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Urban Sprawl: A development exacerbating climate change challenges in the 21st century

Understanding the impacts and drivers in order to promote sustainable settlement and mobility

Name
Larissa Zündorf

Aalborg University
Cities and Sustainability

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Author:
Larissa Zündorf

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Department of Planning
Rendsburggade, 14
9000 Aalborg
http://www.plan.aau.dk/

Supervisor:
Rasmus Nedergård Steffansen

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Abstract

This study investigates, if, and how urban sprawl exacerbates climate change challenges and how a more sustainable development in terms of land take and mobility can be achieved by looking at Ravensburg, the city of interest in Germany. More precisely, the underlying reasons and drivers of urban sprawl and its tremendous environmental consequences are analysed.
A secondary intervening aim is to assess the public transport system and mobility behaviour, respectively preferences. A relationship between urban structure and mobility was established. Whereas urban areas are often characterised by great public transport systems, rural areas are often disadvantaged.
Surveys and Interviews were used as a means to get more in-detail information. A total of 61 surveys and 6 interviews were conducted. The main findings related to relocation preferences are on the one hand in line with previous literature, including motives such as nature, family formation, memories and individual preferences and on the other hand, indicate problems related to availability and affordability.
Generally speaking, the public transport system is perceived as bad in terms of high ticket costs and poor frequencies and timing.
Based on the primary and secondary data including plans, concepts and literature, recommendations are made in order to align with the no net land take by 2050 initiative and to contribute towards the achievement of the sustainable development goals. This research shall highlight urban sprawls' adverse influence on climate change as well as demonstrate the urgent need for new planning strategies.

Acknowledgements

I would like to express my sincere gratitude to Rasmus Nedergård Steffansen who helped me through the process of writing my master thesis. Besides this, I would like to thank all the participants of the survey and the interviews as well as the urban planner of Ravensburg. Last but not least, I am thankful for the time, people spent peer reviewing my survey, interview questions and final thesis.

Executive Summary

The earth, the habitat of human life is threatened by climate change primarily caused by anthropogenic activity. Total greenhouse gas emissions have increased significantly leading to a warming in the atmosphere. The causes range from burning fossil fuels to deforestation. As a response, the United Nations [2017] introduced the *Sustainable Development Goals* and the European Commission [2016] initiated *no net land take by 2050*.

One development exacerbating climate change challenges is addressed in this research. More precisely, this research aims to understand the impacts of urban sprawl, as well as its drivers. This poses the following main research question: *"To what extent does urban sprawl exacerbate climate change challenges and how can a more sustainable development in terms of land take and mobility be achieved (by looking at the city of Ravensburg)?"* Additionally, two sub-questions were formulated helping to answer the main one. Whereas the first one relates to understanding the main drivers and motives on the macro, meso and micro level. The second one is based on the answer to the first one and aims at addressing the impacts of urban sprawl in terms of sustainable mobility and settlement.

In this context, urban sprawl is defined as a low-density development in the outskirts of the inner city, often characterised by single-family houses and higher car dependency. Accordingly, urban sprawl leads to higher land take as a result of more living space per capita and space needed for infrastructure. Subsequently, valuable soil is sealed and turned into artificial land. During the process of deforestation, carbon pools are removed and carbon is emitted. Furthermore, it prevents ecosystems from regulating the micro-climate. Another aspect worth mentioning is an on average higher car dependency and passenger-km and thus the emission of greenhouse gases, as well as additional surfaces sealed for the provision of proper streets and parking spots.

In order to address urban sprawls' adverse influence on climate change, a literature review focusing on individual relocation motives and motives for choosing their main mode of transport was conducted.

Macro and meso factors such as economic growth, purchasing power, urban planning policies, globalisation, urbanisation and increasing land prices in inner cities set the framework conditions for urban sprawl. Especially the following meso factors, namely the spread of the automobile, higher inner city prices, enabling policies and incentives can be seen as very influential.

According to previous studies, motives for choosing the main mode of transport depend on options, habits, comfortableness, costs and rapidity.

On the basis of these information, an analysis, including spatial analysis, surveys and interviews in the area of interest were conducted. A total of 1050 surveys were distributed in 16 districts of Ravensburg. With a returning rate of 5.8pct., 61 answers were analysed using descriptive statistics. The main aim of the surveys were to gather more information on peoples relocation choices, respectively why people live where they live as well as information about their mobility behaviour and preferences.

As a means to get more in-detail information on those themes, follow-up interviews were conducted. A total of 5 inhabitants were willing to participate.
The main motives for choosing a residential area include nature, family formation, memories and individual preferences. However, a large share of those surveyed and interviewed indicated problems related to availability and affordability during the relocation process, leading to compromises in the decision-making process and final destination.
In terms of mobility choices, the reasons for choosing the car as their main mode of transport include habits, comfortableness and rapidity, but more important the lack of alternative options such as public transport. Public transport seems to be too expensive while having a poor frequency, timing and routing. Additionally, cycle paths are perceived as unsafe.
Understanding urban sprawls' impacts and drivers, as well as motivations for relocation and mobility choices, recommendations could be made. The following suggestions may help tackling the problems of unsustainable settlement and transport options and thus accelerating the achievement of the SDGs and no net land take by 2050.
The majority of those surveyed uses the car as their main mode of transport caused by the poor public transport system. Whereas ticket prices should be lowered, frequencies should be increased. Another recommendation relates to the cycling infrastructure. Continuous and especially safer cycle paths are suggested. Last but not least, the housing problem can be addressed by offering affordable housing close to the city, especially for families.
In general, it is highly recommended to rise awareness towards the external costs of certain lifestyle patterns as well as offering and promoting alternatives.

Overall, this research shall demonstrate the urgent need for reviewing urban planning and national policies. By identifying the causes of urban sprawl, suggestions for improvement were made on the local scale. However, it can be assumed that these problems are also present on the national.

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1 Intro

Human settlement and relocation patterns change constantly. In today's urbanised society more than half of the world's population and an even larger percentage in developed countries live in urban settings. In the case of Germany, almost 78pct. live in urban areas with a projected increase of 7pct. until 2050 [United Nations, 2018]. Subsequently, the population in rural areas decreases.
Even though people tend to move towards rather densely populated areas, the overall space per capita continues to rise, leading to the transformation of undeveloped land into sealed areas. As a response, the European Union introduced the initiative "no net land take by 2050" [European Commission, 2016].
Especially the phenomena of urban sprawl, which has happened during the past 50 years is defined by its tremendous impacts on the environment. In general, changing lifestyles, patterns and developments have impacted the world contributing towards a changing climate. Accordingly, the United Nations adopted a blueprint, namely the 17 Sustainable Development Goals (**SDGs**) to achieve economic, social and environmental sustainability in all countries [United Nations, 2017]. A vital part of this research is to specifically address SDG 11 "Sustainable Cities and Communities", SDG 15 "Life on Land" and the no net land take initiative. More specifically it aims to identify the underlying reasons and forces of urban sprawl, respectively housing preferences and relocation motives in decision-making processes as well as motivations for choosing the main mode of transport. Understanding those drivers and motives shall serve as a basis to establish sustainable solutions tackling urban sprawls' adverse influence on climate change.
In this context, urban sprawl refers to low-density settlement patterns in rural areas [Batty et al., 2003; Galster et al., 2001]. Residential relocation is not a new phenomenon and thus many scholars have developed theories and models to predict and explain possible drivers in the decision-making process in the past. Broadly speaking, the main drivers include economic growth, family formation, the desire for nature, but also the emergence of the car and hence better mobility as well as high prices in inner cities [Christiansen and Loftsgarden, 2011; Aner, 2016; Stockdale, 2014; Obikwelu et al., 2017; Jetzkowitz et al., 2007; Reckien and Luedeke, 2014]. Larger distances and increased mobility lead to another problem namely energy consumption and emissions caused by an increased car usage and land take for infrastructure.

Using the German city Ravensburg as the area of interest, surveys and interviews were conducted as a means to get a deeper understanding of the phenomena of urban sprawl and mobility choices. Based on this, recommendations to decrease external costs are made and assessed.

Problem analysis 2

As shortly touched upon in the introduction, the built environment and settlement patterns have changed over the years. These human developments are of great importance, as some worsen the environment. In the following, the impacts of urban sprawl, which has been dominantly happening since the 1970s are elaborated on in detail. This chapter starts with defining urban sprawl, followed by an introduction to its causes from the macro and meso perspective, as well as its impacts on the environment. Finally, its relation to the *Sustainable Development Goals* and the *no net land take by 2050* initiative is highlighted. Accordingly, decreasing urban sprawl and land take as well as mobility can contribute towards reaching the goals.

2.1 Urban Sprawl

The beginning of the industrial revolution is also said to be the beginning of urban sprawl [Couch et al., 2007]. However, with an increase during the past 50 years, it has gained considerable attention.
After periods of urbanisation and rural decline, rural in-migration was recorded in the 1970s. According to Christiansen and Loftsgarden [2011] there is no general definition of urban sprawl, however, some keywords are commonly used. Urban sprawl is characterised by unplanned and scattered settlements in low-density (rural) areas with no /barely any mixed functions. Jaeger et al. [2010] emphasise the same problem of no coherent definition being existent and criticises the mixture of causes, consequences and the actual phenomena when defining the term. In their literature review, various definitions are introduced. Terms that are widely used when describing urban sprawl include low-density settlements, located in the outskirts/fringe of urban agglomeration as well as segregation of activities.
As shown in Figure 2.1 urban development, respectively sprawl can take up very different patterns. In its origin, the white squares illustrate vacant parcels and the blue ones undeveloped land. The dots and lines illustrate units, respectively the size of the area [Galster et al., 2001].
The first one *Compact Development* implies a high-density area, the leapfrogging and scattered development indicates a low degree of concentration and density. Buildings are randomly located outside of the core city. The third development pattern *Linear Strip Development* is a development along a transit line and thus a lower compactness. Moreover, poly-centres may emerge (See polynucleated Development) without having a core centre.

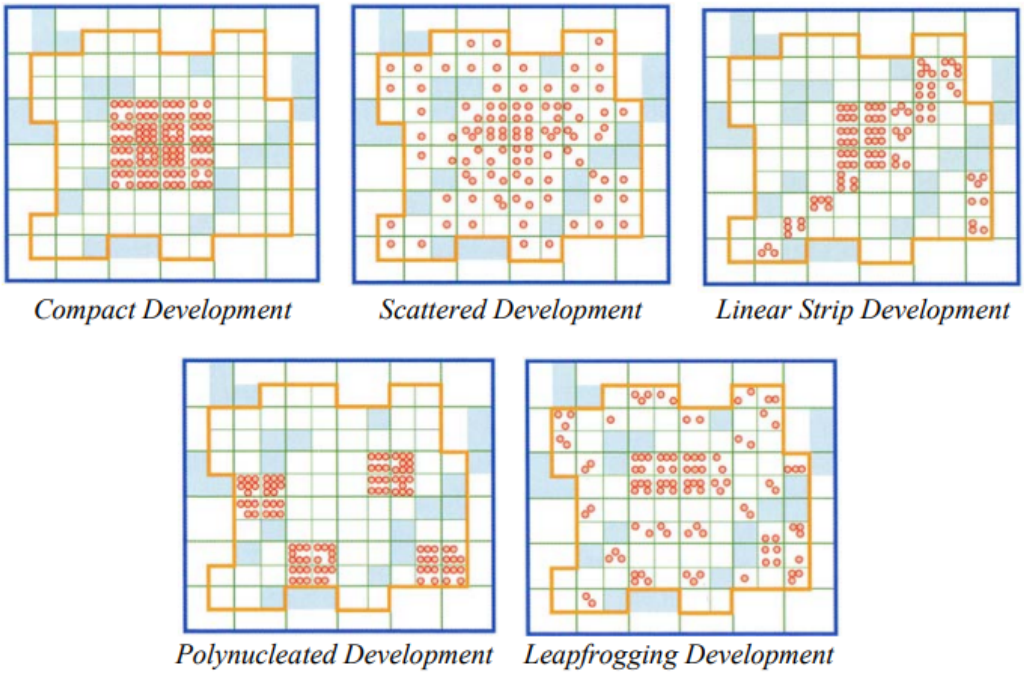

Figure 2.1. Five patterns of development, (Adapted by Batty et al. [2003] based on Galster et al. [2001] findings

In this research, urban sprawl refers to rather unstructured and low-density development of urban settlements outside of the densely populated and built up area. In order to keep the definition separately from the causes and consequences, these are elaborated on in more detail in the following sections. Looking at the area of interest Ravensburg, the development pattern can be compared to the Scattered development (See Figure 2.2) which is characterised by low-density, but highly dispersed areas separated from the inner city [Batty et al., 2003; Galster et al., 2001].

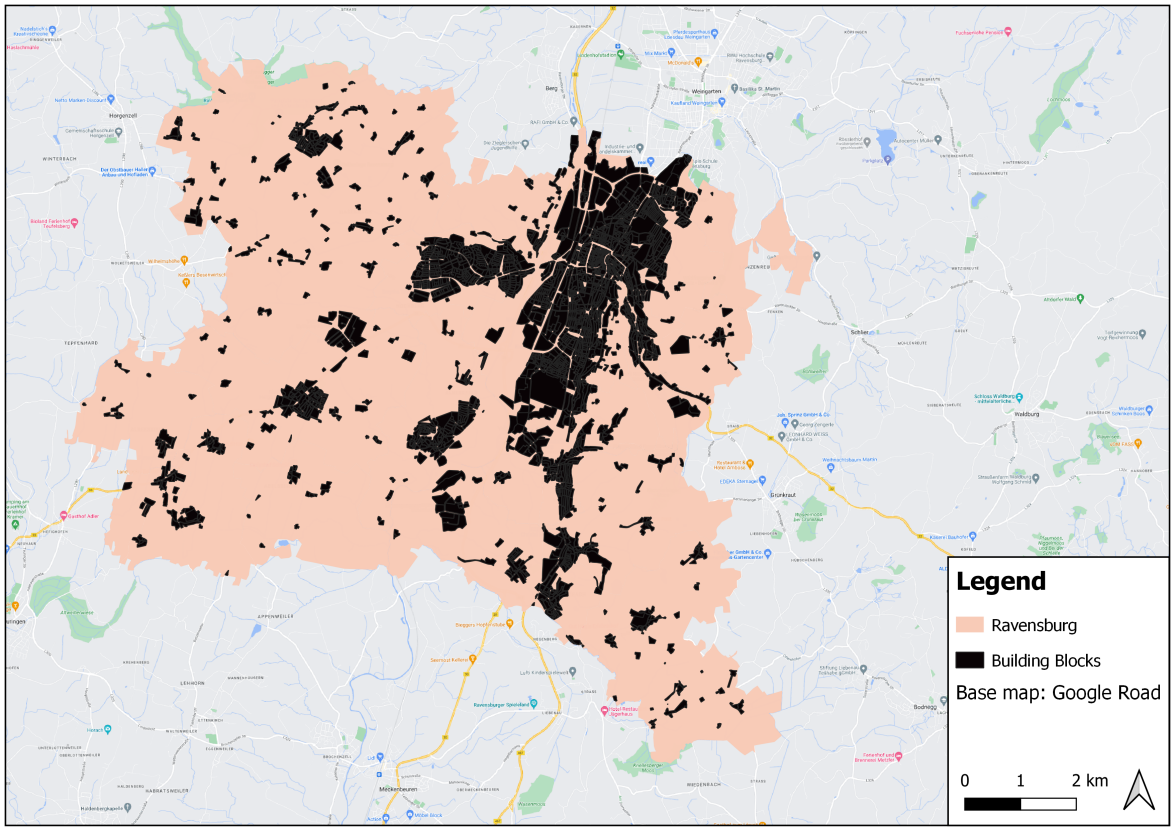

Figure 2.2. Settlement Development Pattern of Ravensburg

2.2 Urban sprawl from a Macro and Meso Perspective - Causes

Many scholars have already analysed the driving forces of different developments, including urban sprawl within different contexts [Aner, 2016; Stockdale, 2014; Obikwelu et al., 2017; Jetzkowitz et al., 2007; Christiansen and Loftsgarden, 2011; Reckien and Luedeke, 2014]. In this section, the most important findings are summarised and classified by macro and meso factors. The highly mentioned macro factors refer to globalisation and the increased competitiveness of regions as well as population growth and in-migration into cities. Subsequently, the demand for housing goes up and with it the housing and land prices.
In the context of the European Union, structural funds were distributed in order to increase the accessibility between cities. As a response to better connectivity, a better road network and higher land prices within cities, industries started to locate outside of cities close to highways.
However, not only larger industries and firms experience increased land prices, but also citizens. With the enormous spread of the automobile and public infrastructure, the burdens of moving to more rural areas decreased. Hence, the relocation towards these areas became more feasible in terms of accessibility and affordability [Christiansen and Loftsgarden, 2011].
The aspect of decreasing land prices can already be classified as a driver on the meso level. Agricultural land is generally speaking cheaper than land reserved for residential or industrial use. According to Christiansen and Loftsgarden [2011] the extent of farming activity has been decreased, leaving more space for development.
However, Christiansen and Loftsgarden [2011] highlight the problem of individual costs, such as commuting costs and times caused by reduced accessibility, which are not taken into account when developing large shopping malls or industrial parks outside of the core. Additionally, urban planning policy seems to be of great importance as it is responsible to steer development into certain directions by allowing developments

in the outskirts. Especially smaller cities close to large cities see the potential of attracting new inhabitants by allowing single-family houses on the outskirts [Christiansen and Loftsgarden, 2011].

Other aspects worth to be mentioned in the context of Germany are laws and regulations stated in the Federal Building Code. §13b allows a simplified procedure for urban development in already existing suburban areas. More precisely, the expansion of human settlements in suburban areas. On the one hand, it can be beneficial to develop already existing areas, but on the other hand, it is not in line with current goals and may lead to further sub-urbanisation. However, since 2017, a new area is defined, namely the *urban area* which allows a higher density in urban areas [FBC, 2021].
Other German incentives enhancing commuting are the so-called commuter allowance and other allowances for travel costs. As criticised by NABU [2019], instead of paying 30cent per km for commuting, the money should rather be used for public transport related costs and its improvement.

The following diagram was developed based on the findings above (See Figure 2.3). It illustrates the enabling factors, such as economic growth, urban planning legislation, digitisation of urban sprawl on the macro level and its influence on the meso level, including low transportation costs, purchasing power and thus the spread of the automobile, as well as urbanisation and the resulting higher land prices within cities. Especially in the recent decade, the rise of digitisation has enabled place independent work and home office.

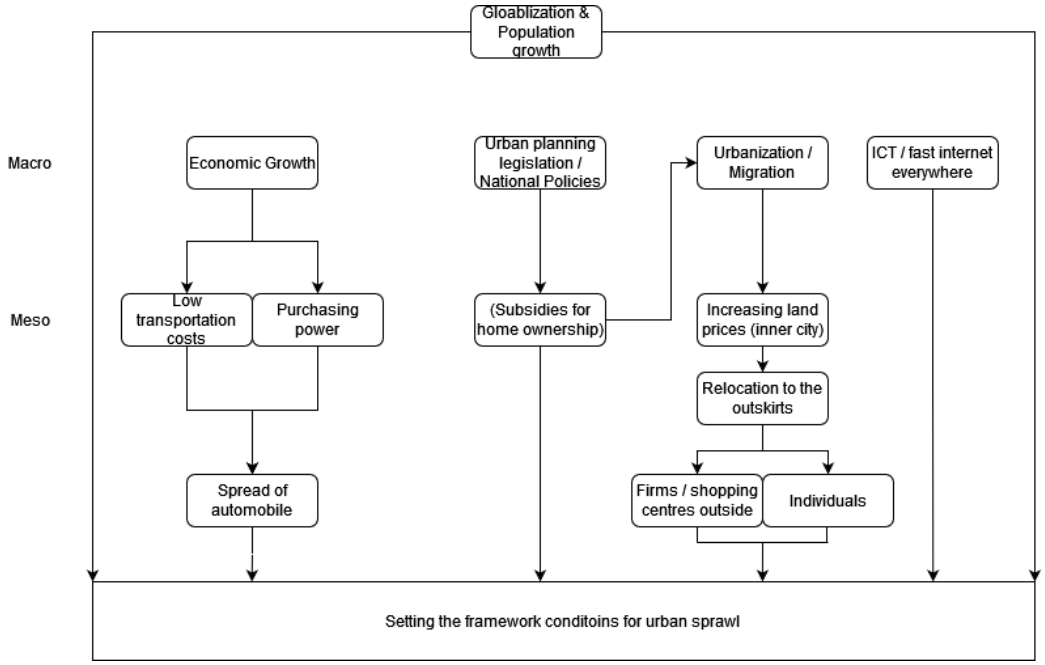

Figure 2.3. Influences on the Macro- and Mesolevel

2.3 Impacts of urban sprawl

Land take

Urban sprawl is the residential relocation from the inner city to the outskirts of cities. Subsequently, it leads to the sealing of surfaces for housing and required infrastructure. Not only visible land-use changes, but also water supply, water sanitation systems, electricity and gas supply consume environmental resources leading to the degradation of soil.
Land take generally refers to the amount of land taken by urban and other artificial development. More precisely, it is the loss of natural and untouched land caused by human activity and urban fabrics [European Commission, 2016; EEA, 2019]. Assessing land take may be problematic, as discontinuous urban fabric, sport and leisure facilities are included as a whole. Additionally, using satellite images with a low spatial resolution may not cover all objects and sealed surfaces [EEA, 2019].
Moreover, transportation infrastructure not only considers sealed areas but also unsealed areas such as areas used for noise control as well as petrol stations, rail infrastructure and airports [Bart, 2010].

Figure 2.4 shows the development of settlement development (red), transportation infrastructure (light blue), working population (dark blue) and population (green) in Germany from 1960 on. Even though the population only records an increase of about 20pct, the settlement development recorded an increase of 140 pct. The same accounts for the transportation infrastructure with an increase of about 40 pct. Even though population growth has stagnated, the area used for settlements are still growing and thus not corresponding to population growth [NABU, 2019].

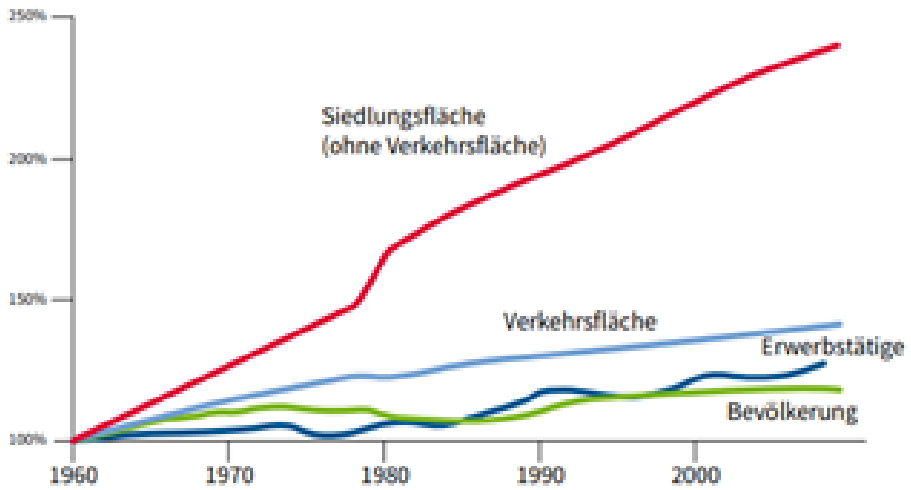

Figure 2.4. Landtake development in Germany from 1960 - 2010

As elaborated on in the previous Section, urban sprawl is driven by many factors. On the one hand by economic growth, high land prices and the spread of the automobile and on the other hand by changed lifestyle patterns and preferences. In the case of Germany, the living space per person has increased from about 20m² to 46m² and the average household size decreased from 3 to 2 between 1950 and 2015. Additionally, the average size of a single-family house increased from 131m² to 151m² during the past 25 years. Moreover, the circulation areas are larger in comparison to enclosed construction [NABU, 2019]. On the European level, at least the size of Berlin is being sealed every year [European Commission, 2016].

Transforming valuable soil into artificial land is tremendous leading to environmental degradation. The soil is enclosed from air and water, thus becoming infertile and preventing plants from growing and regulating the micro-climate. The sealing of surfaces leads to the degradation of land and the reduction of space for habitats and ecosystems, which are inevitable for a life on land. It is the habitat for plants, animals and humans and should be protected to a maximum [NABU, 2019]. Those changes are considered to be irreversible [Barbosa et al., 2017]. Even if the land is transformed back into natural land, chemicals are still existent leading to soil pollution. Accordingly, it takes years to regenerate the loss of biodiversity.
Furthermore, surface runoff and water infiltration are hindered which in the case of extreme weather events can lead to floods [EEA, 2019]. Land take comes with severe costs, not only for the biodiversity and ecosystems, but it also contributes towards the climate change by carbon emissions through the removal of vegetation [Barbosa et al., 2017]. Eespecially forests are great carbon pools. The removal leads on the one hand to the emission of carbon and on the other hand, to the overall loss of storage capacities capturing carbon while releasing oxygen [European Commission, 2016; Feng and Gauthier, 2021].
For instance, only one tree can take up the amount of carbon, that a car produces while driving 126.000km [EEA, 2012; Statista, 2021]. Thus, changing the land cover from natural to artificial land has severe consequences for the environment and the society. It reduces the quality of life, contributes to climate change and air pollution and not only has impacts on the local level but globally [EEA, 2019; Feng and Gauthier, 2021; NABU, 2019].

