Christian-Albrechts-Universität zu Kiel

Mapping Alternative Mobility Accessibility in Kiel

The Argument for Auto-reduction Strategies

Master's Thesis

M.Sc. Sustainability, Society and the Environment

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Abstract

Car powered mobility systems have become an integral part of every major city around the world. As cities have grown, so too has the interconnected web of roads, streets, bridges and freeways that support this system. With these systems, also comes many negative side-effects that cities are struggling to deal with, which include increasing levels of traffic, CO^2 emissions and safety concerns. The city of Kiel in Germany is currently in the process of re-imagining its transportation system to be one that relies less on cars and more on alternative forms such as walking, bicycling and public transit. This thesis aims to contribute to this ongoing process by developing a novel method for assessing walkability within the city. Adding this dimension into future analysis can help provide stronger arguments for the types of car reduction strategies which are also covered in this thesis. Also examined will be the correlations between walkability and mobility preference by comparing walkability with recent results from a survey conducted in Kiel.

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Introduction

In many cities the world over, the car has been given a prominent place in the hierarchy of possible transportation modes. So much so, that our cities are now configured for the needs of the car and predominantly "car-mobile" societies. This car-dominant form stands in stark contrast to what came before it; transportation dominated heavily by pedestrian traffic. The differences between these two ways of orienting a city can be seen when we look at development patterns within cities before and after the advent of the automobile. Older parts of cities typically have a mixed use approach where businesses and residences share the same space in a more compact area, whereas more modern, car-friendly urban development favors the separation of living and work space and manifests itself as sprawling suburban developments.

The transition to cars was a long process which lasted most of the 20th century, and although this form of transportation still offers many benefits, this form of personalized mobility also brings plenty of negative side-effects. Many cities recognize that (gasoline powered) cars contribute to greenhouse gas emissions which are driving changes in our climate, and regardless of the fuel type, automobiles contribute to accident fatalities and noise pollution. Many cities have also begun reaching a breaking point with the amount of traffic they suffer under, creating not only a bad experience for the drivers, but those who must navigate around this traffic. Signs are becoming clearer and clearer that cities need to begin proposing and implementing viable alternatives to car centered transportation systems.

One city hoping to answer these calls is Kiel in Germany. Like many cities across Europe, Kiel has plans to reduce its dependency on automobile transport and hopes to contribute positively to Germany's national greenhouse gas emission reduction goals. The city itself exhibits both qualities of a car-friendly and a pedestrian-friendly city, so the idea that Kiel could quickly become a city in which the car loses predominance is not entirely far-fetched. In comparison to other cities, especially those in North America and Australia, Kiel is relatively densely populated with its population concentrated in a handful of urban centers.

Quantifying this density in a meaningful way and determining just how accessible alternative mobilities are in Kiel will be the focus of this thesis. Specifically, a method will be presented which was developed to measure walkability in the city of Kiel. In order to draw even more interesting conclusions from this data, we will also be comparing calculated measures of walkability with a recently conducted survey from the Combination project (supported by Fachhochschule Kiel and Nahverkehr Schleswig-Holstein, https://combination-sh.de/). By combining these two data sets, we will be able to see whether urban form is correlated to an individual's transportation habits and attitudes towards public transportation. In addition to this, several proposals will be made for concrete measures that could help reduce car use in Kiel. These proposals will be informed by the walkability assessment of Kiel, and the data collected from the surveys will help us infer how strong or weak public support may be. Ultimately, it is this thesis' goal to contribute to the conversation already underway for how Kiel can create a better, more sustainable transportation system in the future.

Thus, once a detailed method for developing a walkability measure has been outlined, this thesis will focus on the following questions:

- Are walkability and preference for alternative modes of transport positively correlated to each other?
- How do we determine areas within Kiel which are good candidates for auto reduction strategies?
- What possibilities exist for implementable measures in Kiel?

Background

In order to appropriately frame the analysis and proposals put forth in this thesis, we must first establish a sufficient level of background knowledge for the readers. To do this, we will first look at important theoretical concepts from transport and urban geography that will serve as a framework for understanding the research questions we are trying to answer. Afterwards we will look at the historical development of automobile usage, what it looks like in Kiel today and what it may look like in the coming years. This is then followed by a section where we cover car-reduction strategies currently being implemented around the world. We will come back to some of these strategies for a more in depth look in the discussion section. Finally, to help the readers orient themselves for the methodology and results section, I briefly introduce geographic composite indexes and their current state of usage in measuring walkability.

Theoretical framework

To build a theoretical framework for this thesis, we first visit the field of Transport Geography to learn a couple key terms. This field of study asks questions related to the movement of people and goods within and between cities, regions and nations. From this field come definitions for two important terms: *accessibility* and *mobility*. Accessibility refers to how easily one can reach a particular amenity or destination or the number of opportunities currently available in a given location (Giuliano & Hanson 2017). Mobility refers to the ability to move between destinations and changes depending on which mode you select (ibid.). For example, when traveling by foot in a particular area, your mobility in the amount of kilometers you can travel decreases. This in turn may also decrease how accessible surrounding amenities are to you depending on how far away they are. When you switch to using a car, your mobility increases as well as your accessibility because you can now travel further (increased mobility) and have more amenities and destinations at your disposal (increased accessibility).

Optimizing accessibility has been the job of transportation planners over the last century, and this has typically been accomplished by implementing the use of new mobility technologies such as automobiles or trains (Giuliano & Hanson 2017). In order to help predict demand for these systems, the field of transport geography uses trip-based and activity-based models (ibid.). Both of these models rely heavily on quantitative analysis, which rely on accurate input data about the users of the surveyed transit systems and the systems themselves. Critics of this purely quantitative approach point out that, "transport geography is simply about getting from A to B, it is not about the journey (the movement) itself; it is oriented towards the narrowly instrumental" (Latham et al. 2009, p.29). With this narrow view of movement, it is hard to account for trips that are not related to any sort of amenity or goal; movement for movement's sake is lost such as dog walks and jogging.

Out of this concern grew an emergent *new mobilities paradigm* that was first described by Sheller & Urry (2006). This new paradigm stresses the fact that as we increased our mobility, something more than purely increasing our traveling range occurred. With this increased mobility, came a fundamental reorientation of how we experience space and time. Metaphorically, we can think of this as the ever expanding horizons of movement that affect our own behavior the more they expand. The more these mobilities expand and change the more they shape the physical world around us and our relationships with others. Because of this, the "new mobility paradigm" understands the world starting with the assumption of movement and fluidity rather than stasis and structure (Latham et al. 2009).

Under the same umbrella as the new mobilities paradigm, which is quite broad including many facets of mobility, is the *sustainable mobility paradigm* proposed by Banister (2008). This paradigm specifically takes into account how we create sustainable transportation within the city itself. It can be summarized by the following four elements:

1. Effectively utilizing technology for efficiency gains and increase occupancy of vehicles while accounting for potential rebound effects
2. Regulation and pricing mechanisms to help internalize externalities
3. Integrated land-use development so that trip distances are reduced
4. Clearly targeted personal information/advertising to help persuade users to shift transport preferences and behaviors

These four elements give city planners and citizens a framework for pursuing the kinds of changes that will make a difference in transportation systems around the world. Banister (2011) stresses that it is important to equally apply the above elements. For example, improvements in efficiency alone are not going to be enough to tackle issues such as CO^2 emission reductions.

Later in the discussion, I will introduce policies based on my quantitative analysis work which closely align with Banister's priorities in designing sustainable transportation systems. This paradigm offers one of the best ways to discuss and propose visions for future transit systems because it goes beyond simple efficiency maximization. Narrowly focused efficiency maximization is what leads to ever widening roads and the increasing price tag of an already very expensive system of streets and freeways. Instead, this paradigm helps us to see the many opportunity costs that spread-out development patterns bring, and it helps us to imagine a future where cars have been traded in for environmentally friendlier forms of mobility like walking and cycling.

Roots of automobility

Now that we have an understanding of the theoretical perspective and paradigms used to frame our discussion, we look at historical developments to see how modern mobility systems came to be, particularly for cities like Kiel. The current state of automobile dependence in Kiel was no historical accident, and understanding why Kiel developed as a car-friendly city requires us to go back nearly a century when the automobile industry was still in its infancy. During this time, industrialized capitalism had already made major inroads in our societies and would subsequently usher in a new era of consumerism into which the automobile would perfectly fit. Where industrialized capitalism would provide the profit motives to build the cars themselves and the vast systems of roads and fueling stations that support them, modern consumerism would cement this dominance by creating a culture around the car, which would propel it to prominence in daily life.

We saw the manifestation of these sides in the form of two key developments: the advent of auto advocacy groups (promoting modern consumerism) and Fordist production techniques (an essential aspect of industrialized capitalism). Advocacy groups did a great deal to improve the situation for motorists in Germany (and around the world) by advocating for projects such as installing standardized traffic lights and controls (ADAC 2021). In addition to that, these same advocacy groups would ensure that the rights of automobile owners were respected and that these groups had a spot at the negotiating table when it came to determining who was in charge of the streets. These negotiations had huge impacts on urban form as they were slowly pushing other forms of traffic, such as foot and bicycles, to the margins in order to clear enough room for cars. What these advocacy groups set in motion over 100 years ago can still be seen today in cities the world over.

Simultaneously, while advocacy groups were gaining members and receiving a louder and louder voice in politics, advancements in production techniques were rapidly increasing the availability of automobiles and constantly driving down their price. In the beginning, most cars were simply expensive luxury items for the elite, and the cause of this lay mostly in the manufacturing process of early automobiles. Each auto was handcrafted and fine tuned to perfection, and while this may have made for some impressive machines, most urban dwellers simply could not afford this level of artisan craftsmanship. But once Henry Ford developed his assembly line manufacturing in Detroit, everything changed. The manufacturing process was now standardized and volumes of production could be achieved which had never been seen before. The precipitous increase in supply also saw an equal fall in prices to the point where those earning middle class wages were able to incorporate automobiles into their daily transportation habits.

In Germany specifically, the dynamics of these two forces began to take place during the National Socialist era, with the National Socialist regime itself being an advocate for automobiles (Gössling 2017). It was also this government which would do a great deal to build out some of the first interstate highways systems or “autobahns” as they were referred to (Becker 2005). But, with the fall of National Socialism and the destruction that laid in its wake, Germany was met with an opportunity to rebuild itself anew. During the postwar era, a new wave of automobility, which was already well underway across the Pacific in the United States, hit many western European countries, including Germany. The auto itself became a symbol of what was known as the “Wirtschaftswunder” (economic miracle), and led to the sorts of car-centered urban development which were common for this era (Harlander 1998). These developments included strict separation of land use and the building out of single family homes on the city edges.

As we approach modern day Germany, we see that the car still plays a huge role in the country’s transportation system with just over one car for every two people in the country (Eurostat 2020). The auto industry also remains one of the top employers in Germany (Jerzy 2020). The ramifications for this are significant for a country wishing to become CO^2 emission neutral by the year 2050 (BMU n.d.). In the following section, we will look at how the city of Kiel wishes to transform its transportation system in order to meet this carbon neutrality goal.

Mobility in Kiel

The city of Kiel itself is the capital of the Federal State of Schleswig-Holstein and is a modestly sized metropolitan area with a population of 247,777 and an area of 419 km2 (Kiel 2020). Future projections have the population of the city increasing slightly, with population groups above 65 growing more than the younger population (Schleswig-Holstein 2013). One of the prominent geographical features of the city is a harbor that splits the city into distinct parts. This geographic feature has historically made it a difficult city to build transportation systems for because there are no bridges or tunnels connecting the two sides. The inner city is made up of relatively dense housing structures with the city edges primarily consisting of suburban development. The wide streets and high number of cars on its roads point to the fact that Kiel was developed with the car in mind and remains a car friendly city more than anything else to this day.

Under the motto “Kiel Bewegt sich - Mobilitätswende jetzt!” (Kiel is moving - Mobility transformation now!), the city of Kiel hopes to redefine its relationship with the way its citizens travel around the metropolitan region in the future (Kiel n.d.a). One cornerstone of this transformation will be the city’s ambitious plans to expand the public transportation system. As it currently stands, only 10% of the city’s mobility needs are met via public transit, which is the exact same proportion when you look at Germany as a whole (Anon 2019; Kiel n.d.b). The public transportation system itself is composed primarily of various bus lines which span the entirety of the city. Traveling by train is also possible, but is mostly for traveling between cities in the region. The city also boasts several ferry lines which hop back-and-forth between stops in the harbor.

Currently under debate is what form this new transportation system will take. According to city planners, the predominately bus serviced system will not suffice in its current form if the city wishes to have an ever increasing percentage of the populace using it (Kiel n.d.a). Therefore, the design of a new system is under way which will consist of either a light rail transit system or rapid-transit bus system (ibid.). Either way, these two options will provide dedicated, high capacity tracks which will be able to quickly transport citizens from one area of the city to the other. The city will be deliberating these plans until 2022 when they will make a final decision on the form they will take with the first projects being completed around the year 2030.

Car-reduction strategies

In order to put Kiel's efforts into perspective, we now focus our attention on the myriad ways that other cities are pursuing urban development policies which hope to reduce the number of cars on their roads. First, we will take a look at trends in general which show that automobility may be reaching its limits in many western and non-western countries (Newman & Kenworthy 2015). Afterwards, we will examine all the concrete measures which are affecting these trends including, street usage fees/toll areas, bicycle infrastructure development, pedestrianization, and public transit infrastructure.

General trends

According to trends beginning in the late 1990s, growth in automobile usage rates in many cities around the world are either slowing down, stalling or completely reversing (Van Dender & Clever 2013; Newman & Kenworthy 2015). In Germany, this trend has been well underway for the last 20 years, and can be attributed to a number of different causes. Included in these are the growth of public transportation, reversal of urban sprawl, rising fuel prices and a growth in the culture of urbanism (Newman & Kenworthy 2011). All of these phenomena combined together comprise something called "peak car use" (ibid.) and point to the fact that many cities have simply reached the limit of how many cars they can accommodate.

