Student thesis series INES nr 471

Smarter geovisualization tools: a user approach

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2019
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Smartare Geovisualiseringsverktyg: Ett användarperspektiv

Master degree thesis, 30 credits in Geomatics
Department of Physical Geography and Ecosystem Science, Lund University

Level: Master of Science (MSc)

Course duration: September 2018 until January 2019

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Master thesis, 30 credits, in Geomatics

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Abstract

Geovisualization tools are continuously becoming more complex. These tools can present vivid and highly accurate representations of the real world. Simultaneously, spatial data is becoming incredibly detailed and the possibilities of interacting with the geovisualization tools are plentiful. Geovisualization tools are indeed powerful. However, in contrast to the well-developed technological side of these tools, the user side is far less explored and understood. In addition, the development process can suffer from bias due to choices made by the developer. In this thesis, the urgent need for applying a user-based approach to the development of geovisualization tools is addressed. The need has been recognized for a very long time; however, the theories about how the users perceive these tools are still lagging. This study is empirical and interdisciplinary, combining the fields of geomatics and cognitive science. It is based on a survey which was submitted among residents in Växjö, a city in southern Sweden. The collected information was used in multivariate statistical analyses to elucidate potential relationships between the cognitive concept "sense of place", demographic factors, and the way participants interpret static and interactive maps. The study is particularly focused in investigating differences across age groups and supporting future tool development applying a user approach. The results demonstrate that differences among age groups were detected and that sense of place can beneficially be used to explore place relationships.

Keywords: *Geography, geovisualizations, sense of place, user approach, interactive maps*

Sammanfattning

Geovisualiseringsverktyg blir kontinuerligt mer komplexa. Dessa verktyg kan presentera levande och väldigt exakta representationer av verkligheten. Samtidigt är rumslig data oerhört detaljerad och interaktionsmöjligheterna är många. Geovisualiseringsverktyg är verkligen kraftfulla. Dock, till skillnad från den välutvecklade teknologiska sidan av dessa verktyg, så är användarsidan betydligt mindre utforskad eller förstådd. Dessutom, kan utvecklingsprocessen påverkas av systematiska val gjorda av utvecklaren. I denna uppsats behandlas det överhängande behovet av att applicera ett användarperspektiv vid utvecklingen av geovisualiseringsverktyg. Behovet har funnits under en väldigt lång tid, men teorierna om hur användarna uppfattar dessa verktyg ligger fortfarande efter. Denna studie är empirisk och interdisciplinär, och kombinerar disciplinerna Geomatik och kognitiv vetenskap. Den är baserad på en enkät som skickades ut till invånare i Växjö, en stad som är belägen i södra Sverige. Den insamlade informationen användes i multivariata statistiska analyser för att klargöra potentiella förbindelser mellan det kognitiva konceptet ”sense of place”, demografiska faktorer, och sättet som deltagarna tolkar statiska och interaktiva kartor. Studien är framförallt fokuserad på att utreda skillnader mellan åldersgrupper och hitta stöd för att utveckla verktyg som använder sig av ett användarperspektiv. Resultatet pekar på att det finns skillnader mellan åldersgrupper och att ”sense of place” fördelaktigt skulle kunna användas för att utforska platsrelationer.

Nyckelord: *Geografi, geovisualiseringar, sense of place, användarperspektiv, interaktiva kartor*

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1. Introduction

Geographic visualizations, also known as *Geovisualization* is a way to present realistic and geographically-accurate representations of the real world (Kerren et al. 2006) The term geovisualization is commonly defined as follows: “Geovisualization integrates approaches from visualization in scientific computing (ViSC), cartography, image analysis, information visualization, exploratory data analysis (EDA), and geographic information systems (GISystems) to provide theory, methods and tools for visual exploration, analysis, synthesis, and presentation of geospatial data” (MacEachren and Kraak 2001). Geovisualization research is a fast advancing domain that often involve environments in e.g. 3D (Çöltekin et al. 2017). These environments can connect to people’s values, beliefs or feelings toward a place, commonly referred to as their ‘sense of place’ (Newell and Canessa 2015; Salter et al. 2009). This connection suggests that geovisualization tools can potentially be developed for and adapted to the user by applying a user-centred approach. In this context, a user-centred approach implies that the user is accounted for when the development occurs. Doing so requires additional tool development to consider different user groups, i.e. exploring how users create mental visualizations of their environment, or in what way they perceive visualized information (Slocum et al. 2001). Many studies have expressed an urgent need for tools that can be better understood by humans (Ricther et al. 2015; Çöltekin et al. 2017). A shift from tech-driven visualizations towards a more user-centred approach has been observed recently; however, still not enough research is applied to this approach. In addition, investigations of the concept ‘sense of place’ in conjunction with geovisualization tools is still in its infancy (Newell and Canessa 2017). Place-related studies have previously been conducted in a multitude of disciplines such as resource politics (Cheng et al. 2003), sustainability projects (Stocker et al. 2012), participatory mapping, ecosystem management (Williams and Stewart 1998) and environmental planning (McLain et al. 2013). However, the majority of these studies do not explicitly incorporate place-based theories with geovisualization tools.

The importance of applying place theory to geovisualization tools becomes evident when examining the relationship between sense of place and how a place is visualized (Newell and Canessa 2018). As previously stated, sense of place comprises feelings towards a place and reflects the values and meanings that people hold to it. Through these values and meanings, beliefs of how a place should be managed can be captured (Yung et al. 2003). Therefore, the reaction to visualizations of management proposals can reflect their degree of sense of place. For instance, in the study conducted by Salter et al. (2009), the participants in a digital workshop showed negative reactions to a suggestion of housing intensification in an urban area. This implied that their mental visualization of that place did not correspond well to the suggested visualized area. Thus, it supported that people's sense of place was connected to visuals (i.e. their visual perception) (Williams and Stewart 1998). This connection can be useful for gaining insight on the relationship between people and place through geovisualizations. For instance, knowing the nature of these relationships makes it easier to understand which elements the user finds important, and how they think a place should appear or be managed (Newell and Canessa 2018). In turn, the geovisualization process can be more sensible and connected to the user.

1.1 Research Problem

The International Cartographic Association (ICA) emphasizes the many research challenges that geovisualization systems are facing today, some of which include cognitive and usability issues (MacEachren and Kraak 2001). The prevailing questions are whether the tools are successfully built (e.g. that they are understood by the users) and what factors determine the success of them. Robinson (2017) has a similar line of thought and argues that geovisualizations are poorly understood and that many map designers face the challenge of creating geovisualizations that make sense and matter to people. A salient and re-emerging challenge is the understanding of differences between certain user groups depending on age, gender or cultural background. These differences might have a huge impact on their perceptual or cognitive abilities, preferences and requirements (Çöltekin et al. 2017; Robinson 2017).

The applied research of geovisualization in conjunction with the theoretical framework of place theory could be considered "human geomatics". Although this field is not yet recognized (and geographers may take issue with the name), human geomatics characterizes the research in a fitting way by combining both disciplines. Doing so might open up new possibilities for advancing the agenda of cognitive-aware and user-centred technology.

1.2 Research Objective

The research objective is to address the immediate issue of understanding human factors in the context of geovisualization tools. The purpose is to make the geovisualization tools smarter by providing applicable methods, such as the highlighting of certain elements and useful insights. Since there is not much research on the varying responses and requirements of different age groups to geovisualizations, the objective is to analyse the response of different age brackets to the same geovisualization. Sense of place, demographic data and mental visualization of place will collectively be used to reach the objective. The results should assist in the development of geovisualization tools that satisfy different requirements for different demographics i.e. which elements (such as, trees or birds) should be included, or which themes should be highlighted. The hypothesis is that response will differ among age classes, and therefore that geovisualization tools should be designed in a flexible and inclusive manner. This is important since there is little research on this topic and by realizing the differences better tools can be developed. The objective was reached by collecting data on people's sense of place which was measured in three preliminary dimensions: place attachment, place identity and place dependence. Exploratory factor analysis was used in order to explore if these dimensions made sense. The participants were also asked about their mental visualization of place. Two statistical methods were employed to find support for a user-centric design. Multivariate analysis of variance was used to test if a difference in response to maps could be observed between age groups. Binomial regression analysis determined if demographic factors, age and other variables could predict the mental visualization of place. To clarify the conceptual framework of the thesis, a figure of its structure is presented in Figure 1.

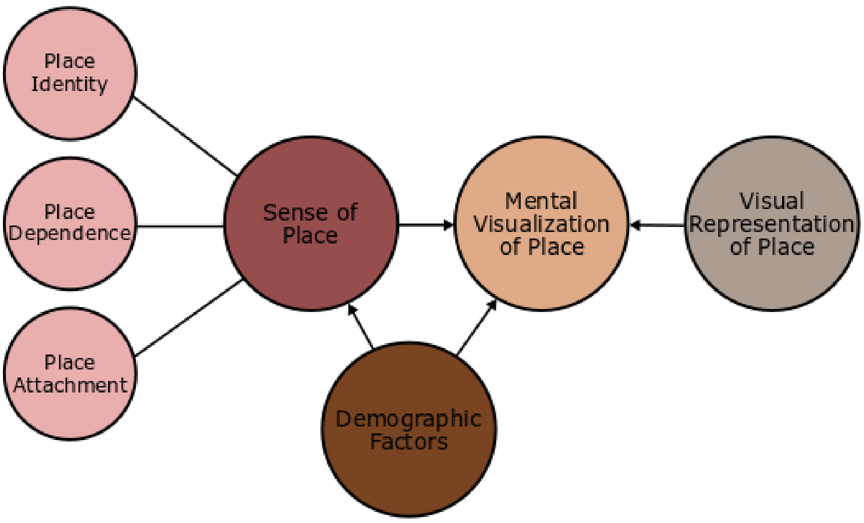

Figure 1. Conceptual framework of hypothesized relationships. Sense of place is hypothesized to consist of three sub-dimensions; place identity, place dependence and place attachment. Demographic factors such as age classes are assumed to have an impact on both the residents' sense of place and how they visualize place[1]. Residents' strength of sense of place influence their mental visualization of place. Finally, the visual representation of place can connect to the residents' mental visualization of place.

[1] In this thesis, 'place' always refers to the residents' home town.

2. Theory

2.1 Place-based theory

Place-based theory refers to people-place relationships, i.e. theories about why people form connections with places and how these relationships look like (Lewicka 2011). Considerable research has recently been carried out on place-based theory within recent decades (Kelly and Hosking 2008; Hidalgo and Hernández 2001; Newell and Canessa 2017; Lewicka 2011). The two fields dominating this research are undoubtedly environmental psychology and human geography (Lewicka 2011); however, more technological disciplines such as geography and geovisualization are now also shifting towards a more human-cantered approach (Kerren et al. 2006). By making use of the many benefits of cognitive science, better geovisualization tools can be developed (Newell and Canessa 2018; Newell and Canessa 2017; Newell et al. 2017).

2.2 Sense of place

The first interpretations of sense of place were made in the discipline of human geography. These formulations strived to understand how human relate to the physical world through methods that addressed humans as emotional beings, with thoughts and feelings (Tuan 1975). It is not uncommon that sense of place can be confused with 'place attachment', which is an expression originating from environmental psychology (Low and Altman 1992). The reason is that the concepts are very similar, and at times place attachment is seen as a synonym to sense of place. Nevertheless, the general perception appears to be that sense of place is the broader concept of the two (Jorgensen and Stedman 2001; Cross et al. 2011).