Low Density Areas and Car dependency

Urban sprawl is characterised by low-density settlement patterns outside of the inner city. Consequently, more energy is used for transport, heating and cooling [Feng and Gauthier, 2021].
Generally speaking, single-family houses are less energy-efficient, recording a higher energy consumption than attached multi-storey houses [Pitt, 2013; Feng and Gauthier, 2021]. Norman et al. [2006] even state a difference between 60pct of CO_2 emissions when comparing high density to low-density areas.
This is in line with Glaeser and Kahn [2010] who analysed the relationship between the use of fuel and the distance to the city centre as well as the population density. He found a positive relationship for the former, and a negative for the latter one. Moreover, Bart [2010] indicates a significant relationship between car ownership and the density of urban settlements. Besides that, a strong relationship between sealed surfaces and CO_2 emissions was established [Bart, 2010].
Accordingly, the primary anthropogenic drivers of climate change are fossil fuel combustion and land-use changes.

As previously mentioned, economic growth and purchasing power lead to the spread of the automobile in the past. Nowadays in wealthy countries such as Germany, the majority of those wanting a car already own a car. Therefore, the large increase in CO_2 emissions cannot solely be explained by that [Bart, 2010]. Additionally, the higher transport-related emissions are not in line with population growth. Sub-urbanisation seems to play a crucial role as people live further away from cities, but still using the city. The poor public transport in sparsely populated areas leads to an increased number of road-passenger kilometres. This number increased by 26pct between 1990 and 2000 [Bart, 2010]. The more spread an area is, the more transportation is required [Feng and Gauthier, 2021].

Figure 2.5 shows the CO_2 emission per passenger kilometre for different modes of transport.

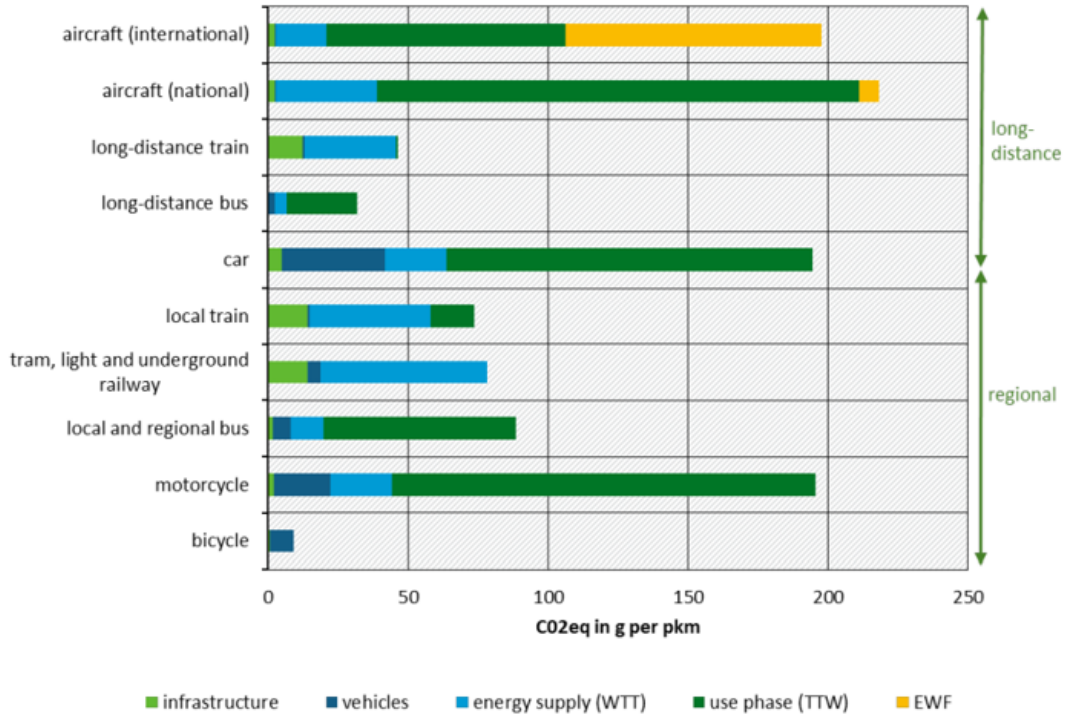

Figure 2.5. Emission of Carbon Dioxide per passenger kilometre in Germany, [Allekotte et al., 2020]

Another important point worth to be mentioned is the increased car dependency in suburban areas and the corresponding land take used for parking. Currently, there are almost 49 million passenger cars in Germany [BMVI, 2022]. When calculating the minimum size of a parking spot, which is in Germany at least 11.5km^2, this number already adds up to 563.500.000m^2 (563,50 km2). Notwithstanding, this calculation only includes one parking spot and does not consider any commercial parking. Another problem worth to be mentioned is the actual usage of a car, as the majority of the time, it occupies space without being used. Decreasing car dependency while increasing public and non-motorised transport can decrease the area sealed for parking. Correspondingly, motorised private transport demands on average 10 times the space than public and non-motorised transport [NABU, 2019]. Another positive side effect is fewer passenger car-related accidents.

To be concluded, urban sprawl comes with negative externalities, which is especially problematic in an era facing climate change challenges. This is primarily caused by higher land take required for single-family detached houses, parking facilities, infrastructure as well as higher energy consumption. It can be stated, that urban sprawl exacerbates emissions contributing towards climate change.
In the remaining part of this Chapter, the measures and goals, namely the no net land take by 2050 initiative and the SDGs are elaborated on in relation to urban sprawl and its impacts.

2.4 Measures / Goals

No net land take by 2050 - initiative

As a response towards the increasing land take, the European Commissions Roadmap to Resource Efficient Europe (COM(2011)571) initiated the *no net land take by 2050*. More precisely, it shall be avoided to further seal agricultural land, forests and natural habitats [European Commission, 2016]. Further provision of housing shall happen through the densification of already existing urban settlements or on brownfields. Another option is through compensation measures. The latter one is already stated in the Federal Building Code of Germany. If untouched land is developed, it must be compensated in terms of green recycling, respectively transforming another area to a high-biodiversity area [FBC, 2021]. In 2019, 52ha per day was transformed in Germany. In line with the *no net land take by 2050*, Germany set its first goal to decrease it to 20ha per day until 2030, and towards 0 until 2050. The initiative is also closely related and in line with some of the SDGs, which are elaborated on in more detail in the following.

Sustainable Development goals

Limiting urban sprawl and car dependency, respectively car usage can contribute towards the achievement of some of the SDGs. The SDGs were adopted in 2015 by the United Nations in order to ensure social, economic and environmental sustainability. The goals, including its subgoals that are predominantly addressed in this study are listed below. The source of the following section is based on the agenda for sustainable development of the United Nations [2017].

SDG 11: Sustainable Cities and Communities aims to make cities *"inclusive, safe resilient and sustainable"*. A vital part of this research is to assess and improve sustainable modes of transport in the outskirts of cities. By doing so, it contributes towards achieving **target 11.2:**

- *By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons*

This is measured by the *"Proportion of the population that has convenient access to public transport, by sex, age and persons with disabilities"*. In the context of this research, convenient access is defined as living within 500m of a bus stop as well as an acceptable frequency and routing of public transport. By analysing this in combination with the demographic and socio-economic characteristics of the inhabitants, a better public transport system and its usage, but also non-motorised modes of transport shall be promoted.

Another aspect is to understand the drivers behind urban sprawl and how settlement patterns are influenced by urbanisation and urban planning legislation and policy in general. By knowing the underlying reasons, planning and policy can be adjusted to the needs and desires of citizens, avoiding further sprawl and unsustainable development. Thus it is in line with **target 11.3**

- By 2030, enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.

This is measured by the *Ratio of land consumption rate to population growth rate*. This SDG aligns with the *no net land take initiative*. Both highlight the disproportional land consumption and population growth and aiming to avoid further sealing of surfaces.

By promoting sustainable modes of transport, limiting urban sprawl and its higher energy consumption as well as avoiding further land take air pollution can be reduced. Correspondingly, **target 11.6** is directly addressed:

- *By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.*

This also aligns with **SDG 13: Climate Action** which aims to *Take urgent action to combat climate change and its impacts*. By the measures mentioned above, the *total green house gas emission per year*, which is the indicator for **target 13.2** can be decreased.

- *Integrate climate change measures into national policies, strategies and planning.*

This can especially be achieved with a successful transformation from motorised individual transportation towards non-motorised and public transportation. The car emissions, which are generally higher in sub-urban areas can be decreased. Additionally, by avoiding further sprawl, the on average higher energy consumption in single family detached houses, which are a typical housing type in rural areas can be limited. Another problem of these housing types is the land take per capita. By reducing urban sprawl and simultaneously the need for developing untouched land into artificial land, it also contributes towards **SDG 15: Life on Land**, which focuses on *Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss*. Especially **target 15.3 and 15.5** are addressed:

- **15.3:** *By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation neutral world*
- **15.5** *Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species*

Protecting natural resources, decreasing green house gas emissions and pollution, it also helps to further achievements of **SDG 6: Clean Water and Sanitation**

- *By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.*

It not only contributes towards achieving more environmental sustainability, but also towards **SDG 3: Good Health and Well-Being**. For instance, by improving the transportation system, subsequently reducing car usage and related accidents aligns with **target 3.6:**

- *By 2020, halve the number of global deaths and injuries from road traffic accidents.*

which is measured by *Death rate due to road traffic injuries*.
Moreover, by reducing air pollution caused by traffic and high energy consumption, it also contributes towards **target 3.9:**

- *By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination*, measured by *Mortality rate attributed to household and ambient air pollution*

Looking at the main impacts of urban sprawl in relation to the SDGs, urban sprawl decelerates its achievement. However, limiting urban sprawl and the corresponding higher car dependency, land take and energy

consumption may help to accelerate the achievement of the SDGs. As previously mentioned, the SDGs not only address environmental sustainability in terms of tackling climate change challenges, but also promote equality as well as good health and well-being, which is among other things addressed by equal access to public transport, less air pollution and fewer car accidents [United Nations, 2017].

Research Question, Design and Structure 3

3.1 Research Question

The previous section highlighted the causes and impacts of urban sprawl by relating it to land use and energy consumption. Additionally, the Sustainable Development goals and the no net land take by 2050 initiative, whose achievement is partly hindered by urban sprawl were introduced. This shall not only raise awareness towards the climate change challenges the world is facing, but also towards the importance of reducing urban sprawl where possible. For the areas, that are already characterised by urban sprawl, the focus is on reducing its impacts in terms of energy consumption and emissions.
This poses the following research question:

To what extent does urban sprawl exacerbate climate change challenges and how can a more sustainable development in terms of land take and mobility be achieved (by looking at the city of Ravensburg)?

In order to answer the main research question, the following sub-questions were formulated. The first one

How can the drivers and motives leading to urban sprawl be understood on the macro, meso and micro level?

serves as a means to get deeper knowledge about the main reasons for relocation as well as its possible influences on mobility choices.

A secondary aim is to tackle the impacts of urban sprawl and to find alternatives, as well as to improve, respectively increase the number of sustainable transport users. This poses the following sub-question:

How can the impacts of urban sprawl be addressed in terms of sustainable mobility and urban settlement?

3.2 Research Design

The following Figure 3 visualises the way, the research was conducted and how the research question was answered by using sub-questions. Prior formulating the sub questions, an in detail assessment of urban sprawls' adverse influence on climate change, including its impacts as well as its macro and meso level drivers was conducted.
Two sub-questions were used. The data sources for the first sub-question include already existing studies on residential- and mobility choices as well as surveys and interviews conducted in the area of interest. Literature, mobility data, geographic information system, surveys and interviews are used as data sources for the second one.
Based on the sub-questions an analysis and discussion took place in order to answer the main research question and to come up with recommendations helping to achieve the SDGs and the no net land take by 2050 initiative

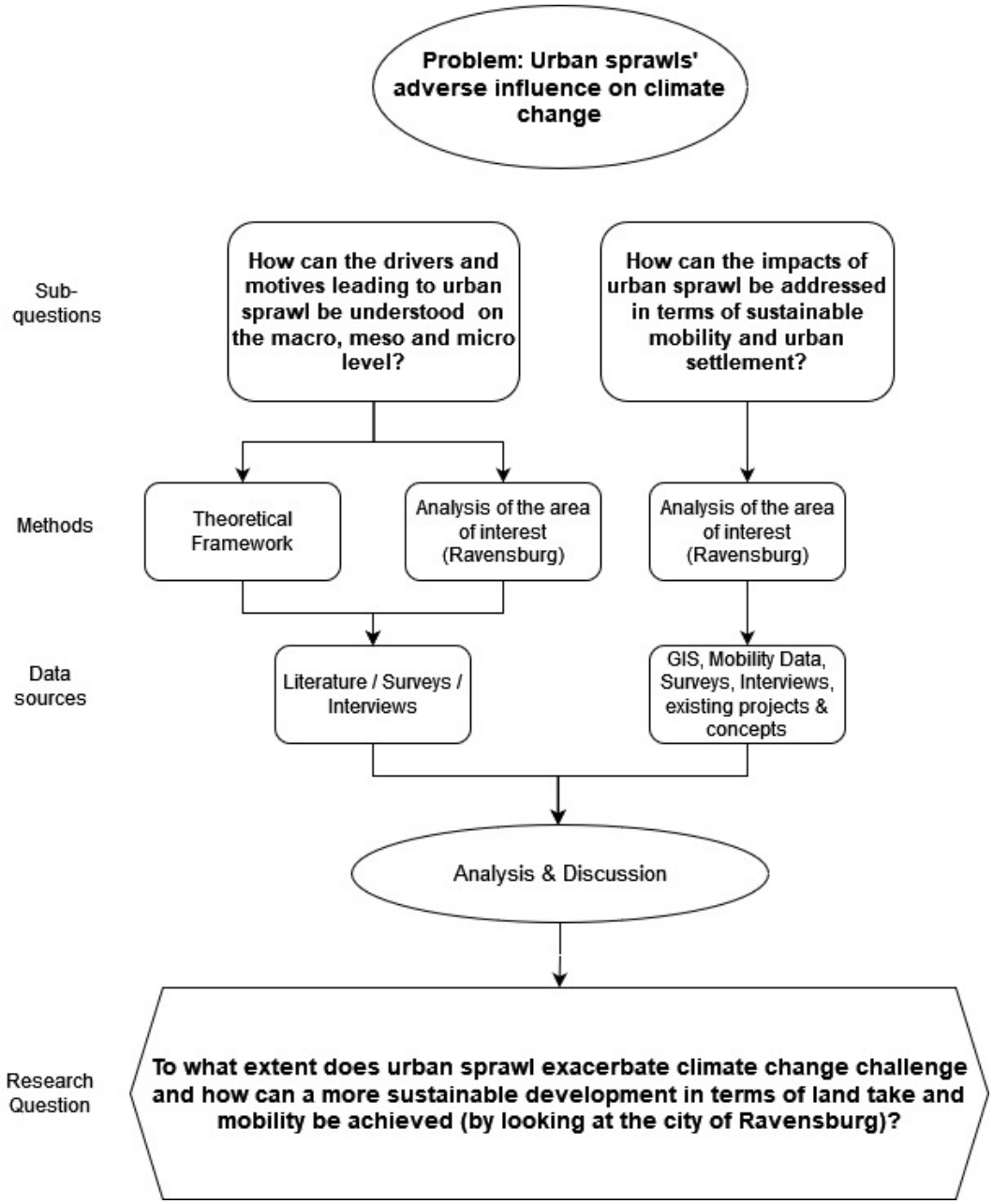

Figure 3.1. Research Design

3.3 Research Structure

The structure of this research is as followed. After introducing the general topic, Chapter 2, the *Problem Analysis* defines urban sprawl, its environmental impacts as well as its relation to the no net land take by 2050 initiative and the SDGs. In the following part, Chapter 4 (*Methodology*), the methods, namely literature review, analysis of the area of interest and surveys and interviews, in order to answer the research question are introduced.
Chapter 5 focuses on already existing literature on residential- and mobility choices. Taking into account the area of interest, the next Chapter is about the German city Ravensburg. More precisely on its location, car usage, public transport system and goals. Additionally, the main part of this study, namely the main findings of the surveys and interviews are summarised.
This leads to Chapter 7 (*Analysis & Discussion)* which is based on the results of Chapter 2, 5 and 6. The outcome of the analysis and discussion are recommendations promoting sustainable mobility and settlement, which are also assessed.
Finally, the conclusion, including the answer to the main research question, strengths and weaknesses as well as recommendations for further research are stated. The bibliography and appendices can be found at the end of this research.

Methodology 4

In the following, the methodology used for this research is introduced. A large part is the literature review, followed by the analysis of the city of Ravensburg, including already existing data as well as surveys and interviews.

4.1 Literature Review

Reviewing already existing literature and studies on urban sprawl and housing preferences served as a means to gather information about the phenomena, respectively the underlying structures and drivers. In order to get a reliable outcome, a large amount of literature was compared and assessed. Moreover, older and more recent studies, as well as studies conducted in different countries were used. The peer-reviewed articles were obtained by using google scholar and the universities library [Aalborg University, 2022; Google, 2021]. Furthermore, reference lists were used to find additional scientific articles related to the topic.
By using different sources, a variety of perspectives and influences shall be captured. These shall complement each other and build the framework for further analysis.

4.2 Analysis of the area of interest

The area of interest was chosen based on its recent development as well as its focus and interest on sustainable development in terms of achieving climate neutrality and no net land take by 2050. The point of departure was to review different documents and studies conducted in Ravensburg. The main documents used are the *Integrierter Verkehrsentwicklungsplan (English: Traffic Development Plan)* conducted by Bernard Gruppe [2021b] and the *Ergebnisbericht der Klimakommission Ravensburg (English: result report of the climate commission Ravensburg)* [Stadt Ravensburg, 2019].
Additional information, such as data on car ownership was provided by the municipality of Ravensburg. Data on public transportation in Ravensburg was retrieved from the Nahverkehrsgesellschaft - Baden-Württemberg [2022], transported and processed in the geographic information system QGIS. More precisely, the location of each bus stop within Ravensburg was imported. The time, frequency and routes along the bus stops were obtained by using the electronic schedule information of Bodensee-Oberschwaben Verkehrsbund GmbH [2022].
Based on the distribution of bus stops, its proximity, distribution of car usage classified by districts, distance to the city centre and census data, the sub-areas within Ravensburg were chosen. Seven areas are within a close vicinity to the city centre and expected to have great public transport options. 9 areas are further than 2.5km away from the main train station in Ravensburg. The different characteristics of the areas shall help identifying trends and locations for improvement.

GIS

QGIS is an open-source geographical information system, which was used for the spatial analysis of the area of interest [QGIS Development Team, 2022]. Maps were created to illustrate the location of the analysed areas and suggestions for further planning.

4.2.1 Primary Data collection

Surveys

The scope of this study is to understand the drivers of urban sprawl, including residential choices as well as to identify possible solutions to address the comparable high energy consumption, emission and land take. Therefore, questionnaires were conducted. Accordingly, this method is great to capture patterns, perceptions and behaviour of a population [McLafferty et al., 2010].
Before distributing the survey, a pilot study took place. This shall ensure that the questions are easily understandable and formulated appropriately.
A total of 1000 surveys in form of a flyer were distributed on the 17th, 18th and 21st of March, 2022. As a response to the low answer rate, especially for the inner city dwellers, 50 more flyers were distributed within the city centre on the 7th of April, 2022. The flyer contained information about the purpose and the aim of the study, data protection notice, contact details as well as the link and QR-code to access the survey. This however presupposes access to a phone and the internet as well as certain know-how. In order to reduce this problem, the potential participant could contact the researcher through mail, e-mail or phone to ask for a hard copy.
The survey was designed in a way, that was proposed by McLafferty et al. [2010]: easy, simple, and short questions with preferable pre-designed answer possibilities. The questions of the survey, including the type of answer possibilities, relation to the research question and literature can be found in Appendix B.1.

Structure of the Survey

The first part of the survey consists of three questions related to the place of residence, work place and main location for leisure activities. This helps to identify the corresponding residential districts as well as the main routes, which are of great importance for further analysis of the main mode of transport, accessibility and public transport. Moreover, the residential locations are needed in order to assess and analyse the second part of the survey, which focuses on the level of satisfaction of the infrastructure for bikes, cars and buses as well as shopping and leisure facilitates within their district. These questions can be answered by using the Likert-scale, ranging from *'not satisfied at all'* to *'very satisfied'*. Furthermore, the participant is asked to rate different aspects related to choosing the residential area. Additionally, an optional open text field is included, where the main aspects for choosing the current area can be described.
The aim of the next part is to gain general knowledge about the sample, including age, gender, occupation, level of education, income, marital status, household composition, type of residency and individual characteristics such as being environmentally friendly and physical active. These information shall help to assess the representativeness of the sample and to compare it to the population of Ravensburg. As the initial plan was to perform analytical statistics, these were also intended to be used as control variables.
This is followed by a more in-detail section about the drivers and motivations for choosing the current residential area. Again, the participants were asked to rate different aspects in terms of its importance. Besides

this, a question related to planned relocation within the next 5 years and its reasons was asked.
In order to gather information about the modes of transport and its reason, the survey includes questions about what mode of transport is mainly used for commuting to work, during leisure time and for shopping and its main reason for choosing this specific type of transport. As an important aspect of this study is to address sustainable mobility, the participants who barely, respectively never use public transport were asked to mention the main reasons using pre-defined answer possibilities as well as open text fields.
Taken into account current development and events, impacts of the outbreak of Covid-19 as well as the increasing fuel prices are assessed by including questions about change in behaviour.
Finally, the participant was asked to participate in a follow-up interview.

Descriptive Statistics

The data obtained from the survey was analysed by using the Statistical Package for Social Sciences (SPSS) [IBM Corp.]. Descriptive statistics allows to analyse sample sizes and to get a first impression of the sample, including patterns and trends. Moreover, visualisations in form of bar charts, pie charts and tables can be developed. Accordingly, these are great ways to illustrate the frequencies. Another important aspect of descriptive statistics is to account for outliers. Prior but also while performing descriptive statistics, the data was pre-processed and unqualified cases were excluded from further analysis.
The main aim of descriptive statistics is to get an overview of the sample and to identify trends and patterns.

A secondary aim was to run statistical tests as a means to gather information about possible correlations and to make predictions based on significant relationships. Unfortunately, the sample size is rather low. Despite the fact, that at least 30 answers are needed to perform analytical statistics, the researcher decided to exclude it from further analysis. On the one hand because non-parametric tests or small sample sizes are less strong and meaningful, and on the other hand, no significant results were found.

Analysis of comments

During the survey, the participants had the chance to leave optional comments related to a more in detail elaboration on their main motives for moving to the current residential area as well as comments related to the improvement of the public transport system and bicycle network. The answers are illustrated in a coding tree, classified by districts (See Figure 6.7 and Figure 6.10).

Interviews

In order to gather more in-detail information about the drivers and motivations of residential and transport choices, follow-up interviews were conducted. The semi-structured interview guide can be found in Appendix B.2. According to Clifford et al. [2016] this is a great method of conducting interviews as it is generally more open than structured ones and more detailed questions based on previous answers can be asked.
Each interview was conducted individually and the more specific questions were based on the answers to the survey. Prior starting, the interviewees had the chance to ask questions concerning the topic, aim and purpose. Besides this, the participant was informed that the participation is anonymous, voluntary and can be ended at any time without giving a reason.
The semi-structured interview guide is divided by topics, whereas one group of questions is based on the results of the interview and therefore chosen individually for the participants. Special attention is paid to the optional open text fields, in which the participants had the chance to elaborate more on their main reason for relocation and to make suggestions, respectively complaints about the infrastructure in Ravensburg.
Overall, all interviews follow the same pattern. After introducing the topic and purpose of the interview, it starts with some opening questions asking the participant to tell something about themselves and how they grew up. Beginning with some easy questions shall help to start the interview and to get familiar and confident with each other.
This is followed by the main questions, which are divided into three groups. The first one relates to previous and planned relocation and its motives, residential preferences and the connectedness to the city, respectively the rural. The next category focuses on the answers given in the survey. This shall clarify the answers and is used to obtain additional and more in-depth information. Questions related to mobility behaviour are the third category. This includes variables such as preferences and motivations of choosing specific modes of transport. Moreover, questions to improve the transport system are asked.
To finalise the interview, closing questions are used. During this, influences of the Covid-19 pandemic and increasing energy prices are picked out as a theme. Besides this, the interviewee can add additional information and ask further questions.