On top of the physical limits to how many cars can fit into a city are the many negative externalities that cars cause every year on their streets. These include the nearly 1.2 million automobile related deaths a year around the world, with approximately 25,000 of those occurring in the European Union (Commision 2020). Additionally, cars encourage more sedentary lifestyles and emit pollution which both have adverse effects on the duration and quality of life (Nieuwenhuijsen & Khreis 2016). These negative externalities also include the roughly 12 percent of global CO^2 emissions worldwide that cars and passenger automobiles contribute to (Ritchie 2020). Finally, the car itself and its infrastructure present an environmental injustice in most cities, as it occupies an inordinate amount of space and often crowds out those wishing to use alternative transportation modes (Gössling 2016).

In order to address these issues, many countries and cities around the world are proactively helping end the era of automobile dependence and are welcoming new mobility alternatives. Especially in Europe, where denser population concentrations make this transformation process somewhat easier, we see many ambitious programs hoping to change its citizen's relationship with mobility. To ease the process of creating these initiatives, the European Commission published its Urban Mobility Package in 2013, which included an annex describing how cities can develop a so-called Sustainable Urban Mobility Plan (SUMP). In the following sections, we will focus on the types of projects which can grow out of these SUMPs and focus on how they encourage sustainable urban mobility while reducing car dependence.

Street usage fees and toll areas

Street usage fees and toll areas have long been used as a way to impact the total demand for driving within an urban area. One the first and simplest systems was implemented in Singapore in 1975 (Jenn 2019). The program itself consisted of a single restricted zone, and drivers were charged to enter this area, but if drivers began their trip within this area, they were not charged. The technology for implementing such systems has vastly improved since Singapore began their system. Now, instead of having officials manually inspect vehicles to check for the correct stickers and decals, electronic systems automatically scan cars using radio transponders and vehicle license scanners (ibid.). This technology gives area toll systems the added flexibility of being able to charge a higher price to drivers when demand is high and a lower rate or none at all during non-peak traffic times.

Although the problems that street usage fees and toll areas wish to address are widespread in many developed nations, the adoption of these techniques in these nations is surprisingly low. This is largely due to the politics surrounding this issue and the heated debates that such policies ignite in cities. Eliasson (2014) refers to the problem of acceptance primarily as a problem of appropriate framing, so whether it is framed in a negative way, “tax” or “toll”, versus a positive way, “environmental charge”, can make a big difference. Subsequently, this will force each political party to try to take control of the framing narrative, while also trying to link their positions to well established political issues such as environmentalism or over-taxation (ibid.). Unsurprisingly these debates typically splinter along party lines, with more conservative parties being against these measures and more liberal leaning parties being for these measures.

To see this process in action, we can examine two separate cities in which these policies failed and succeeded in Copenhagen and Stockholm, respectively. Copenhagen is known worldwide for its progressive policies on urban mobility, especially in the area of bicycle infrastructure, so it is not very surprising that this city would consider an area toll within its city center. It was initially proposed that the revenue from this toll would be diverted to broader transit initiatives, including improvements to freeway, mass transit and bicycle infrastructure (Henderson & Gulsrud 2019). This proposal would ultimately fail because of several negative narratives which either saw this as a measure that would disproportionately affect suburban populations (those needing to drive into Copenhagen) or labeling it as, “a new medieval city wall” which would further divide city districts (ibid.). As it stands today, this policy is not currently under debate nor will it be in the foreseeable future.

Stockholm on the other hand was able to permanently establish an area toll after a voter referendum in 2006 (Kloas & Voigt 2007). Before being permanently established, the city initially allowed the area toll to be implemented as a trial. Despite its initial negative reception, once drivers were able to see the positive impacts of reduced traffic, opinion shifted to being in favor of the area toll (Eliasson 2014). Additionally, the funds from the toll were clearly earmarked for improvements to existing road systems, which let drivers know their money was going towards something directly benefiting them (ibid.). In Copenhagen, the framing was co-opted by members of the left who were openly hostile to cars in the city, and their proposal had the explicit goal of making Copenhagen even more uncomfortable for cars while simultaneously increasing trip quality for public transit and bicycles (Henderson & Gulsrud 2019).

Any street usage fee or area toll system's success will be measured by a variety of factors including whether it is able to reduce congestion, whether it adequately raises revenue it promises and whether it can divert commuters to other forms of transportation. For Stockholm, the years directly following the implementation of the area toll saw a 20% decrease in motor vehicle traffic entering the city (Börjesson et al. 2012). Although the investment cost was initially high, revenues generated and low operational costs since then have meant that this is a profitable system for the city (Jenn 2019). Furthermore, the city of Gothenburg, also in Sweden, was able to use the same technologies Stockholm developed while implementing its own area toll system. This meant that Stockholm's initial investment had benefits beyond just its single use case. The final benefit worth mentioning is that the reduction in car traffic translated directly into more public transit ridership (Börjesson et al. 2012).

Pedestrianization

Pedestrianization, simply put, is the process of making city streets more friendly to pedestrians. This is necessary because car-friendly practices in urban development have dominated in cities since the post-war era. Car-friendly development creates urban environments which can be mildly annoying to pedestrians in the best case scenarios and extremely hazardous to them in the worst cases. If wide roads, high speed limits and high parking availability (in the form of on- and off-street parking) represent car-friendly environments, then narrow roads, low speed limits and lower parking capacity represent a pedestrian-friendly environment. Mixing these two types of urban form can be dangerous, and the reasons for this are fairly obvious: cars travel faster and far outweigh their pedestrian counterparts. The inherent danger of mixing car and pedestrian traffic is something that urban planners must be cognizant of, and the inability to do this well can result in loss of life. In EU countries, nearly 21% of the 23,339 traffic fatalities in 2018 were pedestrians (Eurostat 2020).

Recognition of these conflicts and dangers occurred at the beginning of motorization efforts for cities in Germany. In response to the growing outcry surrounding the ways the automobile was threatening inner cities, Germany introduced about 400 pedestrian zones in its cities beginning in the 60s (Monheim 2003). These pedestrian zones were primarily intended to increase the attractiveness of commercial districts within these cities, and the policy was successful as now virtually every moderately sized city in Germany has some sort of auto-reduced district. Although these districts were intended to be friendly to pedestrians, they were ironically not easily accessible to pedestrians. The reason being that they were primarily designed with car accessibility in mind (ibid.). This meant that the areas were often separated by large beltway road systems, and accessing them by foot meant walking long distances and crossing wide roads or highways. This was good for cars but bad for pedestrians wishing to access these areas.

In the previous decades, more and more efforts have been gaining momentum to promote pedestrian centered approaches to urban development. An example of this can be seen in the northern German city of Lübeck where efforts have been underway to expand their auto-free area to more than just a few central commercial streets since at least the early 90s (Topp & Pharoah 1994). Currently, these efforts are taking the form of deliberate pedestrianization policies that are removing car parking, making it more difficult for thru-traffic and planting trees and gardens where cars once stood. "Project Beckergrube" is currently implementing these measures for Beckergrube street located in downtown Lübeck (Anon 2021a).

Another example of pedestrianization efforts in Germany can be seen in the planning and development of the Vauban neighborhood in Freiburg. Formerly a French military base, this brownfield was converted into a residential zone in the early 90s (Foletta & Henderson 2016). At the outset of the project, a group of environmental campaigners formed what was known as the Forum Vauban. They did this in order to ensure more radical measures, like no on street parking, were introduced into the city's plan for the area. They were ultimately successful, and the numbers show it with only 172 cars per 1,000 residents within this area which is well below the national average for Germany (ibid.).

Bicycle infrastructure

Biking infrastructure can take many forms, from the widening of existing bicycle lanes to the creation of separate sign systems to make cities more navigable. In recent years, an increasingly popular way to make biking a more desirable mode of transport is the creation of so-called bicycle highways. These are special paths which do not share the way with motorists or pedestrians and are intended to give bicyclists a safer and more direct route to their destinations. Perhaps the most ambitious of these projects currently underway in Germany is the planned "Radschnellweg Ruhr" that wishes to link multiple cities in a 95 Kilometer long route (Verkehr des Landes Nordrhein-Westfalen 2021). When finished it will connect the cities of Duisburg in the west and Hamm in the east and will be the first project of its kind in Germany. Other initiatives that are focusing on better bicycle transportation within the metropolitan region include FrankfurtRheinMain (2020) plans for creating cycle highways connecting the inner city with its outer suburbs. In total, there are nine planned routes which the city hopes will provide much needed relief for the current traffic congestion as the metropolitan area continues to grow.',

Tools for measuring urban environments

In the following section, several methodologies are outlined that are currently being used to measure urban form. Discussed first will be the use of composite indices and how these are useful for making generalizations of geographic space. This discussion includes how they are constructed as well as their limitations. Afterwards, we go in depth on several composite indices being used to measure urban form and in particular mobility in urban environments. Two different indices: "walkability" and "bikeability" will be highlighted. On top of that, a short discussion concerning the short-comings of current tools to measure walkability will be presented.

Geographic composite indices

A composite index is a statistical tool used for combining potentially many statistics into a single one making it easier for end users to interpret. A common set of composite indices are those used for describing stock market performance such as the NASDAQ or S&P 500. With this single statistic, one need not examine all the individual companies which comprise it in order to get a general sense of where the entire market is. So what then is a geographic composite index? In essence, it functions the same as the composite indices of stock markets except that we gain the ability to make generalizations of a geographic extent instead of a financial market. A further explanation is provided by Singleton et al. (2018)

> (Geographic composite) indices are typically calculated to measure phenomena within urban areas that either cannot be directly observed or, by definition, are a construct of multiple influences.

With their definition, it is clear that composite indices not only enable us to make generalizations about a particular area, but also enable the discovery of entirely new insights by combining singular data measures into a combined metric.

Just because these indices can be used as powerful tools for bringing attention to particular issues, does not mean they are always designed with pure intentions. Like any statistic, these indices can be crafted in ways meant to deliberately deceive those who consume it, and this means that creators can specifically craft these models to meet their needs. Therefore, in their *Handbook on Constructing Composite Indicators: Methodology and User Guide* the OECD recommends that any composite index be grounded in a strong theoretical framework (OECD et al. 2008). Doing this will guide the creators in their choices about what to include and exclude and what data should be considered more or less important. For example, in the *English Index of Multiple Deprivation 2019* report, their theoretical framework includes a description of deprivation including the following factors: income, employment, education, health, crime, access to housing and services and living environment (McLennan et al. 2019). The assumption that deprivation in fact does include these and only these factors is their theoretical framework and lay at the foundation of what this composite index represents.

Walkability

We now move on to a composite index which is particularly applicable to this study: walkability. The definition of the term "walkability" encompasses many different aspects of urban form and may likely change depending on which profession is defining it (Lo 2009). For example, transportation planners may decide to define it in strictly quantifiable measures such as sidewalk widths, route directness and sidewalk continuity, whereas urban planners/designers may choose a more subjective measure such as how aesthetically pleasing the buildings on a given street are (ibid.). Frank et al. (2010) also developed a walkability index based on land use mix and residential density among other factors. It is this variety of factors which makes walkability a good candidate for calculation as a composite index. Although, it should be noted that a variety of theoretical frameworks exists which have the possibility to skew the results in one direction or another. This happens when researchers choose which factors they wish to include and later assign weights (i.e. levels of importance) to these factors. Therefore, these composite indices should be as transparent as possible to allow the readers to see where the theoretical framework's biases lie.

An example of this type of composite index comes from a study by Lwin & Murayama (2011) which focused on walkability through an ecological/psychological perspective. The goal of the study was creating a tool to find a walking route with the most foliage and tree cover possible, with the underlying assumption that exposure to natural settings can boost psychological well-being. Another example comes from Gilderbloom et al. (2015) who use walkability as a tool for correlating broad factors of urban sustainability, such as housing valuation and crime rates, to walkability. The first study mentioned created a new method to calculate a "greenness score" for walking routes. The details for creating the index were laid out in the study and gives other researchers a great starting point for picking up where they left off. Furthermore, it allows us to clearly connect their theoretical framework and the output of their composite index. The second study however, relied in part on a proprietary data set from a tool called Walkscore^{tm}. Because the second study relied on a proprietary tool and data set for their analysis, it means that the exact details of how this composite index was calculated cannot be revealed. Parts of this analysis will forever be "black boxed", and we are left with merely hoping that the expertise of the company providing the data can be trusted.

It is worth discussing the Walkscore^{tm} (https://www.walkscore.com/) tool further because it is a good example of why proprietary tools are not good candidates for creating composite indices. From their own website, "Walk Score measures the walkability of any address using a patented system" (Anon 2021b). A patented system here means that the exact way in which they calculate this composite index is kept secret. A short description is provided which gives a very vague overview of how it works, but it is certainly not enough for any would-be researchers to be able to completely replicate it on their own. Furthermore, by patenting their method, they make it potentially risky for others to replicate their research for fear of lawsuits. When others are unable to replicate the research themselves, it becomes very difficult to draw a line from the initial theoretical framework driving the design of the composite index to the final output of the model.

Bikeability

On top of walkability, a city or metropolitan region's bikeability can also be measured. Previous studies on this topic include Winters et al. (2013) where they set out to map the entire metropolitan area of Vancouver, Canada. Unlike the previously mentioned Walkscore^{tm} tool, this study put an emphasis on transparency and reproduction in the hopes that it may be reproduced and adopted by other metro areas. Important to the weighting of their index were a series of surveys and focus groups that were carried out prior to the actual construction of the index. Out of this came the realization that route separation, the degree to which the route is separate from other forms of traffic, was an important variable to figure into their analysis. The results from this analysis show the bikeability index as a continuous surface across the entire metro-area in Vancouver (see figure 1).