At present, there is little agreement on how to characterize the concept of sense of place, and it can be regarded as a highly vague term (Thompson and Prokopky 2016; Shamai and Ilatov 2004). Clarifying the concept may be an impossible task, with respect to Relph's (1976) statement that sense of place "is not just a formal concept awaiting precise definition… and clarification cannot be achieved by imposing precise but arbitrary definitions" (Relph 1976). Even if sense of place resists a clear definition, there are ways of investigating the concept. Many research papers are measuring it and results indicate that these methods are useful for many purposes, e.g. it can be a way to estimate and measure people's response to environmental impacts (Kaltenborn 1998) or measuring the public's feelings toward their residence (Shamai and Ilatov 2004). A noticeable trend is that research treats sense of place as a multidimensional term comprised of place attachment, place identity and place dependence (Newell and Canessa 2018; Jorgensen and Stedman 2001; Nanzer 2004; Kaltenborn 1998). In short, place attachment is the emotional bond that develops between human and place. Place identity refers to the beliefs regarding self and place. Place dependence describes the degree to which one can pursue their personal goals in a geographic location, e.g. career, hobbies, and recreational activities (Jorgensen and Stedman 2001).

The significance of sense of place in the context of place-based geovisualization tools is reflected in questions such as “Who are the users?”, “What relationship do certain user groups have to place?”, “Does the user have a special meaning to place?”, “How do the values and meanings vary across cultural and demographic categories, such as age and gender?”, “Where do place meanings conflict with each other, e.g. in relation to proposed land management actions?” and “To what extent is the user connected to the place and do they depend on it?”.

Furthermore, getting an understanding of people’s sense of place allows for inclusive and collaborative approaches in a discipline such as urban planning (Natori and Chenoweth 2008; Thompson and Prokopky 2016). By including people’s beliefs and interests, urban planners can better identify and act in regards to people’s different needs and requirements (Thompson and Prokopky 2016). There are also indications that it can assist in developing geovisualization tools in a clear and comprehensive manner (Newell and Canessa 2015).

2.2.1 Place attachment

The way people choose to spend their lives create prerequisites for how they will develop relationships with others and with elements in their physical environment. Through these relationships, place attachment can be formed (Nanzer 2004). Since place is where the formation of social bonds take place, place attachment can also be explained by the connection between people and specific places (Hidalgo and Hernández 2001). Williams and Patterson (1999) regard place attachment as an emotional dimension of meaning, i.e. “as an indication of the intensity, depth, or extent of meaning – with symbolic and spiritual meanings associated with high levels of attachment” (Williams and Patterson 1999). In general, place attachment is defined as a positive relationship between people and place (Low and Altman 1992). Several studies interpret place attachment as a superordinate including place identity and place dependence as sub-components (Kyle et al. 2005; Williams and Vaske 2003). However, this study will follow the line of thought which defines place attachment as its own distinct dimension and as a sub-component of sense of place (Jorgensen and

Stedman 2001). Further, place attachment is in this thesis reflected in the residents' feelings towards their home town, Växjö. This connection is measured in statements such as "The forest around Växjö, Växjösjön and other open spaces are important to me", "I care about what happens in Växjö" and "I would like to live in Växjö for a long time".

2.2.2 Place identity

Proshansky (1978) claims that the physical environment may have an impact on how we identify ourselves, e.g. living in a forest might make you identify yourself with nature. Therefore, it is common that self-identity is expressed and defined by the place we live in. Thus, place identity can be defined as a component of self-identity (Proshansky 1978), describing the strength of our emotional and symbolic bond to a place (Williams and Roggenbuck 1989), which may give an indication of the degree of belonging to a place (Relph 1976). Relph (1976) suggests that place identity is a compound of three elements including; the static physical setting, the activities, and the meanings. For example, a person can be highly objective and view a town as it is seen in a photograph; merely a place consisting of buildings which are physical objects. In contrast, a person who experiences the buildings observes them significantly differently. They may be useful, distant, an office or a home. In other words, they are meaningful (Relph 1976). In place-based research, place identity is sometimes expressed as a dimension of sense of place (Jorgensen and Stedman 2001; Newell and Canessa 2018; Cross et al. 2011), and sometimes as a dimension of place attachment (Kyle et al. 2005; Hidalgo and Hernández 2001; Williams and Vaske 2003). In this thesis, place identity is defined as a dimension of sense of place and expresses how one's self-identity is formed and affected by the physical environment. A statement from the survey reflecting this dimension is "living in Växjö is a part of who I am".

2.2.3 Place dependence

Place dependence is distinctly different from place attachment and place identity (Williams and Vaske 2003) and can be seen as a functional attachment (Cross et al. 2011). In 1981, Stokols and Shumaker defined the concept as "an occupant's strength of association between him- or herself or specific places". At the present time, the definition is altered and the most common of them is how well a place can serve a person's behavioural goals, e.g. job opportunities, and proximity to recreational environments or hobbies etc.) (Cross et al. 2011). In other words, this type of attachment is rooted in the physical character of a place. Thus, place dependence can be perceived as a functional relationship where a person has an association to a specific place setting. In this study, a statement such as "Växjö is a good place for my hobbies and activities" can describe this dimension.

2.3 Geovisualizations and Sense of Place Measurements

In recent years, geovisualization systems have experienced strong development, resulting in powerful tools with highly realistic environments, e.g. 3D models of urban areas where the user can get the sensation of "being there" (Lewis et al. 2012). A great advantage with this development is that it allows urban planners to communicate with the public in a completely new manner, that is, three-dimensional environments with high spatial accuracy which allows for recognizable real-world places (Salter et al. 2009) Communication in this fashion makes it possible for urban planners to suggest modifications to the environment, such as land use change, in a very relatable way (Newell and Canessa 2015). However, such abstractions of a familiar environment are also proven to evoke strong negative response, particularly when they involve suggestions for modifications to these environments (Salter et al. 2009). That kind of response supports the theory that depictions of proposed land changes can connect to people's beliefs and meanings towards a place (Natori and Chenoweth 2008), in other words people's sense of place.

Although, the popularity of geovisualization tools has increased over the years, improper understanding prevents them from being used to their full potential (Çöltekin et al. 2017; Lewis et al. 2012). The majority of these advancements within the field of geovisualization tools are predominantly aimed at developing new and advanced technology (Lewis et al. 2012). Unfortunately, this new technology tends to neglect questions behind, such as "how to apply a technology that assists rather than frustrating the user" (Newell and Canessa 2015). In addition, the development of geovisualization tools is oftentimes in the hand of urban planners, which means that they may not be developed in an objective way. The planners can either intentionally or unintentionally inject their own interpretations when illustrating the data, which might result in errors or bias in the way it is represented (Lewis et al. 2012).

The solution to the issues appears to be an interdisciplinary approach, which is to combine sense of place theory with geovisualization research, although, few researchers are exploring this potential (Newell and Canessa 2018). The hesitation may stem from the interdisciplinary nature; geovisualization belongs to a technical area of research whereas sense of place belongs to environmental/humanities research (Newell and Canessa 2015). The principal purpose of geovisualizations is to make sense of abstract spatial data. Consequently, the majority of the research aims to pursue an agenda focusing on spatial science and data visualization. As a contrast, research on sense of place belongs to humanistic geography, which seeks to understand humans, and how they relate to their physical environment (Tuan 1975).

Furthermore, Çöltekin et al (2017) points out several of the present challenges regarding geovisualization tools. These challenges include human factors (e.g. evaluation of usability, understanding human visual and spatial cognition- and perception), data (e.g. data filtering), and representation (inclusion/consideration of context, personalization), among others (Çöltekin et al. 2017).

2.4 Visualization effectiveness

The effectiveness of visualizations is essentially about how the technology is used by people, and less about what the technology is capable of. This implies that it is analogous to policies, methods and certain standards rather than computational abilities (Lewis et al. 2012). Sheppard (1989) discusses "perceptual effectiveness", which is a very similar expression and states that visualizations are effective when they create "reactions and judgements similar to those that would be obtained from views of the real scene" (Sheppard 1989). When it comes to visualization outputs, there is always an imminent risk of giving the wrong message. For example, it was shown in a study by Forester (1988) that biased interpretations of land use suggestions can lead the public and decision makers to overlook significant disadvantages and impacts of a proposal (Forester 1988). The reason for intentionally or unintentionally giving the wrong message can be rooted in the preparation work. There are many factors to consider and decisions to make before presenting geovisualizations. These factors (e.g. viewpoint selection or lighting of the environment) can profoundly influence how the geovisualization is perceived, and what emotions might be evoked. Putting aside the technical and data-driven design, Lewis (2012) mentions some of these factors:

- **Visualization output:** Resolution, aspect ratio, viewpoint selection and labelling).
- **Colouring and lighting of the environment**: Seasonal effects, weather, sun light, water and land cover.
- **Population of the environment**: Inclusion of people, animal, vehicles etc.

To facilitate smarter geovisualization tools and understand the users, it is crucial that developers are aware of the aforementioned factors regarding settings and conditions in geovisualization environments. Additionally, by collecting information about the users' preferences of these factors the tools can be adapted accordingly, and thus align with their perception of the physical environment. Consequently, the tools can hopefully be more sensible to the user.

3. Methods

3.1 Study area

The study was conducted in Växjö, a city located in the southern part of Sweden (Figure 2). According to the ‘Svenska Statistiska Centralbyrån (SCB)’, the city has a population of 65 383 (SCB 2016). The urban area is approximately 3541 ha. Further, the city is surrounded by numerous lakes and spruce- and broadleaves forests (Skogsstyrelsen 2018). The study area was chosen due to good opportunities for obtaining an adequate sample, in terms of both size and diversity.