In addition to interviews with the inhabitants, one expert interview with an urban planner of Ravensburg was conducted. The main aim was related to the feasibility of possible solutions of the problems and how they could potentially be realised. Therefore, the urban planner was informed about the citizens' concerns and suggestions.
Accordingly, the interview took only place after the analysis of the results of the surveys and interviews with the inhabitants of Ravensburg. To increase the readability and avoid repetition, the results of this interview are only included in the feasibility assessment (See Chapter 7, Section 7.1).

Analysis of the interviews

The main purpose of the follow-up interviews is on the one hand to get a deeper insight into the motivations, influences and tipping points of relocation decisions and on the other hand on mobility behaviour and preferences. As secondary aim is to assess how mobility choices can be steered towards more sustainable choices by asking what needs to be improved, respectively what must happen in order to choose a non-motorised mode of transport or public transport.
As a result of the current circumstances, the Covid-19 pandemic all interviews were carried out via telephone. This can disadvantage the collection process in terms of no non-verbal reaction and less personal contact.

Prior data collection, a coding tree was developed based on the literature review and assumptions and later adapted based on the interview results (See Figure 6.11 and Figure 6.12). Two main topics, namely *Residential Choices* and *Mobility Behaviour* were established. These main groups include various sub-groups such as preferences, life-stage, push- and pull factors for the former one, and preferences, main reasons and habits for the latter one.
The interviews were transcribed and analysed by using the software *atlas.ti*. The data analysis follows the guidelines introduced by Gratton and Jones [2010]. The interviews were transcribed and the data reduction phase took place. The data was coded based on the preliminary and later adapted coding tree. Irrelevant data was excluded from further analysis and the data was organised and structured.
The following step was displaying the data. During this phase, the finalised coding tree was developed, including the times a code was mentioned considering the context.
Based on the coding tree, but also by looking back and forward to the transcripts, conclusions were drawn. Special attention was paid to the right categorising of the codes, any contradictory results, new patterns, as well as relationships.

4.2.2 Method Triangulation / Mixed methods

Combining quantitative -and qualitative data can help to broaden the perspective and underlying structure and drivers of the studied phenomena. In this case, surveys and interviews were used to gather information about urban sprawl. Doing this can outweigh the deficiency of only one method and thus strengthen the validity. Additionally, the methods complement and support each other when using the strength of each data collection method [Bryman, 2004; Gratton and Jones, 2010].
Using surveys has the advantage of being able to analyse a large data set within a rather short amount of time. However, no in-depth information is obtained and no follow-up questions can be asked. On the contrary, conducting interviews is a time-consuming process in terms of doing the interview, transcribing and analysing it. Nevertheless, the interviewee has the chance to ask for clarity and to elaborate on the answer. The same applies to the interviewer.
Therefore, the data collection is based on the method triangulation approach in terms of carrying out surveys first and then conducting follow-up interviews.

4.3 Research Ethics

A vital part of conducting primary data collection is to address ethical considerations. If not stated otherwise, the researcher must protect the personal data of the participants, do good and avoid harm as well as to collect the data in an appropriate manner [Hay, 2016]. Accordingly, this study follows the guidelines of 'Netherlands Code of Conduct for Research Integrity' [The Dutch Research Council, 2018]. The main aspects addressed are honesty, transparency, responsibility and anonymity.
The participation in the surveys, respectively in the interviews is completely voluntary and the participant has the right to withdraw from the study at any time without giving a reason. Moreover, no confidential data is published. The obtained data is stored and processed on the researchers laptop and no access is given to third parties. Addressing honesty and responsibility, the purpose and aim of the study is elaborated on as well as how the data is used. Introducing the data collection- and analysis methods shall secure transparency and for others to be able to understand the results as well as to repeat the study in another context.

Literature Review 5

The Literature Review forms the basis for further analysis. Previous studies and literature on relocation decisions, living preferences as well as on mobility behaviour and choices are compared, assessed and summarised. On the one hand, the drivers, such as costs are taken into account, and on the other hand individual relocation choices and preferences from the micro-level perspective are reviewed.
The remaining part introduces possible external influences such as the Covid-Pandemic on residential choices and increasing energy prices.

5.1 Individual relocation motives

The drivers on the micro-level refer to the individual choices and motives. It must be mentioned that the framework conditions on the macro- and meso-level have a rather large influence on the decision-making process on the micro-level. For instance, the meso-level, more specifically the land and housing prices seem to be of great importance when choosing a new residence.
Previous studies indicate the change of preferences during life cycles. More specifically, dependent on where you are in life, there may be different factors influencing residential choices [Aner, 2016; Stockdale, 2014].

One commonly known model to explain residential relocation is the 'stress threshold model' developed by Wolpert [1965] and tested and adapted by other scientists [Robson, 1975; Brown and Moore, 1970]. Accordingly, relocation is caused by stress and residential dissatisfaction.
However,the processes behind the decision-making is unlikely to follow a circular pattern. There are personal thresholds as well as other influences. For instance age and home-ownership.
As highlighted by Bell et al. [1968], there are three types of movers, namely the *Careerist* who moves for work-related and economical reasons, the *Consumerist* who prefers downtown areas and the city-lifestyle and the *Family oriented one* who primarily moves to quiet and safe areas with good access to schools and playgrounds. This is also in line with Mitchell Clare [2004], differentiating between motives and classifying it accordingly. Especially stages in life seem to be of great importance when considering to relocate [Aner, 2016; Stockdale, 2014]. Additionally, Mincer [1978] highlights the influence of family ties during the decision-making process. Early child hood memories and the way people grew up may have an impact on the decision-making process when choosing a new residential area as well [Aero, 2006].

Similarly, Mitchell Clare [2004] differentiates between relocation motivations and came up with three different classifications. The first one describes a group of individuals who move outside of the city, but are still closely connected to it in terms of commuting there on a daily basis. The next category refers to the displaced ones, who are being forced out of the city by housing and living costs. The third group is defined as the anti-urbanists, whose relocation motivation is the rural idyll.

Based on the classifications discussed by Mitchell Clare [2004], Aner [2016] analysed the motivations of families with children moving out of the inner city in more detail. The study took place in Copenhagen, Denmark where almost 30pct. of the 'movers / relocaters' between 1990 and 2002 were families. Moreover, only 11.3pct. of the total inner-city population are children with families. In her study, Aner [2016] distinguishes between two extremes, namely the *housing motive* and the *anti-urban move*. The results of the interviews indicate that 'housing motive' movers are triggered by family formation and thus changed housing requirements. As these cannot be afforded in the inner city, the feeling of being forced out was mentioned. According to Christiansen and Loftsgarden [2011] income does indicate housing preferences and subsequently the location of the residential area.
Moreover, the perception of the city often stays the same and they still see themselves as urbanists. Perceiving the city as a diverse and tolerant place, it is considered to be a great place for children to grow up and develop a good personality.
In comparison, the anti-urban movers perceive the city in a negative way in terms of upbringing children. The relocation to the rural area is described as a homecoming to a little community, characterised by safety, clean air and green space. Besides that, childhood memories are an influential factor as well [Aner, 2016].
Motives and drivers seem to change with the entrance into another stage of life. Examples are moving out of the parental home, start studying, respectively working, forming a family and retiring.
In that context, Stockdale [2014] analysed the decision-making process of early retirees moving to mid-Wales. He came to the conclusion, that the decision is not dependent on only one driver, but an interrelation between many with one serving as the so-called *tipping point*. Some defined tipping points are early retirement, inheriting money, loss of family members, families ties in certain places and children leaving the parental home. Accordingly, it is a process of being freed by ties and enabling factors. Furthermore, Stockdale [2014] highlights the importance of making compromises especially within relationships as well as on the desired residential area and residence. The choice of residence is highly dependent on the property market including the affordability of houses, childhood memories, as well as the accessibility to the previous residential area. Only one interviewee mentioned the importance of being close to public infrastructure and thus able to still be mobile if driving is not an option anymore. Overall, these studies show the importance of considering multiple drivers steering migration towards the outskirts and rural areas.
The previous section introduced more general motives, as well as motives based on life stages, in which different moving patterns are established. It is important to highlight, that all the drivers of the macro, meso and micro are closely connected and intervening. Moreover, a relocation outside of the inner city, but also in general is not dependent on only one motive.

As this research takes place in a German context, two studies which were conducted in Germany are reviewed and the individual reasons why people live where they live, respectively consider to move to sub-urban/rural areas as well as the factors for the choice of relocation and residence are assessed. Reckien and Luedeke [2014] and Dähner et al. [2021] conducted surveys and established various motives classified by age, marital status and living situation. The motivation for a relocation to the countryside seems to be strongly associated with space, freedom and nature - especially for the ones that are planning to move in the near future. This is in line with an escape out of the hectic, noisy and busy city [Dähner et al., 2021]. A quiet neighbourhood is especially a preference for retirees and elderly [Reckien and Luedeke, 2014] as well as for families seeking safe neighbourhoods.

When it comes to choosing the specific rural area, not only landscape and nature were mentioned as the most important factors, but also fast internet connection and network coverage (< 50pct.) Besides this, the neighbourhood and the social as well as shopping facilitates seem to be of importance for young families [Reckien and Luedeke, 2014]. This is not completely in line with Dähner et al. [2021] who came to the result that those who are planning to move do not consider shopping facilitates as an important factor when choosing the new residential area.
It is worth mentioning, that the studies had a different approach in conducting the surveys. Dähner et al. [2021] differentiated between rural inhabitants, newcomers and those who are planning a relocation. Reckien and Luedeke [2014] differentiated between life stages and marital status. Whereas young couples seem to prefer a close proximity to work and shopping facilities, important factors for young families are family-friendly neighbourhoods, good schools and childcare facilities as well as close proximity to family and friends [Reckien and Luedeke, 2014]. Considering this, it can also be assumed that the surveyed young couples have not thought about staying there and forming a family [Reckien and Luedeke, 2014]. This is partly in line with the finding, that only about 20pct. mention family formation as a reason to live in more rural area [Dähner et al., 2021].
Another aspect is car ownership and car dependency, which is higher in rural areas. This can also be translated into these studies, as only a small share takes accessibility by public infrastructure as one of the most important factors into account [Dähner et al., 2021]. However, Reckien and Luedeke [2014] states, that a rather large share (< 50pct) prefers good public transport, except of middle-aged singles (approx. 20pct.). Notwithstanding, a good road network seems to be more important. These findings are in line with the fact, that all of those middle-aged singles surveyed own a car. In comparison, the percentage of car ownership for young couples and families is lower.
Furthermore, housing affordability and availability are important factors in the relocation-process. Especially those who are currently planning to move choose these as important and influencing factors.
Another interesting finding is that the relocation motive of those who are currently planning to move is often related to the Covid-19 Pandemic.

The following Figure 5.1 summarises and classifies the different findings by using an adapted version of the Push-Pull-Model developed by Lee [1966]. In its origin, it aims to explain cross country-migration. Ever since it was developed, it has been used as a basis to understand migration - between countries, but also within countries. The Push-Pull model stresses that migration is not only caused by one single factor but many. For instance by economical, cultural, educational, environmental and social ones. As the name already indicates, push factors are factors inducing people to leave a certain location. Examples may include high land prices, poor public transport, air pollution, no job opportunities, but also natural disasters. On the contrary, the pull factors attract people to a certain location. These factors are more or less the opposite of the just mentioned push factors, including job opportunities, lower land prices and good public transport [Lee, 1966; Krishnakumar and Indumathi, 2014; Khalid and Urbański, 2021]. For instance, public transport is a pull factor in urban areas, but a push factor in rural areas caused by insufficient service and coverage.
However, each location has its own push and pull factors, perceived differently by individuals. Whereas young people tend to move towards the inner city, families tend to move out of the inner-city for different reasons. Depending on the lifestyle and stage of life, the push and pull factors differ. In this study, these are defined as neutral ones - which are positive for some, but negative for others. As assessed during the review of the literature, an example is the different perceived quality of life in urban and in rural areas (See Urbanist and Anti-Urbanist).

Enabling factors are especially of importance for a relocation towards rural areas. Information and communication technologies and a great purchasing power in Germany have decreased the burdens of moving towards rural areas.
In addition to push, pull and enabling factors tipping points should not be ignored. Push, respectively pull factors may be present, however, a certain event must occur for the final decision. Lee [1966] also highlights intervening obstacles that need to be overcome when moving. Examples are moving costs and stress.

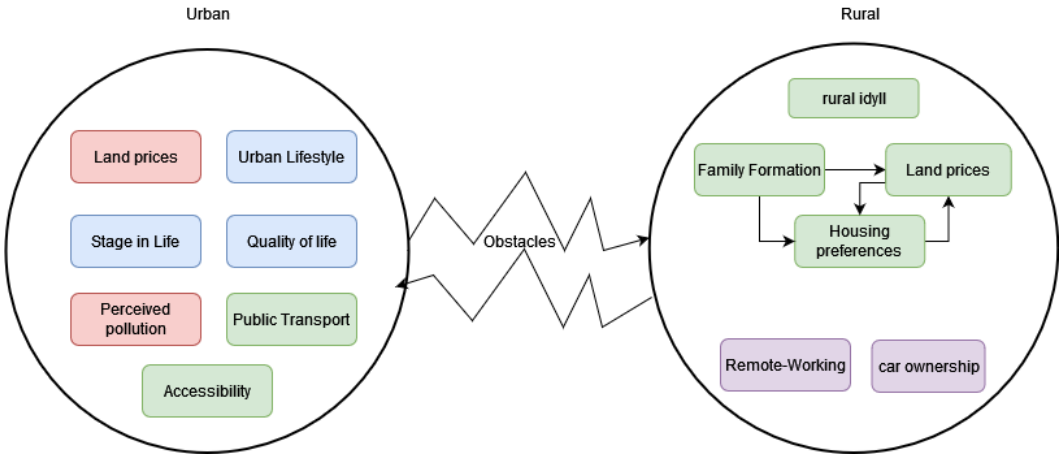

Figure 5.1. Inspired by Lee, added according to literature review by author. ; green refers to positive perceived variables, red to negative perceived variables and blue to either neutral or negative for some, but positive for others and purple for enabling factors

Figure 5.1 primarily focuses on the individual preferences as well as settings on the macro and meso level influencing decisions. Generally speaking, push factors lead to dissatisfaction at the current residential area and subsequently to the desire to relocate. When choosing a new residential area, the pull factors are most important.
It is worth to be mentioned that factors such as the place people grew up and family ties are of great importance as well [Aero, 2006]. However, it can be assumed that the former one is reflected in the individual preferences and that the latter one mostly has an influence on the location rather on whether it is urban or rural.
Overall, it can be concluded that various push and pull factors are influential, dependent on personal preferences and stages in life.
It cannot be stressed enough that the factors, motives and preferences not only differ between individuals, but may also change over time - with entering into a new stage of life. Moreover, the framework settings seem rather stable, however, changes on the macro and meso level can have direct influences on the micro level.

5.1.1 Influences of recent and current events

Covid-19 Pandemic

Previously, the macro- and meso-level were elaborated on in terms of setting the framework conditions for urban sprawl. However, it is not a static but dynamic process. Thus, recent and current changes may still impact urban settlement and subsequently urban sprawl. The increased digitisation in combination with the start of the Covid-19 Pandemic enabled and enhanced home-office / place independent work. Accordingly, every 5th person of those surveyed at the end of 2020 would relocate to the rural area if home-office would be possible [bitkom, 2021]. This is in line with research conducted by Dähner et al. [2021], where 1/4 of those considering relocating to the rural mention Covid-19 as a reason.

Increasing energy prices

The number of commuters has increased in the past 20 years from 15 million in 2000 to 19 million in 2018, partly caused by an increased labour force [Der Spiegel, 2014]. Additionally, the distance travelled increased as well, especially for rural inhabitants.
At the same time, the petrol prices went up, with the tendency to increase even further when taking into account current developments and events.
This could potentially result in a rethinking relocating further away from job opportunities or in a modal shift, especially for leisure-related purposes.

5.2 Motives for choosing the mode of transport

5.2.1 Residential Choices and Public Transportation

As the main focus of this project is to understand the motives behind relocating towards rural areas, respectively the outskirts of cities, as well as to enhance a more sustainable development, the influence of public transport accessibility on residential choices is assessed using existing literature. Accordingly, Scheiner [2006] analysed the factors influencing the destination and the change of commuting patterns after a relocation took place. The study took place in Germany, where in general the purchasing power is rather low and the transportation costs are rather high compared to other European countries. As previously mentioned, high housing prices and the desire for own property leads to out-migration of downtown areas. However, those with access to a car are most likely to move to sub-urban areas. This result could be explained by the fact, that people may have bought the car prior to the planned relocation. On the contrary, people who do not own a car are less likely to move to suburban areas [Scheiner, 2006] due to the increased car dependency. Travel demand and accessibility to public transportation seems to play a crucial role for the locational choice in some cases. As found by conducting a study in Munich, 69pct. of those who moved to a suburb indicated that the distance to the next public transport stop was an important pre-condition [Scheiner, 2006]. Nonetheless, other factors such as the market price should not be ignored.
Another factor worth to be mentioned refers to the preferences of the transportation modes and correspondingly towards residing within areas where the preferred mode is well developed. In other words, people who prefer to use public transport as their main mode of transport are less likely to move to areas with bad access to public transport [Van Wee et al., 2002].

This is in line with research conducted by Taplin and Sun [2020] who state that people who choose a new residential location close to a bus stop, are also more likely to take the bus compared to people who chose to move to rather distant location. If public transport is in close proximity, the likelihood of using it increases [Næss et al., 2019].
Individual preferences determine the attractiveness of certain neighbourhoods, especially for those who are in favour of public transport [Van Wee et al., 2002]. This can be explained by the fact, that in comparison to public transport, car infrastructure is generally equally well developed.
Næss et al. [2019] analysed the changes of transport modes after a potential relocation. On the one hand, a modal shift from the car towards either public transport or non-motorised transport is likely if relocated from a more rural place towards the inner city. On the other hand, if moving from the inner city towards the outskirts, the opposite is likely to happen. Furthermore, Van Wee et al. [2002] state that, the preferences are (at least to some extent) related to personal and household variables. Whereas one or two person households, elderly and females are more likely to have a preference for public transport, people under the age of 46, car owners and people with a high-income are more likely to have preferences for using the car.

Urban Structure and mobility behaviour

Another aspect worth to be mentioned is the urban structure and its influence on mobility. Accordingly, urbanity is associated with sustainable mobility options, such as walking, biking and public transport. This can be explained by its close proximity to facilitates and activities as well as great functionality of public transport. On the contrary, living further away seems to constrain people from walking, biking and using public transport. Nevertheless, these factors cannot solely be considered on its own. Socio-demographic characteristics (age, gender, income) are also influential [Silva et al., 2014; Næss et al., 2019; Engebretsen et al., 2018]. This will be elaborated on on more detail in the next section.
Næss et al. [2019] analyse two areas, namely Oslo which can be characterised as monocentric and the Stavanger area, mostly polycentric in terms of the built environment and mobility behaviour (commuting) as well as densities and workplaces and socio-demographic characteristics. Accordingly, there does not seem to be a difference in choosing their mode of transport for people living further away from the city centre. On the contrary, living close to either the Stavenger area or Oslo shows differences in terms of travel modes. Besides this, Næss et al. [2019] show similar commuting distances for the inhabitants of Stavenger, regardless of living close or further away from the centre. In the case of Oslo, the distance is about 50 pct. less for inner-city dwellers.
Not only the commuting distance was assessed, but also the mode of transport in relation to the urban structure. Not surprisingly, people living in or close to the inner-city are more likely to use non-motorised modes or public transport. As already stated by other scholars, high-density cities with centralised functions have in general a better transit system than low-density areas. Generally speaking the better the options and conditions, the more people travel by using public transport, respectively walking or biking.
Furthermore, by comparing different and similar urban structures, Silva et al. [2014] found out that not only structure plays an important role, but also politics, lifestyles, self-selection and excess travel.
On the one hand, monocentric and high-density cities such as cities of short routes are said to be environmentally friendly considering less car use, shorter commuting distances and less energy use than polycentric and low-density areas. On the other hand, some argue that polycentric areas and thus the decentralisation of functions and jobs can reduce commuting as a result of being closely located to the residents. In that context, sub-urban areas are assumed to have lower passenger-km as a result of facilities and

functions, such as grocery stores and schools being close by. However, if those facilities are not sufficient or satisfying, an increase in travel distance can be recorded as other facilities are further away. This is especially the case for specialised functions and work-places [Antipova, 2010; Næss et al., 2019].
Overall, it can be argued that different urban structures have different influences on passenger-km and modes of transport.

5.2.2 Demographic and Socio-economic characteristics and Transportation

Demographic and socio-economic characteristics have an impact on the chosen transport mode as well. Summarising Næss et al. [2019]'s and Engebretsen et al. [2018]'s findings, gender, income, university degree and the household composition influence the main mode of transport. Whereas females tend to drive less, households with a higher income; young people and families with children tend to drive more. However, it is also argued that individuals with a university degree tend to commute less for work. This can be explained by the fact that those jobs are often located in the inner city, which is characterised by a rather good public transportation network and rather bad car accessibility. This is in line with the finding, that highly educated people are more likely to be regular commuters of non-motorised modes. Nevertheless, the findings also show that professionals and managers have on average longer commuting distances than students, clerks and technicians.
When talking about facilities, work and non-work related, not the closest facility but the most favourable one is predominantly chosen. In the case of leisure activities, highly educated people tend to accept larger commuting distances. According to Næss et al. [2019] it could potentially be because of a 'narrow' cultural taste and specific interests. On the other hand, older people and families choose closer facilities, potentially caused by physical mobility, respectively limited time.
Another finding, related to work facilities is that those surveyed would accept an increase in commuting time (from 30 minutes to 45 minutes) if the salary would be increased by 10 pct. and even a larger increase in commuting time if not only the salary is increased, but also the interestingness of the job. Women seem to be less inclined to do so.
Apart from the infrastructure, personal attitudes, environmental awareness and norms should be stressed as influencing the decision. Accordingly, a pro-transit attitude increases the likelihood of regular transit commuting [Næss et al., 2019]. Additionally, environmental awareness seems to have a rather large impact on travel behaviour [Van Wee et al., 2002].

5.2.3 Other influence on public transport use

Many scholars have analysed the relationship between the distance to a bus stop, respectively train station and its impact on the mode of transport. On that account, the optimum walking distance from home to the bus stop is between 200 and 600m, approximately 10-15minutes [Sarker et al., 2019; Mohamad et al., 2021; Stanesby et al., 2021]. As shown in Figure 5.2 the likelihood of walking to the transit decreases with an increased distance.
However, the acceptable distance varies with the density of the area, but also with demographic characteristics such as age and physical mobility [Sarker et al., 2019].
Moreover, studies indicate that people are more willing to walk further (approx. up to 800m) to a train station than to a bus stop [Sarker et al., 2019].

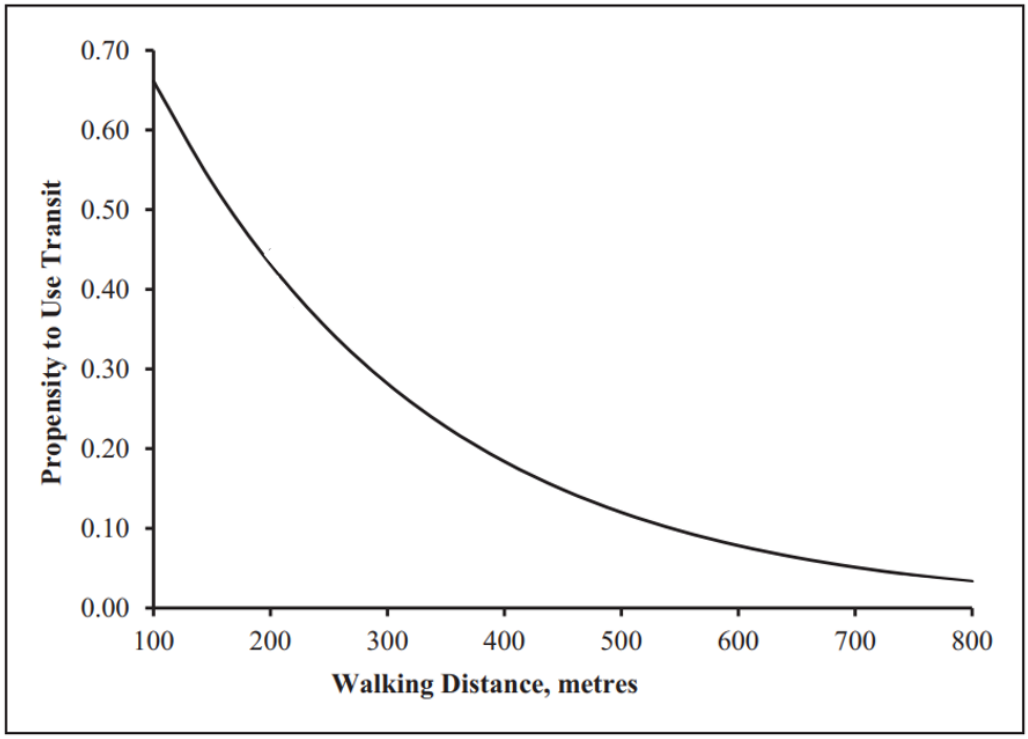

Figure 5.2. Likelihood of using public transport based on walking distance, [Zhao et al., 2003]

However, the likelihood is also dependent on other variables. As stated by Stanesby et al. [2021] the frequency plays a crucial role. Correspondingly, half of those surveyed are willing to walk further if the frequency was improved. Especially young people, physically active and those without access to a car were associated with it [Stanesby et al., 2021; Sarker et al., 2019]. Besides this, the preferred mean walking time increases in low-density areas and suburban areas [Sarker et al., 2019].
Not only the distance and the frequency influence the likelihood of taking public transport but also travel cost and the ticketing system, travel time, traffic condition and punctuality [Mohamad et al., 2021; Taplin and Sun, 2020; Dell'Olio et al., 2011]. Accordingly, the ideal trip is described as cheap, comfortable and short [Mohamad et al., 2021].
Another possible influence worth to be mentioned is the actual route to the public transport, especially in terms of safety [Mohamad et al., 2021; Taplin and Sun, 2020].