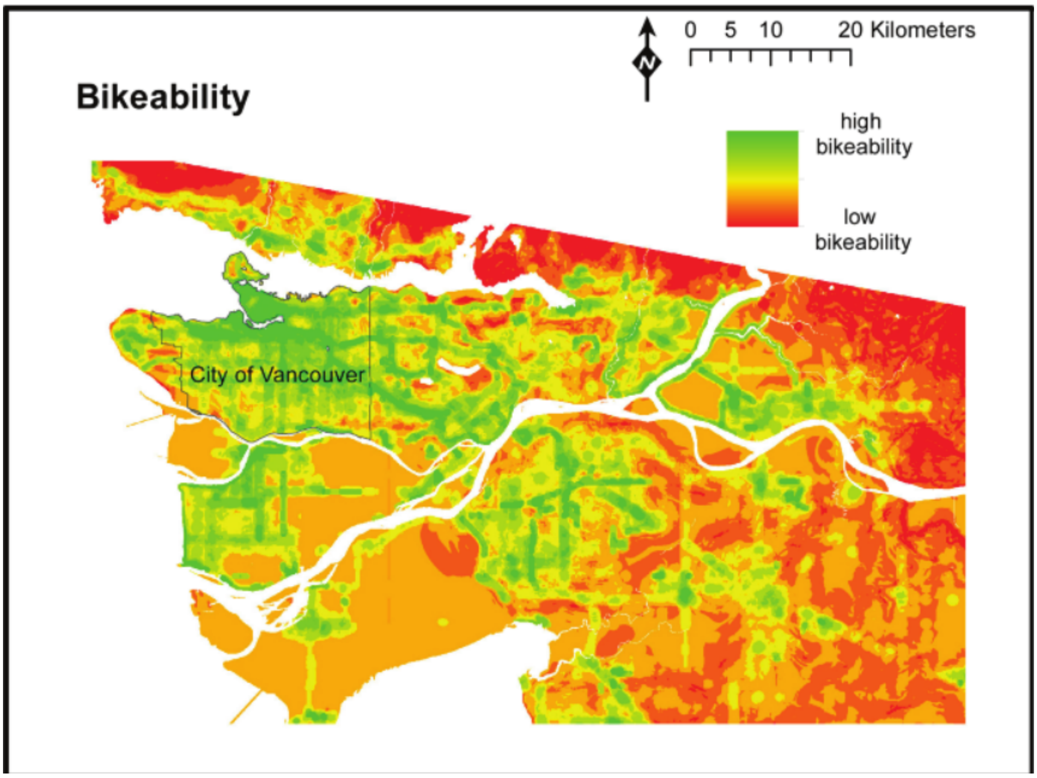

Figure 1: Map showing bikeability as a continuous surface in Vancouver (Winters et al. 2013)

Methodology

In the previous section, a variety of subjects were covered on how cars affect our urban environments and what tools we have available to measure these environments. In this section, a technique is introduced that will allow us to measure Kiel's urban form in respect to how accessible it is to walking. This method was deliberately chosen so that it is transparent and repeatable. Specifically, I have chosen the data so that this method may be repeated easily in more cities in Germany and beyond. All software written to do this analysis is open source and is available at the following source code repository: https://github.com/travishathaway/altmo. The data used is also open and comes from OpenStreetMap (OSM). This means that future researchers will be able to build upon the techniques used in this thesis freely, without interference of copyright or proprietary issues. The general steps to this approach are detailed in the following sections along with the underlying rationale. For a detailed, step-by-step technical overview of how to reproduce the results, please see the source code repository linked to above.

Rationale

Identifying trends and patterns at a superficial level is something that statistical analysis is particularly well suited for. Interpreting these trends, imputing meaning upon them and determining an appropriate response is then left mostly up to communities and governments with access to this data. With this in mind, it is important to understand that the following methodology aims to give citizens of Kiel a better overview of which areas in their city are highly accessible by foot and which ones are not. Possible responses to this data will be argued for later in the thesis, and these will include what measures could be taken to align auto-reduction strategies within Kiel's urban form. Therefore, it is important to remember that this tool was developed in part so that these arguments can be grounded in quantitative measures of the city.

The exact thing that I am setting out to measure is the distance between residences and amenities. For the purposes of this thesis, residences are places where people live on a continuous basis and may include single family homes, duplexes and apartment buildings among other things. Amenities are defined as places of interest that people either want to visit (like restaurants, bars and cafes) or must visit out of necessity (e.g. supermarkets, pharmacies, doctors and dentists). By first calculating the travel times to each of the nearest amenities for a residence and then averaging out all these travel times to a single measure, I believe I can provide a reasonably good picture of the relative walkability for a given address. When repeated for each residence in the city of Kiel, we will then be able to map these variables across the city, which may be of use to city planners and advocates.

It is important to mention that the collection of data for trips back and forth to places of employment were intentionally left out as they go beyond the scope of what this thesis intends to study. A study including this data would have necessarily relied on data sources which at the time of writing this thesis were not available. Furthermore, this data would likely not be available to others wishing to replicate this method for their area of interest.

Data collection

The primary data source for the analysis came from the OSM database. This is a database which anyone can freely contribute to and use, and it is continuously updated and monitored by an online community of contributors (Haklay & Weber 2008). OSM data is updated daily and the copy of the database used for this thesis was acquired on June 6th, 2021 from https://download.geofabrik.de/. The data collected from OSM was used to create a list of all residences and amenities in Kiel for the extent shown in figure 2. The number of residences collected was 67,965 and the total number of amenities was 5,660.

Figure 2: Map of study area extent

In order to collect residences from the OSM database, this method relied on OSM's system of labeling within its database. Contained within this database are the outlines of every building within our study area. Also found in this database are data available which give us information about the predominant land use types for large swathes of land (e.g. a single neighborhood or part of the inner city). By querying for all buildings located within a particular land use area ("residential" in this case), fairly detailed data about each residence in the study was collected. The most important piece of data was the exact coordinate location of the residence. To help further ensure the accuracy of the method, a handful of residence locations were manually cross-referenced with Google Maps.

Amenities were collected in a similar process; however, a more elaborate tag system was used to collect the necessary amenities for the study. The categories of these amenities can be found in table 1. Category collection was a crucial aspect of this study as these can have a big impact on the walkability measured for the various addresses. In order to create this list, some exploratory data analysis was conducted on the OSM database to see how many amenities of each type existed. Amenities with very few or just one record were immediately thrown out. Each amenity was grouped into a corresponding category that I myself created and were not present in the OSM database.

Data analysis

The second part of the methodology used involved calculating both euclidean and network distances between residences and amenities. Euclidean, or straight line distance, is the most direct route between two points, whereas network distance is the shortest possible distance between two points using the provided road or path network (see figure 3 for further explanation). Using GIS database queries, the euclidean distance between all residence and amenity pairs were found and then sorted by length. With this information, it was now known approximately which amenities were the nearest to all of our residences.

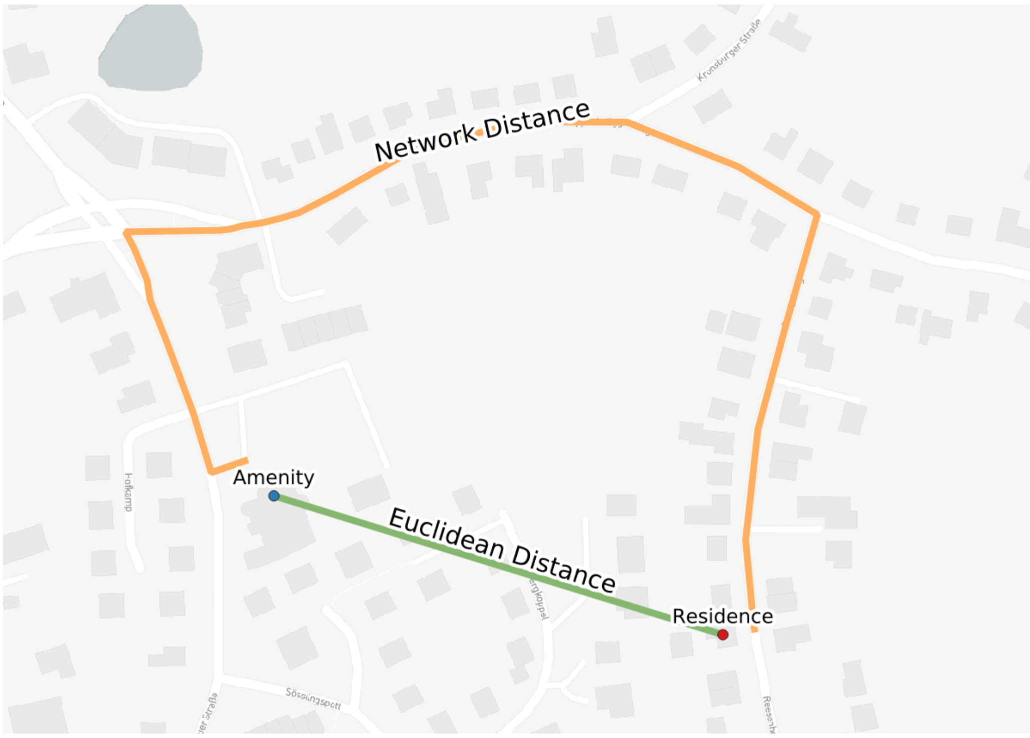

Figure 3: Euclidean versus network distance

The next step taken was finding the network distances between the nearest amenities and a single residence. To do this, a special open source routing software called Valhalla was used which also relies on OSM as its data source. Valhalla supports various costing mechanisms such as automobile, bicycle and pedestrian, and by using these costing mechanisms, it was possible to find an optimized route and the estimated duration of the route. For this study, the duration was the key piece of information needed for calculating walkability and bikeability.

The very last step of the analysis was generating a map of the collected trip durations. To do this, all trip durations were combined into a single composite average duration by weighting each amenity. Thus, the final output will be a time which is the measure of how far away a person is on average from all amenities nearby. Across all eight broad amenity categories, amenities were weighted equally when calculating this average, but within the categories, certain amenities were given higher weights than others. For example, within the category “groceries” the amenity “supermarket” was given a higher weight because it provides a wider variety of services and fulfills more needs than the other amenities in this category.

With this composite average calculated for each residence, it was then possible to create a heat map style raster image where every pixel in a residential area represented how far away it was on average to all amenities nearby. To provide a more visually appealing end product, especially at higher resolutions, an interpolation algorithm was used. Specifically, this was the “Inverse Distance Weighting” (IDW) algorithm, and it runs under the assumption that objects nearer to each other are more alike than objects further away. When a pixel value must be interpolated because it is not known, the values closest to the unknown pixel have the greatest influence on it.

Presentation

Along with the printed maps contained within this thesis, a website was built in order to offer a more interactive experience for users exploring the data. This website was designed as a prototype which could be further developed and used by city planners or those advocating for changes in the current transportation system in Kiel. The website is currently available under the following URL: https://altmo.thath.net. The title of the website is “AltMo”, which stands for Alternative Mobilities.

Table 1: List of amenity categories and their corresponding weight used to calculate the composite index.

Category	**Amenity**	**Weight**
Administrative	Bank	25%
	Townhall	25%
	Police	20%
	Post office	20%
	Post box	10%
Community	Community centre	25%
	Library	25%
	Social facility	25%
	Place of Worship	25%
Groceries	Supermarket	75%
	Bakery	25%
Health	Doctors	20%
	Pharmacy	20%
	Dentist	15%
	Hospital	15%
	Clinic	10%
	Nursing home	10%
	Veterinary	10%
Nature	Park	30%
	Sports	30%
	Forest	20%

Category	**Amenity**	**Weight**
	Allotment	10%
	Cemetery	10%
Outing destination	Bar	10%
	Cafe	10%
	Cinema	10%
	Events venue	10%
	Fast food	10%
	Ice cream	10%
	Nightclub	10%
	Pub	10%
	Restaurant	10%
	Theatre	10%
School	Childcare	20%
	School	20%
	University	17.5%
	Kindergarten	15%
	College	12.5%
	Driving school	5%
	Music school	5%
	Research institute	5%
Shopping	Clothes	11.12%
	Books	11.11%
	Florist	11.11%
	Furniture	11.11%
	Hairdresser	11.11%
	Marketplace	11.11%

Category	Amenity	Weight
	Optician	11.11%
	Second hand	11.11%
	Sports	11.11%

Results

Contained within the results are two sections: the first outlining the results from the walkability analysis and the second comparing these results with the Combination survey. To make the walkability results more relatable and easier to explain, several examples of actual resident addresses across Kiel will be examined along with the walkability map itself. Each of these addresses were chosen in an attempt to begin drawing broad categories of walking accessibility in Kiel. In the second section, the study area is split into four separate regions to allow us to compare walkability and the Combination survey results.

Walkability results

Figure 4 shows the walkability surface for the city of Kiel. More walkable areas are shown in blue (15 minutes or less) whereas less walkable areas are shown in orange and red (more than 30 minutes). At first sight, it is clear that that walkability decreases the further one moves away from the city center of Kiel. In table 2, we see the average walking time for the entirety of Kiel is 26 minutes and 43 seconds, and figure 6 shows the shape of the distribution as a standard normal curve with a right skew. While this number does not mean much on its own, this average of averages could be used as a metric to compare regions or cities with each other. Furthermore, this number could also be utilized as one of several key performance indicators (KPI) for a city, where future developments in a city could actively try to push this number down as much as possible.

Table 2: Descriptive statistics of walkability for the entirety of Kiel by category.