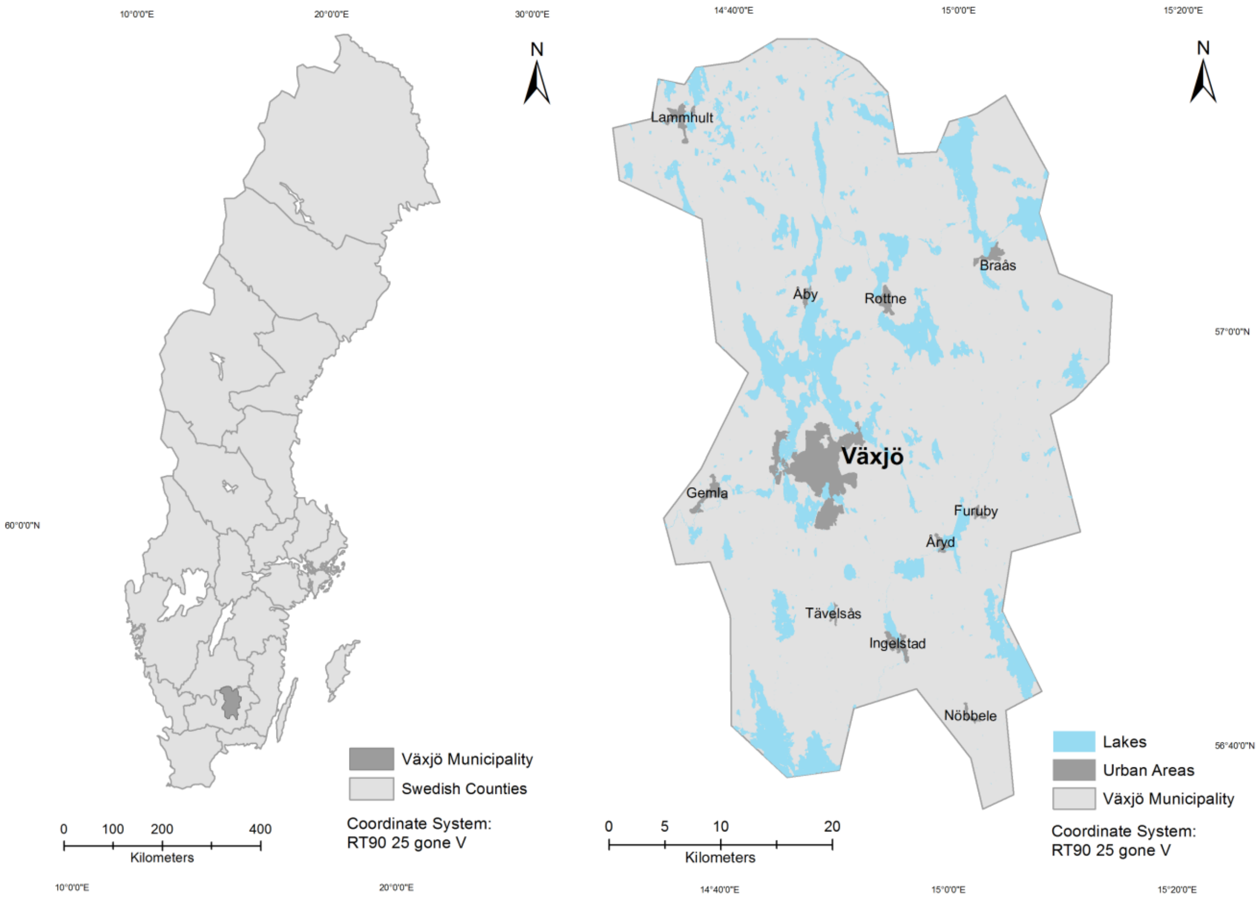

Figure 2. The map to the left provides an overview of Sweden at the Municipality level. Växjö Municipality is highlighted in dark grey. The map to the right shows Växjö Municipality and the location of the urban area of Växjö. Data source: Swedish Survey Department.

3.2 Data collection

Data was collected through a survey written in Swedish (English version in Appendix). The survey was sent to people living in Växjö with the ambition to reach out to as many residents as possible, and to obtain data with large age dispersion. Hence, various methods of contacting people were employed, including social media such as Facebook, where about ten contacts within my own network living in Växjö were messaged and encouraged to spread the survey. High schools and Linnaeus University were also contacted, where both students and teachers received an e-mail regarding the survey. Teachers and principals were e-mailed and they forwarded the survey to their students. Additional contacts working in Växjö were encouraged to spread the survey throughout their offices. The final number of participants reached was n = 108. This sample size should be fair using item ratio guidelines for factor analysis. With just under one hundred respondents and 3 estimated factors (place attachment, place identity and place dependence) the ratio in this study is approximately 30:1. This ratio should produce correct solutions in most cases (Costello and Osborne 2005). Regarding sample size for multiple regression a rule thumb is suggested by Green; $N > 50 + 8m$ (where m is the number of independent variables). The sample size of this thesis is equal to the equation (the number of independent variables is 6), meaning that it is on the border of acceptable and non-acceptable (Green 2010).

The structure of the survey was inspired by previous research conducted by Thompson (2016) and Newell (2018). They included sense of place together with temporal questions and demographic factors. However, the current survey included two additional parts; static maps and interactive maps. The reason for adding these was to facilitate interpretation and assessment of how different age groups respond to both static and interactive maps. In total, the survey consisted of five parts. The 1st part collected demographic data, such as age and gender. Age was organized in three groups to distinguish various stages in life. The distinction between the age groups were done according to typical norms, < 18 years old, a non-independent person living at home, ≥ 18, < 30 years old, a person who has left home and become independent, >= 30 years old, a person who has most likely created a family. Along with the demographic questions, a temporal factor was included. This was added because the time spent in a place is believed to have a crucial impact on a person's sense of place (Tuan 1975; Kelly and Hosking 2008).

The 2nd part of the survey comprised the participant's mental visualization of place. Here they were asked to mention five physical elements that they visualize when thinking of Växjö. A free-form narrative was purposely avoided due to increased complexity regarding interpretation and coding of data. Once data was collected all physical element words were scrutinized. Thereafter, all these words were coded into homogenous groups representing different categories, each category with a set of items (words) that describe the same thing. In sum, ten categories were formed and comprised by: centrum elements, culture, infrastructure, nature, negative, sensation, social, specific places, and weather. There are myriad ways of categorizing; however, these categories were deemed to be the most sensible.

The 3rd part measured the participant's sense of place. This was done by using a Likert scale ranging from 1-6, where 1 corresponds to 'do not agree at all', and 6 to 'totally agree'. The range of the scale was chosen in order to avoid the ambiguity in neutral responses. The participants had to grade assertions like "I feel at home in Växjö". The applied methodology was inspired by previous place-based research (Kelly and Hosking 2008; Cross et al. 2011; Soini et al. 2012; Gosling and Williams 2010; Williams and Vaske 2003; Kaltenborn 1998). Sense of place was divided into three dimensions: place attachment, place identity and place dependence (Figure 1). This division was based off previously successful studies which employed the same definition. Further, Hidalgo and Hernández (2001) and Shamai and Ilatov (2004), among others, emphasize the importance of social connections in place based studies. Therefore, two questions reflected this matter.

The 4th and 5th part included two examples of interactive maps and two examples of static maps, respectively. Three statements could be found for each static/interactive map and the respondents were asked to rank each of them according to the above mentioned Likert scale (Appendix, 12-15). The reason for choosing the same questions for each map was that the interpretation becomes easier and it enables inter-comparison of the responses for each static/interactive map.

3.3. Exploratory Factor Analysis (EFA)

Using the statistical software SPSS, exploratory factor analysis was conducted on the sense of place data. Exploratory factor analysis is a statistical method to reveal latent variables in large sets of data (Tabachnick and Fidell 2013). This was done in order to explore the hypothesized dimensions of sense of place and to test whether the theory makes sense. The concept is based on the idea that a number of observed variables have related responses due to that they are all associated with a latent variable (i.e. a variable that is not directly measured). Thus, it may be possible to measure a large set of data with only a few variables. Factor analysis base the number of variables on shared covariance between the observations. Therefore, factor analysis can suggest either fewer or more dimensions than the ones being hypothesized.

Prior to the analysis, the data was screened for outliers and missing values. The Mahalanobis distance, a statistical method for detecting outliers was used to quantify how far individual observations were from the centroid of all observations. A large distance indicate that the observation might be an outlier (Tabachnick and Fidell 2013). The threshold for removing outliers was chosen to be $p < 0.001$, as recommended by Tabachnick and Fidell (2013). 7 outliers were removed. Some missing data were detected. When an observation was missing a large amount of data (e.g. a participant skipping an whole section in the survey), the entire observation was removed (Tabachnick and Fidell 2013). When data for only one question/statement within each part was missing, the data was extrapolated by averaging the other answers within that dimension or part (Tabachnick and Fidell 2013). After screening the data, the sample size was reduced to $n = 98$. Thereafter, Cronbach's Alpha was used to investigate the internal consistency within each dimension. This is a coefficient of reliability, and gives an indication of how closely related the items in each factor are (Cronbach 1951).

3.4 Multivariate Analysis of Variance (MANOVA)

In order to investigate whether responses vary across age groups, a Multivariate Analysis of Variance (MANOVA) was conducted using SPSS. There are several reasons why this statistical test was chosen. Firstly, it is a multivariate test and allows analysis of several variables at once (Spicer 2011). Secondly, it tests whether differences in the mean among groups on a set of dependent variables (DVs) has occurred by chance. This can provide useful information to the thesis's objective which seeks to understand the user and the relevance of age. The third reason for using MANOVA instead of multiple ANOVAs is that it prevents the inflated Type I error caused by multiple tests of likely correlated DVs (Spicer 2011; Tabachnick and Fidell 2013). The inflated Type I error refers to the increased risk of falsely rejecting H_0 as more hypotheses are tested (Tabachnick and Fidell 2013).

Prior to running MANOVA, a set of variables was selected (presented in Table 1). Each of the dependent variables is an average of several items describing the same theme. This was done in order to avoid redundancy and to achieve parsimony. In MANOVA there are some practical issues and assumptions that ought to be fulfilled in order to perform a powerful analysis (Tabachnick and Fidell 2013). These issues concern unequal sample sizes, missing data, multivariate normality, outliers, homogeneity of variance-covariance matrices, linearity, absence of multicollinearity and singularity. All of these issues were taken into consideration. The homogeneity of variance-covariance matrices was confirmed by Box's M test of equality of covariance matrices (Tabachnick and Fidell 2013). A Shapiro Wilk test was used to check for normality (Shapiro and Wilk 1965). All steps taken for both factor analysis and MANOVA are visualized in a flowchart in Figure 3.

Table 1.

Descriptive statistics for the selected independent variables (IVs) with its sub-categories and the DVs. A higher score of sense of place can be interpreted as a stronger attachment to place (including both place attachment, place identity and place dependence). The other variables can be interpreted in a similar way, i.e. a high score of environmental concerns signify high environmental concern, and a high score for static maps and interactive maps means that they are well understood by the user. The youngest participant is assumed to be 14 years old (because that is the youngest a student can be at the schools participating in the survey) and the oldest participant is unknown.

Independent Variable (IV)	**Dependent Variables (DVs)**
Age Groups	Sense of place
< 18 years	Environmental concerns
≥ 18, < 30	Static maps
>= 30 years	Interactive maps

