Journal of Urban Mobility 9 (2026) 100182

Contents lists available at ScienceDirect

Journal of Urban Mobility

journal homepage: www.elsevier.com/locate/urbmob

Residents' preferences for land use and sustainable mobility solutions in densifying urban residential areas: Towards a more user-centered planning approach

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ARTICLE INFO

Keywords:
Vignette study
Land use
Sustainable mobility
Densification
Acceptability
Preferences
Green spaces

ABSTRACT

Densifying existing residential areas typically involves not only adding new buildings to accommodate additional residents, but also new parking spaces to meet the ongoing demand for convenient motorized mobility. This often comes at the expense of green areas. To protect these areas and preserve their ecological and recreational value, measures could be considered to ease the growing pressure on land, like reducing the number of parking spaces and providing sustainable mobility alternatives. However, reducing parking spaces is often met with little acceptance. This study, conducted between 2023 and 2024, addresses this dilemma from the perspective of residents living in post-war housing estates in Germany, who could potentially be affected by densification in the future. Using vignettes, 236 adults evaluated three strategies for reallocating space in the neighborhood under assumed densification, which have varying impacts on the available space for parking or greenery. These were combined with three sustainable mobility alternatives (improved public and active transport (1), innovative shared mobility offers (2), or local facilities to reduce travel distances (3)). The aim is to gain insights into how residents assess competition for space and to what extent sustainable mobility options increase acceptability of parking space reductions. Binary logistic regression models and descriptive analyses of given reasons for a decision show that respondents prefer relocating parking spaces to collective garages on the outskirts of the neighborhood. Such garages preserve space for greenery and alternative uses, while guaranteeing parking spaces, albeit with longer access and egress distances. Respondents' frequency of car use, age group, and environmental awareness significantly influence evaluation of scenarios, while the sustainable mobility alternatives in our study play a minor role. Planning implications include introducing target-group specific and supporting measures to foster the adoption of sustainable mobility alternatives, as well as allowing for participatory processes that take residents' perspectives into account with the help of experimental empirical methods

1. Introduction

Today, about 55 percent of the global population lives in cities, a proportion expected to rise to almost 70 percent by 2050 (UN-Habitat, 2022). This ongoing trend of urbanization is accompanied by increased traffic and land consumption. Moreover, if urban growth is not managed, it will lead to a further dispersed low-density expansion of urban areas into the surrounding areas – commonly referred to as urban sprawl (EEA, 2006). This development, which has been facilitated by the rapid increase in private car ownership (Gärtner et al., 2021), has a number of negative environmental consequences and is therefore in stark contrast to the principles of sustainable land use (Behnisch et al., 2022).

Urban densification or infill projects, meaning constructing on land within existing building stocks, offer enormous potential for sustainable urban development (Angelo & Wachsmuth, 2020; Pont et al., 2021). They create housing opportunities, avoid additional soil sealing and urban sprawl, and allow for a revision of outdated land use practices to better meet modern needs, like innovative mobility and mixed land use. However, increasing population density can lead to conflicts, especially in existing residential areas, where different interests compete for limited spatial resources, e.g., for housing, green spaces, recreation, traffic and transportation (Wicki & Kaufmann, 2022; Bauer & Duschinger, 2024). Balancing possibly competing demands on space is

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https://doi.org/10.1016/j.urbmob.2025.100182
Received 7 July 2025; Received in revised form 25 November 2025; Accepted 19 December 2025
Available online 12 March 2026

primarily the responsibility of property owners and planning authorities. In Germany, for instance, the '*triple inner urban development*' planning principle provides guidance on how different spatial requirements can be reconciled. It simultaneously promotes (1) space-saving construction, (2) green space development, and (3) transport and mobility transitions in urban areas, with the aim of achieving both sustainability and a high quality of life for all residents (Schubert et al., 2023). At the European level, the New Leipzig Charter (2020) provides guidance on how to implement welfare-oriented, integrated and sustainable urban development. It calls for a dense, compact, polycentric settlement structure of diverse uses to reduce transportation and mobility needs.