Category	Mean	Std. Dev.
All	**26 min. 43 sec.**	**17 min. 7 sec.**
Administrative	13 min. 40 sec.	8 min. 29 sec.
Community	26 min. 13 sec.	22 min. 7 sec.
Groceries	11 min. 20 sec.	11 min. 54 sec.
Health	27 min. 53 sec.	17 min. 24 sec.
Nature	13 min. 9 sec.	6 min. 22 sec.
Outing Destination	37 min. 43 sec.	22 min. 7 sec.
School	45 min. 21 sec.	24 min. 42 sec.
Shopping	33 min. 20 sec.	20 min. 2 sec.

Inner city

We will now go to the ground level by examining several addresses in various parts of the city. The first address is located in the inner city near Exerzierplatz at 16 Jungfernstieg. For this address, the average walking time to all amenities nearby is about six and a half minutes. This number can be better understood when we look at the various categories which comprise it. The combined average for the category “groceries” shows a total of three minutes and 49 seconds with the nearest supermarket about 5 minutes away and the nearest bakery right next door (less than a minute). Within the category “outing destination”, containing things such as bars, cafes and restaurants, we see that many of these amenities are less than five minutes away by foot with the category itself averaging just about four and a half minutes.

Across the Förde in Gaarden-Ost is where we find our next location at 9 Stoschstraße. Here, we see the same urban density with comparable averages for the categories “groceries” at four minutes and “outing destinations” closer to six minutes. Overall this area lies within the top 25th percentile for the entire study area with an average trip to an amenity lasting about nine minutes and 10 seconds.

These two locations represent Kiel at its most walkable. Not only are amenities reachable by foot within a reasonable amount of time, they fall well under the average for the entire area. In these areas, we can expect that many trips would be taken by foot while carrying out daily activities.

Suburbs

Our next addresses are located in the suburban areas of the city. The first one is located in Elmschenhagen at 19 Teplitzer Allee. Here we see a significant increase in the total average time for this part of Kiel, with the average for all amenities being about 19 minutes, putting it underneath the mean of about 26 and a half minutes for the entire data set. Of all the categories listed, only “administrative”, groceries and nature maintain average walking distances below 10 minutes. It is worth mentioning now that these are the three best performing categories for the entire city, and regardless of which part of the city it is, most people should expect to be able to walk comfortably to these amenities.

The next suburban location is in Russee at 80 Russeer Weg. The average time across all categories is still below the average for the entire study area at a little over 23 minutes. Just like our previous address in Elmschenhagen, we see an increase across all categories again with the categories administrative, groceries and nature being the only amenities on average that residents are able to comfortably walk to.

Outer suburbs

The last area we will examine is located in Strande at 5 Bülker Weg. Strande is a more isolated community to the north of Kiel that is right on the shoreline. The average walking time across all categories rises to a little over 47 minutes. Within the sub-categories all average times are above 15 minutes. Although there are restaurants, parks and cafes within walking distance, other amenities like grocery stores, pharmacies and others lie beyond where one could comfortably walk to. That is why this area receives one of the worst scores in our designated study area.

Online maps

There are numerous maps showing the entire study area region online. The reader is encouraged to visit this website now at https://altmo.thath.net in order to discover what the walkability surface looks like for each of the categories. These online maps also enable users to see detailed walkability information for every single residence included in this study. Walkability maps for each category are also available in the appendix of this thesis.

Combination study results

As mentioned earlier in the introduction, individual data was made available by the researchers of the Combination project which allow for the comparison of walkability and individual preferences. This project is a joint effort between Fachhochschule Kiel and Nahverkehr Schleswig-Holstein (NAH.SH) to find out how to motivate people to choose climate-friendlier transportation alternatives, especially those which reduce overall CO^2 emissions. As a contribution to this effort, we will now examine how walkability and preferences for mobility are related to each other.

The survey itself was conducted in the summer of 2021 and admitted online to those living in and around the city of Kiel. Part of the data collected was the postal code of participants, which allowed for the geographical grouping of survey results. To further group these participants in regions which were relatively homogeneous and contained enough results to analyze, four regional extents were defined as shown in figure 7. These include city center, north Kiel, west Kiel and east Kiel. The groups themselves were created by combining postal code areas together.

One category of questions in the Combination survey asked participants about their preferred mode of transport across the following trip types: work/school, free-time activities, large purchases, small purchases, picking someone up, business travel and miscellaneous errands. These categories cover a broad range of possible mobility scenarios that most adults carry out during the course of a normal week. The possible choices for transport mode included auto, bicycle, walking, bus and train among others. To make a clear comparison between car vs. no car preference, auto was placed in its own category and all others in the no car category. The results of car preference by city region can be seen in figure 8. The comparison between the percent of people who prefer cars and walkability can be seen in figure 9.

In the preceding figures, it is clear that there is a correlation between how walkable an area is and the preferences of residents who live there. Unfortunately, the city of Kiel is too small of a sample area and population to say for sure that this relationship holds in most cases. Ideally, an analysis such as this would be conducted across a variety of metropolitan regions to truly understand the strength of this relationship. But, for urban planners in Kiel, this is yet another reminder of the importance of urban form itself for mobility and should encourage planners to build denser and locate necessary amenities strategically within the city. As the city of Kiel goes forward with its mobility system plans, results like these also point to where the most work will need to be done to reduce car dependence, namely the less walkable areas.

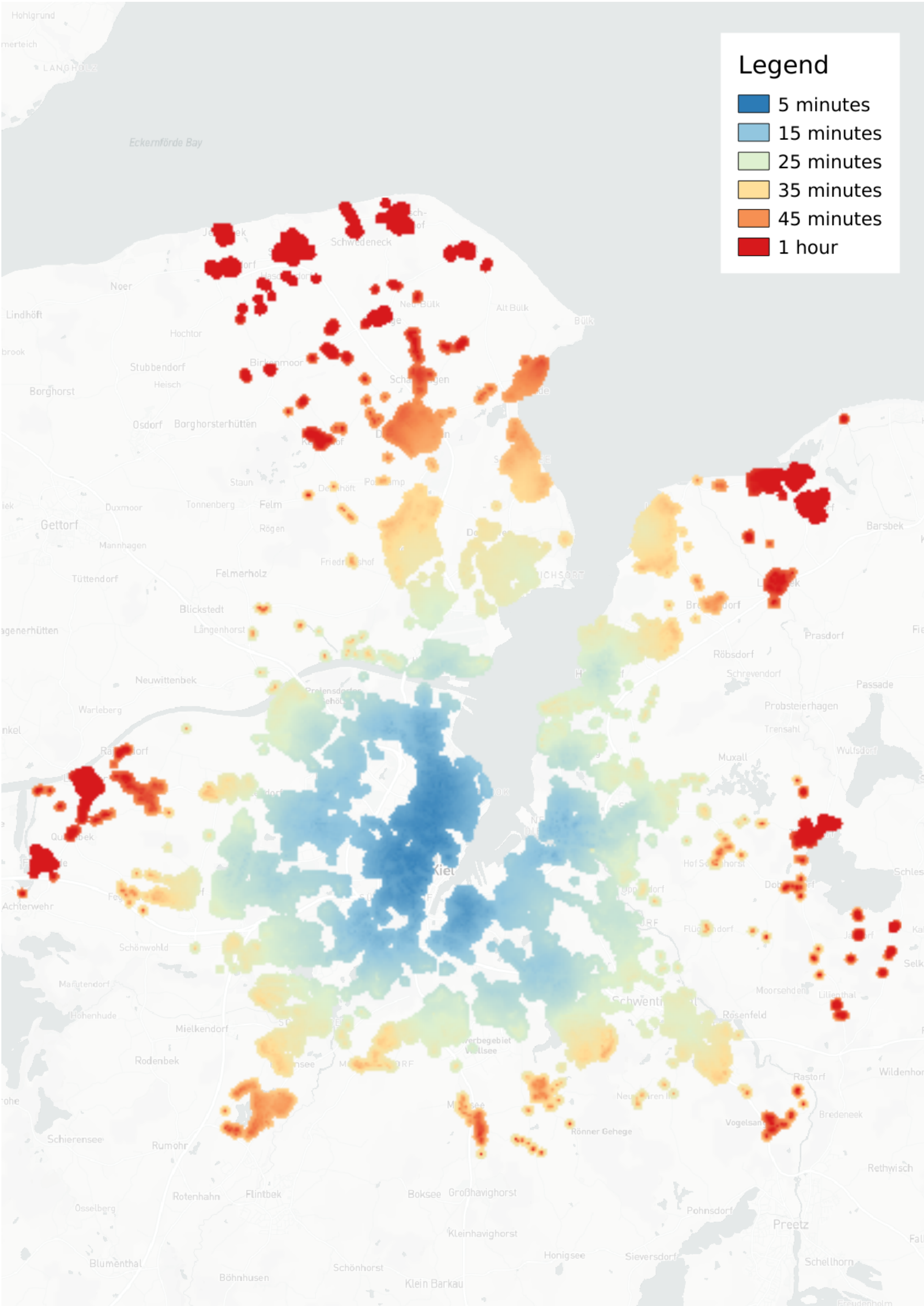

Figure 4: Map of Kiel showing its walkability surface

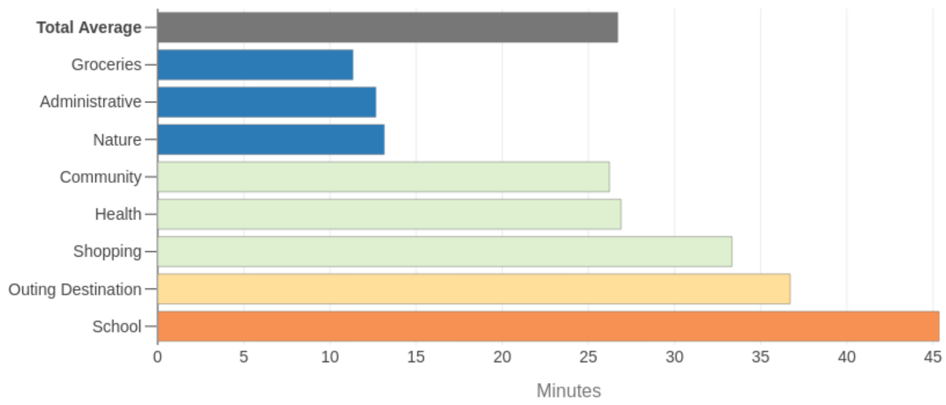

Figure 5: Walkability averages by category

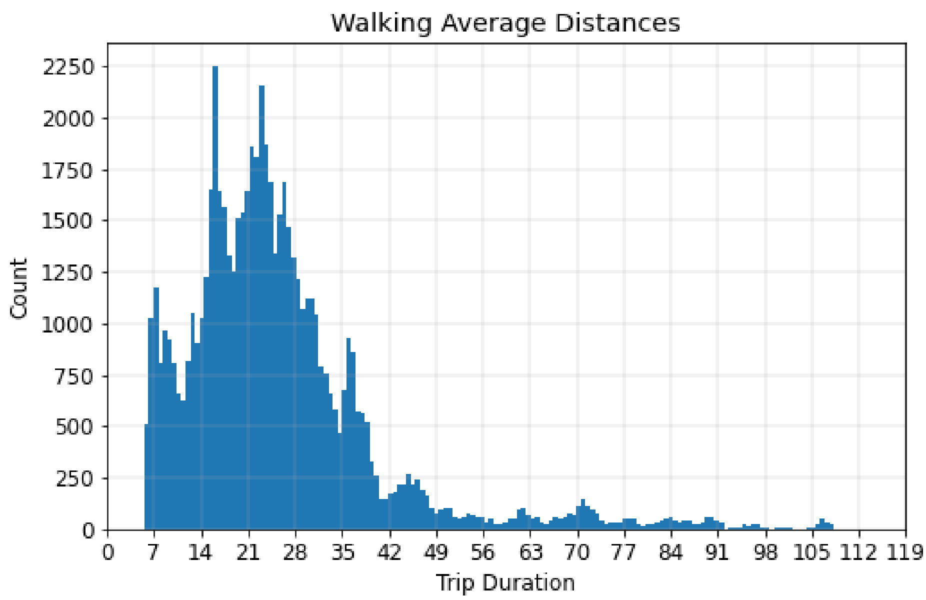

Figure 6: Histogram showing average walking times across all categories

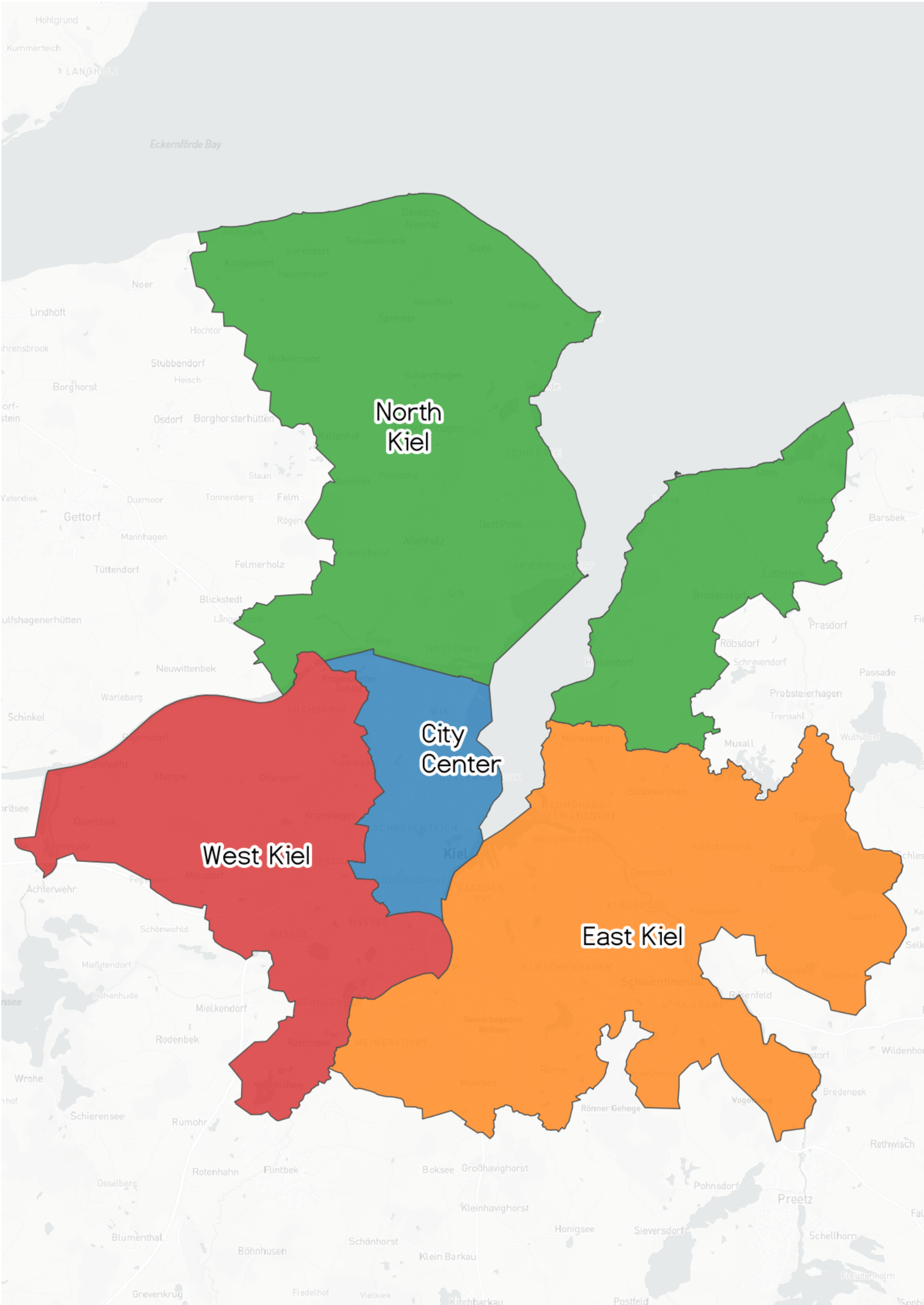

Figure 7: Survey regions used for the analysis, which were composed of postal code areas