To be summarised, increased use of motorised transport is partially caused by urban sprawl in relation to poor public transport in rural areas. Urban structure, personal preferences and socio-demographic characteristics seem to be the most influential ones when it comes to choosing the main mode of transport. However, even though personal preferences tend towards public transport, urban structure and a poor public transport system may not allow this and subsequently the need for a private car emerges. Mobility preferences are not always in line with residential preferences and vice versa. As mentioned previously, some are forced out of the city due to high living costs and availability. This in return leads to relocating towards cheaper, mostly rural areas, characterised by poor public transport and a rather high car dependency.

Ravensburg - Area of Interest 6

6.1 Ravensburg

Ravensburg is located in the southeast of the southern German state Baden-Württemberg. Friedrichshafen and Lake Constance are about 20km south of Ravensburg (See Figure 6.1). The total area of Ravensburg is 92.04km^2. Ravensburg has a total of about 50.000 inhabitants. This number however has been increasing in the past years and is also expected to increase further.
The average age is 43. The share of inhabitants below 18 years was 16.2pct and above 65years was 20.4pct in 2019 [AdminStat, n.d.].

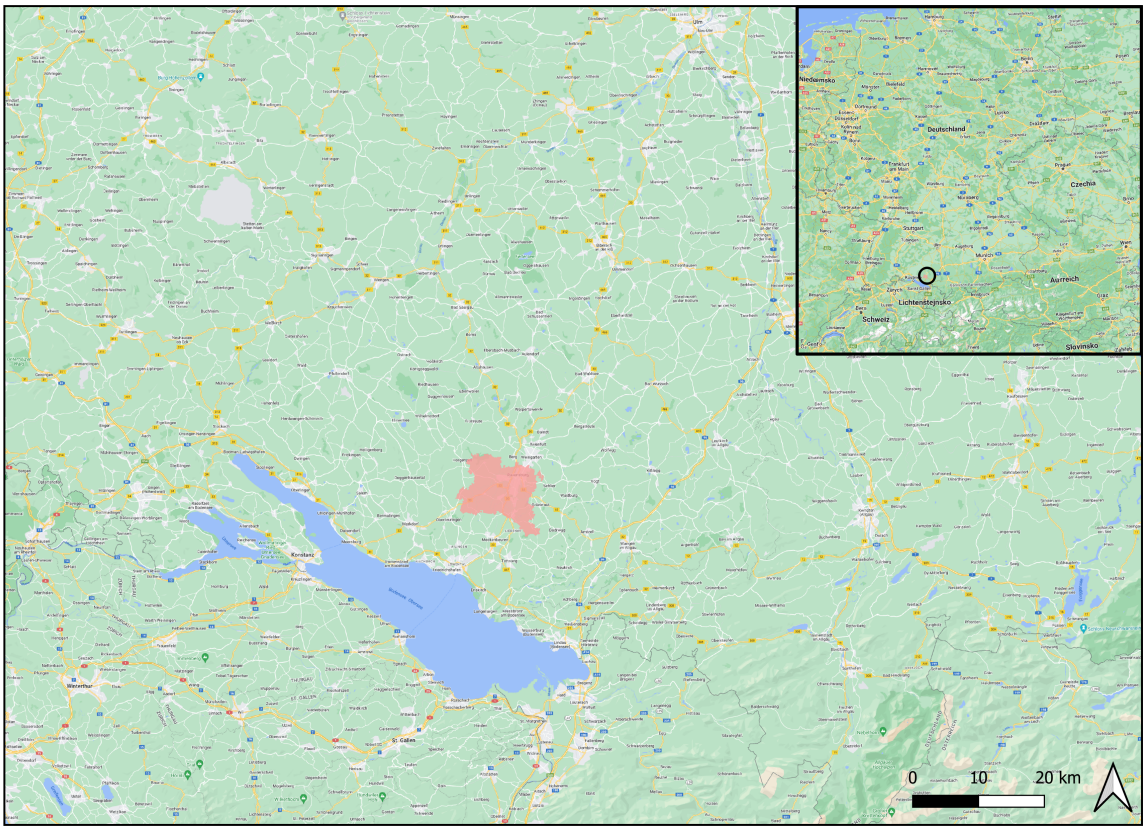

Figure 6.1. Aerial - Ravensburg

Being part of Baden-Württemberg, it must be in line with the legally binding regional plans stated in the so-called state-development plan. During the past 60 years, changes in the spatial settlement structure lead to adjustments. Especially population and economic growth as well as a higher degree of motorisation in combination with comparable low housing prices are reasons for sub-urbanisation and thus for new objectives. The state development plan aims to ensure a sustainable development while considering different types of areas.
Ravensburg is presented, together with Friedrichshafen in the south and Weingarten in the north, as a central place. The region shall ensure the provision of high qualified and specialised facilities and workplaces to its inhabitants. Ravensburg itself is a middle centre [Wirtschaftsministerium Baden-Württemberg, 2002].
This structure and terminology were introduced by Christaller [1933] aiming to explain human settlements and the function of places in the South of Germany.
New investments are preferably made in middle centres as well as in central places. Because those places are of great importance, the closure of public facilities such as hospitals is to be avoided.

Urban Sprawl in Ravensburg from 1950 on

The city of Ravensburg has been growing from approx. 13.400 inhabitants in 1900 to almost 26.000 in 1950 and 50.776 in 2020. Before World War I, the main development areas were along the roads connecting Ravensburg with Weingarten, Friedrichshafen/Tettnang and Wangen. After World War II, the development was centred around the river Schussen and the train line. Especially after 1950, many new residential areas were developed in all directions and the sealed surface was doubled. One of the largest developments is the densely populated district *Weststadt*, which contains residential houses, shopping facilities, churches and schools [leobw, n.d.].
In the 1970s the city of Ravensburg was merged with some of the surrounding villages, especially in the South and West. More specifically, Eschach, Schmalegg and Taldorf and Adelsreute (See Appendix A, Figure A.1 for the location of the districts) [Bundesamt, 1982].

6.2 Transportation

Car ownership and usage

In the past 10 years, the number of private cars increased from 23494 in 2012 to 26290 in 2021, respectively from 3049 to 4368 for commercial vehicles in Ravensburg. This can partly be explained by population and economic growth.
Besides this, Figure 6.2 illustrates not only an increase in the total number of cars, but also an increase in electronic vehicles and hybrid/plug-in vehicles.

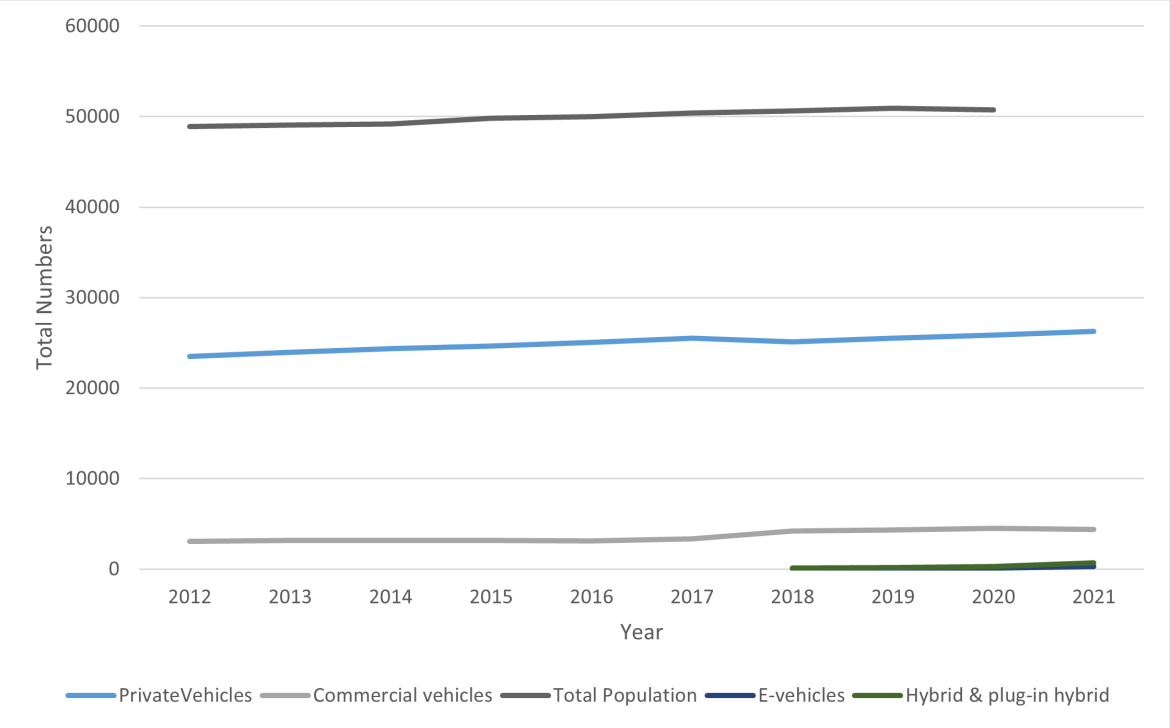

Figure 6.2. Distribution of car ownership in Ravensburg (Total number of cars and total number of inhabitants)

Figure 6.3 shows the distribution of the car as the main mode of transport in percentage divided by districts. It can be seen that the districts with the largest share of car use (51pct - 64pct) are mainly located in the outskirts. Close to the city centre, the share is between 31 and 46pct. (See also Appendix A, Figure A.2 for the distribution of other modes of transport).

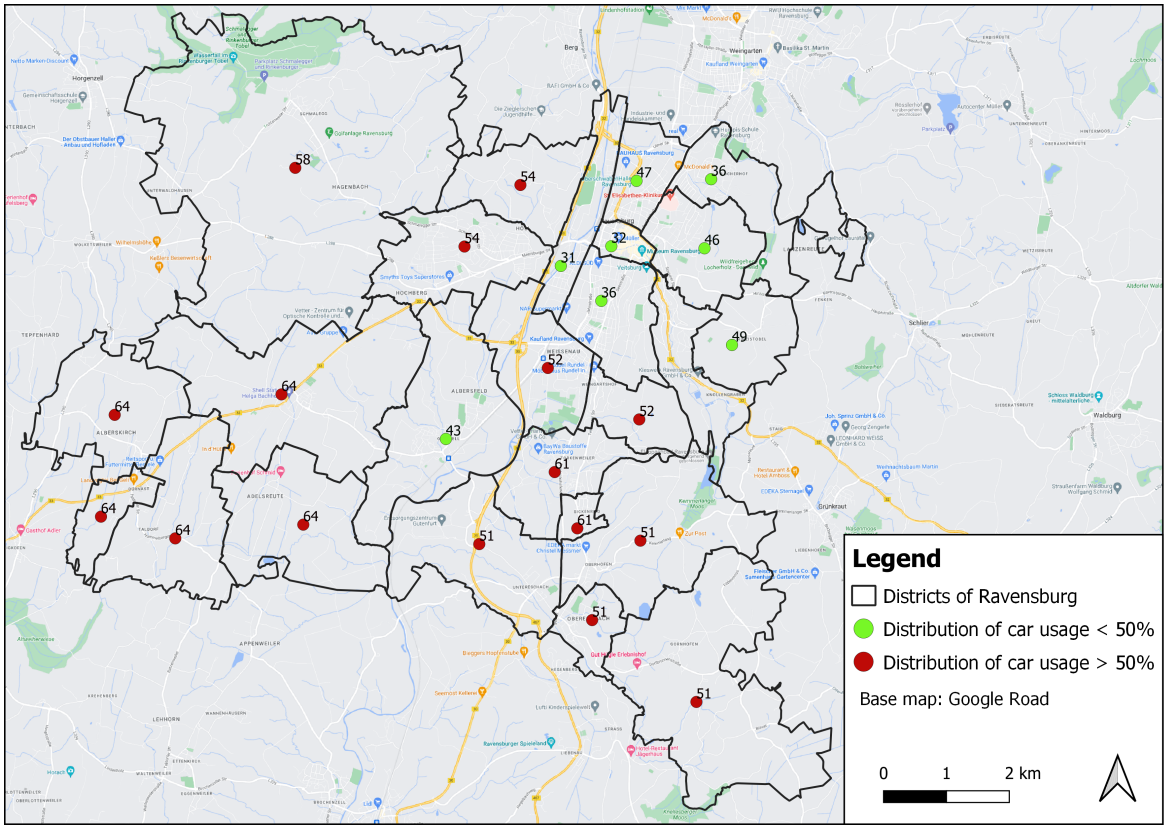

Figure 6.3. Distribution of car usage in Ravensburg, divided by its districts

This is in line with Næss et al. [2019] stating that inner city dwellers have on average a lower usage of cars and a higher rate of non-motorised transportation modes. In comparison, the further away from the inner-city, the longer the commuting distances and the higher the car dependency.

6.3 Districts in Ravensburg

Figure 6.4 illustrates the different areas in Ravensburg, where the surveys were distributed. For the analysis, the areas are divided into two groups. More specifically, the group within a proximity of 2.5km of the train station and the group further than 2.5km away from the train station. Looking at the buffer, it can be seen that the areas Nordstadt, Sennerbad, Schussensiedlung/Deisenfang, Weststadt, Altstadt, Südstadt and Weißenau are within and Schmalegg, Bavendorf, Dürnast, Taldorf, Oberzell, Torkenweiler, Obereschach, Gornhofen and Oberhofen are outside the vicinity of 2.5km.

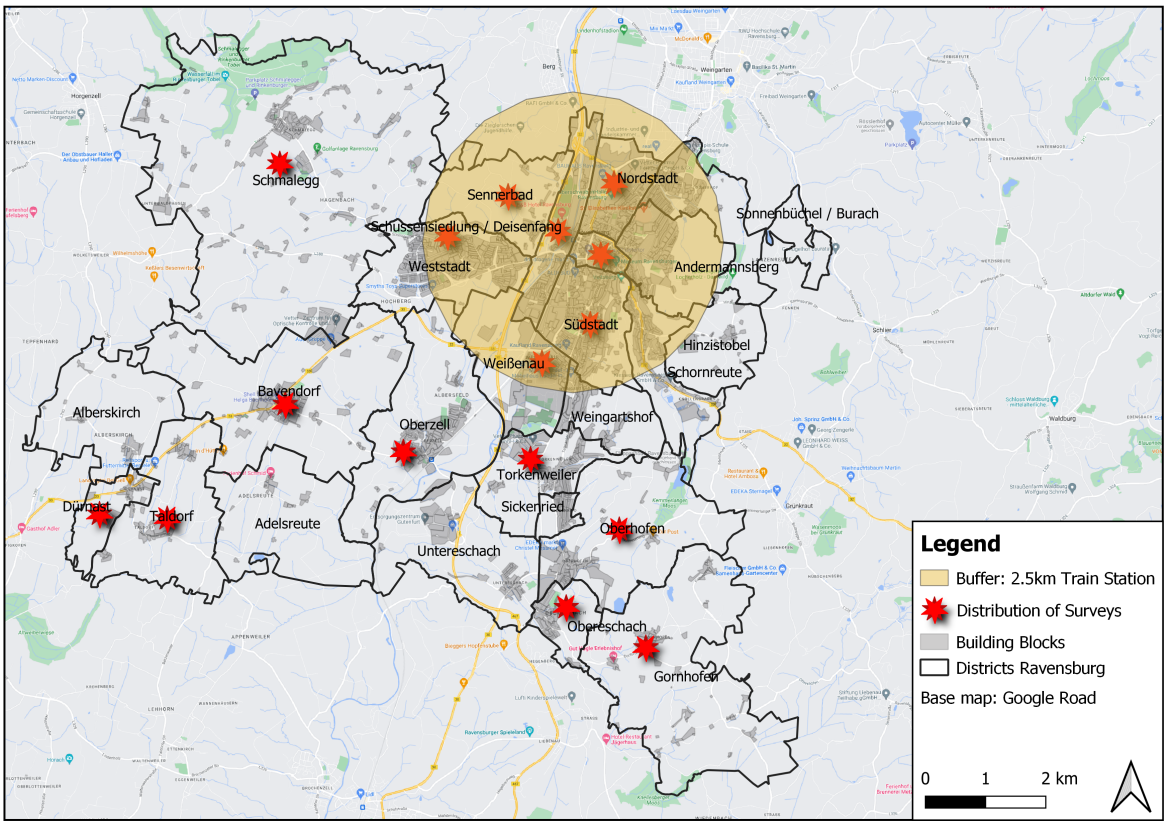

Figure 6.4. Districts of Interest in Ravensburg - distribution of surveys

6.3.1 Assessment of public transport service

In the following, frequencies, distance to bus stops and the total duration from each area to the main train station in Ravensburg are assessed. The data of Table 6.2 was obtained by using the local public transport services website *BODO*. In order to represent a normal weekday, respectively working day, the frequency of each bus line is based on the schedule of Tuesday, the 2nd of March 2022. The assessment of the frequency is shown in Table 6.1. More information about the accessibility, reference address, reference bus stop and reference bus lane can be found in Appendix A.

Evaluation	Frequency
++	every 10-20 minutes
+	half-hourly
o	half-hourly in rush hour hourly
-	hourly / two-hourly
–	barely

Table 6.1

The following Table serves as a means to give a general overview of the public transport system of the surveyed areas in Ravensburg.

Case Study Area	Distance to train station	Frequency	Duration total bus	Duration to bus stop (walking)	Difference car / bus (time saved)	Difference car / bike (time saved)
Bavendorf	6.5km	o	18	7	7	4
Dürnast	9.5km					13
Gornhofen	9km	o	35	3	20 - 30	10
Oberhofen	6km	+	30	5	25	10
Obereschach	7km	++	30	7, 5	18	9
Oberzell	5km	++	12, 22	8,5	6	6
Schmalegg	6-9km	o	20 -40	5-30	4-35	5-15
Sennerbad	2.5km	-	60	7	55	8
Torkenweiler	4.4km	+	16	4, 4	7	4
Taldorf	9.3km	o	22	5- 11	7	13
Weißenau	2.6km	++	20	2-5	15	2
Weststadt	3km	++	12	4	5	2

Table 6.2

The areas next to the train station, namely Schussensiedlung, Nordstadt, Altstadt and Südstadt are not included in the assessment. Overall, the distances to the train station vary and are between 2.6 and 9.5km. Comparing the areas it can be said that on average, the further away the area is, the worse the frequency, connection and duration of public transport. Even though using the car is faster in all areas, time for parking and walking to/from the car is not considered in the analysis.

When comparing the share of the main mode of transport with the public transport system of each district, it can be seen that Bavendorf, Dürnast, Taldorf and Schmalegg have the highest share of car users and the poorest public transport frequency. The same accounts for Gornhofen and Adelsreute. Even though Obereschach and Oberhofen have a rather good frequency, the percentage of people using the car as their main mode of transport is still larger than 50pct. The rather central districts have a smaller share of car users and on average a good frequency of public transport. For instance, in Oberzell only 43pct. use the car as their main mode of transport.

The difference between driving the car and cycling is only dependent on the distance from the reference address to the train station and thus inconclusive when comparing the areas. However, it can give some indications on the likelihood of switching from a motorised mode of transport towards a non-motorised one. Generally, larger distances are most likely to be done by car.

6.4 Sustainable Development in Ravensburg

6.4.1 Climate Consensus Ravensburg 2030

"Think Global - Act Local" is the motto of Ravensburg. Accordingly, the climate commission of Ravensburg developed the climate consensus to reach the goals set by the European Commission and its own goals. Focus areas include Mobility, Buildings and Compensation. Moreover, reaching environmental awareness is of great importance. The aim is to become climate neutral until the latest 2040 while having a CO_2 reduction of approx. 47pct until 2025, respectively approx. 74pct. until 2030 and 87pct until 2035.
As the focus of this study is on mobility, the climate consensus will be elaborated on in more detail on mobility. The following sub-targets were set.

- 50pct of all routes should be done by food / cycling until 2030
- Increase of public transport in modal split (currently: 7pct | Target: 14pct until 2030
- More CO_2-neutral vehicles until 2030
- Reduction of cars per person (2017: 625 cars per 1000 inhabitants | Target: 500 cars per 1000 Inhabitants)
- Reduction of passenger-kilometres
- Increase of promotion of bicycle transport from 5€/person to 15€/person to improve cycle highways and infrastructure

In order to reach these targets, the following measures were introduced. The first one refers to parking space management in terms of controlling parking lots and parking fees. The revenue shall be used for improving the public transport services and bicycle and foot transportation. The second measure relates to a decrease in mandatory parking spots. Besides this, more shared spaces and traffic-calmed zones are planned, if legally possible [Stadt Ravensburg, 2019].
Moreover, the Traffic Development Plan was developed which deals with more specific measures targeting a larger area. The main aspects are an express line connecting Baindt and Ravensburg, improvements in the public transport sector, introducing a CO_2-neutral shuttle between Ravensburg station and Marienplatz (city centre) and a flexible on-demand service, a business mobility management and mobility hubs as well as measures related to the cycling and foot transportation [Bernard Gruppe, 2021b].
Bernard Gruppe [2021b] already conducted a detailed mobility analysis, including spatial analysis, workshops and surveys.
The most important results are introduced in the following.

Modal split

In all three categories (Work, Leisure and Shopping) is the car the main mode of transport. The only exception is travelling for educational purposes (See Figure 6.5). This can be explained by the fact, that most people attending education are below the age of 18 and thus not allowed to drive a car. People below 19 are least likely to use the car as their main mode of transport.
With an increasing age (above 65 years), the likelihood of taking the bus increases, and the likelihood of taking the car decreases. Simultaneously, the share of biker users decreases. However, a small increase in e-bikes is recorded (See Appendix A, Figure A.3).
Figure 6.5 illustrates a lower share of car users when travelling to leisure activities or to go shopping. Whereas the percentage of being a passenger increases for leisure and shopping activities, the share of using the train

or bus remains almost the same. The same applies for cycling, with and without a motor. Another difference between work and leisure, respectively shopping is the share of pedestrians.

This may be explained by proximity. Job opportunities tend to be further away and leisure activities, respectively shopping facilitates are mostly chosen based on its vicinity.

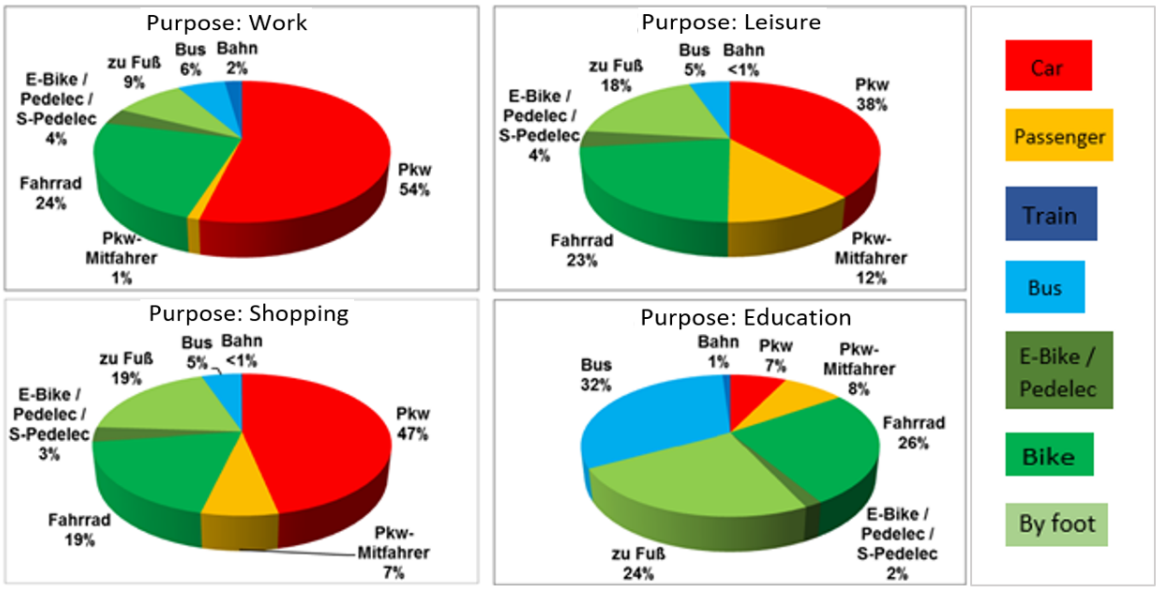

Figure 6.5. Main Mode of transport in Ravensburg, classified by purposes

Citizens participation

For the development of the Traffic Development plan, surveys amongst the citizens were conducted. Accordingly, the main aspects related to public infrastructure include a better public transport schedule, more and better connections, higher frequency, more bus stops as well as general improvements [Bernard Gruppe, 2021b]. Additionally, an increase in safety and attractiveness of the cycling infrastructure is highlighted. More specifically, a large share of the citizens perceives the current cycling infrastructure as insufficient and dangerous, partly caused by car traffic.

