A Toolbox to Analyse Sustainable Mobility in Land-Use Planning Processes: Methodological Challenges and Approaches for Residential Developments in Rural Areas

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1 ABSTRACT

A major challenge in promoting sustainable mobility behavior in rural areas is the spatial structure. Mapping and modelling the causal interactions between land-use, mobility behavior, and local accessibility is associated with considerable methodolgical complexity. Accessibility analyses have to be linked with tangible applications in order to generate real added value for land-use planning. In the project move.mORe, an approach was developed, building on current research and practical findings, to use accessibility analyses effectively in advising rural municipalities on land-use planning..

Empirical evidence shows that structural parameters such as residential density, mixed land use, accessibility to public transport, and proximity to essential services strongly influence travel behavior. Areas with higher density, diverse land use, and efficient public transport connections exhibit lower car ownership rates and higher shares of walking, cycling, and public transport use. Longitudinal and quasi-experimental studies indicate that changes in the built environment can causally affect mobility behavior, although the extent of these effects is moderated by self-selection processes, whereby individuals choose residential locations aligned with their pre-existing mobility preferences. This poses challenges for researchers and planners seeking to disentangle causality from selection effects.

To address these challenges, the project move.mORe developed a multimethodological toolbox designed to support rural municipalities in evaluating and promoting sustainable mobility within the land-use planning process. The aim of the toolbox is to provide a scientifically grounded impact assessment. This enables municipalities to identify potential traffic-related effects of residential developments already in the early stages of the planning process and to develop evidence-based strategies to support the sustainable mobility of residents. On this basis, site-specific solutions can be developed to promote sustainable mobility. Policy interventions can support sustainable mobility through “pull measures” that enhance the attractiveness of environmentally friendly transport modes, as well as “push measures” that limit car dependency, such as parking management or restricted vehicle access.

The toolbox employs two primary indicators to evaluate the sustainability of the mobility in planned residential developments: traffic-related greenhouse gas emissions and the provided accessibility for residents. Greenhouse gas emissions quantify the ecological impact of transport demand generated by the development area, representing the environmental boundary of sustainability. Accessibility measures the ability of residents to reach essential destinations such as supermarkets, schools, healthcare providers, and public transport nodes within a defined travel time, reflecting the social needs dimension of sustainable mobility. Accessibility analyses within the regions and municipalities of the project area are conducted using weighted destination categories and isochrones based on the concept of “15-minute city” and transferring its ideas and applications to a “15-minute rural region”. The project’s core structure allows the analysis of these cities these “smaller” cities and municipalities in rural regions and explore different use-cases for accessibility analyses.

Keywords: toolbox, accessibility, sustainable mobility, rural areas, land-use planning

2 BUILT ENVIRONMENT AND MOBILITY BEHAVIOUR – THE INTERACTION BETWEEN CAUSALITY AND SELF-SELECTION

The development of mobility and built environment in rural areas can be described as a “vicious circle”. Since the mid-20th century, the increasing prevalence of the automobile and the expansion of car-oriented infrastructure have promoted an increasingly sprawling settlement structure. This leads to longer daily journeys and increased traffic volumes. In order to cover longer trip distances, many people rely on fast modes of transport, especially private cars, which reinforces car dependency. Increased travel speeds reduce sensitivity to distances, leading to the acceptance of longer journeys and inducing additional car-oriented traffic flows. This in turn encourages people to choose more distant residential locations and exacerbates urban sprawl. In such structures, residents are heavily dependent on motorised individual transport and generate comparatively high greenhouse gas emissions (Holz-Rau and Scheiner 2019; Jarass 2018). This process has not only ecological but also social implications: public services are often only accessible by car, which places a financial burden particulary on low-income households and limits the social participation of people without access to a private car.

It is widely accepted in the literature that the settlement structure plays a significant role in shaping mobility behaviour of the residents and hence changes in the spatial structure can lead to changes in mobility behaviour and promote sustainable mobility (Planersocietät 2012; Holz-Rau and Scheiner 2019).Many authors assume that the mobility behaviour of residents differs depending on various built environment characteristics. Above all, constraints such as residential location, mixed land use, degree of integration into the existing road network, accessibility of daily trip destinations and developments in locations with good public transport connections can influence the mobility behaviour of residents. This is reflected in lower motorisation rates and a high proportion of enviromentally-friendly transport modes in settlement locations with good public transport infrastructure, sharing services and accessibility to daily destinations (see also Beckmann 2020). However, it should not be overlooked that individual parameters such as socio-demographic factors, lifestyles and mobility styles, as well as other structural parameters such as the transport system, also play an important role in shaping mobility behaviour and must therefore not be ignored (Beckmann 2020; Holz-Rau and Scheiner 2019; Jarass 2018).