However, these concepts and associated guidelines are based on generalized, normative assumptions about the measures necessary to achieve the desired outcome (Jessen, 2018). Furthermore, and contrary to the principle of triple inner urban development, current densification practices typically involve not only expanding residential buildings but also providing additional parking spaces to meet the ongoing demand for convenient motorized mobility and additional parking facilities of the old and new residents (Kaufmann, 2024; Bauer & Duschinger, 2024). As a consequence, this puts pressure on existing open and green spaces that are ecologically valuable in adapting to climate change and highly appreciated by local residents (Ives et al., 2017; Hunter & Luck, 2015). A reduction in the number of parking spaces could be considered in order to reduce pressure on green spaces and ease the competition for different uses. However, this is often met with little acceptance among the population, especially when cars are frequently used and as the only means of transportation (Andor et al., 2020; Lanzendorf et al., 2024). After all, driving a car is often associated with freedom, flexibility, and autonomy, important aspects of subjective well-being and quality of life (Selzer & Lanzendorf, 2022; Freudendal-Pedersen, 2016).

In order to implement targeted and socially acceptable densification measures, empirically based knowledge about residents' preferences regarding different forms of land use and sustainable mobility solutions is needed. In particular, negotiations on competing land uses, such as those related to transportation infrastructure and green spaces, must be examined to encourage more (empirically) informed planning processes (Schwedes et al., 2023). Academic research has begun examining the acceptability of individual measures for redesigning public space in favor of green spaces, pedestrians, cyclists and public transport at the expense of cars (e.g. Lanzendorf et al., 2024; Andor et al., 2020). However, there remains a lack of methodological approaches for evaluating combined measures and competition between different land use intentions among residents – particularly as densification processes intensify competition for limited space.

To address this gap, this paper presents results of a vignette study on the hypothetical expansion of housing stock in residential areas of the 1950s and 1960s in the Rhine-Main and Cologne region in Germany (Kleinekort et al., 2025). In vignette studies, participants judge hypothetical scenarios, situations or persons according to perceived fairness, attitudes, or intended actions (Jasso, 2006; Auspurg & Hinz, 2015). In our case, assuming increased construction and population in the residential area, participants evaluated a series of prospective land use scenarios with experimentally varying characteristics (Auspurg et al., 2009). One dimension included three different options of distributing space – (1) at the expense of car parking spaces and in favor of green spaces, (2) with restricted access to parking spaces and still space for greenery, and (3) with the same number of parking spaces despite densification and possibly less space for greenery. The second dimension contained three sustainable mobility options (improved public and active transport (1), innovative shared mobility offers (2), and expanded local facilities to reduce travel distances (3)). The aim of this survey is to capture the dilemma faced in residential neighborhoods – limited space, increasing density, demand for parking spaces, mobility as well as green and recreational spaces – from the perspective of residents. This allows us to assess how residents evaluate those emerging spatial conflicts on land use.

The innovative aspect of this study lies in using an experimental vignette approach to present scenarios of dealing with more intensive land use in a clear and comprehensible way. Therefore, the vignette method is employed to examine whether residents would accept a reduced parking space accessibility if this enabled the preservation of more green areas. By combining the land use changes with sustainable mobility offers within the scenarios, the study can also explore interaction effects between these dimensions. This, helps to answer the question of which sustainable mobility alternatives can increase the acceptability of parking space reductions and, overall, which combinations of land use strategies and sustainable mobility solutions are likely to gain broader public support.

In Germany, as in other countries (Baur et al., 2022), post-war housing estates of the 1950s and 1960s ('structured and low-density' type) are often key targets for additional housing and mixed-use development. This is because they are considered to offer enough space and therefore particularly suitable for further development. Also, they account for a significant proportion of the building stock and are largely homogeneous in terms of their monofunctional structural layout and ample green spaces (Kaufmann, 2024; Köberl et al., 2024; Kleinekort et al., 2025). Densification issues in these residential areas are particularly sensitive, as resistance to densification is higher in less dense, suburban residential areas than in urban neighborhoods (Wicki & Kaufmann, 2022).