Ravensburg, as part of the Traffic Development Plan already aims at improving the public infrastructure and cycling system in a wider area. Additionally, the Climate Consensus for Ravensburg was developed in order to strengthen those systems by setting goals including the reduction of car usage, respectively the usage of CO_2-neutral vehicles as well as promoting non-motorised transport options.
The next section introduces the main findings of the surveys and interviews conducted with citizens of Ravensburg. It mainly focuses on housing preferences or in other words the causes of urban sprawl, as well as reasons for choosing the main mode of transport.

6.5 Main Results of the Survey

In addition to analysing already existing data on the study area, surveys were conducted to get a deeper insight and more topic-related information on residential choices and mobility behaviour. A total of 73 answers was recorded during the data collection process. However, 12 were not completed and thus excluded from further analysis, leading to a final data set of 61 participants.
The focus is on descriptive statistics, namely analysing patterns and behaviour as well as on the comments left by the participants. In the following, the most striking results are summarised.

The data-set consists of 31 females and 30 males, distributed across all age groups. In total, about 50.000 people live in Ravensburg, 50.5 pct female, 49.5 pct. male with an average age of 43.7 years. The majority of the participants are married, followed by being in a relationship (same household). 16 of those surveyed indicated to be single, 1 in a relationship but in a separate household and 3 are widowed. Comparing the sample to the whole population, the average household size of the sample is slightly higher (+0.15). Most of the participants have a high level of education, namely a bachelor's degree or above and have on average a higher level of education than the whole population. Besides this, the sample can be described as environmentally aware as no one indicates to not be environmentally aware. A similar result was found for the variable 'physically active'. Only 6 participants answered to not be physically active.
When comparing the type of residence in relation to the place of residence, more specifically whether they live within 2.5km or further than 2.5km away from the train station, the majority of those living within a radius of 2.5km to the train station are more likely to live in a rented flat. For those living further than 2.5 away from the train station and subsequently the city centre, the distribution is more equally distributed among the different types, whereas the majority live in their own property, either a house or a flat.

In order to assess whether there are any differences between people living close to the inner city and people living further away, 2 groups were formed. The first group consists of those living within a radius of 2.5km of the train station, and the other group consists of people living further than 2.5km away.
Table 6.3 shows the distribution of the main mode of transport in relation to their place of residence (Within or outside 2.5km of the train station). In total 22 people live within 2.5km and 39 live outside 2.5km of the train-station. In order to simplify the comparison, percentages are used. In all four scenarios, the percentage for using the car for commuting is higher for people living outside the range of 2.5km. However, on average more people living close to the train station seem to be more likely to use public transport, bike or walk than people living further away. Even though a small difference can be established when only looking at those numbers, neither significant correlation nor relationship could be found during the statistical analysis.

	Car (petrol, diesel)	**Car (elctronic)**	**Public Transport**	**By Bike**	**By Foot**	**n.a**
Commuting to work						
Within	45	0	9	18	18	9
Outside	64	0	5	13	8	10
Leisure Time						
Within	50	0	5	18	27	0
Outside	64	3	3	21	10	0

Table 6.3 continued from previous page

	Car (petrol, diesel)	Car (elctronic)	Public Transport	By Bike	By Foot	n.a
Shopping						
Within	50	9	0	9	32	0
Outside	92	5	0	3	0	0
Activities - relatives						
Within	32	0	9	9	0	50
Outside	56	5	5	8	5	21

Table 6.3

The overall response related to the main mode of transport was surprising. It does not seem to be of any interest by the sample to use public transport, neither for commuting, leisure time, shopping or other activities. More precisely, only 4 participants use public transport to commute to work, respectively 2 in their leisure time, 4 for activities with relatives and no one for shopping.
As shown in Figure 6.6, the main reasons for not choosing public transport are *Poor connectivity* and *Duration*. As already analysed in the subsection 6.3.1, there are large time differences between taking public transport and the car. This is in line with the participants' answer to use the car as their main mode of transport because of the rapidity and comfortableness.

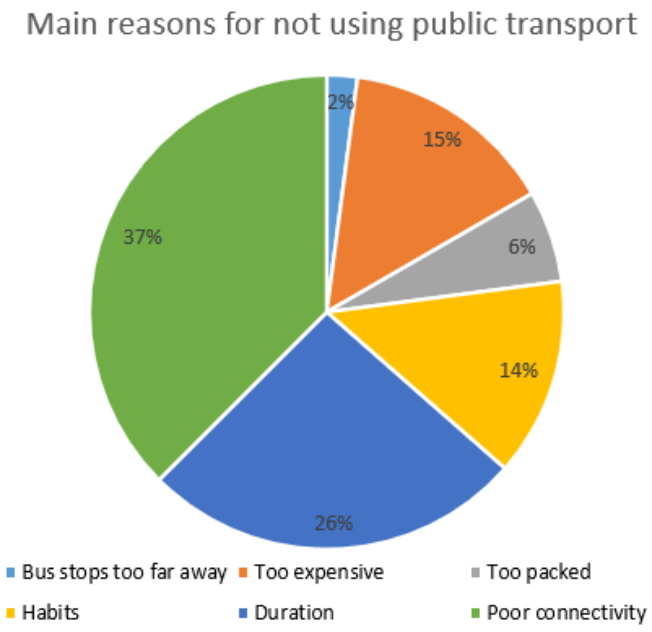

Figure 6.6. Main reasons for not using public transport

When looking at the variable "level of satisfaction: frequency of public transport", the majority of those living in Schmalegg are unsatisfied with it. The same applies for the districts of Torkenweiler, Dürnast and Gornhofen. On the contrary, people living in the district Weststadt and Altstadt are the ones most satisfied with the frequency of public transport. The closer to the city, the more public transport options and thus the more satisfied the people are. The distance to the next bus stop does not seem to be a great problem in the districts. However, if the frequencies and connections are not sufficient, it can be assumed that the distance does not influence the decision-making process.

Additionally, almost half of the participants left comments related to the public transport system and cycle paths. The main ones are summarised in the following Figure 6.7 and divided by residential districts. As already mentioned above, the level of satisfaction differs between the participants and districts. As shown, Gornhofen, Bavendorf, Torkenweiler, Dürnast and Schmalegg seem to have the greatest problems with the overall frequency and connections. Besides this, the ticket prices were criticised and categorised as too expensive.
In terms of the cycling path, the need for continuity and light is highlighted by most of the participants.

Figure 6.7. Recommendations and complaints about public infrastructure and cycle paths, categorised by residential areas (The numbers in brackets relate to the total number of participants in the residential area)

Important factors when choosing a residential area

Even though the majority uses the car as their main mode of transport, good public transport seems to be of great importance when choosing a residential area. On average, the most important variables are shopping facilitates, good car accessibility, costs and good public transport. The distance to the centre does not seem to be too important, which is also closely related to an generally high level of importance for landscape and proximity to nature (See Figure 6.8).

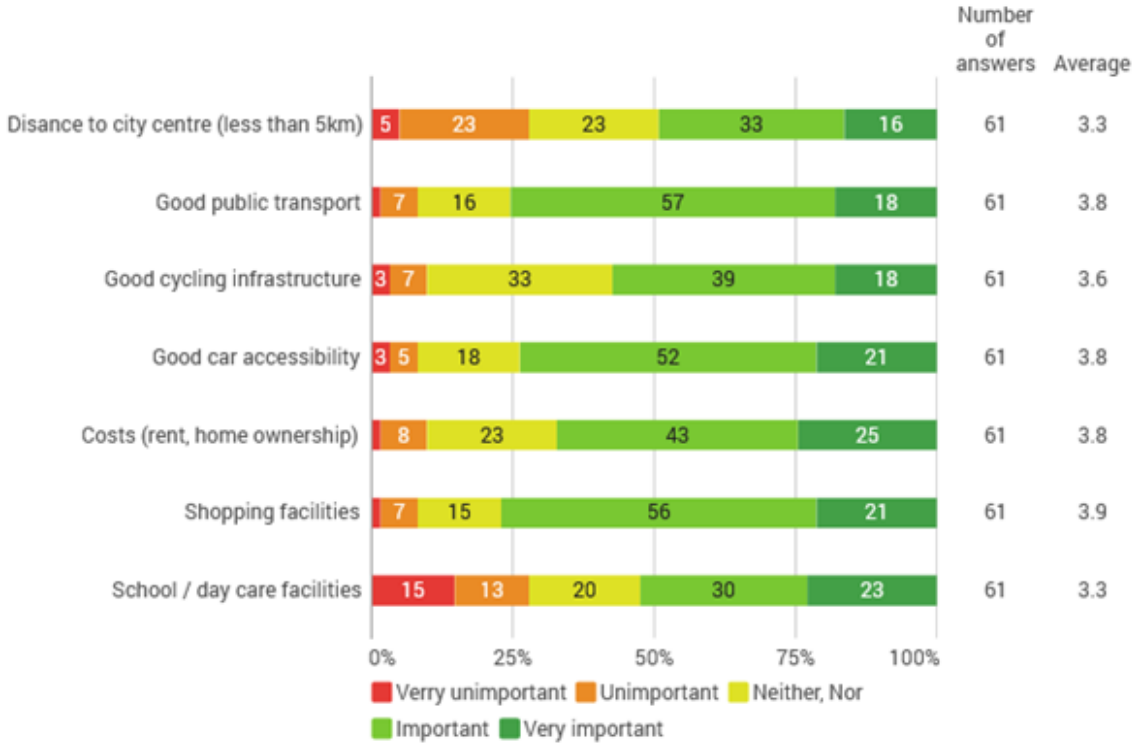

Figure 6.8. Rating of the level of importance of the following variables when choosing a new residential area

Figure 6.9 relates to a more specific question about the most important factors that influenced the decision-making process of relocating to the current residential area. Accordingly, availability, size and nature seem to be of great importance. A similar result was also found during the interviews, which will be introduced in the following section.

When only looking at the figures and results, it seems that most of the variables are very influential when choosing a new residential district. However, when looking at the results of the interviews, it becomes clear that some of those variables are dominant and more or less determine the new residential area. Those variables include availability, size and cheap housing costs. Even though nature and public transport are rated rather high, it does not necessarily influence the decision-making process.

Furthermore, when asked those who moved from the urban to a more rural area, the main reasons were family formation, cheap living costs and nature.

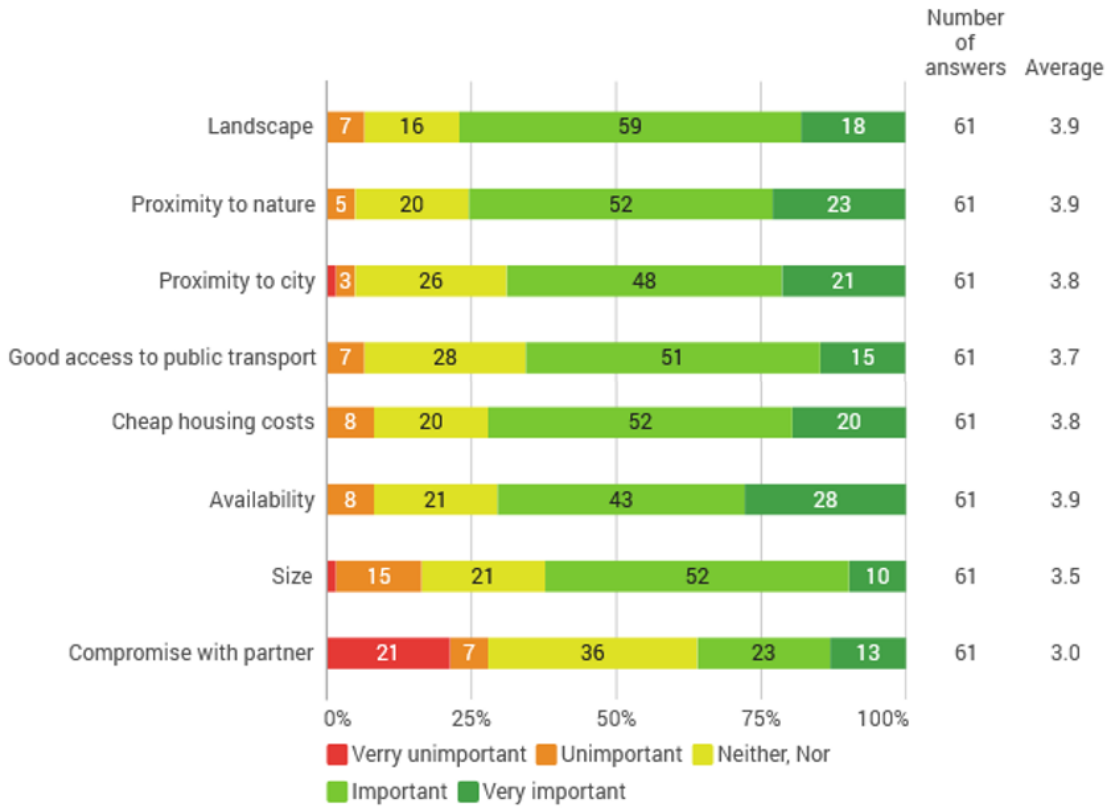

Figure 6.9. Rating of the level of importance of the following variables for choosing current residential area

In order to get a deeper insight into the relocation motives of the participants, everyone could leave a comment with reasons for their specific residential choice. A total of 43 comments were recorded.
Figure 6.10 summarises the results of the open text field categorised by the districts of Ravensburg. The category *price* was mentioned the most often, 20 times in total. Nature on the other hand only 5 times. However, it can be assumed that in those districts that are further away the nature is close. Nevertheless, this was not the primary reason for the relocation choice. Based on the comments, it can be assumed that even a suburb without nature, but with cheap and available housing would have been chosen. The districts Torkenweiler, Bavendorf and Gornhofen seem to be relatively cheap with available housing.
Another important aspect is the proximity to the city. It must be taken into account that Ravensburg is not a very big city and the districts are relatively close to the city centre, but not close enough in order to cycle or have proper public transport. When taking a closer look, the variables 'shopping facilities' and 'good public transport' are dominantly mentioned by participants with children.
Free parking also seems to be important when choosing a new residential area, respectively is perceived as a great advantage.
On the contrary, the ones living in the city centre mention that they do not need a car as everything is in walkable distance, such as public transport, work and shopping facilities.

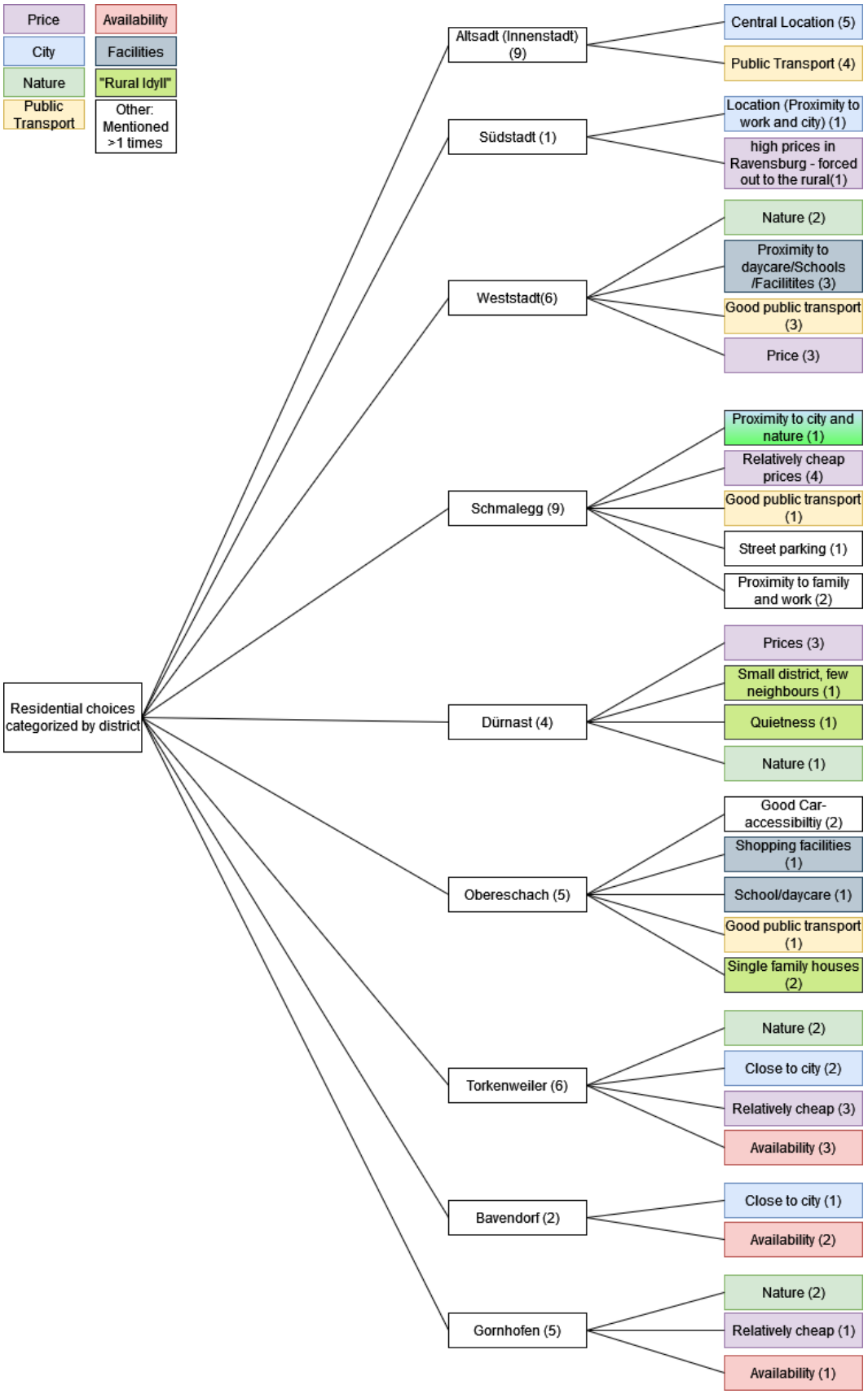

Figure 6.10. Reasons for choosing the residential area (The numbers in brackets relate to the total number of participants in the residential area)

6.6 Main findings of the Interviews

The interviews served as a means to get a deeper understanding of the relocation motives and choices of the main mode of transport. When looking at Figure 6.8 it seems that good public transport, shopping facilities and good car accessibility are important factors when choosing a new residential area. When it comes to actually finding a new residence, factors such as size, availability and housing costs are influential.
In total, 5 interviews of approximately 25 minutes with inhabitants of Ravensburg were conducted. All interviewees were middle-aged women with at least one child. Table 6.4 gives an overview of the main characteristics of the interviewees.

Inter-viewees	Gender/Age	Place of residence	Reason for place	Type	Main mode of transport
I1	Female, 36-50	Taldorf	Could not find anything else Forced to be there	Rural	Car
I2	Female, 36-50	Bavendorf	moved there 20 years ago availability and price	Rural	Car
I3	Female, 51-65	City centre	Homeownership (flat) Moved there 31 years ago, short routes - no car	Urban / City centre	Walking tries to avoid public transport
I4	Female, 36-50	Schmalegg	Home ownership (flat)	Rural	Car
I5	Female, 36-50	Schmalegg	Rented flat	Rural	Car

Table 6.4. Main characteristics of the interviewees

4 out of 5 interviewees use the car as their main mode of transport. Only one person does not own a car and mainly walks, respectively uses public transport if the distance is too far. When asked about their first relocation, all participants answered it was study or/and job-related and subsequently relates to a relocation towards a larger urban area. Interviewees 1, 2, 4 and 5 grew up in a rural area in the state Baden-Württemberg and Interviewee 3 has always lived in an urban area.

Relocation Motives

Figure 6.11 shows the tree code used for the analysis of the interviews concerning the relocation motives and residential choices. The drivers and causes are differentiated in 4 categories, namely pull factors / preferences, push factors, tipping points and life stage. The former two and the latter two are closely related. Not surprisingly, leaving the parental home and starting a new job, respectively education was mentioned for the first relocation. Additional reasons dominantly mentioned include affordability and availability. This has already been found during the analysis of the comments left in the survey. Another aspect is the size of the home, which is also related to different stages in life such as family formation. Even though facilities and location played an important role when choosing a new residence, affordability and availability was primarily influencing the location, at least within the city of Ravensburg.

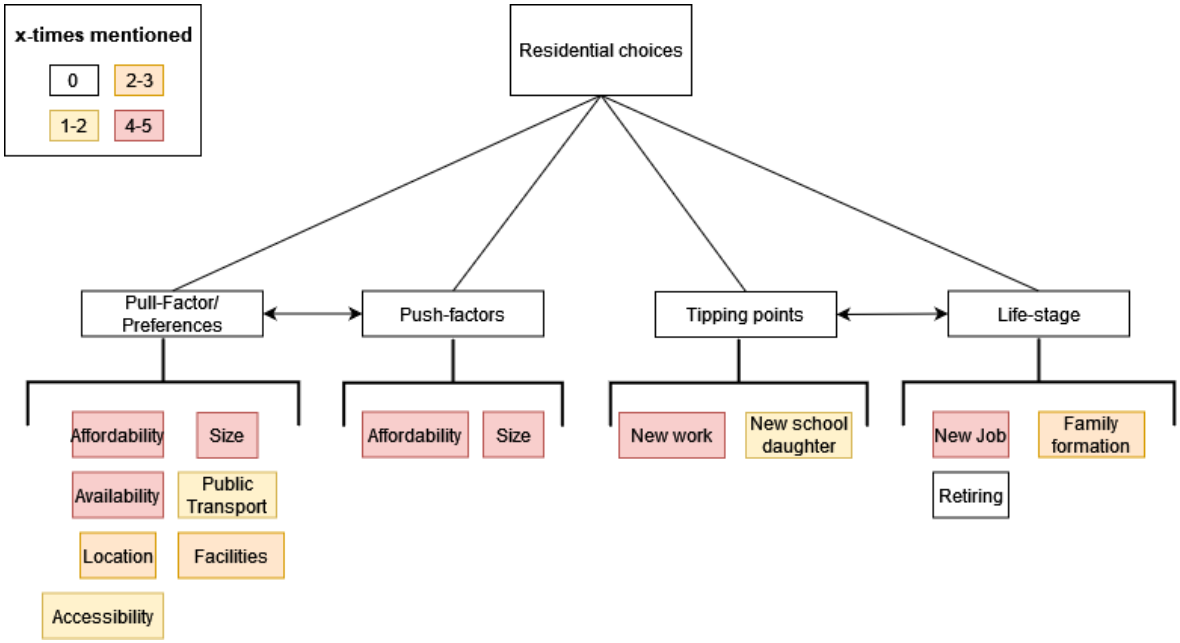

Figure 6.11. Tree Code - Residential Choices

In line with the main reason for the first relocation, I1 moved out of the parental home in order to study and the next relocation was job related. However, it was a decision she made with her former partner - both applied in the same city for a job. After starting to earn money the next step was to purchase a car which I1 never regretted.

I1: "It was such a relief to have an own car"

However, it must also be mentioned that she moved to a place where it is not possible to get around without a car. Especially when she started to work in another city, the car was necessary, but she still uses the bike quite frequently. After splitting up with the previous boyfriend, the next relocation took place, still Ravensburg but closer to the centre where she started to use the bike more often. After living there for 2 years, she moved in with her new boyfriend and got married. Together, they decided to move to a more rural location in Ravensburg (Taldorf) as they planned to start a family together. This was also the main reason for purchasing a second car.
However, after the divorce in 2019, I1 was more or less forced to move again, which she described as very

problematic.

I1: "I did not have any requirements at the end, I was just happy to find a place to stay - the housing situation is catastrophic... very tense in Ravensburg - the municipality must do something"

The current residence was only chosen based on affordability and availability and not based on any residential preferences. Thus, she would like to move, as everything is rather far away. Taking into account her preferences she would love to live close to the city but with nature and great public transport. This is also how she grew up close to Freiburg. A lot of nature, somewhat close to the centre and still functioning public transport. Even though she has been looking for a new residence for the past 3 years, she cannot find anything. Especially the fact that the daughter is about to change school, the need for relocation to an area with better public transport and school buses increased.