A study by Christiansen et al. (2017) from Norway, which focuses on commuting, shows that parking availability at work and at home has a significant influence on the choice of transport. The longer the walking distance to parking at home, or if there is no fixed parking space at the workplace the less likely commuters choose the car as their mode of transport. This effect is even more pronounced when there are no parking facilities at the workplace. A combination of limited supply and additional parking fees proves to be particularly effective.

Næss (2011) examined the modal split of commutes in inner-city development projects ("new urbanism development") compared to conventional suburbs in Denver, USA. The results show that, in addition to non-spatial parameters such as transit pass ownership and socio-demographic factors, the availability of free parking at the destination is also correlated with the choice of transport mode.

Schwarze et al. (2025) demonstrate in their empirical study in Germany that walking distance to everyday trip destinations significantly increases the proportion of walking, cycling and public transport use, while reducing car use and the household motorisation levels. Multiple motorisation of households is also less common in residential areas which offer good local accessibility. Interestingly, households in such locations travel more frequently, but their journeys are shorter on average.

The longitudinal study by Bauer et al. (2005) examines the mobility behaviour of households before and after moving within the region of Dresden and shows that moving from the city centre to the surrounding area is often associated with an increase in motorisation level. This study also emphasises the role of car orientation in residential location preferences, so that moving from the city centre to a more peripheral location both requires and promotes car orientation.

Another study by Bauer et al. (2022) examines the influence of mobility concepts in car-reduced new neighbourhoods of Germany on the mobility behaviour of residents. The results show a decline in the degree of motorisation after moving, with less use of private cars in favour of public transport. In addition, the use of car sharing has increased after moving to new neighbourhoods.

A central question in the discussion on the interaction between settlement structure and mobility behaviour concerns, whether observed correlations are causal or whether they result primarily from processes of self-selection. This means that people consciously choose places to live that correspond to their existing mobility behaviour or mobility preferences (Scheiner and Holz-Rau 2007; Bruns 2014; Van de Coevering et al. 2018). Several studies therefore question the thesis that built environment characteristics alone shape mobility behaviour. Bagley and Mokhtarian (2002), for example, emphasise that the influence of built environment characteristics is often overestimated in comparison to socio-demographic variables and lifestyles.

Various methodological approaches have been developed to address the question of causality. Vance and Hedel (2007), for example, analyse variables that correlate with the urban form but are not directly correlated with mobility decisions.

Studies that use longitudinal approach to examine households before and after a move have been able to demonstrate a causal influence of settlement structure changes on mobility behaviour in some cases. A particularly illustrative example is provided by the study by Cao et al. (2019) from Norway, which uses a hybrid method combining a quasi-longitudinal approach and qualitative analysis in the form of interviews. One interviewee reported that after moving from a location close to the city centre to a peripheral location, she purchased a car, even though she had had no intention of buying a car before the move. The reason for this decision was that everyday trips were no longer feasible by public transport. This qualitative observation supports the assumption that the change in mobility behaviour was a consequence of the residential location and the built environment characteristics at the new place of residence and not an expression of pre-existing mobility preferences in the sense of self-selection when choosing a place to live.

Robert Cervero (2017) argues that sustainable mobility depends less on increasing the speed of travel and more on improving accessibility and the ability for people to reach jobs, services, and daily needs efficiently. This shift places land-use planning at the core of transportation policy. Rather than expanding road networks to ease congestion, Cervero advocates for compact, mixed-use, and transit-oriented development patterns that reduce travel distances and automobile dependence. By aligning urban form with high-quality public transit, walkability, and cycling infrastructure, cities can lower greenhouse gas emissions, improve public health, and advance social equity. Sustainable mobility is achieved not simply through cleaner vehicles, but through reshaping urban development to prioritize proximity, accessibility, and people-centered design.

3 LAND-USE PLANNING AS A LEVER FOR SUSTAINABLE MOBILITY IN RURAL AREAS

Despite the ongoing discussion on causality and self-selection there is a broad consensus that both transport mode choice and travel distances vary depending on the built environment characteristics and the spatial context (Jarass 2018; Scheiner 2009). Integrated land-use and transport planning is therefore an important planning approach, particularly with regard to ensuring that everyday destinations can be reached without a private car and creating a healthy and liveable environment (Holz-Rau and Scheiner 2019). Transport planning based on the principles of integrated land-use development forms the basis for promoting sustainable mobility behaviour. Only where suitable built environment structures and appropriate infrastructure conditions are in place do residents actually have the opportunity to adapt their mobility behaviour in favour of environmentally friendly modes of transport.