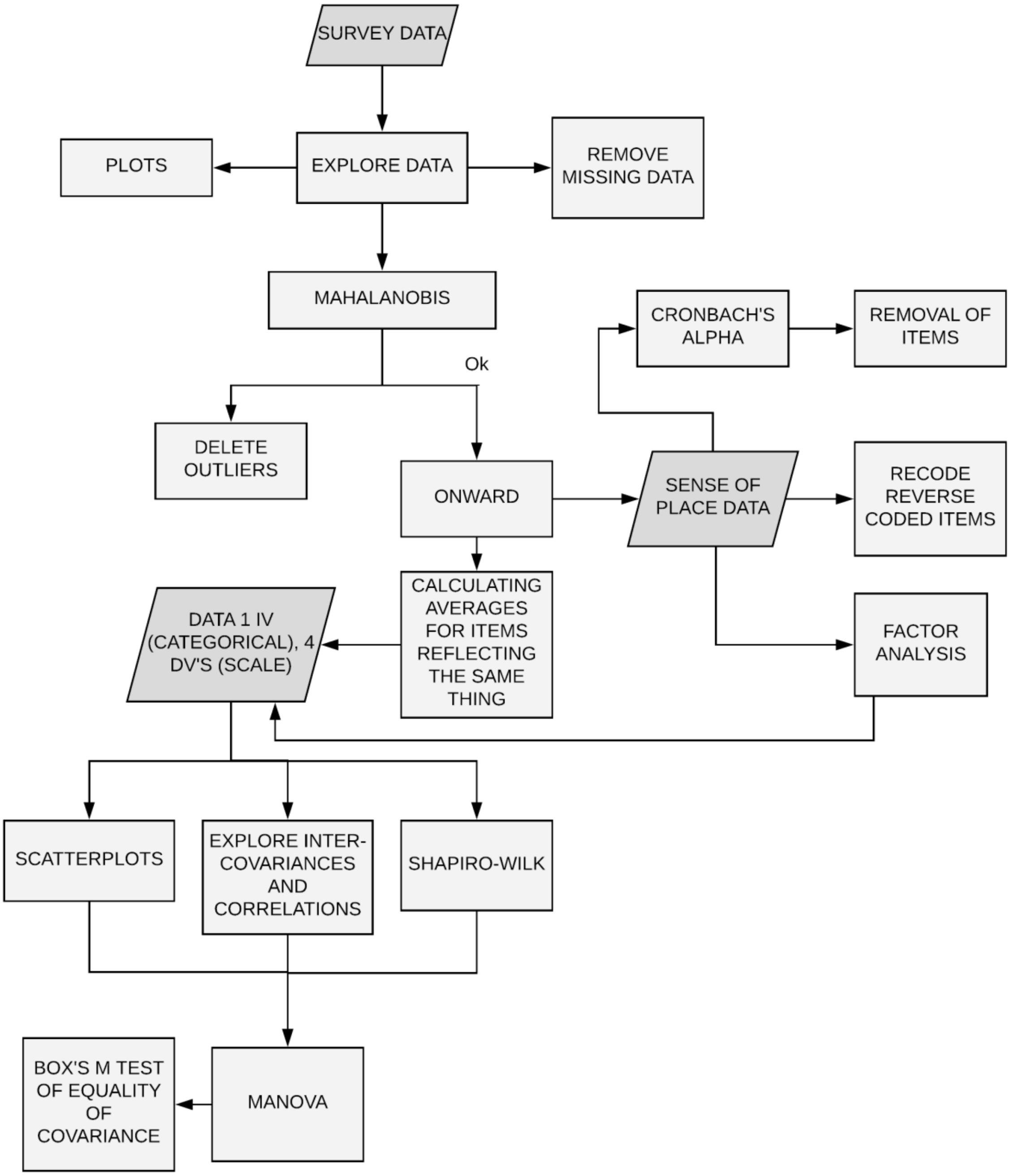

Figure 3. Flowchart showing the steps taken prior to factor analysis and MANOVA.

3.5 Binomial Logistic Regression

Logistic regressions were used to explore the participants' mental visualization of place. These were performed because it allows to investigate how well a set of variables can predict a discrete outcome. Additionally, the assumptions for binomial logistic regression fits the type of data in this thesis. The reasons why this test is ideal are; a linear relationship between the IVs and DVs are not required, the residuals do not need to have a normal distribution, homoscedasticity is not necessary and the dependent variable do not need to be measured on an interval or scale (Tabachnick and Fidell 2013). The dependent variable 'visualized element' (V_i) was coded into 1 if present and 0 if absent. The predictors consisted of sense of place (S), environmental concerns (E), the age groups (A_1, A_2, A_3) and gender (G) (Equation 1).

Equation 1. The equation for the binomial logistic regression with six predictors for mental visualization of Växjö.

$$V_i = \beta_0 + \beta_1 S + \beta_2 E + \beta_3 A_1 + \beta_3 A_2 + \beta_3 A_3 + \beta_3 G$$

The gender variable was coded as 1 for female and 0 for male. The age groups were coded with a dummy variable. A_1 represented participants under 18 years, A_2 participants between $\geq 18, < 30$ years old and A_3 participants 30 years or older.

In the course of performing the logistic regressions, the methodology had to be changed to some extent. Categories that were initially too broad made it difficult to predict anything. Consequently, logistic regressions were run with the physical elements having the highest frequencies (instead of using the whole category). The expectation for running this analysis was to see differences between the predictors, if certain predictors could predict certain elements, and to explore the relationships between the variables.

4. Results

4.1 Demographic Factors

Table 2 summarizes the descriptive statistics for part one of the survey responses. The age distribution was skewed toward the older age groups, with participants older or equal than 30 making up 53.1% of the total respondents. Nevertheless, the younger age group were considered to have sufficient participants to allow statistical tests. The distribution of gender was more evenly distributed with 54.1% female and 45.9% men. The result of the temporal factor revealed that most of the participants have lived in Växjö longer than 10 years. Therefore, it was decided that the temporal aspect could as well be reflected by the age groups, since age also indicates how long a person has spent in place.

Table 2.
Descriptive Statistics for the survey responses part one.

Data shown as a proportion (N=98)	
Female Gender	54.1
Male Gender	45.9
Age <18	9.2
Age <30	37.8
Age >=30	53.1
Recently moved to Växjö	4.1
Lived in Växjö less than 10 years	25.5
Lived in Växjö for 10 years or longer	70.4

4.2 Mental Visualization of Place

An illustration of the participants' mental visualization of Växjö can be seen in Figure 4, and the exact frequency of each item in Table 3. The categorization was completed by generalizing and forming groups of items to form distinct clusters, in a method comparable to Newell's (2018). It is worth noting that the number of participants in this study was far lower than Newell's (2018), resulting in less-specific categories.

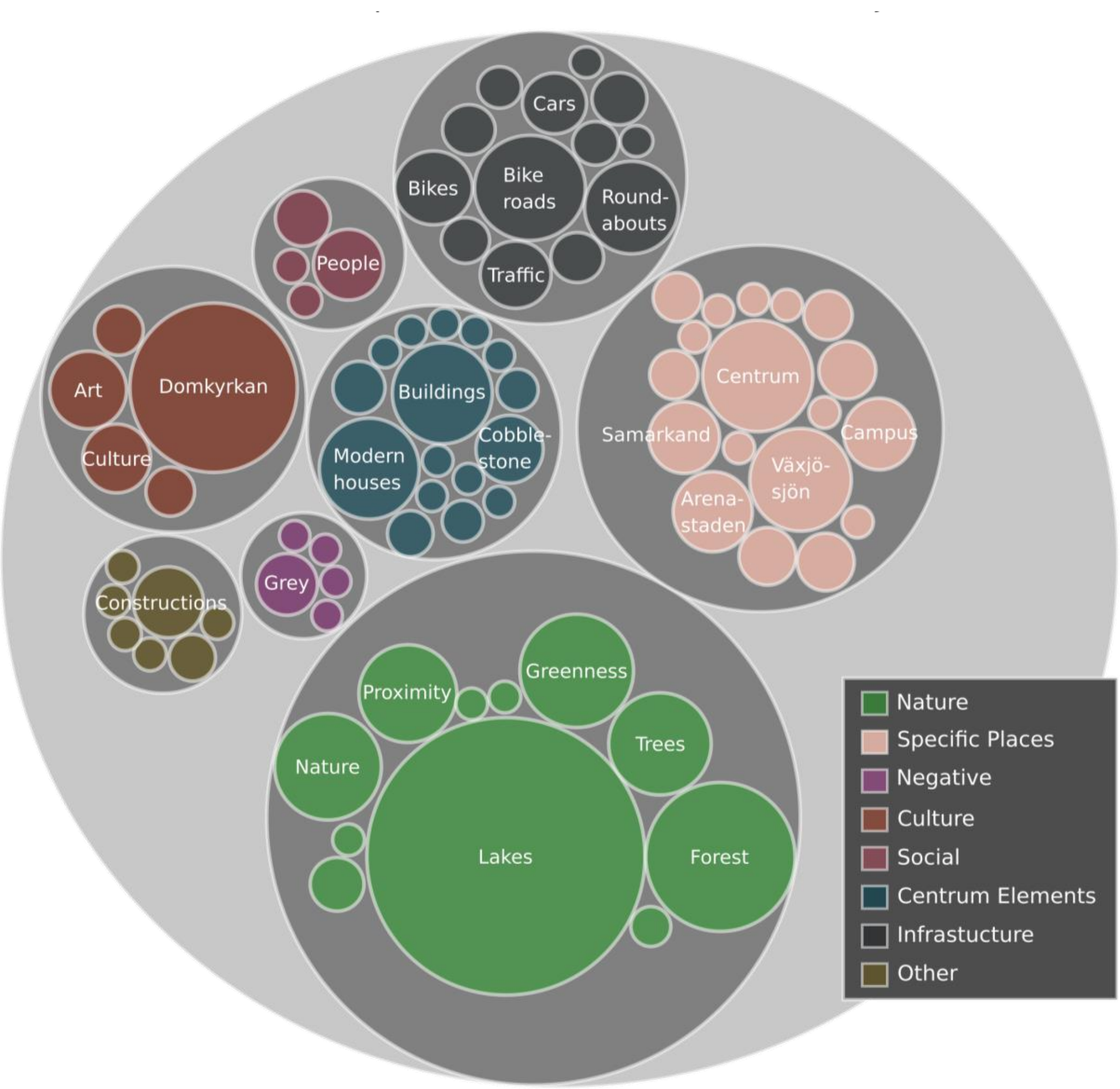

Figure 4.

A Bubble chart demonstrating the participant's mental visualization of Växjö. Each bubble is proportional to the number of times it is mentioned. In other words, the most visualized elements are lakes, Domkyrkan (a known church in Växjö), bike roads and forests. The bubbles with missing labels indicate elements that are only mentioned a few times.

Table 3.
The table shows the participants' mental visualization of Växjö, the categories and their items. The number defines the number of times (N) that the item is mentioned.

Centrum elements		Specific Places		Nature		Infrastructure		Social	
Houses/ Buildings	10	Centrum	12	Lakes	68	Bike roads	11	People	5
New houses	9	Växjösjön	10	Forest	20	Round-abouts	9	Play-ground	3
Cobblestone	4	Arenastaden	6	Green-ness	12	Bikes	5	Friends	1
Stores	3	Samarkand	5	Nature	11	Traffic	4	Kids	1
Market place	2	Campus	5	Water	10	Cars	4		
Clean	2	The hospital	3	Trees	9	Bike possibilities	3		
Restaurants	2	The library	3	Proximity to nature	9	Roads	3		
Brick house	1	The University	3	Parks	3	Trains	2		
Low houses	1	Araby	2	Stones	2	Good public transport	2		
Tall houses	1	Trummen	2	Nature reserve	1	Buses	2		
Rental houses	1	Linnéparken	2	Plants	1	Bad infrastructure	1		
Ugly buildings	1	Växjö Fria	1	Good for hikes	1	Pedestrian street	1		
Few pubs	1	McDonalds	1	Islands	1				
Dirty/old houses	1	Evedal	1						
Stadiums	1	Dalbo	1						
Wood houses	1	Hovshaga	1						
		Katedralskolan	1						
		Bokhultet	1						

Culture		Negative		Weather		Sensation		Other	
Domkyrkan	26	Grey	4	Sun	1	Cosy	3	Construction sites	5
Art	6	Chaos for cars	3	Boring weather	1	Calm	2	Water tower	2
Culture	4	Dying centrum	2	Rain	3	Nice	1	Separated villages	1
Music	2	Cold	1			Expensive	1	Food	1
Teleborgsslott	2	Quiet	1					Foreigners	1
		Dead	1					Industrial areas	1
		Boring	1					Graveyards	1
		Pretending being the greenest city	1						
		Big city complex	1						
		No parking	1						
		Bad infrastructure	1						

4.3 Factor Analysis

Prior in running factor analysis, Cronbach's Alpha was calculated for each dimension. The dimensions received the following alpha values: place attachment 0.754, place identity 0.829, place dependence 0.783 and social relations 0.842. The threshold for an acceptable Cronbach's Alpha ranges from 0.7-0.9 (Fabrigar et al. 1999). Thus, the obtained values for Cronbach's Alpha were deemed to be sufficient and allow for further analysis.