A similar path was chosen by Interviewee 2, who relocated for her studies and later for a new job approximately 20km away from Ravensburg. After a while, I2 moved in with a new partner and a few years later they decided to relocate to one of the rural districts in Ravensburg. The main reason were the rural idyll, home ownership and family formation. As already mentioned by I1, the housing situation is very tense, and this was already the case 20 years ago.

I2: "My partner and I always wanted to buy our own house and thus were looking for a building plot - but it was not easy to find anything with a somewhat good infrastructure and affordable back then - we lowered our standards and bought the plot we are now living on"

I2: "We did not think about a lot of things back then - now I do not know if I would make the same decision.. there are no shopping facilitates and the public transport is not well developed [...]. Especially with children, they cannot just go to the supermarket or take the bus to go somewhere independently .. when I grew up it was different [....]. When it was only my husband and I, we just did the grocery shopping on our way home from work once a week but now with children I need to go 3 or 4 times a week [...] Now we do not have the time and energy to look for something better, and we are happy here - great neighbours, friends around the corner - the only problem is the mobility"

I4 has a similar relocation pattern as I2. After relocating a few times for her studies and her first job, she and her former partner moved to a medium-sized city in Bavaria and formed a family. A few years later they broke up and she relocated within the same city. I4 mentioned that

I4: "I always wanted to go back to Ravensburg, my parents are still there and my brother moved away from Ravensburg. I feel responsible to take care of them in the future and want my children to have their grandparents close by".

The tipping point was on the one hand the separation of her partner, but more importantly the fact, that the eldest daughter was about to finish primary school and starting secondary school soon. Considering this she said *I4: "Now or never".* The choice of her current residency is closely related to the availability, as there were not many affordable options, as well as the desire to live in the outskirts, somewhat close to her parents. However it was of importance to have a bus connection, especially for the children.

I4: "I did not want to have the same for my children, I grew up pretty rural and there were no buses going so I could not go independently somewhere [..] Therefore, I do not want the same for my children, it was terrible"

On the contrary, I3 has always lived in urban places and never owned and also does not want a car. Therefore, she prefers to live central, where she can reach everything by foot or public transport. Additionally, she mentioned

I3: "I have always lived in Ravensburg and bought the flat 31 years ago. It was important for me to live in the city, close to day care facilitates and schools for my children". Furthermore, she never thought about leaving her current residency, not when the children moved out and not after retiring. As a very environmentally aware person, she is concerned about the impacts of cars in relation to the emission and noise. Accordingly she mentioned *"The city of Ravensburg should be car-free, if that is not possible, at least free from trucks and there should be a limit of 30km/h"*

I5 grew up in a village and relocated for her studies after finishing high school. After living in the north of Germany for a few years and experiencing some job-related relocation, she went back to where she grew up. After forming a family, another relocation was necessary due to the need for more space. However, as told by I5

I5: "grateful that we eventually found a flat that is large enough - we spent 4.5 years looking for something, it is not easy and yeah.. with time we begun to be less picky"

Furthermore, the inner city was never a topic when discussing the new residential area with her husband. He used to live in the inner city most of his life and has enough. For I5, the inner city was never attractive.

I5: "My children grew up in a rural place and enjoy it - all the green, space and possibilities. I do not think I would do them a favour with moving to the city centre - they do not know it differently. Also to find a large flat in the city would be horrible".

Considering their requirements, the only one left in the end was to find a flat with 3 bedrooms and one office. However, at the end of the interview it becomes very clear that another requirement is the rural.

I5: "I would never give up having the sunrise on the one side, the sunset on the other side, and green everywhere just to have a better public transport system close by"

The surveys, including the comments left by the participants as well as the interviews indicate that there is a great housing problem in Ravensburg. Availability and affordability were the main burdens when it comes to residential choices and relocation decisions. This leads to a conflict of the individual preferences and possibilities. Some of the interviewees could not really choose where to live, but were to some extent forced to relocate to a certain area caused by high prices and a housing shortage, leading to urban sprawl rather than dense settlement patterns.

Main Mode of Transport

Figure 6.12 gives an overview of the adapted tree code, which was used for the analysis of the main mode of transport of the interviewees. Each category, more specifically car, public transport, bike and walking includes sub-categories, namely the main reasons for either choosing or not choosing this specific mode of transport. Whereas 4 out of 5 participants use the car as their main mode of transport, no one uses public transport as their main mode of transport caused by its poor frequency, connection and timing as well as the high ticket prices. When the interviewees talked about cycling infrastructure, they mostly referred to their children and used words such as dangerous, unsafe and weather condition.

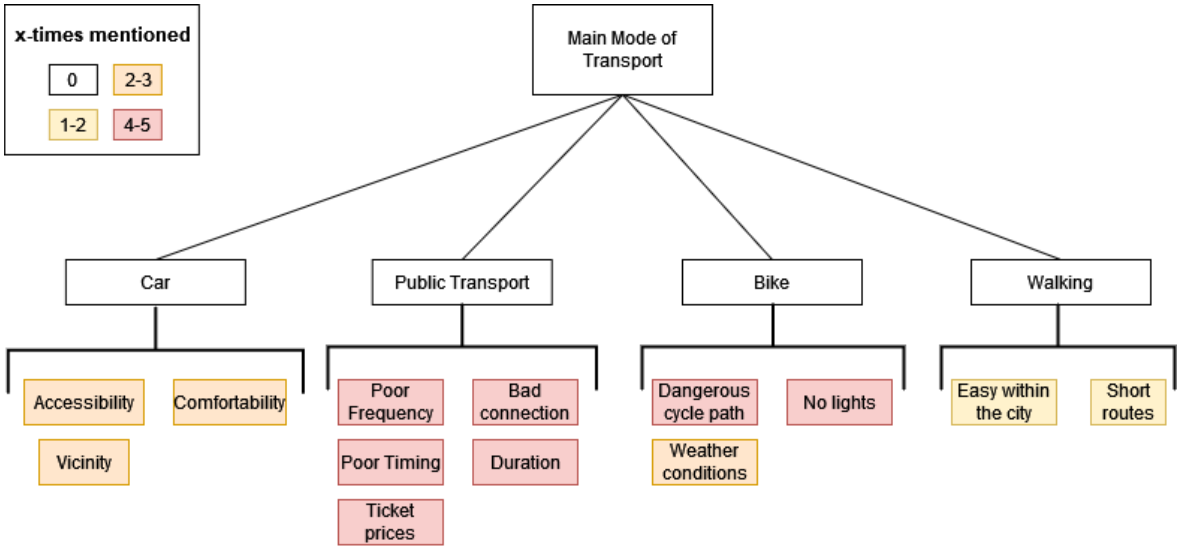

Figure 6.12. Tree code - Main Mode of Transport

Car

Another similarity between all the interviewees is that when growing up, the families owned at least one car. However, the level of awareness of the environmental costs were not that dominant and the public transport system was not developed very well. This is in line with Interviewee 1 who said:

I1: "It was normal to have a car, no-one talked about the environmental impacts, you just used it because it was convenient and everyone did it".

However, it is highly dependent on where you live and whether you can afford having a car. For instance, two of the interviewees bought a car right after starting a new job. One could assume it is highly related to purchasing power, but the underlying reasons differ. Accordingly, I4 mentioned:

I4: "Well, when I lived in Stuttgart, I did not need a car, but now in Ravensburg, where the public transport is terrible, it would not work out without a car, especially not with children"

Especially in larger cities, the need for a car decreases as a result of great public transport systems. This also aligns with I2 stating that if the public transport would be improved, she could imagine only having one family car instead of two. But she would never sell both cars. An important aspect is not only the rural area they are living in but also having a family with children.

I2: "Time is precious, I do not have time to wait for the bus, or if I go grocery shopping for 4 people, I do not want to carry everything around. The same accounts for activities or appointments. We just need to have at least one car in order to make sure to reach all our destinations and appointments"

Another factor worth to be mentioned, which is also related to the relocation towards another area, is the changed behaviour after purchasing a car. The main purchasing reasons were poor public transport, affordability and children. Therefore, not only the mobility behaviour changed, but behaviour in general. Furthermore, parking seems to be of great importance when choosing the car over public transport. As mentioned by I4, free parking and parking close to the workplace were influential factors. This is also in line with I2, stating that if the parking spot close to her workplace would be closed, she might consider taking the bike or public transport.

The interviewees who own a car show a similar pattern. A large purchasing factor was starting a job and the relocation to a more rural area. Additionally, family formation and the related responsibilities seem to be influential.

The public transport system

Besides the high ticket prices and poor connections, I1 highly criticised the school buses from Taldorf to Ravensburg. Her daughters way to school takes about 45 minutes by bus, whereas it only takes about 20 minutes by car. Additionally, there is no bus that arrives on time, she either has to wait 30 minutes or is a couple of minutes late.
Similar events were observed during other interviews. It seems especially problematic in Bavendorf. I2 talks about very poor bus connection for pupils, especially since the bus was being adjusted on the newly electrified train line. Her children have to take an earlier bus in order to be on time. Even though the bus stops at the residential area, her son has to wait in front of the school for 40 minutes, regardless of the weather and temperatures.
Another aspect worth mentioning is that the same problem has been relevant for the past 20 years.

I2: "When we looked at our building plot 20 years ago, public transport was already a problem and widely discussed - I still have some cutouts from the newspaper, but nothing really has changed since then".

This leads to the fact, that I2 drops off and picks up her children all the time, which is a very time and energy-consuming process. For the summer month, the family bought e-bikes allowing them to cycle greater distances and for the children to be more independent. I2 would take the e-bike to go to her workplace, which is located close to the train station. She even rented a bike house but it is too small for her e-bike and thus she cancelled it and would need to park it somewhere outside. Even though the family tries to use alternative and sustainable modes of transport, problems seem to arise everywhere. Furthermore, the interviewee stated that

I2: "For private activities such as appointments, sport activities, the car is indispensable - would be too time-consuming - if it would even be possible to do everything without a car and be on time".

However, taking into account current development in Ravensburg such as the redevelopment of the parking spot close to the train station, I2 might need to take the bus or bike in the future, as there will be no more convenient and close parking spots close to her workplace.

I3 also highlights the problems with the school buses. The connection seems to be acceptable if the school starts on the first hour and stops on the sixth hour, otherwise the children may need to wait up to 45 minutes for the next bus. This leads to school pick-ups and drop offs which could be avoided. Not only buses for school are lacking, but also for activities. For instance, there is not even a bus line going to the indoor swimming pool. However, during the analysis of the public transport system, a regular line from the train station to the pool was established. Thus, it may lack on proper and up-to-date information. When asked whether she could live without a car she answered:

I4: "NOO, Well yes, maybe... If the system would be fully developed I could imagine. But as it is now - It just does not work"

Asking I5 about the public transport system the answer was clear

I5: "What public transport systems? haha, there is no public transport in our residential area".

The next bus stop is about 15 minutes by bike away and subsequently the car is used for everything. The family owns 2 cars, especially for work-related reasons as both parents need the car to go to work. Furthermore, the children are either dropped off at the next bus stop or directly at the school or other facilitates. However, I5 tries to combine and connect all the ways. For instance, the school drop off and pick up is connected with her way to work. She also mentions that there is a bus line in the neighbouring district, but first you need to get there.

I5: "The bus connection and frequency has a lot of potential for improvement, it is not as one would expect it"

When it comes to her decision and preference to live in a rather rural area, she is also aware of the impacts.

I5: "But well.. that is what you get if you want to live rural, you just need to accept it if you want to live rural. You will not find a bus stop right in front of your door, but it would be nice if the buses would be more frequent.. but probably not enough people using it"

Besides this, a great aspect for owning a car are the children in combination with the lacking public transport system. As long as the children are small, it is not an option to sell one car.

I5: "If something happens with the children, it would just take too long to be there".

She also talked about the current ticket prices in form of:

I5: "With the current ticket prices I do not think it is worth for either me or the children to use the bus, as I still need to either drive to the bus stop or to pick up the kids as no more buses are going or they would need to wait a long time"

As already mentioned by the other interviewees the public transport should be improved. Accordingly I3 states that she tries to avoid public transport as much as possible as the connection is bad, the duration is too long and the buses are often crowded.

Overall, a great problem that leads to regular driving are lacking school buses and in general poor connections, especially the timing of different buses.

Cycling infrastructure - hot spots

Even though it only takes about 15 minutes for I1 to cycle to work, she rather takes the car mainly because she does not feel safe on her way. She mentioned the way from Dürnast to Bavendorf, which is completely dark, has many cars and one cannot really see a lot as a cyclist. When looking to the city centre, the cycling path just stops and there is no continuous cycling concept in Ravensburg. So either you are using the pedestrian path or the street. Besides this, I1 elaborates on her changing cycling style, which used to be calm, but nowadays it becomes more and more aggressive as a response to the traffic. Consequently, she tries to avoid cycling to the city centre.

Influences of increasing fuel prices and the Covid-19 outbreak

When considering the increasing prices for petrol and diesel, almost half of the participants of the survey either use the bike or walk more often. 4 people indicated to use public transport more often. However, more than 50pct are highly dependent on the car and still need it on a daily basis. 11 pct (6) started to think about buying an electronic car.
As a response to the increasing energy prices in Germany, the government decided on the relief package which includes the so-called 9€ Ticket allowing citizens to use the bus and train for 90days for 9€ per month starting on the first of June.

I1: "When the government started to discuss the 9€-ticket, I realised that I would take the bus more often.. If it would not be that expensive"

The increasing fuel prices change the behaviour to some extent. For instance I1 tries to use the bike more often or with the introduction of the 9€-ticket the bus.
I5 also mentioned the 9€-ticket and the possibility to use it for her way to work. However she would only use it during the holidays when the children are taken care of. As previously mentioned, the bus connection would not allow her to be at the children's school fast enough in case of an emergency.
But even with the cheap ticket option, using the bus on a frequent basis would not be an options, especially not for grocery shopping or late at night. This means that her behaviour would not really change as a result of the 9€-ticket.

When taking into account the Covid-19 Pandemic, the mobility behaviour has changed to some extent resulting in about 20 pct of those surveyed trying to avoid public transport, 19 pct using the car more often and 30 pct indicated to use the bike more often.
More than half of the ones surveyed answered to generally drive less since the start of the pandemic, partly caused by home-office and the cancellation of activities.

Considering the results of the surveys, especially the comments left and the interviews, it could be assumed that not only the desire for nature but more importantly availability and housing costs promote urban sprawl. Even though, some of the participants rated a close proximity to the city as an important factor when choosing a new residential area, the reality of actually choosing a new home is different. During the decision-making process, other factors (prices, availability, size) become more influential. Mainly during the interviews, family ties and childhood memories were mentioned as pre-conditions for choosing a certain residential area.
As a result of residing further away from the city, energy consumption, land take and car dependency

increases. An expensive and insufficient public transport system and unsafe cycling paths were mentioned as the main reasons for not choosing sustainable modes of transport.

Analysis & Discussion 7

Based on the findings of the previous Chapters, namely Chapter 2 (Problem Analysis), 5 (Literature Review) and 6 (Case Description) especially considering Section 6.5 (Surveys) and 6.6 (Interviews) an analysis and discussion was conducted. The second part of this chapter deals with recommendations addressing the problems mentioned during the surveys and interviews, as well as a feasibility assessment of these recommendations.

Relocation Motives & Living Preferences

Solely looking at the results of the survey, it seems like landscape, location and shopping facilities are of great importance when choosing a new residential area. This impression however is contradicted when taking a closer look at the interviews. Other aspects including affordability, but especially availability are very influential.

The studies conducted by Reckien and Luedeke [2014] and Dähner et al. [2021] only assessed surveys, which may lead to a wrong assumption. As shown in Figure 6.9 and 6.8 the variables rated as important align with the results summarised by Reckien and Luedeke [2014] and Dähner et al. [2021] . However, the concept of the 'rural idyll' and family formation as the main reasons for out-migration are not necessarily the case.

During the interviews and the comments of the survey it became clear that some were forced out of the city centre towards the rural. Even though some of those people would prefer to live closer to the city centre, have more shopping facilities and proper public transport, the high housing prices in the inner city area are not affordable, respectively there is no appropriate housing available. This refers to the so-called displaced ones, who are being forced out by living costs [Mitchell Clare, 2004]. Nevertheless, one could assume that they were only placed in this category after the family formation process and subsequently the changing housing requirements.

Even though one could get the impression that housing availability is an enormous problem in Ravensburg which lead to sub-urbanisation, one must also consider the housing preferences. On the one hand, some of the participants, regardless of during the interviews or the surveys mentioned high living prices, but on the other hand they also mentioned the desire for nature and space. Surprisingly, the word safeness was neither mentioned during any of the interviews nor the comment section.

When looking at the relocation motives from the beginning, a similar pattern could be established. The first relocation took place after graduating from school, either to start university or a job in the city centre and further away from home (See *Careerist* and *consumerist*, Bell et al. [1968]). Later on, most of the interviewees relocated back to Ravensburg to be closer to their families and familiar environment. Especially family formation seemed to be influential in the decision to return *home* to their own childhood memories. As mentioned by Aner [2016] and Stockdale [2014], people undergo different stages in life and correspondingly their housing needs and desires change. During the interviews and surveys people indicated family formation, moving in with the partner and separation as relocation motives, respectively tipping

points.

When looking back at the push-pull model introduced by Lee [1966] (See Figure 5.1, Chapter 5), a large focus is on the individual preferences and desires. Even though it considers obstacles, the ones mentioned the most in relation to the model only account for moving costs, leaving the familiarised environment and stress. Notwithstanding, variables such as family ties [Mincer, 1978] as well as growing up and habits [Aero, 2006] should not be left out when analysing relocation motives. For choosing the place of residence, affordability and availability are also of great importance.

Mobility Behaviour

In the following, the importance of considering the residential area and the choice of transport is discussed. As highlighted by Næss et al. [2019], the mode of transport is dependent on the urban structure. Ravensburg has a functioning public transport system in the inner city, connecting different cities via bus and train. However, the sub-urban and low density districts are lacking a well functioning system, leading to many people using the car.
Those interviewed who own a car have owned a car most of their life. The purchase mostly took place after starting a job and relocating out of the city centre. In that context, the mobility behaviour changed simultaneously with the relocation. This is also in line with Van Wee et al. [2002] stating that people choose their place of residence based on their mobility behaviour and preferences. I3 never owned a car and could not imagine to live outside of walking distance to the city centre and facilities, subsequently choosing the place of residence based on accessibility.
But even if people would prefer taking public transport, respectively non-motorised modes of transport, it is not necessarily possible in the residential area they are living in. For instance, one of the interviewees was to some extent forced out of the city centre and the poor connectivity and frequency does not allow her or her family to properly use sustainable modes of transport. As mentioned in Chapter 5, larger distances generally decrease the likelihood of walking, biking and taking the bus.
In line with Næss et al. [2019] findings, families with children in Ravensburg tend to drive more frequently. On the one hand for school and activity drop-offs and pick-ups, and on the other hand due to strict time management. However, if the public transport system would be well functioning, it could save time in terms of time needed for drop-offs and pick-ups and families with children would not rely that much on the car. This in return would decrease the road-passenger kilometres. As stated by Stanesby et al. [2021] the frequency is one of the main influencing variables for choosing respectively not choosing public transport. Additionally, during the comments and the interviews the high ticket prices, travel time and reliability were mentioned as factors for not using public transport, which also aligns with previous research [Mohamad et al., 2021; Taplin and Sun, 2020; Dell'Olio et al., 2011].

In the survey, the variable *good public transport* was on average rated as important when choosing a new residential area. However, the majority of those surveyed use the car as their main mode of transport. Additionally, no significant relationship could be found between the main mode of transport and the level of importance of a good public transport system. As mentioned previously, public transport and facilities are of importance when choosing a new residential area. However on the one hand the desire for nature and landscape and on the other hand availability and affordability play a crucial role when it comes to the decision-making process. Subsequently, these variables seem to be more influential.
Notwithstanding, a better public transport system, including school buses, better timing with other buses and trains, a higher frequency and lower prices may increase the likelihood of using buses and trains.

According to some of the comments and the interviews, because of the current frequencies, timing and routing of the buses, public transport is not considered an alternative to the car, especially not for families with children and limited time.

To be summarised, a large share of those surveyed and interviewed indicated to have relocated to the outskirts as a consequence of rather high prices close to the city centre and lacking availability. Simultaneously, the car dependency increases due to a poor public transport system in terms of frequencies and high ticket costs in those areas. This is also in line with research conducted by Bart [2010] and Feng and Gauthier [2021].
At this point, it shall be mentioned that this does not apply to everyone. Some consciously decide to live rurally and choose a car as their main mode of transport, partly caused by habits, childhood memories, comfortableness and individual preferences (See Chapter 5 Section 5.1 and Chapter 6, Section 6.5 and 6.6).

7.1 Recommendations

In the following, the main recommendations in order to improve sustainable transport options, including public transport and cycling are listed. Besides this, a small section about housing and sustainable development is included. The recommendations are based on the results of the surveys and the interviews and visualised in Figure 7.1 and Figure 7.2. By addressing the problems and concerns mentioned in Section 6.5 and 6.6, sustainable mobility and settlement can be promoted and enhanced.
In the remaining part of this chapter, the feasibility of these recommendations is assessed.

Cycling Infrastructure

Problems related to the cycling structure were mentioned during the surveys and interviews. Therefore, the following recommendations are made and the locations are visualised in Figure 7.1.
Firstly, to improve the cycling paths in terms of its continuity. Some just end in the middle of nowhere and the ride has to be continued under poor conditions. This leads to the second recommendation, namely addressing the safety concern, especially in Bavendorf. Signs and proper paths might tackle the problem of the dangerous crossing, where car users do not seem to be aware that cyclists go first. Additional paths in need of improvement are located in Obereschach, Gornhofen, Torkenweiler, Weststadt and Weißenau.
Not only continuity and priority rules are problematic, but also the lack of lightning, especially outside of the city centre and on federal roads (For instance: Bavendorf - Dürnast). Thus, proper lightning should be implemented.
Another recommendation is related to proper bike parking at the train station. As the bike boxes are to small, newer and bigger ones are suggested.