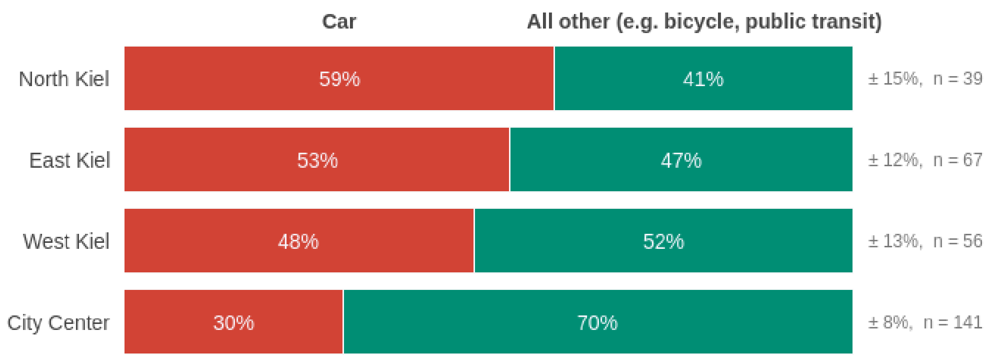

Figure 8: Car vs. no car preferences by city region

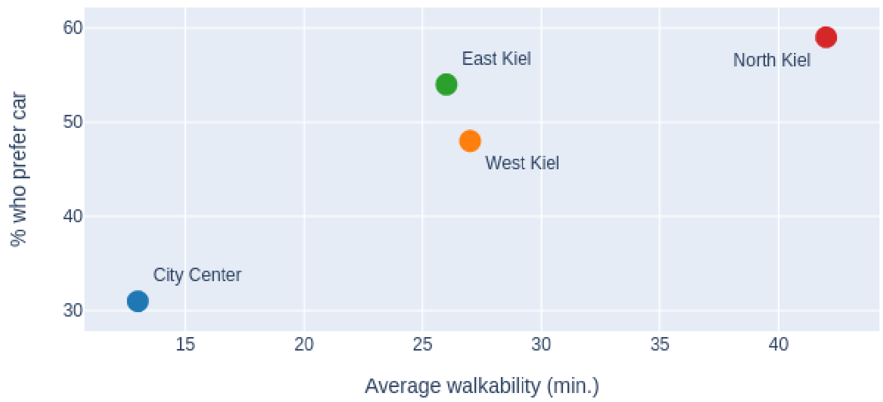

Figure 9: Car preference vs. walkability

Discussion

From the results previously shown, it is clear that Kiel's urban form affects amenity accessibility, which subsequently impacts the mobility choices of residents. Unfortunately, urban design patterns in Kiel still favor the car, even in areas highly suited for walking or cycling. In this section, the walkability data calculated is used to identify areas which are highly accessible by foot. These areas will serve as potential areas where we can implement some of the car reduction strategies mentioned earlier. Once these areas are determined, two proposals for the city of Kiel will be made and compared with similar measures in other cities in Europe and North America. By the end of this section, the reader should be able to clearly envision these measures and what they could mean for the city of Kiel.

Best suited areas

To find the best suited areas, the map for average walkability was used and a threshold of 15 minutes was set to narrow the results. Walking at a leisurely pace, one could expect to walk about one kilometer within this amount of time. In figure 10, all areas with an average walking distance of less than 15 minutes are shown. These areas are primarily everything within the inner city, including the districts of Exerzierplatz, Schreventeich, Altstadt and Düsternbrook among others. A smaller section of this area is also present across the harbor in Gaarden-Ost.

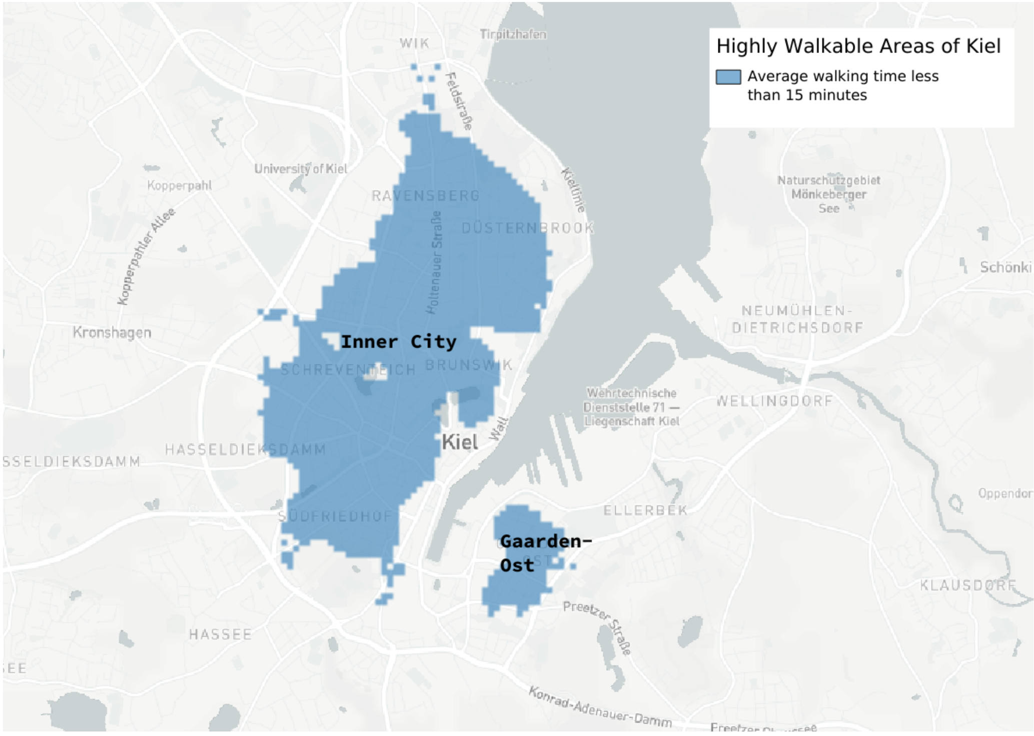

Figure 10: Areas best suited for car-reduction

This does not mean that these are the only areas in Kiel appropriate for car-reduction strategies. Other areas in Kiel with higher walkability averages are certainly just as deserving of policies aimed to promote alternative mobility options. This determination was made because it is believed that such policies in parts of the city, which are already highly accessible by foot and bicycle, are less likely to meet confrontation from the local population. This in turn means that they may have a higher success rate when being debated over by the public and local politicians.

Proposal one: streetscape redesign for Holtenau

The first proposal brings attention to spatial imbalances when it comes to transport planning in many big cities, including Kiel. The battle over space is crucial when it comes to transportation planning and can determine whether or not streets are more likely to be friendlier to alternative modes of transport or primarily to cars. As noted by Gössling (2016), these imbalances appear in cities such as Freiburg in Germany where although driving only accounts for 32% of trips, cars are allocated more than 55% of total space for transportation infrastructure. Although no studies have been conducted to measure these statistics in Kiel, we can only assume that with cars making up 38% of total trips in the city (Kiel n.d.b), this may be equal or even higher. As Gössling (2016) also states, this presents an equity issue in cities where specific types of commuters are systematically disadvantaged compared to their car driving counterparts.

So what can be done to rectify such problems? The solutions here lie primarily with space reallocation or phrased more elegantly, "streetscape redesign". A streetscape can be thought of as everything that collectively makes the environment of a street within a city. This includes the road itself but also the adjacent sidewalks, buildings and vegetation. Redesigning a streetscape is normally undertaken in order to address a particular concern whether it be road safety or making a particular street more inviting to pedestrians and cyclists. These redesigns involve many affected parties and are highly prone to becoming politically charged, which is why compromise is necessary to find the best possible solution for the most affected parties.

With this in mind, we will now go over a proposal for a streetscape redesign on Holtenau Street between Knooper Weg and Lehmberg in Kiel.

This section of Holtenau Street is located in the central part of Kiel and is lined with many businesses and restaurants and has a good walkability rating (< 15 minutes). The problem with this section of Holtenau Street is the priority given to cars versus other forms of transportation. Throughout this section of Holtenau Street we see parking on both sides of the street and two lanes of traffic in both directions. In many parts of this section of Holtenau Street, this amounts to the equivalent of six lanes of dedicated space for cars. Bike lanes are present on this street, but they are either neglected, very narrow or merge with normal traffic.

Before we go over the exact recommendations for what to do about this imbalance, it would help to examine a city which has already done exactly that for one of its streets. Foster Road in Portland, Oregon in the United States was once a four lane road with vehicle parking and no bike lanes. The area that was targeted for redesign lies between Powell Blvd. and 92nd Ave. and is a mixed use area with both residential and business establishments. According to the city, one of the primary factors motivating the streetscape redesign was safety concerns (PBOT 2014). Since 2009 at least five pedestrians have lost their lives along this stretch of road, and the city has categorized Foster Road as a “high crash corridor”. This section of Foster Road was also a part of the city that had been neglected in the past and is therefore targeted for strategic re-investment as part of the “Lents Town Center Urban Renewal Area” (ibid.). Therefore, another aspect of this project was improving street infrastructure to make it more inviting to businesses and residents.

To achieve these goals, the City of Portland completed the following projects:

- Added curb extensions and crossing improvements at targeted locations
- Reduced the number of travel lanes from four to three to improve safety (added center turning lane)
- Introduced bicycle lanes along Foster Road
- Widened sidewalks in certain areas with street trees and new curb ramps
- Added street trees, street lighting and transit improvements throughout the corridor

Measures that could also be implemented on Holtenau Street are the bicycle lane additions, sidewalk widening and dedicated car lanes. Although Holtenau Street technically does have bicycle lanes in the redesign area, they would be much safer and inviting if they were wider and clearly demarcated. Furthermore, the area removed from the existing inadequate bike lanes could be absorbed by the sidewalk and give even more room for pedestrians in certain areas. All of this could be accomplished by removing one or two car lanes from this section of Holtenau Street.

As with any project of this nature, it is likely to upset many citizens accustomed to the status quo or those that heavily prefer cars. The project outlined in Portland was certainly not immune to this (Duin 2016). In order to overcome this opposition, Siemiatycki et al. (2016) found in their research of a similar project in Vancouver, BC in Canada that,

> ...developing a design that is acceptable (if not entirely preferred) by as many groups as possible is critical when developing the political constituency of support required to proceed with a controversial initiative.

For the City of Portland this meant keeping cars prioritized during the planning and execution of this project. Although the street was transformed into single lane traffic both ways after the completion of the project, the addition of a center lane for left turns arguably makes driving on this street a better and safer experience. All the while, safety for all forms of transportation were kept in mind. This allowed the city to come up with a creative plan which did its best not to neglect any one group or give higher preference to another.

Although it could be argued, as previously done, that cars should be deprioritized in areas highly accessible to pedestrians like Holtenau Street, the fact is that cars represent the status quo and must be given consideration during these types of plans. Perhaps removing two entire lanes may be a bit too bold and would anger too many drivers, or perhaps this could be done in a way that reduces off-street parking allowing for a left turn lane similar to the one on Foster Road. All of these are the kind of questions that concerned stakeholders (e.g. residents, city officials, etc.) need to answer in public forums in order to come up with a plan that most agree with.

Proposal two: toll area for Kiel's inner city

While the first proposal aims at changing the urban form to make it more friendly to pedestrians and bicyclists, the second proposal uses a tool which combines technology and pricing mechanisms to reduce the amount of cars on the road. As previously discussed, a toll area is a tool which makes driving in and out of particular areas of a city more costly. This tool has been shown to reduce the amount of traffic and divert commuters to other forms of transport in both London and Stockholm (Eliasson 2014; Leape

2006). Implementing such a scheme in Kiel could also have similar benefits, and when paired with streetscape redesign efforts like the one just proposed, it would send a clear message to its citizens that the city is committed to de-prioritizing car use.