At the same time, implementing appropriate measures, such as increasing density and mixed land use, improving access to public transport stops or redesigning public spaces, often involves considerable time and financial expenditure once a settlement is developed. This makes it all the more important to consider these aspects at an early stage when planning new settlements. Nevertheless, existing areas also offer certain scope for action. The expansion of infrastructure for eco-friendly transport (e.g. through bicycle and pedestrian infrastructure, better public transport connections) and supplementary measures such as mobility hubs or parking management can provide behavioural incentives.

The spatial planning system in Germany shapes the built environment through a two-stage system of local spatial development planning comprising preparatory land-use plan (Flächennutzungsplan) and binding land-use plan (Bebauungsplan). Preparatory land-use plans define the intended types of land use for the entire municipal territory in accordance with proposed urban development strategies, aiming to address the anticipated needs of the municipality over often a ten- to fifteen-year period. These plans provide the overarching framework and serve as the foundation for binding land-use plans. Binding land-use plans constitute the principal instrument for implementing local government planning. They are developed based on the preparatory plans and contain legally binding provisions that guide and regulate urban development patterns, including the use of land for development and other purposes.

Both types of plans regulate a wide range of measeres that influence the mobility behaviour trough the built environment. For example, the preparatory land use plans affect future traffic volumes, in particular by specifying development sites and their integration into existing infrastructure. A compact, short-distance-oriented settlement structure and the concentration of new developments along high-capacity public transport corridors can significantly enhance the attractiveness of sustainable modes of transport (SRL-FMV Working Group 2020).

Binding land-use plans adapt these objectives to local conditions and have a direct impact on accessibility and mobility behaviour through regulations on density, mixed land use and the design of public spaces. Requirements for transport facilities such as cycling and pedestrian infrastructures, bicycle parking facilities or car-parking regulations create the structural conditions for sustainable everyday mobility (SRL-FMV Working Group 2020). Once settlement structures have been established, they play a formative role in the mobility behaviour of residents for many years. Land-use planning therefore offers a fundamental opportunity to shape mobility behaviour in the long term and create the basis for sustainable mobility.

Mobility impact assessments for spatial development plans have become increasingly common in recent years, they are often limited to estimating car traffic volumes for the purpose of designing transport infrastructure. Assessing whether an urban development plan promotes or enables sustainable mobility behaviour in the long term is rarely the focus of consideration. The move.mORe project is an IHS-funded transfer project of the Karlsruhe university of applied science and Offenburg university of applied science. (IHS – Innovative Hochschule is a federal-state initiative designed to promote research-based ideas, knowledge and technology transfer).The work package "Region of Short Distances" focuses on the development of a practical toolbox that can be used to assess the extent to which specific measures at the urban land-use planning level will contribute to the development of sustainable mobility in the future. The toolbox builds on existing methodological approaches, which have been systematically combined as a multi-method approach in the project context, further developed and adapted to the specific conditions of rural areas. The adaptation to rural conditions includes the use of data from rural sites as well as the design of the toolbox for application in small not specialized adiminstrations. The aim of the toolbox is to provide a scientifically based impact assessment to support municipalities in rural areas in promoting sustainable mobility. This enables local authorities to identify the potential transport impacts of planned residential developments at an early stage of urban land-use planning and, if necessary, to take countermeasures at an early stage. On this basis, area-specific measures can be derived that promote sustainable development.

4 EXISTING APPROACHES FOR ASSESSING THE IMPACTS OF RESIDENTIAL DEVELOPMENTS ON SUSTAINABLE MOBILITY

A review of existing approaches to assessing the traffic impacts of residential developments is provided, which served as the basis for the development of the toolbox's multi-method approach. These approaches either enable an overall assessment of the plans in terms of their sustainability or focus on individual planning measures and estimate their specific traffic impacts.

4.1 Qualitative checklist: Options for establishing measures for greater climate protection in transport within the framework of binding land-use plan procedures

The Climate Mobility Competence Network (KKM) supports local authorities in promoting climate-friendly transport planning in state of Baden-Württemberg, Germany. It offers local authorities "guidance and advice on possible courses of action, contact persons and funding opportunities" (https://www.klimaschutz-bewegt.de/anlaufstelle/).