The article is structured as follows: Section 2 summarizes literature on the current practice of designing shared open spaces and sustainable mobility options in densifying residential areas (a) and research on peoples' preferences on this, providing the basis for our research hypotheses (b). Information on data collection, study design and method of analysis can be found in Section 3. Section 4 presents the statistical results, followed by their discussion in Section 5. The article ends with a summary and concluding remarks based on the empirical findings.

2. Literature review

a. Mobility-related land use practice in urban neighborhoods today

Living in a car-centric system (Geels, 2012) or a system of automobility (Urry, 2004), our interpretations of how to approach mobility-related land use are strongly related to space for cars. Over the past centuries, the widespread use of cars has affected how cities are developed and designed. This made low-density housing possible by enabling the suburbs to be accessed by car and establishing the "automobile city" (Newman & Kenworthy, 1996). Within housing estates, such as the post-war residential areas of the 1950s and 60s, traffic-related infrastructure is also mainly oriented towards cars. Due to the functional separation of uses typical of post-war housing estates, these areas primarily offer space for stationary rather than flowing traffic. These neighborhoods therefore mainly have cul-de-sacs with turning areas and parking spaces that provide access to the surrounding residential buildings (Kaufmann, 2024). Combined with the 'predict and provide' planning approach (Owens, 1995) this dominance of the car has persisted until today (Martens, 2017; Paddeu et al., 2024; International Transport Forum (2022)). Thus, when it comes to densification of urban housing estates, car-oriented planning assumes that an increase in residents will be accompanied by an increase in cars and that adequate transport infrastructure must be established. In Germany, this is institutionalized in planning law: building regulations (*Bauordnungen*) and parking space regulations (*Stellplatzsatzungen*) determine the number of car parking spaces that must be provided for new buildings in different types of urban areas (Forschungsgesellschaft für Straßen- und Verkehrswesen, 2023; Blees et al., 2019). A recent analysis of densification projects in post-war residential areas reveals how these regulations are implemented in practice. In seven out of eight projects analyzed, the

main mobility strategy was to provide additional parking space, either above or below ground (Kaufmann, 2024). At times, this has meant reducing public (green) space. In (growing) urban areas, transport hence competes with space for other uses, such as housing and green spaces.

The 'predict and provide' paradigm has been criticized for its high land-use demand (Newman & Kenworthy, 2015), inadequate consideration of equity and justice (Martens, 2017), and support of unsustainable mobility (Berger et al., 2014) as it often leads to additional traffic generation through capacity expansion (International Transport Forum, 2022). Thus, alternative planning approaches have been introduced, such as the sustainable mobility and 'design and provide' paradigms. The sustainable mobility paradigm argues that transport planning should aim to avoid traffic, shift traffic to more sustainable modes, and improve the efficiency of transportation modes (Banister, 2008). This requires a shift in planning practices from car-centered to car-reduced planning that combines restrictive (push) and incentive-based (pull) measures to support car independency and usage of other modes of transport (Schröder & Klinger, 2024). In line with this, the 'design and provide' approach emphasizes vision-led planning and reverses the logic of 'predict and provide': rather than forecasting future demand and accommodating it, planners first define a desirable future and then plan proactively to achieve it.

In recent years, several examples of urban redevelopment and densification projects that enable car-reduced living in urban neighborhoods have been realized in Germany and other European cities. Although these approaches are still rare (Schröder & Klinger, 2024), they are gaining importance. Most prominently, this includes new neighborhoods such as Freiburg Vauban, aspern Seestadt in Vienna, GWL Terrein in Amsterdam and Lincoln in Darmstadt (Selzer, 2021; Coates, 2013), which are sometimes redevelopments of old industrial areas. These new developments are particularly well-suited for alternative planning approaches, as they provide a blank space for a car-reduced design (Blees et al., 2023). Implementing car-reduced neighborhoods in existing settlements brings specific challenges related to already existing infrastructure, particularly the reallocation of existing space, such as converting roads or parking areas into green, recreational, or cycling infrastructure (Bauer et al., 2022). While there are some practical examples of the redesign of existing neighborhoods into car-reduced neighborhoods (e.g., Verkehrsclub Deutschland e.V., 2020), the topic still remains under-researched.