Exploratory factor analysis was run with different settings, using both orthogonal and varimax rotations. The purpose of rotating the data is to make the result of factor analysis interpretable. In the orthogonal rotation the axis are kept at a 90º angle, which forces the factors to be uncorrelated. In the oblique rotation the angles do not need to be 90º and thus allows factors to be uncorrelated (Costello and Osborne 2005). The reason for using both methods was to compare the results, and to see if they would yield different results. All runs gave comparable results indicating an extraction of one factor. When interpreting results of factor analysis, most researches advocate the use of multiple methods (Fabrigar et al. 1999). Following this line of thought, the scree plots together with the total variance and the factor loading table were examined. In all runs, the scree plot had the same appearance, bending after the first eigenvalue and indicating only one factor should be extracted (Figure 6). Following this, the total variance table demonstrated that one factor alone would explain approximately 50% of the variation. The two remaining factors explained about 8% of the variance each. Ultimately, the factor-loading table revealed a high presence of crossloadings, which can be considered a weak result. Factors should have distinct clusters (Costello and Osborne 2005).

According to the analysis, the result was weak and exhibited high uncertainty. Therefore, the conceptualization of sense of place was revaluated. Instead of being conceptualized as a multidimensional model, it was defined as a one-dimensional model where all items could be seen as a whole (sense of place) and not defined by sub-dimensions (place attachment, place identity and place dependence) (Figure 5).

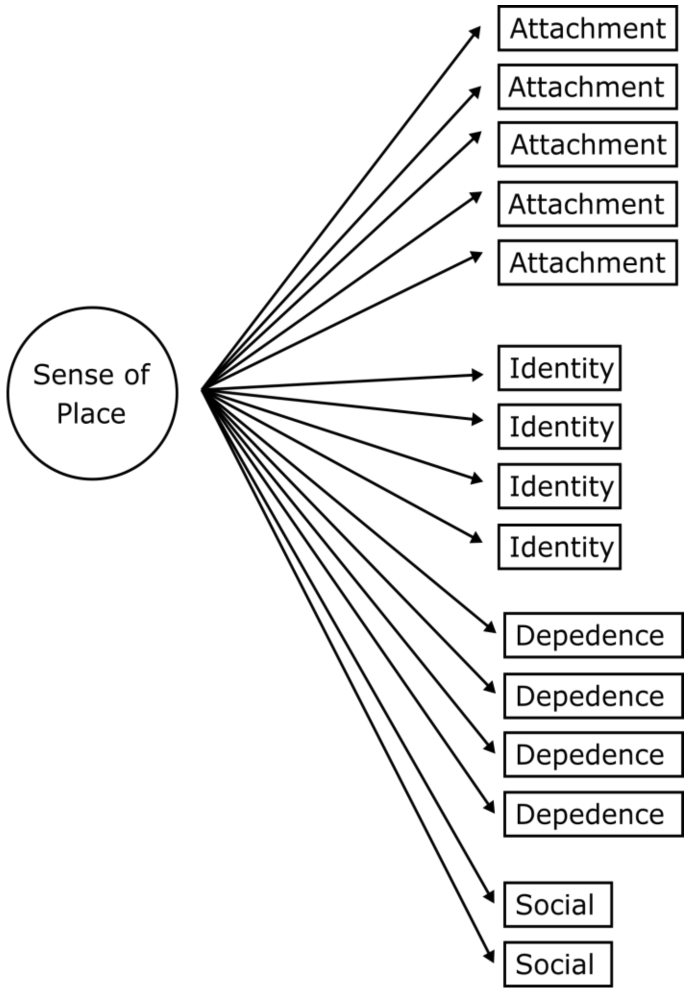

Figure 5. A one-dimensional model of sense of place. The number of times that a variable is shown reflects the number of items in that category. Attachment, identity, dependence and social together define sense of place.

The scree plot (Figure 6) manifests an explicit result where the bend occurs immediately after the first eigenvalue. In addition, the rest of the data exhibits a flat trend, which means that there should be no risk of misinterpretation or ambiguity in this conclusion. The plot clearly proposes that one factor should be extracted.

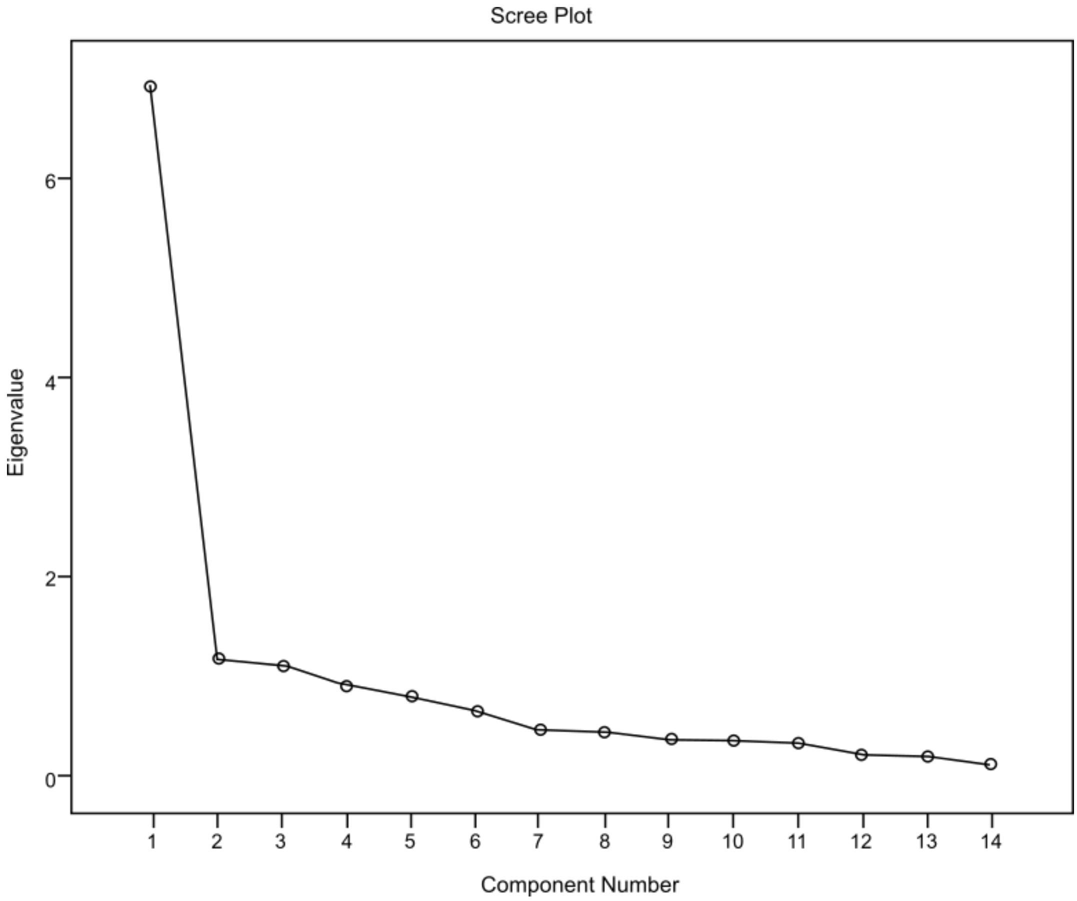

Figure 6. The eigenvalues for each component in the factor analysis. The plot clearly exhibits one component having a value higher than 6 and the rest around 1 and lower.

Following the scree plot, an outcome of the factor analysis is a table of Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test. As the name indicates, KMO tells whether the sample is adequate for analysis or not. According to Cerny and Kaiser (1977) a value between 0.8 – 0.9 is considered to be 'great'. Thus, the value of 0.88 should signify that the sample is acceptable for an analysis (Table 4). Bartlett's Test of sphericity yielded a significant result of 0.000, and verified that there were significant correlations between the variables (Tabachnick and Fidell 2013).

Table 4.

Results for KMO and Bartlett's test. The value for KMO indicates that the sample is appropriate for analysis. Bartlett's Test is significant at p<0.001.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.88
Bartlett's Test of Sphericity	Approx. Chi-Square	822.071
	df	91
	Sig.	0.000

The factor loading table provides information about the eigenvalues (Table 5). This allows for interpretation of the Kaiser Criterion. The Kaiser Criterion proposes that an eigenvalue above 1.0 is a reasonable lower bound to decide if a factor is meaningful or not. The reason for this value is that the eigenvalue is the sum of the squared factor loadings, and to reach 1.0 or greater it is necessary to have fairly high loadings. However, values around 1.0 should be considered carefully. A hypothetical question is whether 1.1 is more sensible than 0.9. In Table 5, there are three extraction sums of squared loadings. One component had a high eigenvalue of 6.944 and the other two have values very close to 1. Observing the percent of variance the first component explained as much as almost 50% of the variance, while the other two explained 8% each. In total, these three components described ~66% of the total variance.

Table 5.

Output from SPSS showing the total variance explained. The table suggests that three components (or factors) should be extracted. The three components are highlighted in bold.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative	Total	% of Variance	Cumulative
1	**6.944**	49.599	49.599	6.944	49.599	49.599
2	**1.160**	8.285	57.884	1.160	8.285	57.884
3	**1.108**	7.912	65.769	1.108	7.912	65.796
4	.911	6.505	72.302			
5	.774	5.531	77.833			
6	.639	4.567	82.400			
7	.463	3.308	85.709			
8	.458	3.271	88.980			
9	.371	2.649	91.140			
10	.352	2.512	94.140			
11	.316	2.256	96.396			
12	.206	1.470	97.866			
13	.186	1.325	99.191			
14	.113	.809	100.000			

4.4 Multivariate Analysis of Variance (MANOVA)

The statistical test of MANOVA run in SPSS provided a Box's M Test of Equality of Covariance Matrices. This yielded an insignificant result of 0.326 ($p > 0.05$, table 6), meaning that observed covariance matrices are equal across the groups. If the test had been significant, robustness of the statistical test would not have been guaranteed and the analysis could yield an uncertain result (Tabachnick and Fidell 2013). Therefore, the result was desired and positive.

Table 6.
Output from SPSS, Box's M Test of Equality of covariance matrices.
The result is insignificant.

Box's M Test of Equality of Covariance Matrices	
Box's M	25.514
Sig.	0.326

The multivariate test is another outcome in SPSS when running MANOVA. It produces several statistical tests that will tell whether the result of MANOVA is significant or not. The most recommended and powerful one is Pillai's Trace, which additionally works best when the data is less suitable for statistical analysis (Tabachnick and Fidell 2013). Since the sample size in the current thesis is fairly small, this test seemed to be the best suited for this data. As presented in Table 7, MANOVA is significant at 0.004 with $p < 0.05$. Hence, the null hypothesis ($H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4$), which suggests that the means of all groups are equal, could be rejected. In Table 8, multiple ANOVAs are presented, which reveals which variables contribute the most to the variation in the independent variable. Two of the variables are significant, and those are sense of place at significance value of 0.002, and static maps at 0.038. The reason for presenting this test was solely to demonstrate the variables that contributed to the significant result of MANOVA.

Table 7.
Output from running MANOVA. Since Pillai's Trace (Sig. 0.004) is < 0.05 the test is significant.

Multivariate tests.	
Effect	(Age) Pillai's Trace
Hypothesis df	8.000
Sig.	0.004

a. Computed using alpha = .05

Table 8.
The variables contributing to a significant result of MANOVA are sense of place and static maps. Both are significant at $p < 0.05$.