One of the KKM's tools is a checklist for the qualitative assessment of climate protection in transport within the framework of binding land-use plan procedures. The aim of this checklist is to support local authorities in avoiding traffic, expanding sustainable transport and strengthening climate-neutral modes of transport.

The checklist takes into account transport-related aspects that can be specified in a binding land-use plan. These include, for example, the location and density of development, the network of bicycle and pedestrian paths, public transport services, mobility hubs and parking management. In addition, supplementary measures that can positively influence mobility behaviour in terms of climate protection are also considered. These can be agreed upon in urban development contracts, e.g. car-sharing services, parking management or mobility consulting services.

The checklist can be applied to development area and analysed using a qualitative evaluation system. This makes it possible to assess the extent to which the planned measures of a development area contribute to climate protection. The great advantage of this tool is its user-friendliness, which allows local authorities to easily obtain a comprehensive overview of possible specifications for promoting climate-friendly mobility.

4.2 Method for estimating the car ownership in neighbourhoods

The study "Parking space allocation and mobility concepts in residential development" by the Technical University of Hamburg, funded by the "Lebendige Stadt" foundation, uses a statistical method to estimate car ownership in residential areas and determine the necessary parking space requirements (Tahedl 2021). The investigations are based on approximately 900 neighbourhoods in the two major cities of Hamburg and Osnabrück in Germany and focus on the question of which spatial and socio-structural parameters influence car ownership. A small-scale neighbourhood-level analysis is applied.

The identified factors influencing car ownership at the neighbourhood level include: Population density and proportion of residential use in the area, walking distance to local amenities, level of mixed land use, walking distance to bus stops and their service frequency, walking distance to S-Bahn stations and their service frequency, public transport travel time to the city centre, household size or apartment size and houshold income.

Based on the assumption that the availability of parking spaces can influence mobility behaviour and, in particular, car use by residents, the underlying approach emphasises the importance of carefully determining the number of parking spaces required in the context of urban land-use planning. The aim is to contribute to the promotion of sustainable mobility behaviour through conscious control of parking space availability. In this context, it is emphasised that the decision on the number of parking spaces to be actually realised must always be made in the context of the conflicting interests of space availability, costs, requirements for public space and the goals of the mobility transition. The estimation of car ownership serves as a methodological basis. According to Tahedl (2021) it must be determined on a case-by-case basis how many of the forecasted vehicles should be allocated parking spaces and to what extent alternative mobility options can be considered as compensation.

Since the underlying factors are based on empirical data from large cities, the method is suitable for use in metropolitan areas as well as medium-sized and small cities (Tahedl 2021). For application in rural, small-sized municipalities, however, context-specific adjustments of the parameters are necessary.

4.3 Elasticity models for mode choice

Transport mode choice models based on elasticities analyse how much the demand for a particular mode of transport changes when travel time or travel costs change as a result of supply adjustments. They therefore enable an assessment of the extent to which measures that influence travel time or travel costs can change the probability of choosing a particular mode of transport. Examples of such models are the elasticity model for transport mode choice for regional routes in Switzerland developed by ETH Zurich (Vrtic and Axhausen 2000) and the standardised evaluation framework for transport infrastructure investments in local public transport, which is developed based on the empircial data in Germany (Intraplan 2016).

A disadvantage of these statistical models is that they can only take into account measures that can be quantified in terms of changes in time or cost. In addition, spatial conditions and socio-demographic characteristics have a considerable influence on elasticity. As a result, the elasticity values determined vary considerably between different studies. As Vrtic and Axhausen (2000) emphasise, the transfer of such model parameters only makes sense under clearly defined conditions and for comparable supply and demand conditions.

4.4 Estimating traffic volumes for modes of transport in development areas with Ver_Bau

The German tool for estimating traffic volume through urban land-use planning projects (Ver_Bau) serves to estimate the traffic impact of planned development projects within the framework of urban land-use planning. The tool enables a forecast of future traffic volume based on empirical values and data. It takes into account different types of areas such as residential, mixed land use, commercial and special areas, as well as large-scale retail facilities.(Bosserhoff and Vogt 2007).

The tool consists of two parts. In the first part, the structural variables and demand groups of the planned project are estimated on the basis of typical land use parameters (e.g. population density). Based on this, the expected traffic volume in the area is determined in a second step. Based on these values, other traffic-related indicators such as modal split, travel frequency, domestic traffic shares, car occupancy rates and hourly shares in car traffic can be estimated (Bosserhoff and Vogt 2007).

