssystem [Strada information system]. Retreived from: https://www.transportstyrelsen.se/STRADA [2018-05-04]

Trost, J., & Hultåker, O. (2016). *Enkätboken*. Lund : Studentlitteratur, 2016.

Unicef (2008). Handbok om barnkonventionen [Handbook about the Convention on the Rights of the Child]. Retrieved from: http://www.manskligarattigheter.se/dm3/file_archive/080125/81db21f2994036a27e03853ac1d679b7/Handbok%20om%20barnkonventionen%20-%20UNICEF.pdf [2018-05-04]

United Nations (1987). *Report of the World Commission on Environment and Development: Our common future.* Retrieved from: http://www.un-documents.net/our-common-future.pdf [2018-02-12]

United Nations (1989). *Convention on the Rights of the Child*. Retrieved from: https://www.globaldetentionproject.org/wp-content/uploads/2016/06/Convention-on-the-Rights-of-the-Child.pdf [2018-05-04]

Wee, B.V., Annema, J.A. & Banister, D. (red.) (2013). *The transport system and transport policy: an introduction*. Cheltenham, UK: Edward Elgar.

Wasström, C., Lönnberg, G., Harrie, L. (2013). Kvalitetsaspekter [Quality aspects]. In L. Harrie (Eds), *Geografisk informationsbehandling; teori, metoder och tillämpningar* (6 ed., p.19-35). Lund: Studentlitteratur

Westman, J. (2017). *Drivers of Children's Travel Satisfaction* (Doctoral dissertation, Karlstads universitet).

Whitzman, C., Worthington, M., & Mizrachi, D. (2010). The journey and the destination matter: Child-Friendly Cities and children's right to the City. *Built Environment*, *36*(4), 474-486.

Wong, B. Y. M., Faulkner, G., & Buliung, R. (2011). GIS measured environmental correlates of active school transport: a systematic review of 14 studies. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 39.