Independent variable	Dependent variable	Sig.
Age	Sense of place	0.002**
	Environmental concerns	0.663
	Static maps	0.038**
	Interactive maps	0.146

** Significant at p<0.05

As the result of MANOVA was significant, the means across the groups should be significantly different. In Figure 7, the differences across age groups becomes evident. The least difference was observed in the environmental concerns category, where the concern is high amongst all groups. However, a slightly higher concern can be seen for the youngest age group, which decreases with age. The two map-related variables exhibit similar trends, where the younger age group has the lowest mean values both for static maps and for interactive maps. 'Static maps' shows a linear trend. This trend reveals that an older participant is more likely to better understand the map, orientate themselves in the map and like the colours. The environmental concerns and the sense of place seem to have similar trends. When the environmental concerns decrease, sense of place does as well. Interactive maps appear to be hard to understand for the participants under 18 years old. The participants both under 30 years old and above have an equally difficult or easy time to interpret and understand the interactive map.

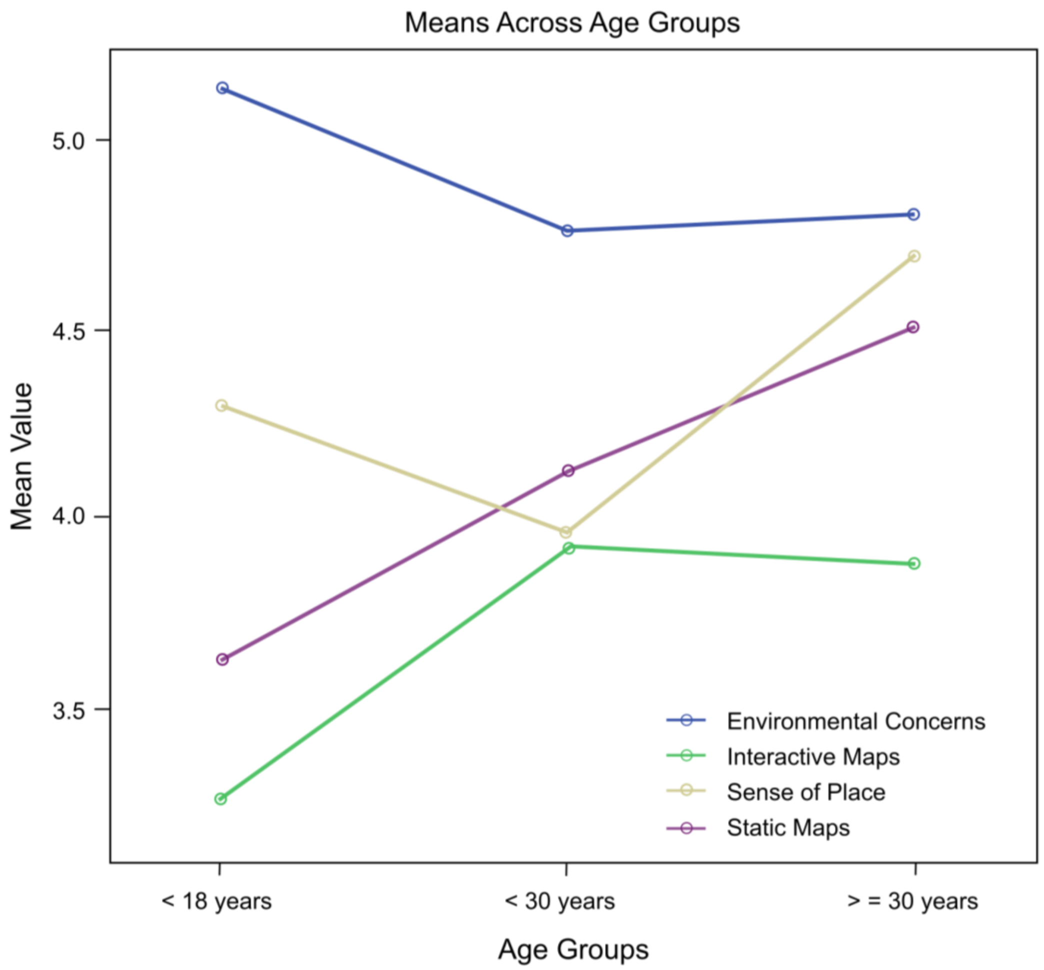

Figure 7. A line chart showing the mean values for each component in the MANOVA analysis.

Table 9. Descriptive statistics including standard deviation, means and the 95% confidence interval.

Dependent variable	**Std. Deviation**	**Means**	**95% confidence interval**	
			Lower bound	**Upper bound**
Sense of place	.992	4.390	4.448	4.964
Environmental concerns	1.121	4.826	4.501	5.122
Static maps	1.074	4.292	4.229	4.806
Interactive maps	.943	3.852	3.637	4.151

4.5 Binomial Logistic Regression

The output exclusively presents the models that had some significant result (Table 10). The odds ratios can be observed to gain insight into which variables increase the likelihood of elements being visualized. The first model 'culture', have two significant variables: age group ≥ 18, < 30 years old and environmental concerns. In other words, a person within this age category and scoring high on environmental concerns is more likely to visualize cultural elements when mentally visualizing Växjö. Running the model using 'bikes' as the dependent variable also gave a significant result. The significant independent variable was participants < 18. This result meant that participants < 18 years old had a higher likelihood of including bikes in their mental picture of Växjö. 'Nature' as a dependent variable gave a significant result on environmental concerns. For the last model, 'lakes', there are two significant variables. These variables are age group < 30 years old and sense of place. It might seem odd that the older age group is excluded.

However, the reason is that the answers given by age group < 30 and >=30 were very similar. Therefore, SPSS excluded the >=30 age group, because keeping both would be redundant. If both would be kept there would be an issue with multicollinearity, which means that two variables are highly correlated, and adding both would not yield a more correct solution. Besides, it can also cause issues when interpreting the result. Each variable must be independent of one another (Tabachnick and Fidell 2013). Since the two age groups yielded very similar results it does not matter which one that is kept.

Table 10. The result from running the logistic regressions. In total, four models yielded significant results; culture, bikes, nature, and lakes. The statistically significant values at p<0.05 are marked with an asterisk.

Visual element (V_i)	**Odds ratio** **B coefficient** ***p***				
	A_1 Participants < 18	**A_2** Participants ≥ 18, < 30	**S** Sense of place	**E** Environmental concerns	**G** Gender
Culture	0.114	0.245	1.116	1.621	1.291
	-2.171	-1.405	0.110	0.483	0.255
	0.054	**0.010***	0.674	**0.034***	0.589
Bikes	6.021	0.700	1.796	0.909	0.875
	1.795	-0.356	0.585	-0.095	-0.097
	0.036*	0.640	0.145	0.732	0.875
Nature	0.919	0.834	1.589	1.824	2.201
	-0.095	-0.182	0.463	0.601	0.789
	0.919	0.158	0.089	**0.012***	0.158
Lakes	0.269	0.306	2.211	1.485	0.789
	-1.313	-1.185	0.794	0.395	-0.237

0.093	**0.023***	**0.003***	0.075	0.631

5. Discussion

5.1 Findings

The objective in this study was to address the immediate issue of understanding human factors in the context of geovisualization tools and to explore varying responses and requirements of different age groups to geovisualizations. The findings cannot support the idea that users have different requirements and that age is an influencing factor in how the tools are interpreted and perceived. The reasons are that the data sample was too small and the data distribution between the age groups was too skewed. However, despite this, the results from MANOVA and the multiple binary logistic regressions gave an indication that differences between the users may exist. This argues for further exploration of demographic factors in the context of geovisualization tools. Both statistical tests yielded some significant results. MANOVA demonstrated differences in mean among age groups and the binary logistic regressions gave different significant result for the younger age group (bikes) versus the age group ≥ 18, < 30 (culture and lakes). Accordingly, it could be considered sensible to develop geovisualization tools from a user-based approach. The differences in mean between age groups and the variation between the variables raise several important questions (Figure 7). If there are in fact substantial differences across age groups, how do we proceed to develop efficient tools that take this into account? What would cause the differences across age groups? Is it the experience of using the tools or can it be related to the time spent in place? Presumably it is a combination of both time spent in place and experience with the tools. In addition, it appears that the type of connection to place might also play a role (since sense of place demonstrated significant result and that it varies among age groups). If a person has a strong connection to place (the strength of sense of place) it has a certain mental visualization of place. Therefore, e.g. an optimal 3D visualization of that place would highlight those physical elements. This argues for a personalized geovisualization tool. However, in practicality it is impossible to develop a tool that satisfy every user's need. In addition, it is very challenging to develop tools that are aimed at e.g. specific age groups, but this is not the point anyway. The point is to realize and highlight that different user needs exist (such as age in this thesis) and suggest ways of how to deal with it.

Another aspect worth addressing is that complexity increases when going from static maps to interactive maps, meaning that the cognitive abilities are more challenged when the complexity of the maps increases (Figure 7). The participants found it harder to understand and interpret the interactive maps as opposed to the static maps. This is also in line with findings in previous studies (Lewis et al. 2012; Newell and Canessa 2018; Çöltekin et al. 2017), that the more interactive a map is the greater challenges in terms of developing tools that make sense to the user. In Figure 7, the mean value for the 'interactive maps' for the age group < 18 years is noticeably low. That indicates that the interactive map is probably not used to its full capacity, since the users are having a hard time understanding it. That stresses the need for always evaluating the user experience or developing theories of the cognitive process in perceiving such a map. This is also an indication that the challenges of understanding the human factors in the context of geovisualization tools still persist. Further, the distinction between the interpretation of static maps and interactive maps may support the notion that more realistic or interactive does not necessarily mean 'better'. In certain situations, it might be easier to convey a message through a standard static map. Therefore, it is always important to consider the purpose for making it interactive and realizing the challenges that follow with it.

Aside from investigating differences across age brackets, the objective also includes getting general insight into the user approach, and how it can benefit the development of geovisualization tools. The mental visualization of place and the usage of key elements is an example of a collaborative process that can increase the awareness of the users' perspective. It provides a quick overview of what people visualize when thinking about their home town (Figure 4). The advantage of this strategy is highlighted in Newell's (2018) study, where the usage of key elements in geovisualization tools is stressed. The benefit of exploring key elements is that it allows development of geovisualization tools that aligns with the resident's way of seeing the city. Accordingly, the geovisualization tools can both connect to people's sense of place and be more meaningful. This can positively contribute to land use planning or resource management in a way that it is not biased by the developer, but is instead collaborative and inclusive and avoiding misrepresentations (Lewis et al. 2012). After all, the purpose of geovisualization tools is to present accurate and useful representations of reality.