While the tool can reliably predict the number of trips within an area, it has shortcomings in its assessment of the mode share and can only provide rough estimates. In order to account for the existing uncertainty in traffic generation forecasts, the results are given as ranges. A major advantage of the tool is the comparatively low time required, as the calculations are based on established parameters. Another limitation of the tool is the relatively rough estimate of traffic volume, as location-specific influencing factors are only taken into account to a limited extent. In particular, traffic-influencing factors such as the the mobility concept of the development area, measures to promote environmentally-friendly transport or connections to public transport are not taken into account.

4.5 Transfer of experience from case studies

As the above approaches are often based on studies in urban areas, their transferability to rural contexts is limited. In addition, many statistical approaches have difficulties in reflecting the complexity of real conditions in rural areas. Comparing the study area with relevant case studies can provide additional insights into the actual effects of planned measures.

However, analysing case studies presents several challenges. For example it is often difficult to identify comparable areas with similar conditions. This is particularly true in the case of new or innovative measures that have so far only been implemented in a few cases, especially in rural communities. In addition, the quantitative transferability of the observed effects is problematic, as they are highly context-dependent. Another methodological disadvantage is that, in real-world planning processes, individual measures are rarely implemented in isolation. Instead, bundles of measures are usually implemented, the effects of which influence and overlap with each other. It is therefore difficult to attribute the effects of individual measures within such a package to a specific cause. For these reasons, the uncertainty of assessments based on case studies is high.

5 TOOLBOX FOR LAND-USE PLANNING AND SUSTAINABLE MOBILITY

Despite the diverse approaches presented above, there are limitations to the evaluation of transport measures in spatial development processes. These weaknesses are particularly evident in the analysis of mobility in rural areas. Most existing approaches are primarily geared towards urban contexts and can only be applied to rural structures to a limited extent. In addition, they often focus on regional and community scales, while small-scale effects, for example at the neighbourhood level, have hardly been investigated to date. The developed toolbox addresses the limitations of previous assessment approaches. It aims to minimise the uncertainties existing in previous approaches while at the same time making targeted use of their potential. The toolbox integrates tried and tested elements from the existing approaches. So the multi-method structure of the Klima Mobil competence network checklist is used to structure the scope of the study, while the Ver_Bau tool is used as the data basis. Other approaches are used to assess the transport impacts of specific measures. The toolbox uses data from a comprehensive literature review on the transport impacts of urban land-use planning. In addition, data on mobility in rural areas from Mobility in Germany (nationwide survey of mobility behaviour: https://www.mobilitaet-in-deutschland.de) is used as a reference value.

5.1 Understanding and indicators Sustainable mobility

In order to assess the contribution of land-use planning to sustainable mobility, two indicators are used: accessibility and traffic-related greenhouse gas emissions. These indicators are based on the understanding of sustainability (Ott and Döring 2011) and the definition of sustainable mobility: enabling society to satisfy basic mobility needs while ensuring safety, health, the functioning of ecosystems and justice within and between generations (Gerlach et al. 2015; Eckart et al. 2020). In this context, “transport-related greenhouse gas emissions” (GHG emissions) represent the ecological upper limit of sustainable mobility (other possible ecological issues include air pollutants, noise, ecosystem protection, water and resource consumption), while the indicator “accessibility” marks the minimum social limit (other social issues include road safety, asset maintenance and fairness), thus reflecting the basic need for mobility. The scope for planning sustainable mobility is within these two limits. The following section describes the structure of the toolbox with its two strands: determining transport-related GHG emissions and the accessibility of the development area (see Figure 1).

5.2 Input values for the assessment

The toolbox is based on a list of measures that influence traffic and can be influenced within the framework of German land-use planning. The toolbox is primarily based on the provisions of the German Building Code and the checklist of the Klima Mobil competence network. The measures considered were verified by an internal expert panel. The measures taken into account include: walking time to the car-parking space at home, walking travel time to the bus station from home, mixed land use, density, distance to the city center and to local amenities e.g.

The toolbox takes into account area-specific inputs, such as the planned number of residential units, the population of the municipality or the spatial typology according to the seven categories of RegioStaR (regional statistical spatial typology of the German federal ministery of transport for mobility and transport research). The input values required for the calculations are based either on data from the national survey Mobility in Germany (https://www.mobilitaet-in-deutschland.de), on the Ver_Bau tool or on user-defined specifications.