To help us determine exactly how such a toll area system would look like in Kiel, we will again use the map of average walkability as a starting point. As figure 10 shows, there are two primary areas where we see high accessibility by foot: the inner city and Gaarden-Ost. The area in Gaarden-Ost is relatively small when compared to the contiguous area of the inner city, so this will automatically exclude it from consideration for this proposal. Instead, we focus on the area of the inner city as the primary target for our toll . As figure 10 shows, this area is entirely contained within the freeway system that surrounds the inner city on the south and west. Using areas with an average walkability of less than 15 minutes, we can create a toll area which encompasses the inner city from the freeway to the harbor in the east, which excludes the district of Wik. This proposed toll area is shown in figure 11.

Now that we have a clear picture in our heads of the exact extent of this system, let us consider how it might be operated. In Stockholm, the city relies on a system of entry points which record vehicles entering and leaving the city, and each time a car either enters or leaves the inner city a charge is levied (Eliasson 2008). These entry points and the toll area itself can be seen in figure 12. The technology operating these entry points rely on radio transponders installed in the cars themselves or by using photography to identify a car's license plate (ibid). It is important to note that cars driving within the toll area do not need to pay a charge. This only happens when a car enters or leaves the toll area. For comparison, in London the city uses

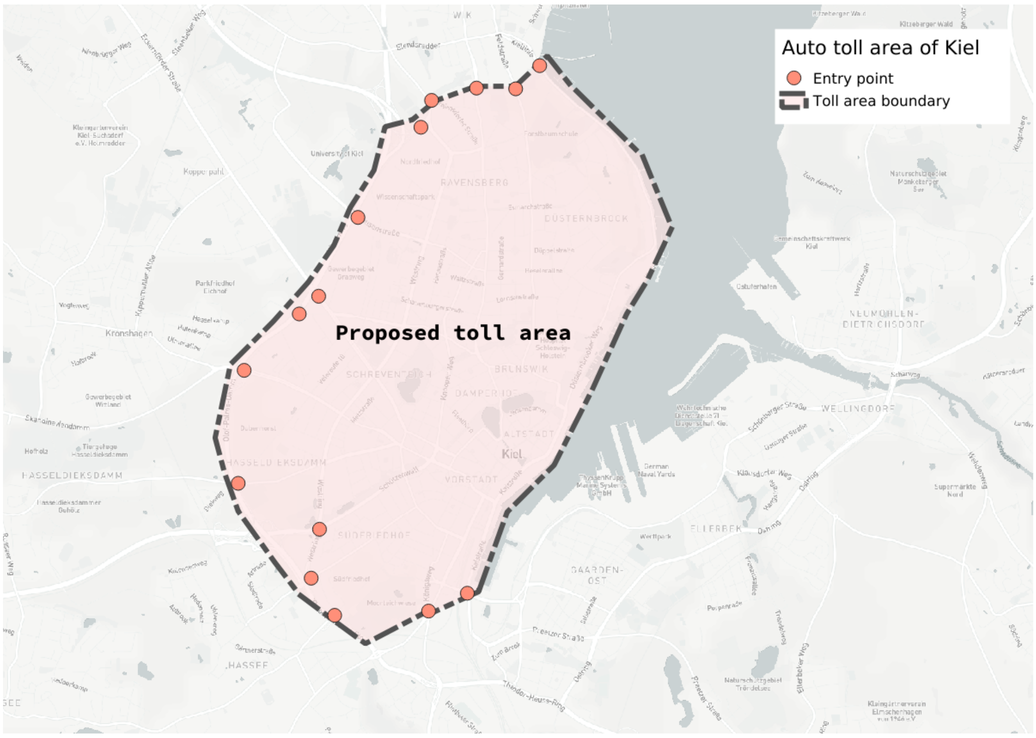

Figure 11: Proposed toll area for Kiel

a zonal scheme which also charges for driving within the toll area (Palma & Lindsey 2011).

The city of Kiel could operate this system almost exactly the same. Figure 11 shows where the city could place its entry points in order to record cars leaving and entering the city. One advantage Stockholm has over Kiel is its geography and the fact that there are many water boundaries which make delineating the toll area much easier. This also means that there are fewer entry points to the city center for an area of its size. Although Kiel does have its harbor which would serve as a water boundary to the east, for the most part the city would have to rely on the freeway which creates a man made boundary for the toll area and helps to concentrate traffic leaving and exiting the city to a relatively small number of streets.

It is important to remember that designing such a system must be done with care and significant amounts of research. Eliasson (2008) is able

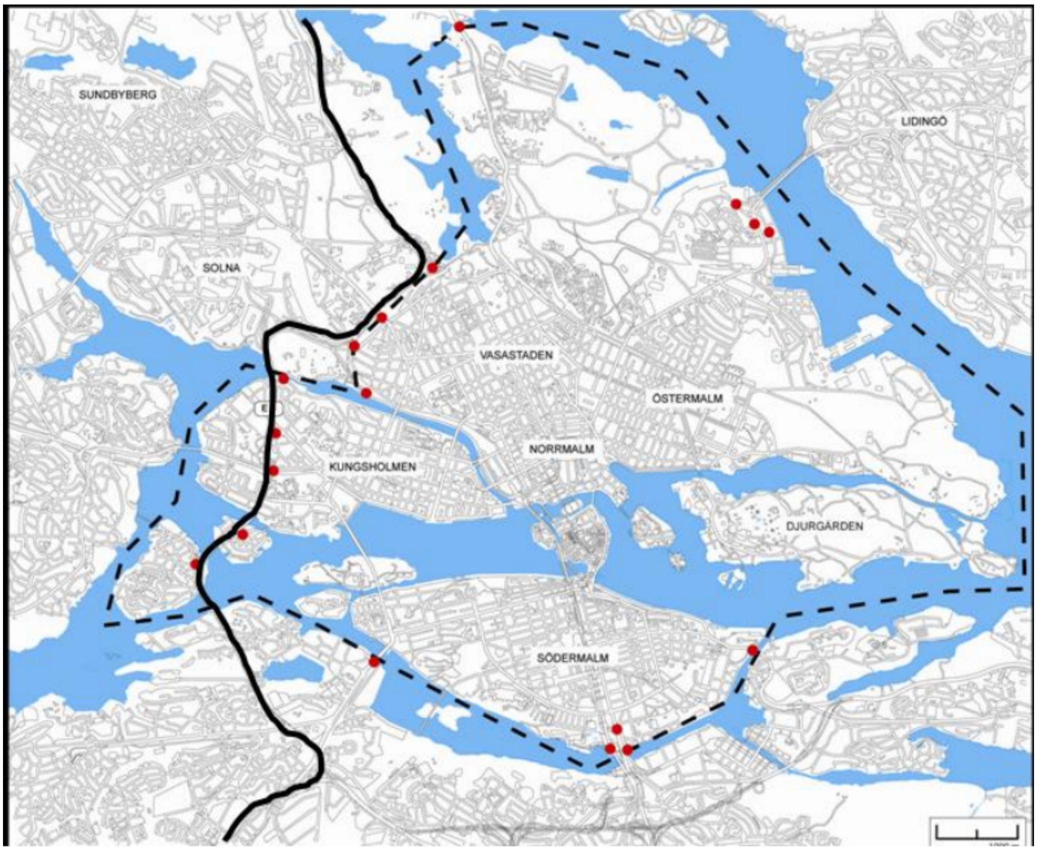

Figure 12: Map of Stockholm's toll area (Eliasson 2008)

to provide advice for those wishing to follow in Stockholm's footsteps:

> …one of the lessons from trying out different designs in the forecasting models was that it was easy to design a charging system that created more problems than it solved, by "moving around" congestion. Hence, spending a lot of effort on the design of the charging system is imperative for any city wanting to introduce congestion charges – it's not just drawing a few lines on a map and converting 20 SEK [toll area charge amount] to the local currency.

So, although we were able to justify this toll area by basing it entirely on walkability, many other variables need to be examined and accounted for to make this proposal more convincing. Perhaps most importantly is the impact this toll area would have on traffic. During Stockholm's trial run in 2006, one important factor contributing to a positive shift in public opinion was the visible effect it had on reducing traffic (Eliasson 2008). Therefore, it will be very important for the city of Kiel to carefully plan their toll area to hopefully receive the same positive side-effects as Stockholm.

Conclusion

Transportation planning in cities is a complex and arduous process which must weigh previously set path dependencies while also responding to external social, environmental and economic forces. Our current car dominant cities are evidence of this process and show the power that modern capitalist consumerism has to shape our urban form. With the world now in the throes of a so-called "climate crisis", many politicians and city planners are becoming more serious about reversing transportation planning schemes once centered around cars. Doing this will on the one hand require limiting mobility by reducing car usage in cities while on the other hand increasing the accessibility via other forms of transport like walking, biking and public transit. This balancing act between convenience and sacrifice is indicative of many issues we face in our modern era. There simply are no easy solutions to these problems as long as we live in a society powered by consumerist capitalism which time and again chooses the weak self-destructive path of convenience over the self-preserving sacrifice necessary to build perhaps less mobile yet highly accessible societies.

With that being said, I do believe that many cities now have the chance to re-imagine their future with fewer cars, even within the confines of the consumerist capitalist system. I believe that the car will still serve an important role, but I also believe it should be the goal of city planners to increase accessibility for all transport modes and not just the car. When this happens, giving up the car will be seen as less of a sacrifice and more of an advantage because it will enable people to live in pedestrian friendly environments. But, because we live in a system that views sacrifice as weakness, we will undoubtedly need measures like those discussed in this thesis to force drivers out of their cars too. This is the so-called “carrot and stick” or “push-pull” approach and is why I highlighted both types of measures earlier (toll areas being the “stick” or “push”, streetscape redesigns being the “carrot” or “pull”).

Ultimately, all decisions made regarding transportation systems within cities are political. As described earlier, the politics of the last 70 years or so were primarily dominated by auto manufacturers and the petroleum industry. While these developments led to the creation of arguably one of the most mobile societies the world has ever seen, we are now clearly running into the ecological limits of what our planet can support. Does this mean that the politics of transportation will react accordingly? What new centers of power will surface to replace the current hegemony? Is there a chance for a post-consumerist mobility to surface? Although we are seeing signs of a shifting hegemony and potentials for post-consumerist mobility, these questions are impossible to answer with certainty. For now, we will have to keep an eye on our cities and streets, remain active in local politics and hope for the best.

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Appendix

Walkability Maps

The following maps show walkability across all eight categories defined in the "Methodology" section.