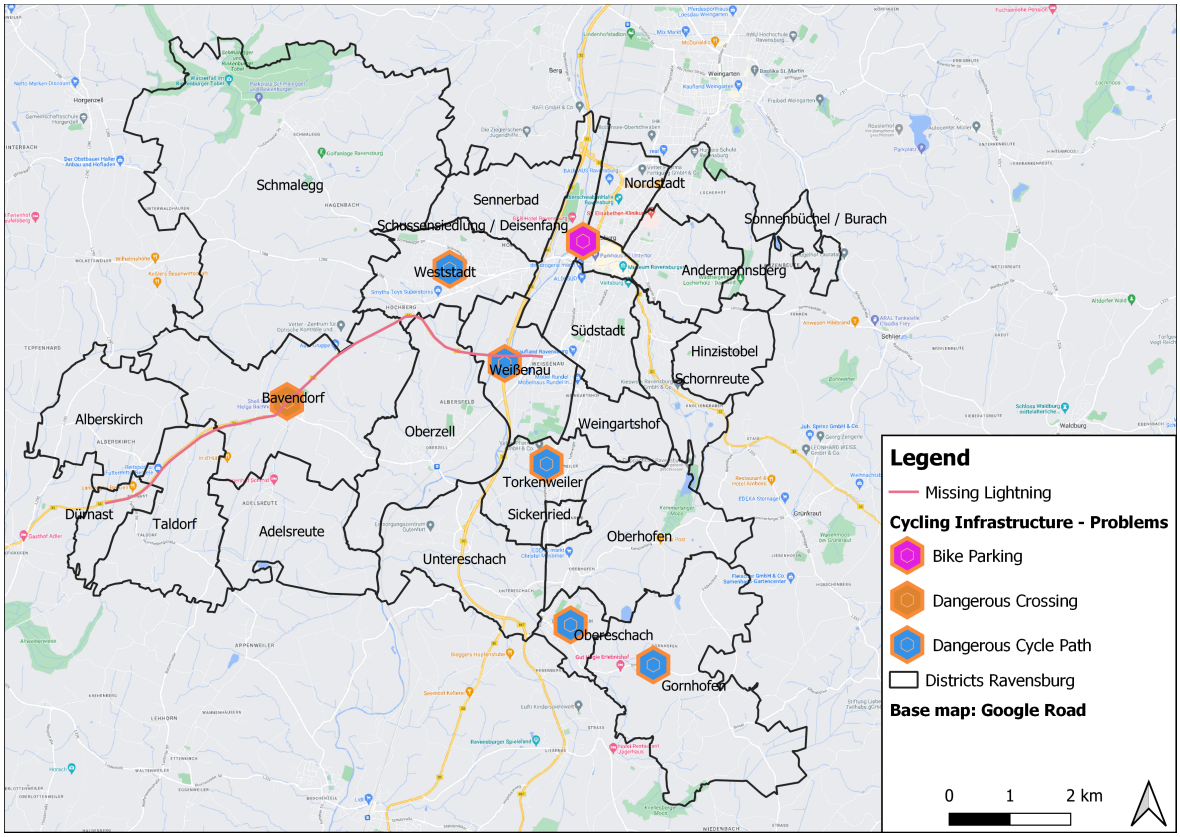

Figure 7.1. Dangerous Cycling Spots - cycling mentioned during the surveys and interviews

Public Transport

As assessed previously, the public transport system is also in need of improvement. The following recommendations shall help to make it more attractive and increase its usage.
First of all, the costs should be lowered allowing everyone to use it regardless of their financial situation. Simultaneously, the frequency must be increased. Hourly does not seem to be sufficient. Besides this, early and late buses are essential for people with early and night shifts.
Another important suggestion is to reassess the timing and connections, especially for school buses that is needed to ensure a functioning public transport system. Thus, the following aspects are suggested for improvement:

- Timing & Connection
  - Better timing with other buses
  - Better timing with school start/end (For instance: Taldorf - Ravensburg school)
  - Better timing for buses and trains (For instance: Torkenweiler)
  - Better connection from Ravensburg City - Allgäu
  - Better connection from Taldorf - Friedrichshafen
    - School bus (For Instance: Schmalegg - Gymnasium Ravensburg - Many children get picked up at Weststadt, Huberesch)
    - Better connection to schools (For instance: Gornhofen -no school bus for children)
  - Bavendorf
    - Better routing and timing of the school bus to Ravensburg / Klösterle / Wilhelmsschule
    - Better connection to gymnastic hall- Weststadt
    - Better connection to schools and facilities in Oberzell
    - Connect Bavendorf to the city bus (respectively connection to Oberzell,which is connected to the city bus)

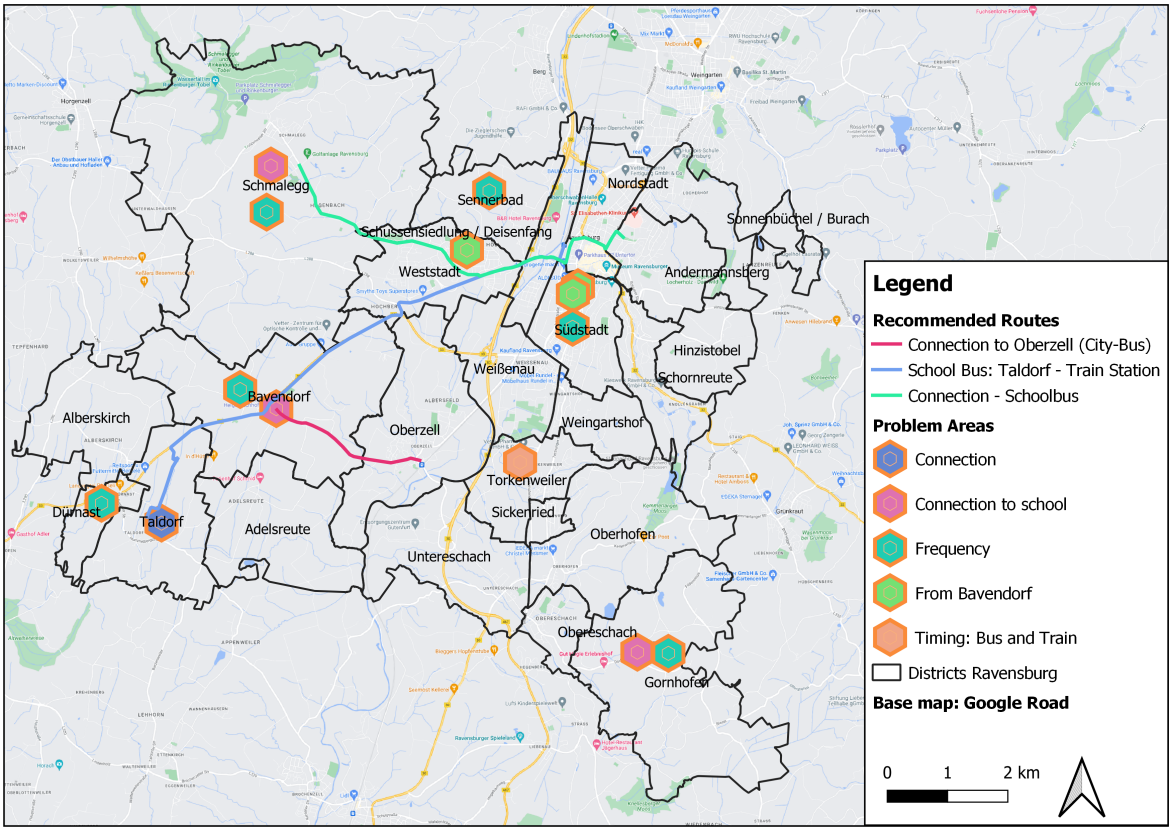

Figure 7.2. Public Transport Improvements based on interviews, surveys and analysis

Housing market

- Affordable housing (Taldorf, Gornhofen, Torkenweiler,Dürnast, Schmalegg)
- Availability within close proximity to the city centre
- Supporting young families

7.2 Feasibility assessment

The feasibility assessment of the previous section is based on documents, Climate Consensus Ravensburg, the Traffic Development Plan as well as on an interview with the urban planner of Ravensburg.

Cycling Infrastructure

The Traffic Development Plan already suggests measures to improve the cycling infrastructure. Accordingly, 81 pct indicated to use the bike more frequently if the cycling infrastructure would be better [Bernard Gruppe, 2021a]. One measure is bike parking in terms of bike houses, which has already been implemented at some places in Ravensburg. However, as mentioned during an interview, the size is not suitable for e-bikes. This problem seems to be known and will be taken care of (I6). The changing preferences and conditions, such as increased size of bikes (e-bikes, cargo bikes) raise new problems and the need for adaptions in the cycling infrastructure. As those changes need time for preparation and implementation, the citizens may get the feeling of not being heard or ignored.
Another problem mentioned quite often are the lightning conditions, especially between Bavendorf and Dürnast, but also in general outside of the city centre. A concept, stating more than 500 measures to improve

the cycling infrastructure already exists for Ravensburg. Worth mentioning, neither the concept nor I6 mentioned, respectively are aware of the lightning problem.
Recently, the local council agreed upon tripling the funding per person and year. However, according to the urban planner (I6), the money should be quintupled in order to efficiently implement all measures. In addition, three more jobs are planned to be created to further analyse, plan and implement the measures. Another aspect is the continuity of bike paths and assessment of dangerous spots, which is already mentioned in the concept. However, the implementation is highly dependent on sufficient funds and may not happen until 2030.

Public Transport

The Traffic Development Plan has already been developed for Ravensburg and was shortly introduced in Chapter 6. In the context of Ravensburg, it aims to increase the frequency, introduce an express bus connecting larger cities as well as Ravensburg station and the university in Weingarten. Besides this, an On-demand bus shall pick up people who do not have access to a bus stop and drop them off at the next station. This may help to enhance the use of public transport. The prices are estimated to be in between the price for a bus ticket and a taxi [Bernard Gruppe, 2021b]. However, people are already complaining about high costs and thus this solution does not seem to be realistic.
Furthermore, ticket prices shall be reduced, which according to Bernard Gruppe [2021b] may lead to a shift from the bike towards the bus rather than shifting people from the car towards the bus. As mentioned during the surveys and interviews, cheaper prices are desired and with the introduction of the 9€ ticket, this problem could be tackled, but only temporary. Another concern mentioned regarding the ticket is that it may raise problems, especially in the touristic area *Lake Constance*, of which Ravensburg is part. Besides this, bikes are allowed on trains, and expected to reach their capacities rather fast, leading to frustration for users, instead of making it more attractive (I6).
Overall, public transport is a complicated and intertwined system and therefore, problems cannot be addressed immediately. The public transport system is mostly regulated by private companies, which have a concessional contract of about 10 years in order to be able to plan it in the most cost-efficient way. The current contract lasts until 2027. In cooperation with the municipalities Weingarten, Baindt, Berg, Baienfurt, Ravensburg plans to develop a non-profit traffic system. This shall ensure a cooperation in terms of costs, improvements, assessments of frequencies, new stops and lines (I6).
This is a very complicated and time consuming process. Even though the current system is still in place for 5 more years, the new one is already in the development phase. As a consequence, people may feel like nothing is changing and it is only talked about.
In the best-case scenario, more people would use public transport, simultaneously leading to better frequencies, timings and connections. By implementing the measures discussed in the Traffic Development Plan, the motorised-individual-transport could be decreased by 6pct (From 49pct to 43pct) [Bernard Gruppe, 2021b].
Notwithstanding, it is of great importance to properly assess the desired connections and frequencies. One example is the right timing for buses and trains, but more urgently have the buses run in line with school start, respectively ends.

According to the study conducted by Bernard Gruppe [2021a], by implementing all the measures and subsequently reducing the motorised-private transport by 4pct until 2030, a reduction of CO_2 emissions of up to 24 pct could be recorded. It must be mentioned that the shift towards more e-cars is included in the computation/calculation as well as that the study refers to a larger area and not only to Ravensburg.

Housing

Solely looking at the property price development within the previous years, the chance of offering affordable living seems rather small. According to the real-estate web-page *ImmoScout24*, the prices per m^2 increased up to 35pct from 2018 to 2022. Not only home-ownership got more expensive but also renting a flat or a house. Those prices increased on average by 18pct from 2018 to 2022.
As a response to the increasing housing prices, Ravensburg in cooperation with Weingarten came up with the initiative *Bündnis für bezahlbaren Wohnraum* (*translation: Alliance for affordable housing*) in 2016. Correspondingly, if a new building right is given out to investors, they are obliged to rent out 20 pct. of the newly developed flats for the cheapest economically feasible renting cost for at least 15 years (I6).
At the moment, 600 new flats shall be developed in the east part of the city, possibly tackling the problem of affordability and availability (I6). Still, this will not be finalised in the close future and thus only addresses the problem in the long-term. However, by developing new residential areas close to the city centre with good access to public transport contributes towards sustainable settlement development and mobility. Another aspect which has been increasing in importance during the past years is green infrastructure. By implementing for instance green roofs and facades, the feeling of having nature close by can potentially be created and thus avoiding further sprawl of people desiring nature.
Nevertheless, traditional development areas will still be existent. But certain criteria shall ensure that families with children as well as socially engaged people have better chances to buy property (I6).

Policy Recommendations

Based on this research, especially taking into consideration the results of the surveys, interviews and the feasibility assessment, the following policy recommendations emerged to promote sustainable development and transport options.
With regard to urban settlements, fostering denser development in urban areas and restrict new residential areas to already existing residential areas with proper access to public transport. Incentives, especially for young families with children may help tackle the problem of further sub-urbanisation and of being forced out of the urban area.
Simultaneously, the public transport system should be improved in those areas. A special focus should be on the affordability of using public transport. The so-called 9€ ticket can already be seen as a good starting point. However, it is restricted to only 3 months. Therefore, a long-term solution is proposed. Additionally, incentives for public transport could be paid and higher taxes for a second car could be levied instead of supporting and paying a commuting allowance.
With regard to the area of interest, proper and continuous bike paths with proper lighting as a means to promote cycling should be implemented and paid for by the local or state government, respectively funding.
Another aspect worth mentioning is to raise awareness of the external costs of urban sprawl. On the one hand on higher land take and energy consumption for single-family houses, increased car dependency and subsequently emissions. And on the other hand to raise awareness to sustainable modes of transport.

By purposely addressing the underlying reasons of urban sprawl and changing policies accordingly, it can be assumed that urban sprawl could potentially be hindered, or at least its impacts in terms of mobility choices. Moreover, generally decreasing the amount of cars leads to the need for fewer parking spots, hence leaving space for green infrastructure and naturalisation of sealed surfaces, aligning with SDG 15 and the no net land take by 2050 initiative, which are both aiming at preserving land. With regard to SDG 11 aiming at decreasing the total greenhouse gas emissions per year, fewer person-km are benefiting. However, this may only happen after the achievement of SDG 11: Sustainable Cities and Communities, more specifically target 11.2 - the provision of affordable, sufficient and sustainable public transport options.
By changing current patterns, tremendous consequences could potentially be avoided. Parking spots could be transformed into either residential areas addressing the problems of affordability and availability or into green areas making cities more sustainable.

Conclusion 8

The environment is threatened by anthropogenic activity through environmental degradation and thus preventing soil from performing its essential functions. Moreover, the loss of carbon-capturing storage as well as higher energy consumption and subsequently emissions has been recorded. [NABU, 2019; European Commission, 2016; Feng and Gauthier, 2021; Norman et al., 2006; Bart, 2010]. The European Commission [2016] initiated the no net land take by 2050 and the United Nations [2017] the SDGs in order to promote sustainable development, addressing climate change challenges. One unfavourable development for the achievement of these goals is urban sprawl. The external costs include increased land take for single-family houses and infrastructure, car dependency as well as an on average higher energy consumption and emission of carbon dioxide.

Therefore, this research aimed at getting down to the essence of the drivers and underlying reasons causing urban sprawl. In that context, the first sub-question:

> *"How can the drivers and motives leading to urban sprawl be understood on the macro, meso and micro level?"*

was formulated. Literature and documents served as a means to get a deeper understanding of the phenomenon on the macro and meso level. The results of the literature review show that economic growth, purchasing power, urban planning legislation, national policies and the emergence of information and communications technologies set the framework conditions for urban sprawl. In order to get an understanding on the micro level, previous studies on the topic were reviewed. Based on that, surveys and interviews were conducted which were in line with the literature. Accordingly, the main drivers can be on the one hand summarised as individual preferences, changes in life and life stages and on the other hand affordability and availability.

This knowledge and understanding was used as the basis for answering the second sub-question:

> *"How can the impacts of urban sprawl be addressed in terms of sustainable mobility and urban settlement?".*

In addition to relocation motives, mobility choices were assessed. Worth mentioning is that mobility choices seem to be influenced by urban structures. Low-density areas often have a poor public transport system and higher car dependencies. Other factors include high ticket costs, poor frequencies and poor connectivity as well as individual characteristics.

The two sub-questions, including the spatial analysis, review of literature and documents, surveys and interviews lead to the answer of the main research:

To what extent does urban sprawl exacerbate climate change challenges and how can a more sustainable development in terms of land take and mobility be achieved (by looking at the city of Ravensburg)?

To be concluded, the impacts of urban sprawl are tremendous. This is not only caused by higher land take, but also increased energy consumption by single-family houses and higher car dependencies. This development is contradictory to the goals and measures of the United Nations and the European Commission, aiming at reducing the net land take and promoting sustainability. By combining the main findings of this study, a more sustainable settlement and mobility can be achieved by implementing new planning policies, improving and promoting the public transport system as well as raising awareness.

By elaborating on urban sprawls adverse influence on climate change, its underlying reasons and motives as well as on mobility choices, this research shall demonstrate the urgent need for change and point out problems in planning and national policies. Overall, urban sprawl decelerates the achievement of the no net land take by 2050 initiative and the SDGs creating a challenge for sustainable urban planning.

Strength and Weaknesses

A few strength and weaknesses of this study should be acknowledged. By reflecting on the data collection and number of surveys, a rather small returning rate of 5.8pct. (61 cases) was recorded. However, more than half of the participants left valuable comments related to housing- and mobility choices. Nevertheless, during the statistical analysis, no significant results could be found and thus excluded from further analysis. The small sample size could be compensated with 5 interviews, respectively 6 interviews when counting the urban planner.
Those who participated in the interviews seemed rather unhappy with the housing situation and the public transport system. On one hand, it could be seen as a skewed result, but on the other hand as a great strength in terms of improvements. Those participants are aware of the problems in Ravensburg and know what needs be changed, respectively improved.

Recommendations for further research

This study offers insights into the process of relocation decisions, housing preferences and motives for choosing modes of transport. Further research should be conducted in all other districts of Ravensburg, as well as on a wider scale. Additionally, a new study with a larger sample size to be able to perform analytical statistics is recommended. The questionnaire could be slightly adapted and re-used (See Appendix B).
In addition, a more in detail spatial analysis of the public transport system in relation to the timing of schools should be done prior the development of the new system in 2027. Getting down to the essence of things, reflecting on the current system in great detail and analyse problems can effectively help for further developments and planning.

Bibliography

Aalborg University, **2022**. Aalborg University. *Aalborg University University Library*. https://www.en.aub.aau.dk/, 2022. Downloaded: 21-05-2021.

AdminStat, **n.d.** AdminStat. *Karten, Analysen und Statistiken zur ansässigen Bevölkerung*. https://ugeo.urbistat.com/AdminStat/de/de/demografia/dati-sintesi/ravensburg%2c-stadt/20177009/4t, n.d. Accessed: 23-02-2022.

Aero, **2006**. Thorkild Aero. *Residential Choice from a Lifestyle Perspective*. Housing, Theory and Society, 23(2), 109–130, 2006.

Allekotte et al., **2020**. Michel Allekotte, Fabian Bergk, Kirsten Biemann, Carolin Deregowski, Wolfram Knörr, Hans-Jörg Althaus, Daniel Sutter and Thomas Bergmann. *Ökologische Bewertung von Verkehrsarten. Abschlussbericht.* 2020.

Aner, **2016**. Louise G Aner. *Dwelling habitus and urban out-migration in Denmark*. European urban and regional studies, 23(4), 662–676, 2016.

Antipova, **2010**. Anzhelika Antipova. *Land use, individual attributes, and travel behavior in Baton Rouge, Louisiana*. 2010.

Barbosa et al., **2017**. Ana Barbosa, Sara Vallecillo, Claudia Baranzelli, Chris Jacobs-Crisioni, Filipe Batista e Silva, Carolina Perpiña-Castillo, Carlo Lavalle and Joachim Maes. *Modelling built-up land take in Europe to 2020: An assessment of the Resource Efficiency Roadmap measure on land*. Journal of Environmental Planning and Management, 60(8), 1439–1463, 2017.

Bart, **2010**. István László Bart. *Urban sprawl and climate change: A statistical exploration of cause and effect, with policy options for the EU*. Land use policy, 27(2), 283–292, 2010.

Batty et al., **2003**. Michael Batty, Elena Besussi and Nancy Chin. *Traffic, urban growth and suburban sprawl*. 2003.

Bell et al., **1968**. Wendell Bell et al. *The city, the suburb, and a theory of social choice*. The new urbanization, pages 132–168, 1968.

Bernard Gruppe, **2021a**. Bernard Gruppe. *Gemeindeverband Mittleres Schussental, Radverkehrskonzept*, 2021a.

Bernard Gruppe, **2021b**. Bernard Gruppe. *Gemeindeverband Mittleres Schussental, Integrierter Verkehrsentwicklungsplan*, 2021b.

bitkom, **2021**. bitkom. *Homeoffice statt Büro: Jeder Fünfte würde umziehen*. https://www.bitkom-research.de/de/pressemitteilung/homeoffice-statt-buero-jeder-fuenfte-wuerde-umziehen, 2021. Downloadet: 08-03-2022.

BMVI, **2022**. BMVI. *Fahrzeugbestand*. `https://www.bmvi.de/SharedDocs/DE/Artikel/G/fahrzeugbestand.html`, 2022. Downloadet: 11-03-2022.

Bodensee-Oberschwaben Verkehrsbund GmbH, **2022**. Bodensee-Oberschwaben Verkehrsbund GmbH. *Fahrplanauskunft*. `https://www.bodo.de/`, 2022. Downloaded: 21-05-2021.

Brown and Moore, **1970**. Lawrence A Brown and Eric G Moore. *The intra-urban migration process: a perspective*. Geografiska Annaler: Series B, Human Geography, 52(1), 1–13, 1970.

Bryman, **2004**. Alan Bryman. *Triangulation and measurement*. Retrieved from Department of Social Sciences, Loughborough University, Loughborough, Leicestershire: www. referenceworld. com/sage/socialscience/triangulation. pdf, 2004.

Bundesamt, **1982**. Statistisches Bundesamt. *Historisches Gemeindeverzeichnis für die Bundesrepublik Deutschland. Namens-, Grenz- und Schlüsselnummernänderungen bei Gemeinden, Kreisen und Regierungsbezirken*. ISBN 3-17-003263-1. W. Kohlhammer, Stuttgart/Mainz, 1982.

Christaller, **1933**. W. Christaller. *Die Zentralen Orte in Süddeutsch- land*. Wissenschaftliche Buchgesellschaft, 1933.

Christiansen and Loftsgarden, **2011**. Petter Christiansen and Tanja Loftsgarden. *Drivers behind urban sprawl in Europe*. TØI report, 1136, 2011, 2011.

Clifford et al., **2016**. Nicholas Clifford, Meghan Cope, Thomas Gillespie and Shaun French. *Key methods in geography*. Sage, 2016.

Couch et al., **2007**. Chris Couch, Lila Leontidou and Karl-Olov Arnstberg. *Introduction: Definitions, theories and methods of comparative analysis*. Urban Sprawl in Europe: Landscapes, Land-Use Change & Policy, pages 1–38, 2007.

Dell'Olio et al., **2011**. Luigi Dell'Olio, Angel Ibeas and Patricia Cecin. *The quality of service desired by public transport users*. Transport Policy, 18(1), 217–227, 2011.

Der Spiegel, **2014**. Der Spiegel. *In Deutschland gibt es immer mehr Pendler*. `https://www.spiegel.de/karriere/pendeln-in-deutschland-nehmen-immer-mehr-menschen-lange-wege-zum-arbeitsplatz-in-kauf-a-08` 2014. Downloadet: 23-05-2022.

Dähner et al., **2021**. Susanne Dähner, Lena Reibstein, Julia Amberger, Sabine Sütterlin, Manuel Slupina and Catherina Hinz. *Digital aufs Land*. 2021.

EEA, **2019**. EEA. *Land take in Europe*. `https://www.eea.europa.eu/data-and-maps/indicators/land-take-3`, 2019. Downloadet: 11-03-2022.

EEA, **2012**. EEA. *Trees help tackle climate change*. `https://www.eea.europa.eu/articles/forests-health-and-climate-change/key-facts/trees-help-tackle-climate-change`, 2012. Downloadet: 11-03-2022.

Engebretsen et al., 2018. Øystein Engebretsen, Petter Næss and Arvid Strand. *Residential location, workplace location and car driving in four Norwegian cities*. European Planning Studies, 26(10), 2036–2057, 2018.

European Commission, 2016. European Commission. *FUTURE BRIEF: No net land take by 2050?* `http://ec.europa.eu/environment/integration/research/newsalert/pdf/no_net_land_take_by_2050_FB14_en.pdfl`, 2016. Downloadet: 23-02-2022.

FBC, 2021. FBC. *Baugesetzbuch*. ISBN: 978-3-406-77980-0, Paperback. Beck-Texte im dtv, edition 52. edition, 2021.

Feng and Gauthier, 2021. Qiu Feng and Pierre Gauthier. *Untangling Urban Sprawl and Climate Change: A Review of the Literature on Physical Planning and Transportation Drivers*. Atmosphere, 12 (5), 547, 2021.

Galster et al., 2001. George Galster, Royce Hanson, Michael R Ratcliffe, Harold Wolman, Stephen Coleman and Jason Freihage. *Wrestling sprawl to the ground: defining and measuring an elusive concept*. Housing policy debate, 12(4), 681–717, 2001.

Glaeser and Kahn, 2010. Edward L Glaeser and Matthew E Kahn. *The greenness of cities: Carbon dioxide emissions and urban development*. Journal of urban economics, 67(3), 404–418, 2010.

Google, 2021. Google. *Google Scholar*. `https://scholar.google.fr/`, 2021. Downloaded: 21-05-2022.

Gratton and Jones, 2010. Chris Gratton and Ian Jones. *Research methods for sports studies*. Hardback. Routledge, 2 edition, 2010.

Hay, 2016. Iain Hay. *3 On Being Ethicalin Geographical Research*. Key methods in geography, page 30, 2016.

IBM Corp. IBM Corp. *IBM SPSS Statistics for Windows*. URL `https://hadoop.apache.org`.

Jaeger et al., 2010. Jochen AG Jaeger, Rene Bertiller, Christian Schwick and Felix Kienast. *Suitability criteria for measures of urban sprawl*. Ecological indicators, 10(2), 397–406, 2010.

Jetzkowitz et al., 2007. Jens Jetzkowitz, Jörg Schneider and Stefan Brunzel. *Suburbanisation, mobility and the 'good life in the country': a lifestyle approach to the sociology of urban sprawl in Germany*. Sociologia Ruralis, 47(2), 148–171, 2007.

Khalid and Urbański, 2021. Bilal Khalid and Mariusz Urbański. *APPROACHES TO UNDERSTANDING MIGRATION: A MULT-COUNTRY ANALYSIS OF THE PUSH AND PULL MIGRATION TREND*. Economics & Sociology, 14(4), 242–267, 2021.

Krishnakumar and Indumathi, 2014. P Krishnakumar and T Indumathi. *PULL AND PUSH FACTORS OF MIGRATION*. Global Management Review, 8(4), 2014.