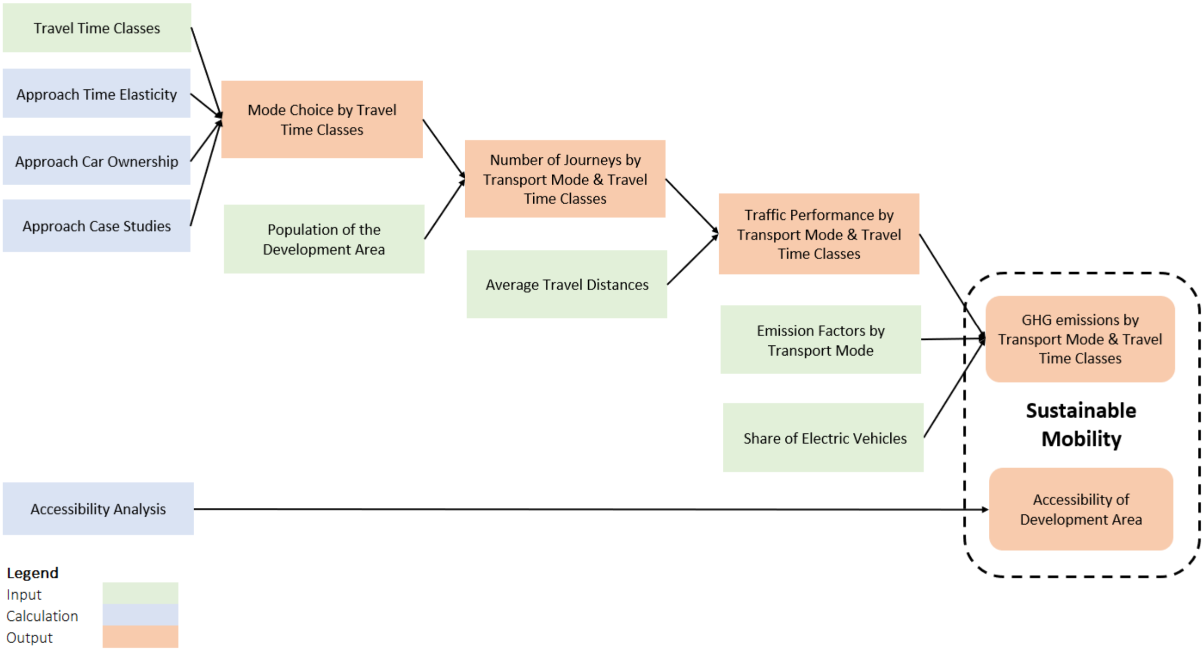

Figure 1: Flow chart of the toolbox

5.3 Determining the choice of transport mode

The modal split is a key factor in assessing the impact of planning on sustainability, as it has a significant influence on transport-related greenhouse gas emissions. Due to the inherent uncertainties of such assessments, the results are presented as ranges. The lower end of the range reflects the more conservative estimates, while the upper end represents the more optimistic effects. The impact of measures in the spatial development plan on the modal split is estimated on the basis of up to three different methodological approaches: car ownership models, time elasticity models or empirically based case studies. The approaches selected are those that are technically suitable for assessing the measure under consideration.

Within the framework of land-use planning, decisions about walking time to the car-parking space at home and walking travel time to the bus station from home are made. Measures such as the location of public transport stops, the location of parking spaces, the mixed land use and accessibility of everyday amenities have a significant influence on mobility behaviour, including the choice of transport mode. The time elasticity model is used to assess these consequences on the modal split. Region-specific boundary conditions that influence elasticity are taken into account when selecting elasticity values.

For measures that influence car ownership, the approach used to estimate the number of cars in neighbourhoods is applied. To ensure a more accurate representation of rural communities, the model was adjusted based on available published data. Due to limited data availability, additional surveys are planned.

The case study approach draws on a pool of empirical examples from the literature research and previous surveys. Suitable case studies are selected based on the measures and context. A forecast for the respective study area is created based on the relative change in the modal split in the selected case study. To calibrate the estimated modal split values, these are compared with empirical data from the project and from previous research in order to refine them and make the forecasts more realistic.