5.2 Mental Visualization of Place and Sense of Place

One intention with this thesis was to investigate specific user groups and to see whether it could assist in predicting how people visualize place. According to previous studies, it is sensible to apply sense of place to place-based research. However, opposed to previous research the result from the factor analysis in this thesis suggested that sense of place should be measured as a one-dimensional construct, and not as a multidimensional construct (as the majority of the research measure it). In addition, considering that the result of factor analysis strongly indicated that only one factor should reflect the concept sense of place, it could be argued that previous place-based studies and the applied methods should be scrutinized (and there are more reasons this). An example is that the methods being used for determining the number of factors in factor analysis have been criticized (Costello and Osborne 2005). According to Costello and Osborne 2005, these methods are outdated and there are better and more sophisticated methods, such as MAP and parallel analysis. Some of the previous research determine the number of factors to extract merely based on factor loadings. This is a concern because factors have a tendency to vary markedly dependent on sample size and rotation method (Costello and Osborne 2005). Moreover, no technique is perfect. Therefore, it is sensible to apply more than one approach for deciding how many factors to extract. In addition to questionable methods, the statistics are in some instances far from the acceptable ranges, i.e. notably high percentages of error variance, which is something that should be taken seriously. In some papers the consistency measure Cronbach's alpha was incorrectly used, as researchers accepted conspicuously low values. As argued by Costello and Osbourne (2005), this can cause profound and unwanted effects on the outcome, because when a factor has a low value of Cronbach's alpha it suggests that the observations may not be measuring the same underlying construct.

If mental visualization of place can easily be used, one may question why sense of place should be used in conjunction with geovisualization tools in the first place. This hypothetical question is touched by Newell and Canessa (2018), who employs an empirical study using binary regressions, thus confirming the presence of a connection between sense of place and mental visualization. That allows one to associate a specific sense of place dimension (place attachment, place identity and placed dependence) with certain physical elements, i.e. that a person with a certain level of place attachment is more likely to observe a certain physical element. However, employing such a strategy makes the user approach unnecessarily complex and impractical. Sense of place is already complex and vague enough, therefore going into further complexity will not make it easier to employ in practise. Although, sense of place is far from useless. In fact, it has several advantages of being used in combination with the development of geovisualization tools. One example is demonstrated by the result of MANOVA, which confirms that sense of place is a significant variable and can discern user groups in terms of age groups. In addition, a high level of sense of place should give an indication of how attached people are to place. Consequently, if this is utilized with their mental visualization it could tell how important it may be to include key elements in the geovisualization. If their sense of place is high, then the key elements should also be of higher importance. In addition, reactions to management proposals may have a completely different outcome when the geovisualization tools are speaking to their sense of place. These outcomes can either be negative or positive. The relevance is that the users may relate to the geovisualization as being more "real" and that the environment is accurately visualized. As a final mark on this matter, it is important to recognize that highlighting or exaggerating certain elements may also be misleading. Therefore, it should be used with high consideration and caution.

5.3 Binary Logistic Regression

First of all, since the sample size for this study belongs to the lower range of acceptable, the findings from the binomial logistic regression should be interpreted with some caution. Regressions are very sensitive to sample sizes and therefore the results can be misleading (Tabachnick and Fidell 2013). However, the result can be observed as indications rather than proof, and therefore conclusions can still be drawn. In the regressions, several significant relationships can be observed (Table 10). Particularly interesting is that there are differences between the younger age group and age group $\geq 18, < 30$. The younger age group has a higher probability of mentally visualizing bikes while the age group $\geq 18, < 30$ have a higher probability of visualizing physical elements belonging to the category culture, or lakes. Essentially, what this means is that there are trends in how different age groups mentally visualize place. This result indicates that the likelihood of including a certain physical element in the mental visualization can be dependent on age groups, which gives further support for geovisualization tools being developed in a flexible way, and hence become more inclusive. A flexible way can mean that the tool allows different viewing angles, different colour options or weather condition. Other findings are that participants with high environmental concerns are more likely to include elements of culture and elements of nature and participants with strong sense of place are more likely to visualize lakes (Table 10). From that knowledge it is possible to adapt the geovisualization tools accordingly. If people are strongly attached to place and the majority of the users visualize lakes in their mental visualization, it may be important to highlight or give focus to lakes in the geovisualization tool. In that way the tool can align with their mental visualization and not conflict with it, i.e. the tool is portraying the 'reality' as the users see it.

5.4 The User Approach and Future Perspectives

The ambition with this study was to address one of the persistent and most urgent challenges that geovisualization tools are facing today: understanding the user, i.e. understanding of how the user interact with the geovisualization tools, perceive and interpret them. The present void between the advancing technology and the users who seemingly are left behind ought to be dealt with. Besides, it is worth remembering that experts are not the only ones using geovisualization tools. Therefore, as a developer, it is reasonable to acknowledge that actuality and deploy methods that takes the user into account, applying an interdisciplinary approach using geomatics and cognitive science in conjunction. Another advantage of attaining knowledge and theory regarding the user's cognitive abilities is that the user testing does not need to be that extensive (when evaluating the tools). If there are well-developed methods that can be applied, the development process can become much more efficient, as well as the tools themselves.

Although, parts of the methodology for reaching the objective in this thesis are exploratory, the information obtained from the analyses provides valuable information for further studies and practical use. It also highlights aspects such as visualization effectiveness and the relevance of key elements. Increasing the awareness of this can show the user approach in a new light, where more effort is put on developing tools from the user side. The results from running MANOVA gave the most interesting the result, because there the objective about finding differences among age groups was tested. Since the outcome confirmed that differences in mean between age groups existed, the objective was reached. The purpose of this paper was to contribute in making the geovisualization tools smarter with insights and applicable methods, therefore, as a final part of the discussion some examples of this are given.

- Further exploration of demographic factors in the context of geovisualization tools, to gain understanding of how these can affect the way these tools are perceived.
- Develop geovisualization tools that apply the usage of key elements (by finding out which physical elements that the users visualize) and develop tools that do not use key element, and then compare the difference.
- Employing more studies that combines geomatics and cognitive science.
- Research that deploys analyses that are statistically robust, i.e. having large samples and proper data preparation.
- Continuously evaluate geovisualization tools.
- Questionnaires regarding residents' sense of place and mental visualization of place (especially when working with 3D environments of urban towns).

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7. Appendix

On the next page follows the English version of the survey. The survey that was submitted to the residents in Växjö was written in Swedish.

1. **Gender**

   - ○ Woman
   - ○ Man

2. **How old are you?**

   - ○ Under 18 years old
   - ○ Under 30 years old
   - ○ 30 years old or older

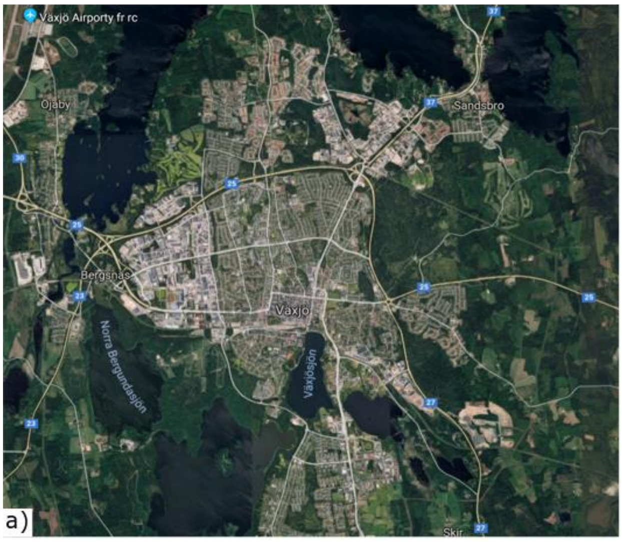
3. **How long time have you lived in Växjö?**

   - ○ Recently moved to Växjö
   - ○ Less than 10 years
   - ○ 10 years or longer

4. **Mention five elements in your physical environment that best describe how you visualize Växjö.**

5. **When you think about Växjö, which picture represent then best what you see?**

   - ○ Alternative a) a perspective from above
   - ○ Alternative b) a perspective from within



a)


b)

6. **How do you visualize Växjö as a city?**

- o An expanding city
- o A city for tourism
- o A recreational place (A place for nature: lakes, hikes, camping)
- o A meeting place

Comment

7. Your relation to Växjö (part 1) – What are your feelings towards Växjö as a city?

	Do not agree at all					Totally agree
The forest around Växjö, Växjösjön and other open spaces are important to me.	o	o	o	o	o	o
I can identify myself with the typical life style and values that people have in Växjö.	o	o	o	o	o	o
I would like to live in Växjö for a long time.	o	o	o	o	o	o
I care about what happens to Växjö.	o	o	o	o	o	o
I can be myself in Växjö.	o	o	o	o	o	o
There are better places than Växjö to live.*	o	o	o	o	o	o

8. Your relation to Växjö (part 2) – How identify you yourself with Växjö?

	Do not agree at all					Totally agree
Living in Växjö is a part of who I am	o	o	o	o	o	o
Sometimes it feels as if I don't belong in Växjö.*	o	o	o	o	o	o
It's important to me to stay in a place like Växjö.	o	o	o	o	o	o
I have a positive emotional connection to Växjö.	o	o	o	o	o	o

9. Your relation to Växjö (part 3) – How dependent on Växjö are you?

	Do not agree at all					Totally agree
Växjö is a good place for my hobbies and activities.	o	o	o	o	o	o
People in Växjö negatively affect my personal goals.	o	o	o	o	o	o
Växjö offer possibilities for me to engage in my favorite activities.	o	o	o	o	o	o
The things I do in Växjö I could as well do somewhere else.	o	o	o	o	o	o

10. Your social life in Växjö

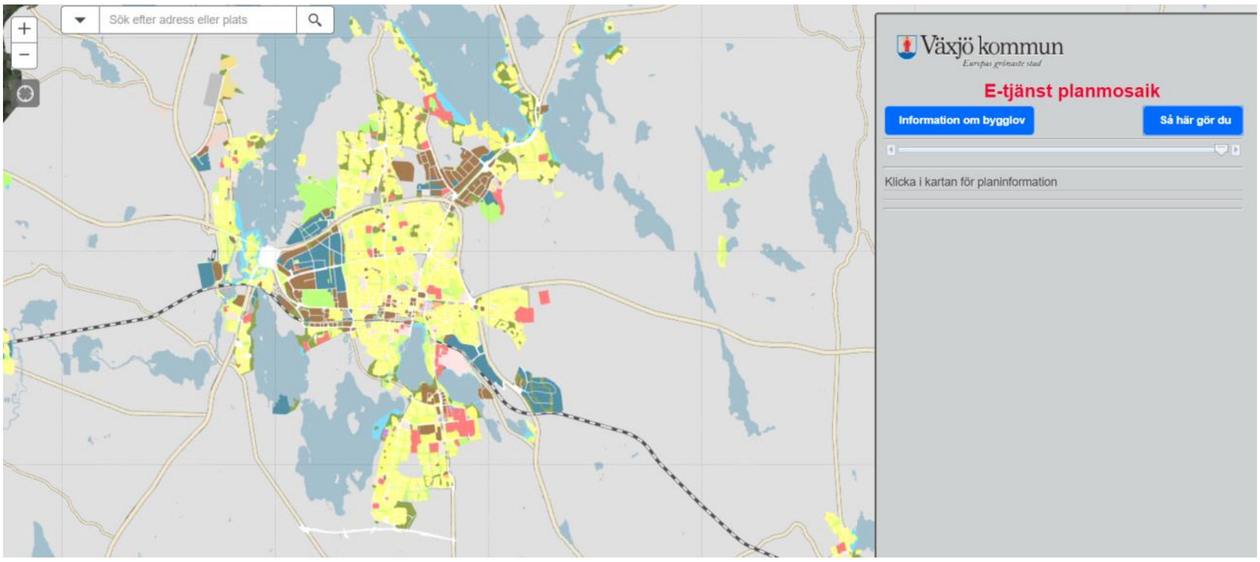
	Do not agree at all					Totally agree
I feel like a part of Växjö.	o	o	o	o	o	o
My social life is in Växjö, it is not a place where I live.	o	o	o	o	o	o

11. The environment

	Do not agree at all					Totally agree
I'm worried about how the climate change can affect Växjö.	o	o	o	o	o	o
We should prioritize the climate change topic in Växjö.	o	o	o	o	o	o
It's important to be aware of climate change	o	o	o	o	o	o

12. Interactive Maps

In the online survey there is a link to this interactive web map service. Here is a screen shot of how it looks like.