Lee, 1966. Everett S. Lee. *A Theory of Migration*. Demography, 3(1), 47–57, 1966. ISSN 00703370, 15337790. URL `http://www.jstor.org/stable/2060063`.

leobw, **n.d.** leobw. *Ortsgeschichte*. https://www.leo-bw.de/detail-gis/-/Detail/details/ORT/labw_ortslexikon/20120/Ravensburg, n.d. Accessed: 07-03-2022.

McLafferty et al., **2010**. Sarah McLafferty, Nicholas Clifford, Shaun French and Gill Valentine. *Conducting questionnaire surveys*. Sage Publications Ltd, 2 edition, 2010. ISBN 9781412935098.

Mincer, **1978**. Jacob Mincer. *Family migration decisions*. Journal of political Economy, 86(5), 749–773, 1978.

Mitchell Clare, **2004**. JA Mitchell Clare. *Making sense of counterurbanisation*. Journal of Rural Studies, 20(1), 15–34, 2004.

Diana Mohamad, Ahmad Hilmy Abdul Hamid et al., *2021*. Diana Mohamad, Ahmad Hilmy Abdul Hamid et al. Acceptable walking distance accessible to the nearest bus stop considering the service coverage. In *2021 International Congress of Advanced Technology and Engineering (ICOTEN)*, pages 1–7. IEEE, 2021.

NABU, **2019**. NABU. *Nachhaltige Siedlungsentwicklung Das NABU-Grundsatzprogramm zum Planen und Bauen in Deutschland*. https://www.nabu.de/umwelt-und-ressourcen/bauen/hintergrund/27607.html, 2019. Downloadet: 23-02-2022.

Næss et al., **2019**. Petter Næss, Arvid Strand, Fitwi Wolday and Harpa Stefansdottir. *Residential location, commuting and non-work travel in two urban areas of different size and with different center structures*. Progress in Planning, 128, 1–36, 2019.

Nahverkehrsgesellschaft - Baden-Württemberg, **2022**. Nahverkehrsgesellschaft - Baden-Württemberg. *Fahrplandaten nach Gebieten*. https://www.nvbw.de/open-data/fahrplandaten/fahrplandaten-nach-gebieten, 2022. Downloaded: 21-05-2021.

Norman et al., **2006**. Jonathan Norman, Heather L MacLean and Christopher A Kennedy. *Comparing high and low residential density: life-cycle analysis of energy use and greenhouse gas emissions*. Journal of urban planning and development, 132(1), 10–21, 2006.

Obikwelu et al., **2017**. Faith E Obikwelu, Koichi Ikegami and Tadasu Tsuruta. *Factors of urban-rural migration and socio-economic condition of I-turn migrants in rural Japan*. Journal of Asian Rural Studies, 1(1), 70–80, 2017.

Pitt, **2013**. Damian Pitt. *Assessing energy use and greenhouse gas emission savings from compact housing: a small-town case study*. Local environment, 18(8), 904–920, 2013.

QGIS Development Team, **2022**. QGIS Development Team. *QGIS Geographic Information System*. QGIS Association, 2022. URL https://www.qgis.org.

Reckien and Luedeke, **2014**. Diana Reckien and Matthias KB Luedeke. *The social dynamics of suburbanization: Insights from a qualitative model*. Environment and Planning A, 46(4), 980–1000, 2014.

Robson, **1975**. Brian Robson. *Urban social areas*. Oxford university press, 1975.

Sarker et al., 2019. Rumana Islam Sarker, Markus Mailer and Sujit Kumar Sikder. *Walking to a public transport station: empirical evidence on willingness and acceptance in Munich, Germany*. Smart and Sustainable Built Environment, 2019.

Scheiner, 2006. Joachim Scheiner. *Housing mobility and travel behaviour: A process-oriented approach to spatial mobility: Evidence from a new research field in Germany*. Journal of transport geography, 14(4), 287–298, 2006.

Silva et al., 2014. Cecília Silva, José Pedro Reis and Paulo Pinho. *How urban structure constrains sustainable mobility choices: comparison of Copenhagen and Oporto*. Environment and planning B: Planning and design, 41(2), 211–228, 2014.

Stadt Ravensburg, 2019. Stadt Ravensburg. *Ergebnisbericht der Klimakommission Ravensburg*, 2019.

Stanesby et al., 2021. Oliver Stanesby, Megan Morse, Lexie Magill, Kylie Ball, Leigh Blizzard, Siobhan Harpur, Kim Jose, Dion Lester, Elaine Marshall, Andrew J Palmer et al. *Characteristics associated with willingness to walk further than necessary to the bus stop: Insights for public transport-related physical activity*. Journal of Transport & Health, 22, 101139, 2021.

Statista, 2021. Statista. *Carbon footprint of selected modes of transportation in the United Kingdom in 2021*. `https://www.statista.com/statistics/1233337/carbon-footprint-of-travel-per-kilometer-by-mode-of-transport-uk/`, 2021. Downloadet: 11-03-2022.

Stockdale, 2014. Aileen Stockdale. *Unravellingsgration decision-making process: English early retirees moving to rural mid-Wales*. Journal of Rural Studies, 34, 161–171, 2014.

Taplin and Sun, 2020. John HE Taplin and Yuchao Sun. *Optimizing bus stop locations for walking access: Stops-first design of a feeder route to enhance a residential plan*. Environment and Planning B: Urban Analytics and City Science, 47(7), 1237–1259, 2020.

The Dutch Research Council, 2018. The Dutch Research Council. *Netherlands Code of Conduct for Research Integrity*. `https://www.nwo.nl/en/netherlands-code-conduct-research-integrity`, 2018. Downloadet: 07-10-2021.

United Nations, 2017. United Nations. *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development*. `https://unstats.un.org/sdgs/indicators/indicators-list/`, 2017. Accessed: 21-04-2022.

United Nations, 2018. United Nations. *World Urbanization Prospects*. `https://population.un.org/wup/Maps/`, 2018. Accessed: 16-10-2020.

Van Wee et al., 2002. Bert Van Wee, Hans Holwerda and Rick Van Baren. *Preferences for modes, residential location and travel behaviour: the relevance for land-use impacts on mobility*. European Journal of Transport and Infrastructure Research, 2(4), 2002.

Wirtschaftsministerium Baden-Württemberg, 2002. Wirtschaftsministerium Baden-Württemberg. *Landesentwicklungsprogramm*. `https://mlw.baden-wuerttemberg.de/de/service/publikation/did/landesentwicklungsplan-1/`, 2002.

Julian Wolpert, 1965. Julian Wolpert. Behavioral aspects of the decision to migrate. In *Papers of the Regional Science Association*, volume 15, pages 159–169. Springer, 1965.

Zhao et al., 2003. Fang Zhao, Lee-Fang Chow, Min-Tang Li, Ike Ubaka and Albert Gan. *Forecasting transit walk accessibility: Regression model alternative to buffer method*. Transportation Research Record, 1835(1), 34–41, 2003.

Appendix A: Case Description

A

A.1 Districts of Ravensburg

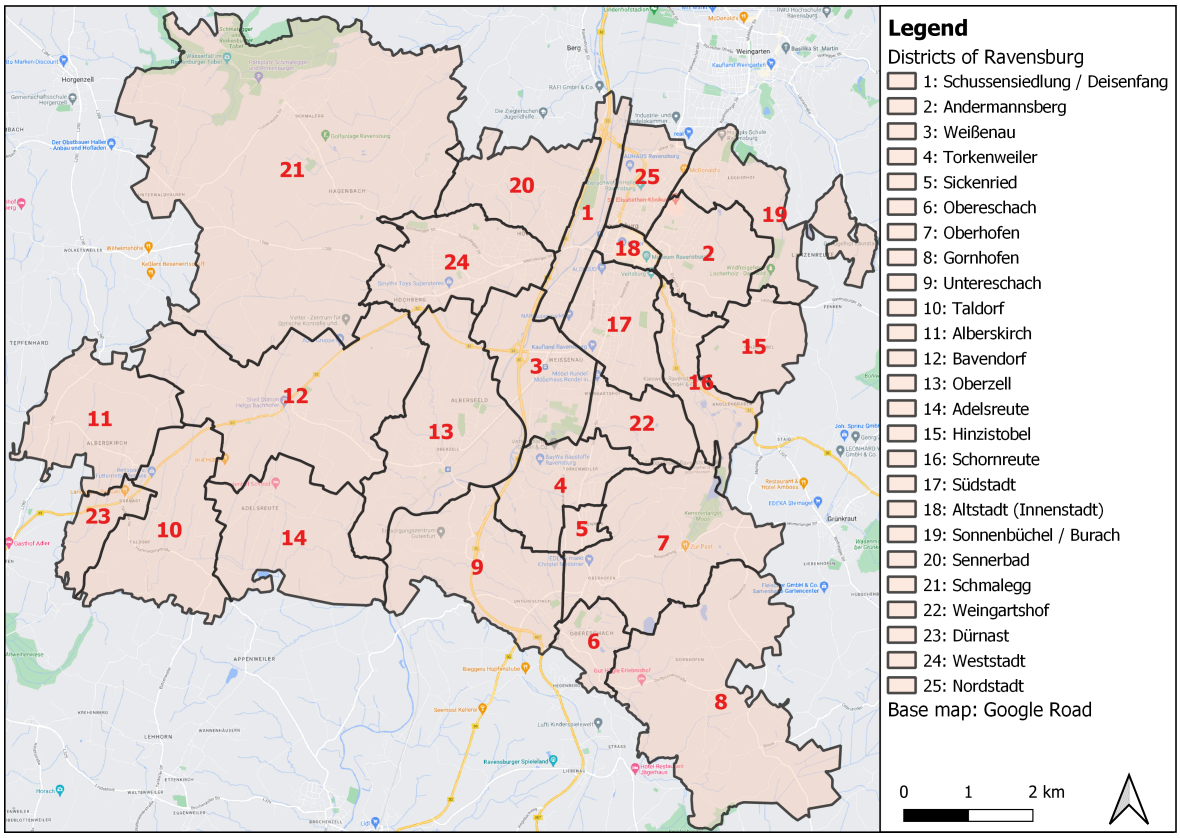

Figure A.1. The districts of Ravensburg

A.2 Full Assessment of Public Transport

Case Study Area	Duration total bus	Duration Car	Duration Cyling	Reference Address	Reference Busstop	Reference Line
Adelsreute	42 min	15 min / 8.4km	23 min / 7.6km	Adelsreute 7	Bavendorf, Ortsmitte	700 / 7537
Bavendorf	18 min	11 min /6.5km	19 min / 6.4km	Im Obstgarten 5	Bavendorf Ortsmitte	700 /7537
Dürnast		15 min / 9.5km	28min / 9.5km	Bonhausen 3		
Gornhofen	35 min	14min /9km	24min / 8km	Dorfbrunnen-straße 27	Gornhofen	3
Oberhofen	25/30 min	10min / 6km	20min / 6km	Kemmer-langer Str. 4	Oberhofen	7454/3
Obereschach	30 min	12 min / 7km	21 min / 6.5km	Kirchweg 15	Obereschach, Gornhofer Straße Obereschach Ort	3
Oberzell	12/22 min	10 min / 5km	16min / 5km	Josef-Graf-Weg 10	Bahnhof Oberzell, Oberzell Bachbrücke	Train / 4
Schmalegg	20 min	11 min /6.6km	18 min / 6.7km	St. Magdalena Ring 2	Schmalegg Ortsmitte	1
Sennerbad	60 min	6min / 2.5km	14min / 3.2km	Krebserösch 3	Berg	12 and 10
Taldorf	22 min	15 min /9.3km	28 min / 9.3km	Alberskircher Straße 1	Dürnast	700 / 7537
Torkenweiler	16 min	9 min / 4.4km	13 min / 4.2km	Gewerbegebiet Mariatal	Gewerbegebiet Mariatal	7
Weißenau	20 min	5min / 2.6km	7min / 2.4km	Blumenstraße	Torplatz / P+R	Train /7545/3
Weststadt	12 min	7 min /3km	9 min / 3.0km	Hochberg-straße 23	Ravensburg Hochbergstraße	1

Table A.1

A.3 Modal Split

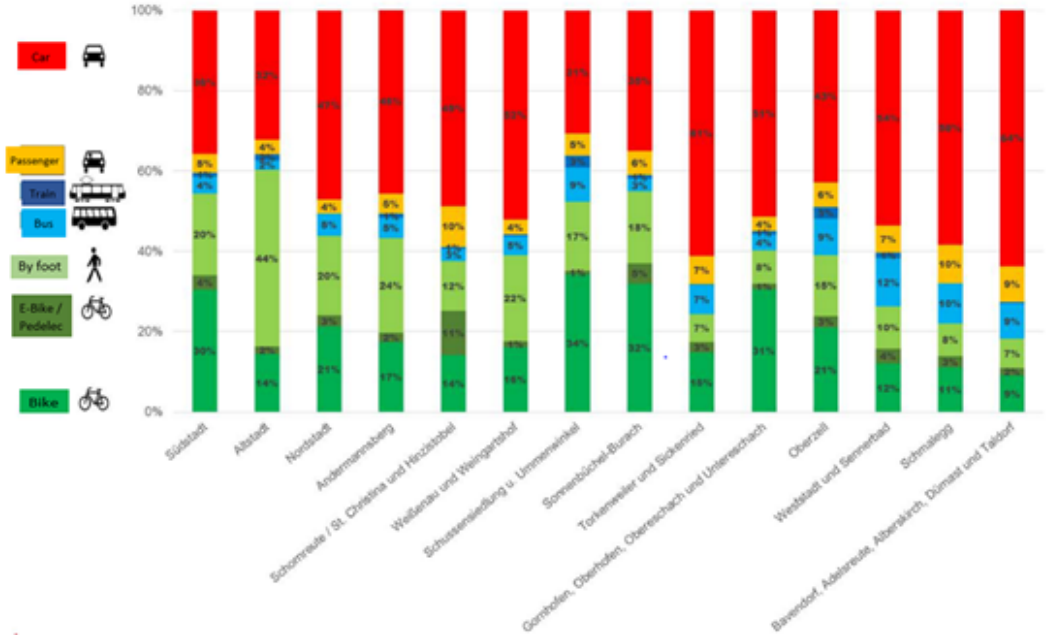

Figure A.2. Main mode of transport in Ravensburg

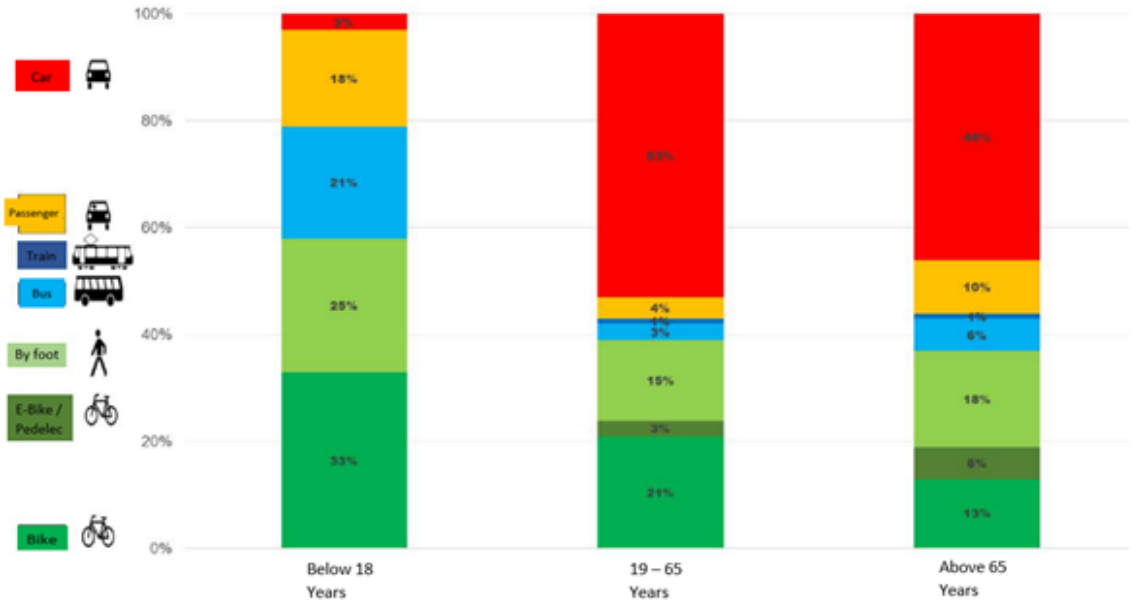

Figure A.3. Main Mode of transport in Mittleres Schussental, classified by age groups

Appendix B

B.1 Survey

Question	Research Question	Reference to study / Literature
Locational questions		
Place of residency Multiple choice	General Information about the sample - influencing variables	General Information about the sample
Place of work Multiple choice	General Information about the sample - influencing variables	General Information about the sample Commuting Distance
Place for leisure activities Multiple choice	General Information about the sample - influencing variables	Different interests among income groups [Næss et al., 2019]
Level of satisfaction in district		
Cycling paths Likert Scale (1-5)	(3) How to enhance a more sustainable development in Ravensburg?	General Information about the sample and the case study areas
Pedestrian paths Likert Scale (1-5)	(3) How to enhance a more sustainable development in Ravensburg?	General Information about the sample and the case study areas
Leisure activities Likert Scale (1-5)	(3) How to enhance a more sustainable development in Ravensburg?	General Information about the sample and the case study areas

Table B.1 continued from previous page

Question	Research Question	Reference to study / Literature
Public transport in general		
Distance to next bus stop Likert Scale (1-5)	(3) How to enhance a more sustainable development in Ravensburg?	Proximity to Public transport influences the likelihood of taking public transport [Sarker et al., 2019; Mohamad et al., 2021] [Stanesby et al., 2021]
Bus connection Likert Scale (1-5)	(3) How to enhance a more sustainable development in Ravensburg?	Travel costs, time, frequency influence the likelihood of taking public transport [Mohamad et al., 2021; Taplin and Sun, 2020] [Dell'Olio et al., 2011]
Frequency of public transport Likert Scale (1-5)	(3) How to enhance a more sustainable development in Ravensburg?	Frequency influences the likelihood of taking public transport [Stanesby et al., 2021]
Path to the bus stop Likert Scale (1-5)	(3) How to enhance a more sustainable development in Ravensburg?	Safety on the way to bus stop / during the ride [Mohamad et al., 2021; Taplin and Sun, 2020]
Importance of aspects when choosing a residential area		
Proximity to city center Likert Scale (1-5)		
Good public transport Likert Scale (1-5)		Some are specifically looking for it when choosing a new residential area [Dähner et al., 2021; Scheiner, 2006] Preferences for Bus – more likely to look for good public transport [Taplin and Sun, 2020; Van Wee et al., 2002]
Good cycling infrastructure		

Table B.1 continued from previous page

Question	Research Question	Reference to study / Literature
Good road network Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	[Reckien and Luedeke, 2014]
Cheap rent Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	[Mitchell Clare, 2004]
Cheap housing prices (home ownership) Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	[Mitchell Clare, 2004]
Shopping facilities Likert Scale (1-5)		Dependent on stage of life [Reckien and Luedeke, 2014]
School / day care Likert Scale (1-5)		Dependent on stage of life [Reckien and Luedeke, 2014]
The most important aspects, that made you choose your current housing? Open question	(2) Possible Drivers of Urban sprawl	Additional information (preferences, motivations)
Demographic and Socio-Economic Characteristics		
Age Multiple choice	General Information about the sample – influencing variables	Relocation related to personal and household variables [Van Wee et al., 2002; Næss et al., 2019]
Gender Multiple choice	General Information about the sample - influencing variables	Relocation related to personal and household variables [Van Wee et al., 2002; Næss et al., 2019]
Employment Multiple choice	General Information about the sample - influencing variables	[Næss et al., 2019]

Table B.1 continued from previous page

Question	Research Question	Reference to study / Literature
Level of education Multiple choice	General Information about the sample - influencing variables	[Næss et al., 2019]
Net Income Multiple choice	General Information about the sample - influencing variables	Relocation related to personal and household variables [Van Wee et al., 2002; Næss et al., 2019]
Marital Status Multiple choice	General Information about the sample - influencing variables	Relocation related to personal and household variables [Van Wee et al., 2002]
Household composition Multiple choice	General Information about the sample - influencing variables	Relocation related to personal and household variables [Van Wee et al., 2002]
Type of Residency Multiple choice	General Information about the sample - influencing variables	General Information about the sample
Characteristics		
Environmentally aware Likert Scale (1-5)	General Information about the sample - influencing variables	[Van Wee et al., 2002]
Physical active Likert Scale (1-5)	General Information about the sample - influencing variables	More likely to walk further to bus stop [Stanesby et al., 2021; Sarker et al., 2019]

Table B.1 continued from previous page

Question	Research Question	Reference to study / Literature
Preferred Mode of transport		Preferred mode of transport influences the location of residential area [Taplin and Sun, 2020; Van Wee et al., 2002] [Næss et al., 2019]
Rating of the most important factors why the current residential area was chosen		
Landscape Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	[Reckien and Luedeke, 2014; Dähner et al., 2021]
Location (close to nature) Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	[Reckien and Luedeke, 2014; Dähner et al., 2021]
Location (close to city center) Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	[Reckien and Luedeke, 2014; Dähner et al., 2021]
Good public transport Likert Scale (1-5)		Proximity to Public transport [Sarker et al., 2019; Mohamad et al., 2021] [Stanesby et al., 2021]
Good accessibility by car	(2) Possible Drivers of urban sprawl	
Cheap housing Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	Affordability [Mitchell Clare, 2004; Stockdale, 2014]
Availability of housing Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	[Stockdale, 2014]
Size of the house / flat Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	Life-cycle / Life stages [Aner, 2016; Stockdale, 2014]

Table B.1 continued from previous page

Question	Research Question	Reference to study / Literature
Compromises with partner Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	[Stockdale, 2014]
If moved from an urban area towards a more rural one: What were the main aspects?		
Family formation Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	Life-cycle / Life stages [Aner, 2016; Stockdale, 2014]
Moving in with partner Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	Life-cycle / Life stages [Aner, 2016; Stockdale, 2014]
Cheap housing prices Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	Affordability [Stockdale, 2014; Mitchell Clare, 2004]
Retiring Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	Stages in Life / Life-cycle [Stockdale, 2014]
Proximity to nature Likert Scale (1-5)	(2) Possible Drivers of Urban sprawl	[Reckien and Luedeke, 2014; Dähner et al., 2021]
Planned Relocation		
Are you planning to move soon? Multiple Choice		
Where would you like to move? Multiple Choice		
What is the main reason for the planned relocation? Multiple Choice	(2) Possible Drivers of Urban sprawl	

Table B.1 continued from previous page

Question	Research Question	Reference to study / Literature
What is the second main reason for the planned relocation? Multiple Choice	(2) Possible Drivers of Urban sprawl	
Main Mode of transport		
Commuting to work Multiple Choice		General Information about the sample
For leisure activities Multiple Choice		General Information about the sample
For shopping Multiple Choice		General Information about the sample
Activities of relatives (drop off/pick up) Multiple Choice		General Information about the sample
If you are barely using public transport – main reasons Multiple Choice	(3) How to enhance a more sustainable development in Ravensburg?	Proximity to Public transport [Sarker et al., 2019; Mohamad et al., 2021] [Stanesby et al., 2021] Frequency [Stanesby et al., 2021] Travel costs, time, frequency [Mohamad et al., 2021; Taplin and Sun, 2020] [Dell'Olio et al., 2011]
Main reason for choosing main mode of transport Multiple Choice	(3) How to enhance a more sustainable development in Ravensburg?	

Table B.1 continued from previous page

Question	Research Question	Reference to study / Literature
What could be improved in the public transport system cycling infrastructure? Open question	(3) How to enhance a more sustainable development in Ravensburg?	

Table B.1

B.2 Interview Guide

Semi-structured interview guide

Introductory Questions

- Can you tell me something about yourself?
  - Socio-demographic characteristics
  - Hobbies
  - How did you grew up?
  - Habits

Main Questions - Residential Choice

- When did you move the first time and what were the reasons? (second time, third time, etc.)
- Are you planning to relocate in the close future? IF yes, why?
- What were the main reasons for choosing the residential area?
  - Any other influences?
  - Have you experiences stress in the previous home?
- Where do you want to live after retirement?
- How would you describe the perfect residential area and residence?
- How do you perceive the city centre?
  - Do you use it regularly?
  - What are the main reasons to go to the centre?

Main questions - Survey Related

- Elaboration on some of the topics from the survey such as:
  - Satisfaction of current residence
  - Compromises with partner
  - Family formation
  - forced out / no choice

Main Questions - Mobility Behaviour

- When you were still living with your parents - Can you describe the mobility behaviour?
- When did you get your first car?
  - How did it change your mobility behaviour?
  - What is your favourite mode of transport and why?
  - Ignoring costs, duration, etc - What would be your preferred mode of transport?
- Did your mobility behaviour change after relocation? (Example: relocation from urban to rural or vice versa)
- Has your mobility behaviour changed during the years? If yes: why and how?
  - Family formation
  - Relocation
  - Financial matters

Closing questions

- What must happen in order for you to change to a non-motorised mode, respectively public transport?
- Would it be possible to completely avoid taking the car?
  - If yes: How
  - If not: Why not?
- Is there anything else you would like to add?