5.4 Greenhouse gas emissions

Based on the estimated range of the modal split, the number and length of trips for each mode of transport and mode-specific emission factors, the greenhouse gas emissions caused by traffic in the development area are calculated on an annual basis. A distinction is made between the emission factors for conventional and electric cars. The result is presented as an indicator of sustainable mobility in terms of the GHG emissions generated by the development area. In order to reflect the uncertainties of such a forecast, the results are presented as a range, with the lower end of the range representing the more conservative values (which will be achieved with a higher certainty), while the upper end represents the possible effects. In addition, qualitative information are provided on the conditions under which the upper or lower end of the range can be expected. It should be noted that the influence of residential self-selection is not taken into account in the toolbox assessments. This methodological limitation can lead to an overestimation of causal relationships between built environemnt and mobility behaviour. Accordingly, a reflective interpretation of the results in the planning context is required.

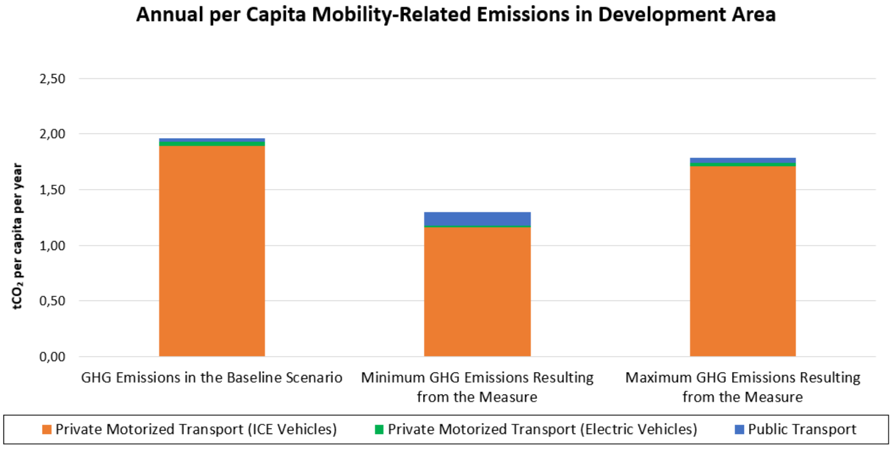

Figure 2: Calculated GHG emissions for a case study

5.5 Accessibility analysis

In parallel the accessibility in the vicinity of the development area is analysed. This is based on the concept of travel time budget indicators for accessibility, which describes how many activities can be reached by a means of transport within a certain travel time (Schwarze 2005). A comprehensive list, containing 24 different everyday activities, is used as a guideline for measuring accessibility (Schwarze 2025). These activities are categorized into four major dimensions: supply, healthcare, education and leisure. These dimensions split into detailed categories like level of schools, different services and types of markets. The toolbox focuses on six categories of everyday activities: supermarket/discount store, daycare centre, primary school, family doctor, pharmacy and local public transport stop. Accessibility of workplaces is not yet part of our categories. The analysis is carried out using a tool developed by the project team based on data from OpenStreetMap and isochrone and travel-time APIs. It determines the number of accessible facilities in each category within a 15-minute walk or bicycle-drive. So the focus are walking, driving by bicycle and in the future also public transport. As results two different indeces are calculated. The first index aims to provide a interpretation of the availability of local everyday destinations. We call it the 15-minute-index. The 15-minute-index describes how many of the twentyfour categories are accessible in 15 minutes by a predetermined mode which makes the most sense for the given category. Respecting the different weights (as in: schools and supermarkets are heavier weighted than ATMs or repair shops) a percentage between 0 and 100 is the result of the calculation, with 100 meaning every category is reachable within 15 minutes. This index can then be compared with similar regions or residential developments. A second, much more descriptive index, called X-minute-index, describes the accessibility of an area based on the average travel time to destinations of the categories. To calculate this index, the travel time to the next destination and the the weight associated with that category are used. The result is an index that illustrates the average travel time in the context of the categories, meaning for example in a 7-minute-city, the average travel time to the important (highly weighted) categories is relatively short. It does not mean the average travel time to every category is 7 minutes, however the lower the value, the closer the important categories are. This index differs vastly dependent on area, population and destinations. Also different weights can alter the indeces. We plan to iterate on weights and categories depending on use cases.

Finally, the local accessibility values are compared with those of municipalities with comparable spatial typologies in Baden-Württemberg and throughout Germany. This is based on data from INKAR (indicators and maps for spatial and urban development) from the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). Due to a lack of data in INKAR, daycare centres and family doctors are not included in these comparisons. An expansion of the accessibility analysis is planned. Based on first results with participating cities and urban planners, the details and weightings of certain categories and destinations will be made variable, to offer a more individual approach depending on the planned development.