Administrative

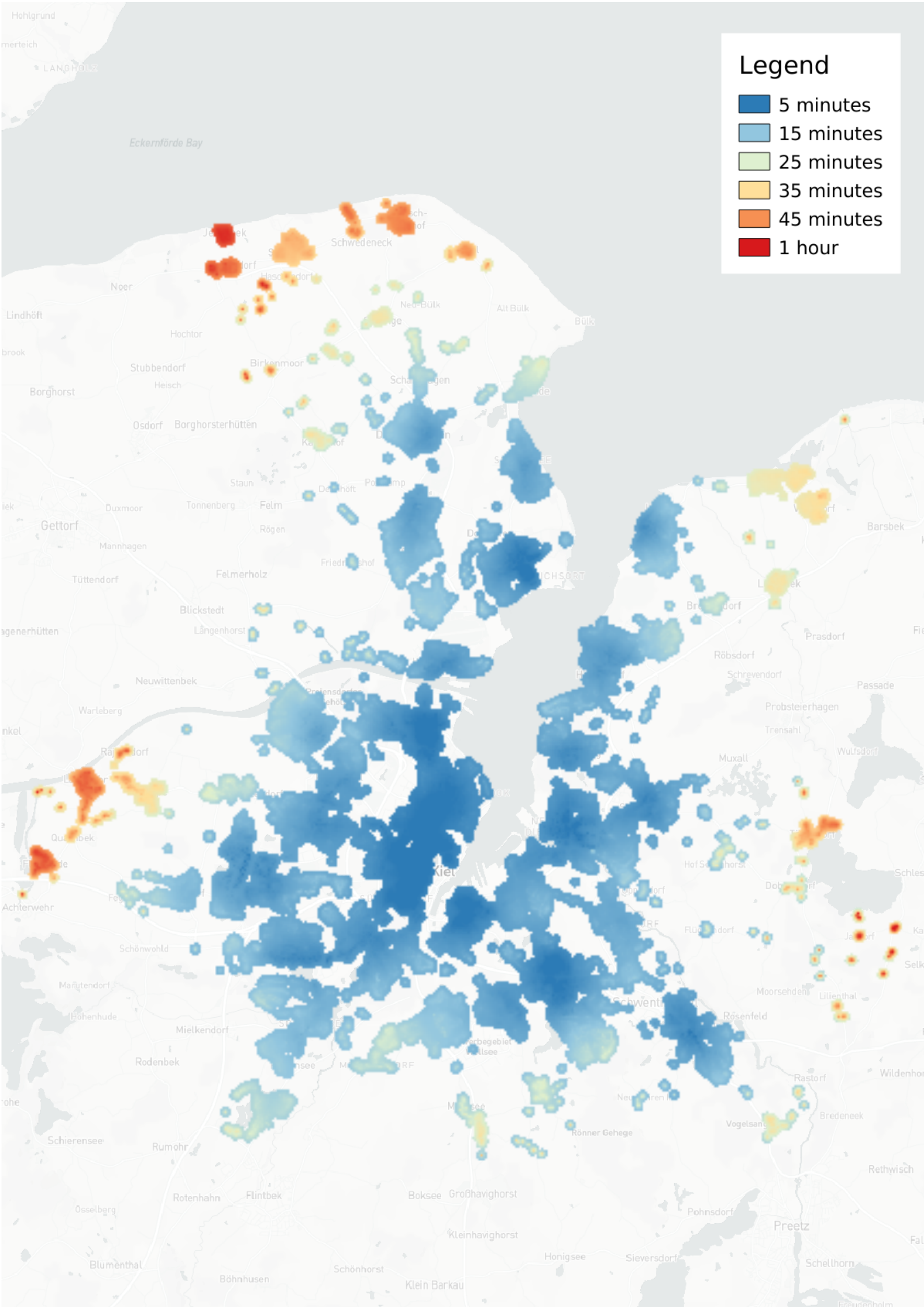

Figure 13: Administrative walkability surface

Community

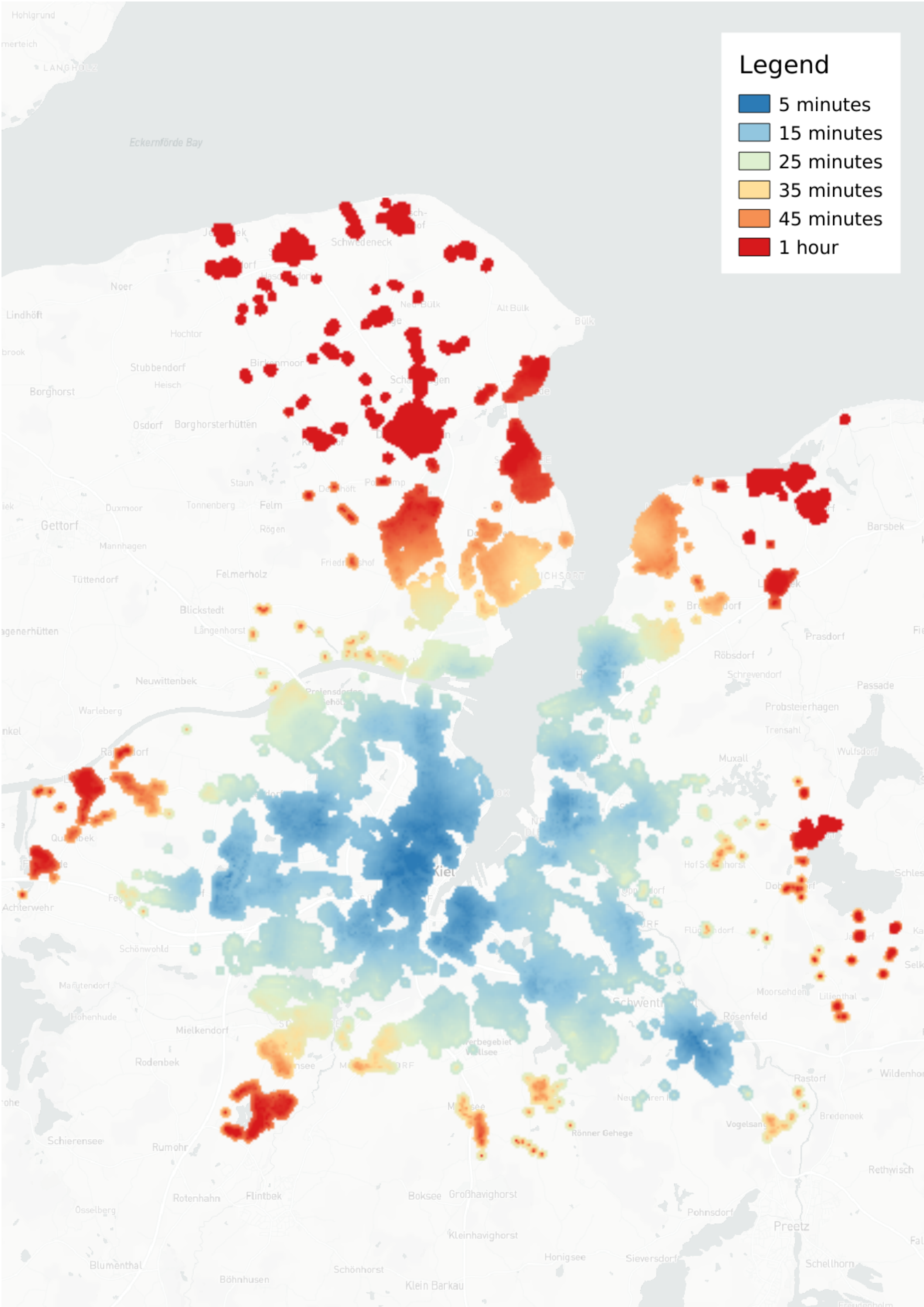

Figure 14: Community walkability surface

Groceries

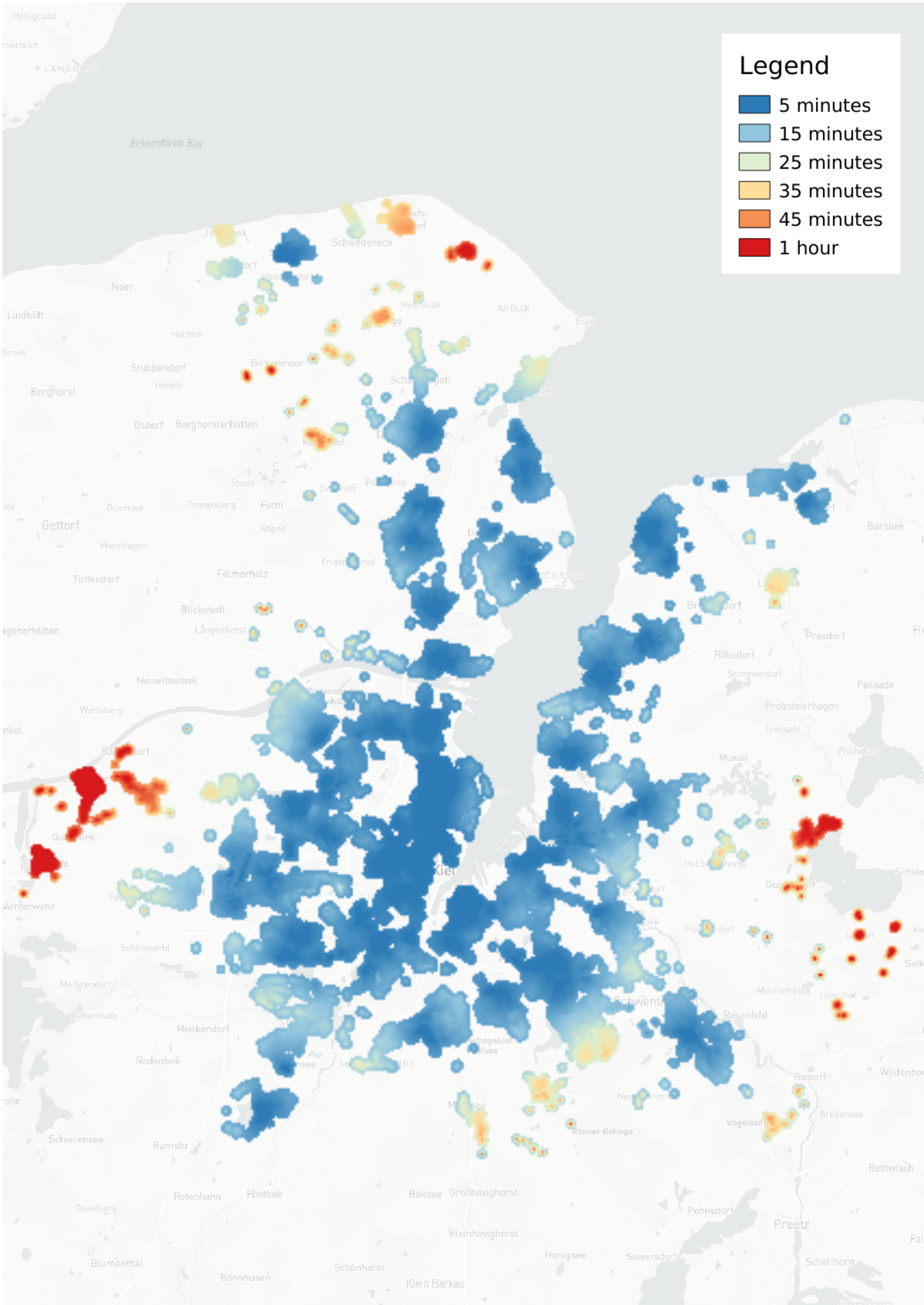

Figure 15: Groceries walkability surface

Health

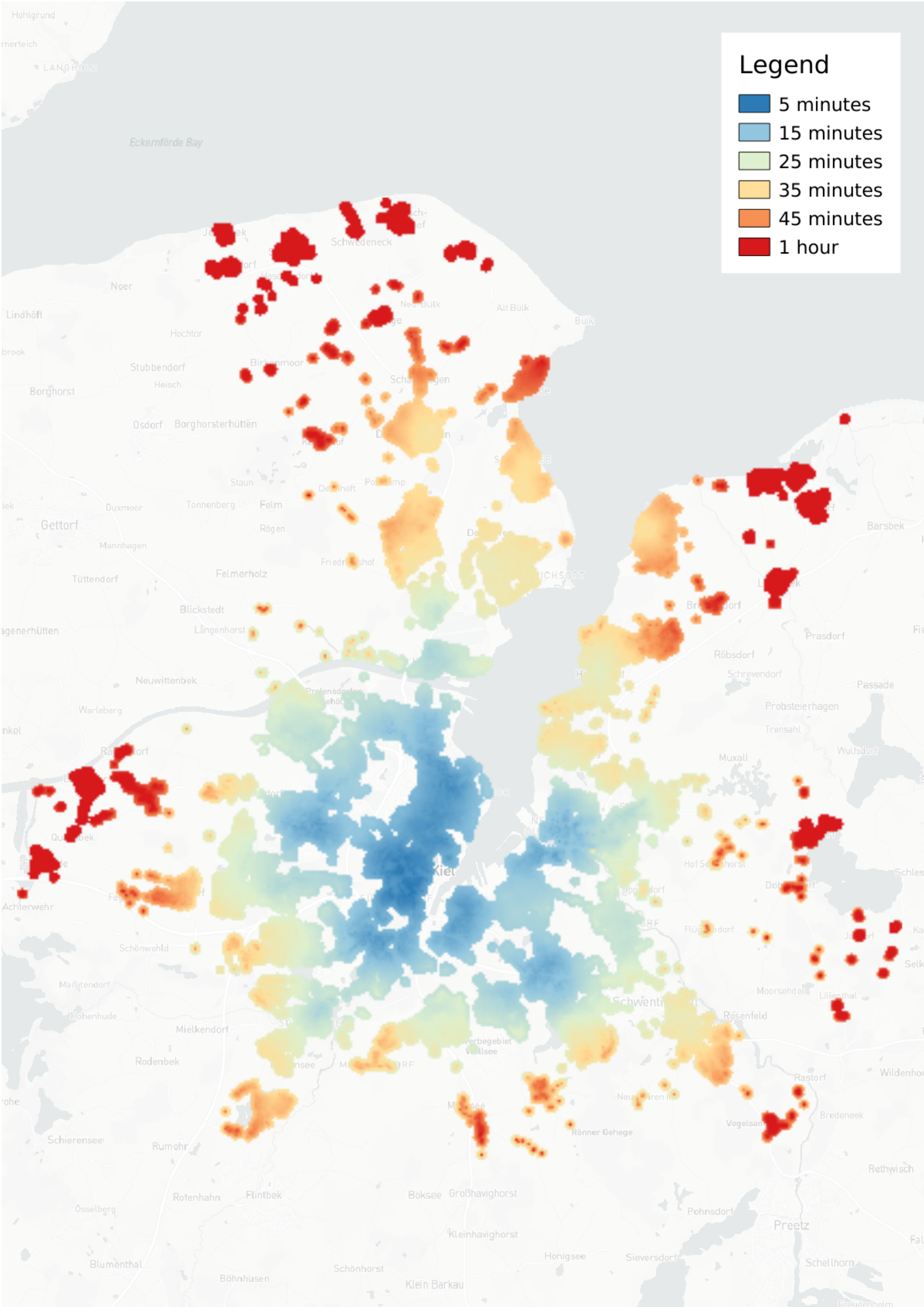

Figure 16: Health walkability surface

Nature

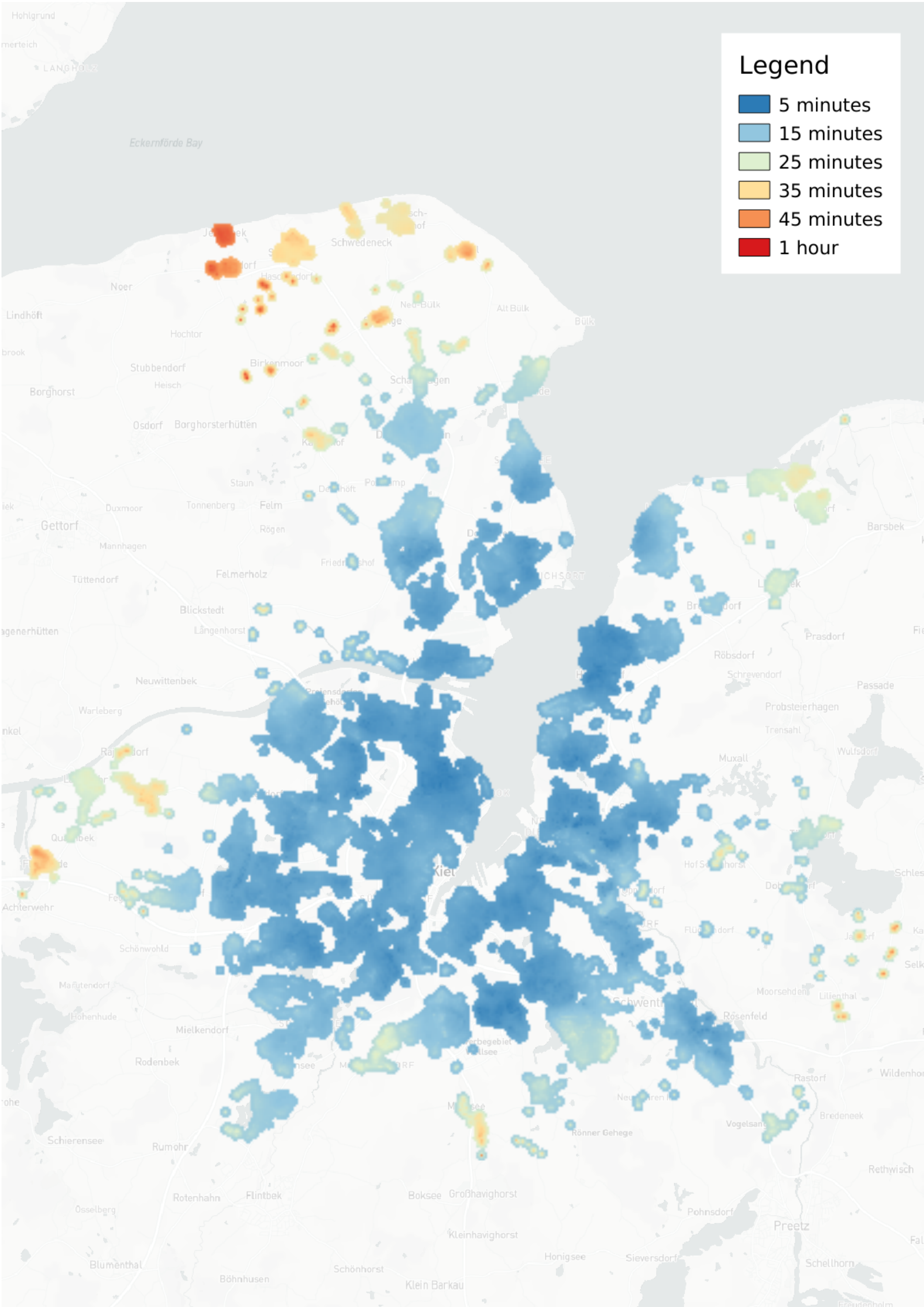

Figure 17: Nature walkability surface

Outing Destination

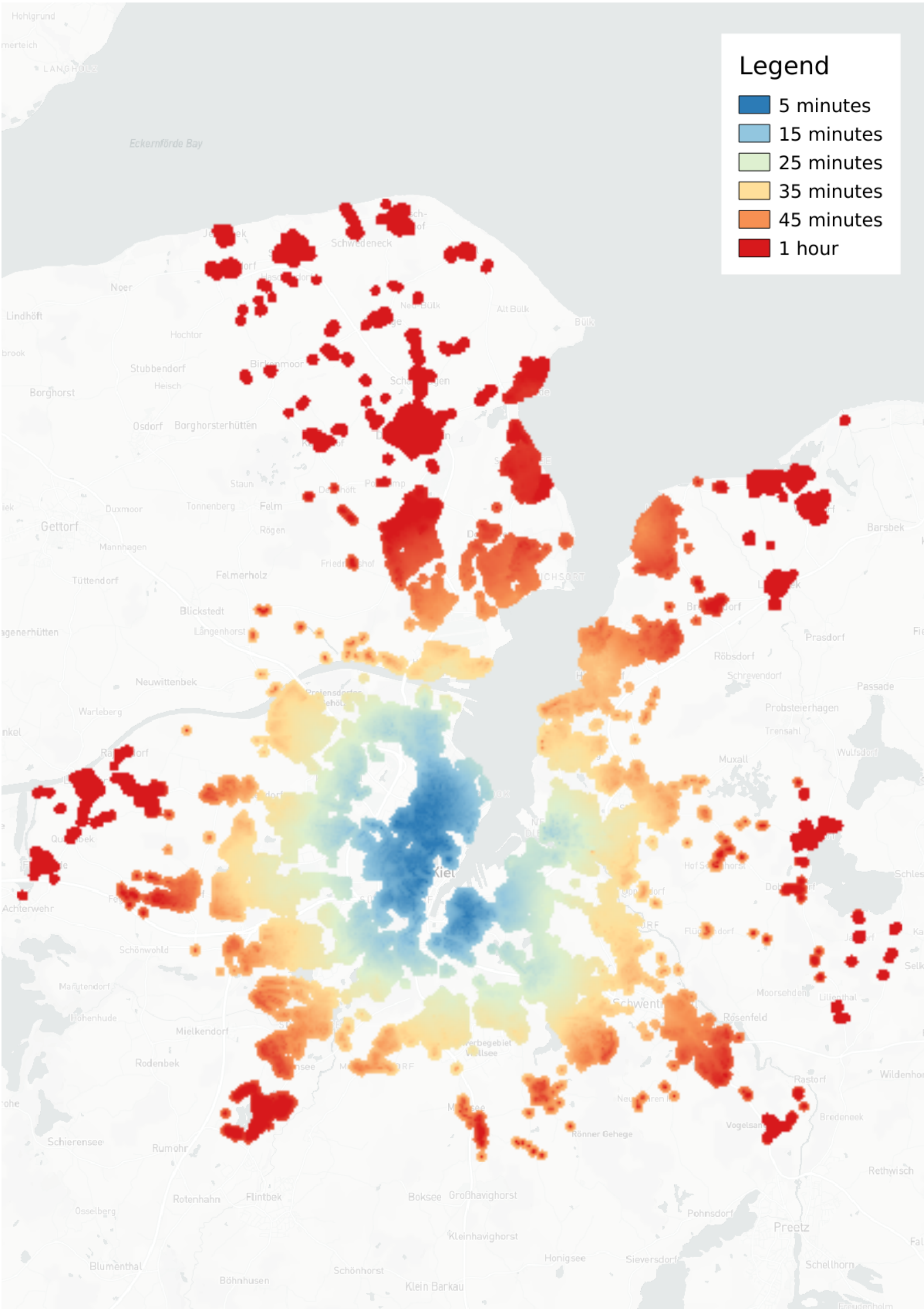