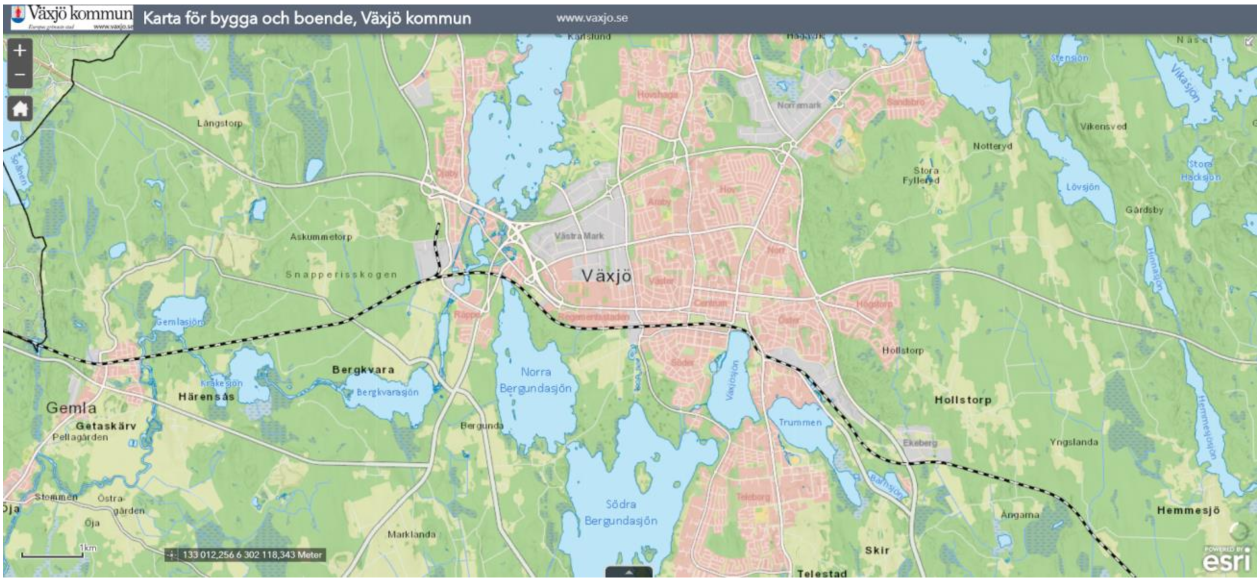


	Do not agree at all					Totally agree
It's easy to orientate in the map.	o	o	o	o	o	o
The colors are good.	o	o	o	o	o	o
I understand how I should use the map service.	o	o	o	o	o	o

Comment

13. Interactive Maps

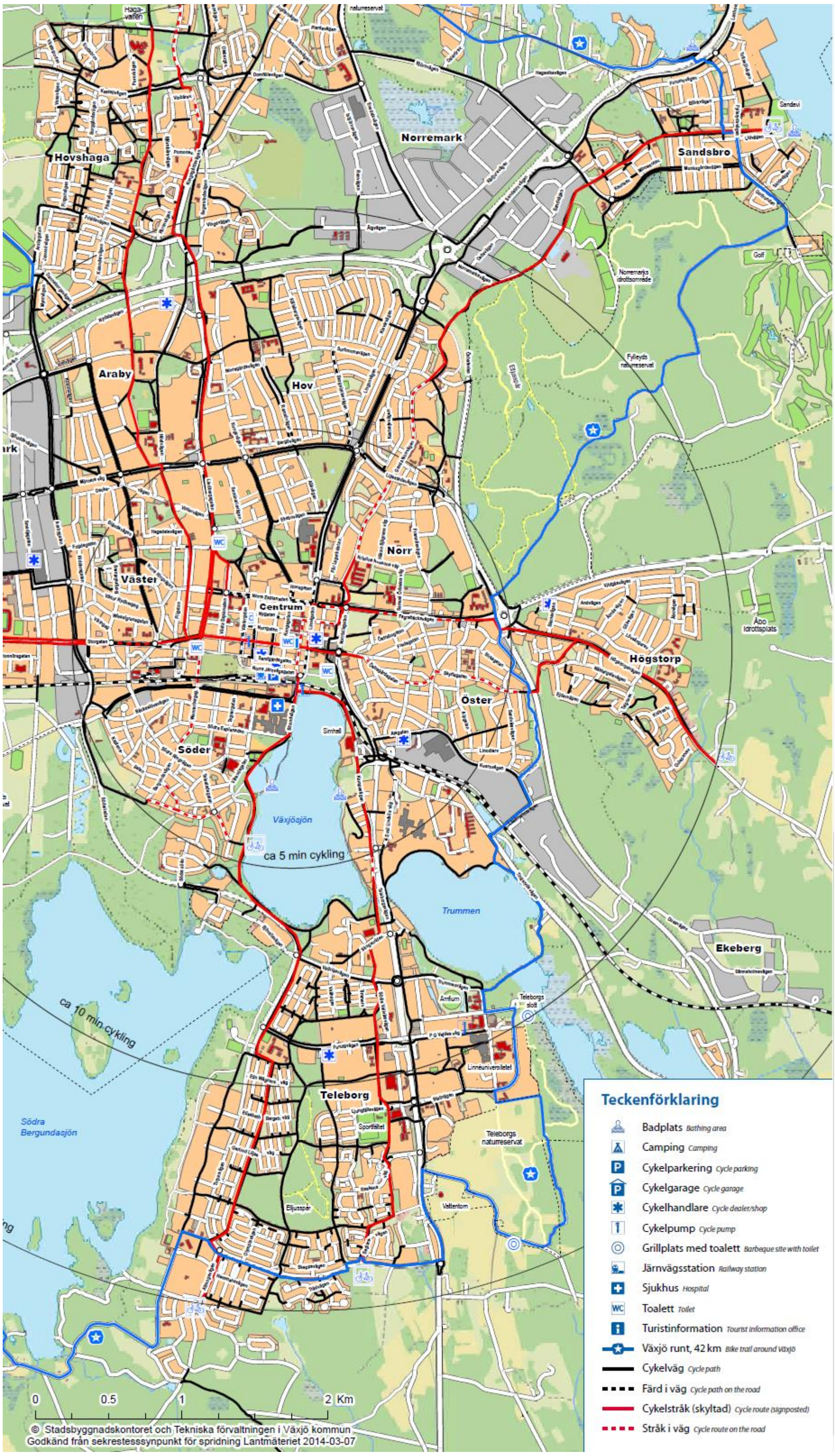
In the online survey there is a link to this interactive web map service. Here is a screen shot of how it looks like.



	Do not agree at all					Totally agree
It's easy to orientate in the map.	o	o	o	o	o	o
The colors are good.	o	o	o	o	o	o
I understand how I should use the map service.	o	o	o	o	o	o

Comment

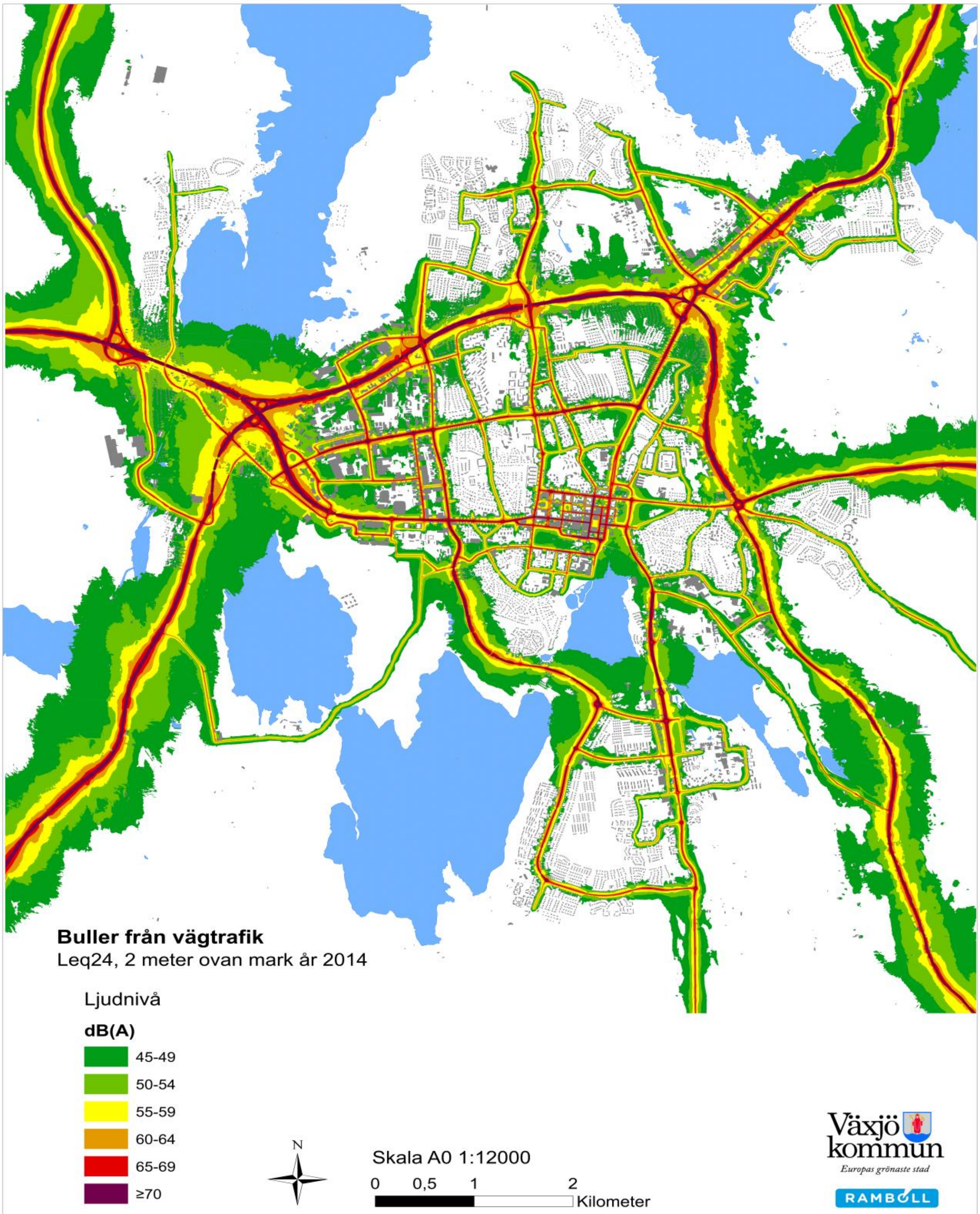
14. Static Maps



	Do not agree at all					Totally agree
It’s easy to orientate in the map.	o	o	o	o	o	o
The colors are good.	o	o	o	o	o	o
I understand how I should use the map service.	o	o	o	o	o	o

Comment

15. Static Maps



	Do not agree at all					Totally agree
It’s easy to orientate in the map.	o	o	o	o	o	o
The colors are good.	o	o	o	o	o	o
I understand how I should use the map service.	o	o	o	o	o	o

Comment