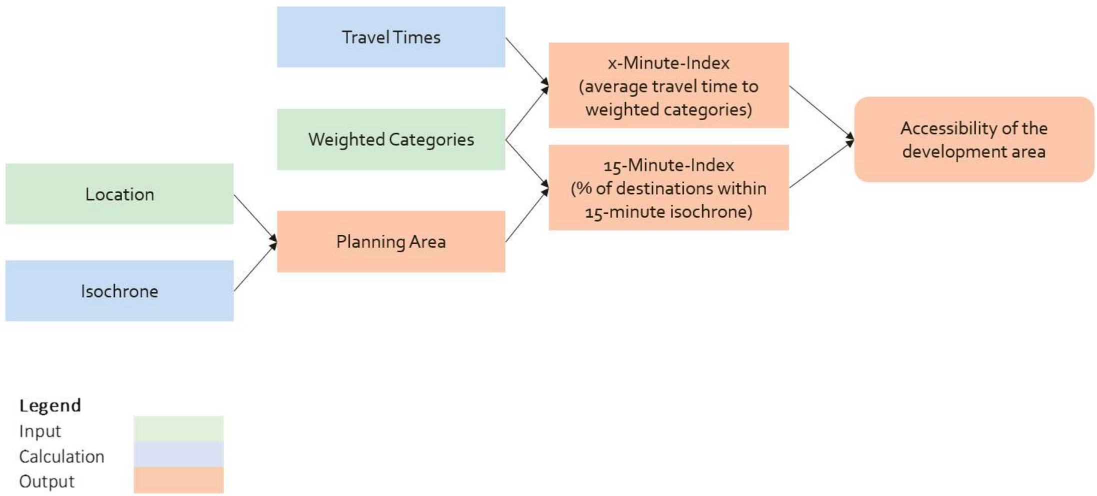

Figure 3: Flow chart of accessibility analysis

5.6 Integrated assessment of sustainable mobility

For the purpose of advising local authorities and decision-makers, transport-related GHG emissions are presented as an indicator of the ecological limits of sustainability and accessibility as an indicator of the social limits of sustainability. The tool is deliberately limited on two indicators in order to facilitate the communication to decision makers and public. By comparing the two indicators for the development area, the contribution of various transport measures to sustainable mobility in rural areas is illustrated. In addition, the contribution of the measures taken in the development area to achieving German Climate Action Programme 2030 (reduction of 55% of greenhouse gases by 2030) is shown.

5.7 Application and need for further development

The current version of the toolbox is being tested as a tool for policy counceling in two pilot municipalities in order to check its functionality in real-life situations and to further develop the methodology on the basis of practical experience. As the testing is still in process, the results are pending. The current version only allows single measures to be evaluated. An extension for evaluating packages of measures in the form of a combination of qualitative and quantitative assessments is currently under development.

The methodology developed in the project has a high potential to be transferred to other countries, particularly where comparable planning frameworks and objectives exist in the field of sustainable residential and transport development. Since the core principles of integrated planning such as promoting short distances, mixed land use, and multimodal accessibility are universally relevant for sustainable transport, the toolbox can serve as a conceptual approach in international contexts as well. However, the transfer requires adaptation to country-specific institutional structures (especially regarding approaches for estimating car ownership and the Ver_Bau tool), legal planning instruments, and available data sources (such as the Mobility in Germany dataset). Differences in spatial structure or public transport organization significantly influence the mechanisms through which planned measures have an effect. Therefore, contextualizing the indicators and evaluation criteria is necessary to provide valid assessments of transport-related impacts. Overall the methodology offers a transferable framework that, through appropriate localization of parameters, can provide a basis for sustainable land use and transport planning beyond Germany.

6 CONCLUSION

Due to the interactions between built environment and mobility behaviour, land-use planning influences framework conditions for sustainable mobility. The toolbox developed in the move.mORe project offers a practice-oriented, scientifically approach that supports local authorities in the early assessment of the transport impacts of settlement developments.

The toolbox can help to prioritise measures in urban land-use planning in a targeted manner and make their contribution to sustainable mobility transparent. This strengthens the capacity to act of small and medium-sized municipalities in rural areas, which often have limited technical resources.

Applying ideas from the "15-minute city" concept to rural areas offers a significant improvement in evaluating, comparing and quantifying accessibility, especially in terms of assisting municipalities in decision-making during stages of land-use planning.

To further develop the toolbox it is planned that the data basis for rural areas is to be expanded further and to facilitate the evaluation of packages of measures. Continuous validation in pilot municipalities can additionally increase feasibility and strengthen acceptance in municipal planning practice.

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