Figure 18: Outing Destination walkability surface

School

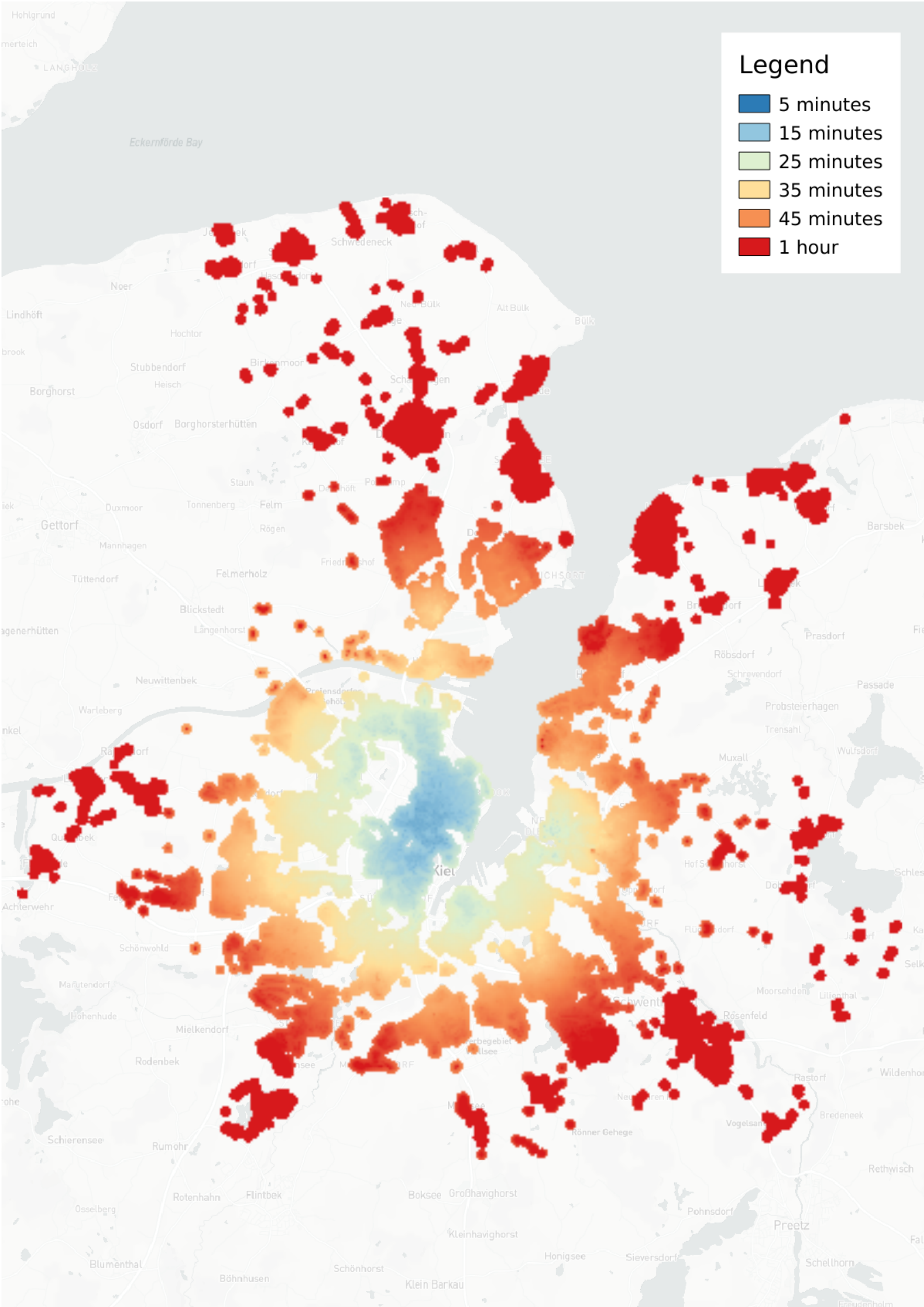

Figure 19: School walkability surface

Shopping

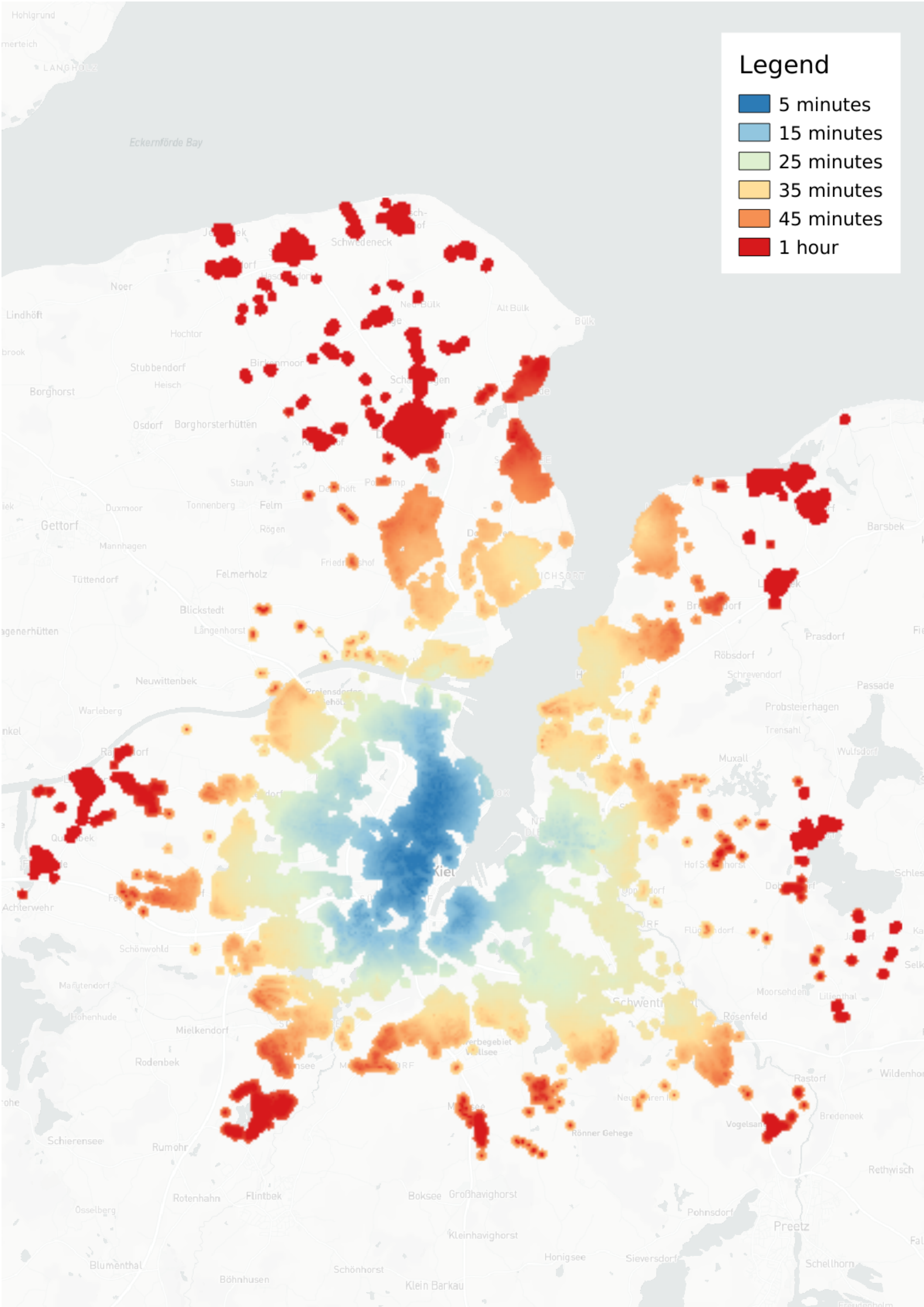

Figure 20: Shopping walkability surface

Declaration

Herewith, I declare that this thesis has been completed independently and unaided and that no other sources other than the ones given here have been used.

Furthermore, I declare that this work has never been submitted at any other time or anywhere else as a final thesis.

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