The specific design of a car-reduced neighborhood depends, amongst others, on its location within the city, its accessibility by public transportation and ownership structure of the buildings (Bauer et al., 2022). Integrated mobility concepts outline the context-specific strategies and measures that are relevant to a particular neighborhood (Heldt et al., 2021). For example, an integrated mobility concept was implemented during the recent densification of a post-war residential area in Frankfurt, Germany (2020–2021). This organizes parking in collective garages and provides space for car sharing, bicycles, shared cargo bikes, and e-mobility charging stations (Kaufmann, 2024).

Evidently, changes to the mobility system require changes to mobility practices. While car-reduced planning aims at changing mobility from 'above', residents also stage mobility from 'below' through their mobility practices. Discrepancies between the two approaches present challenges to achieving a car-reduced vision (Selzer, 2021). Therefore, the success of the measures also depends on bridging the planning perspective of a car-reduced vision and perspectives of local residents. From a planning point of view, this can be done through participatory urban planning (Innes & Booher, 2004). However, we want to take a step back and thoroughly consider residents' acceptance and preferences of car-restrictive land use changes and mobility alternatives.

b. Preferences for car-reducing land use changes in favor of green spaces and sustainable mobility: state of research and derivation of hypotheses

There is a growing body of literature on livability in residential areas and residents' desires regarding different land use options. Looking at preferences for the use of open spaces and (mobility-related) neighborhood characteristics, Brookfield (2017) used focus groups to find that a certain compact form, good pedestrian infrastructure, sociable spaces, ample greenery and local amenities (not directly adjacent) were preferred. In a stated preference study in the Swiss canton of Zurich, Wicki und Kaufmann (2022) found that the loss of parking spaces has a negative effect on the assessment of densification measures, while the creation of more recreational areas has a positive effect. Nevertheless, how residents prioritize among these aspects of land use when spatial and ecological constraints prevent their equal implementation is not addressed.

To shed light on this, it is useful to draw on acceptance research. The study results generally show a relatively high level of acceptability for measures to transform car-dominated mobility, even if they are comparatively restrictive. In a representative survey and street interviews in the Berlin district of Friedrichshain-Kreuzberg, Ruhrort et al. (2021) found out that relatively drastic redesign measures of public space at the expense of car traffic received a surprisingly high level of support. Respondents ranked the creation of more green spaces in residential areas by far the highest priority, followed by more space for cycling, pedestrians and areas for people to linger and play. However, the more restrictive the measure for car traffic, the greater the rejection of the land use scenarios studied, even if space is created for other uses (see also Tröger et al., 2025). Kirschner and Lanzendorf (2020) discovered that approval of restrictive measures that include increasing parking fees and parking space restrictions is lowest. Since the proposals in our study for land redevelopment also include parking space restrictions to varying degrees and the introduction of charges, we firstly assume that the acceptability of land use redesign depends on the severity of the parking restrictions. While green spaces are likely to be supported, the complete removal of parking spaces will probably be rejected:

H_{1a}: The space reallocation option that allows for traffic calming as well as green and recreational spaces while maintaining parking spaces in the surrounding area will be most preferred.
H_{1b}: The space reallocation option that completely eliminates public parking spaces in the neighborhood will be least preferred, even if it creates a high amount of green and recreational spaces.

In terms of sustainable mobility alternatives, researchers generally agree that the public is more likely to accept 'pull' measures than 'push' measures, or a combination of both (Buring, 2024; Wang et al., 2020; Tröger et al., 2025). Kirschner and Lanzendorf (2020) observed the highest acceptability rates for improved public transport and an improved bicycle infrastructure. In a 2018 survey of 7.000 household heads there was also a high level of acceptability for measures aimed at redistributing public space in favor of bicycles and public transport, even if space for car traffic was to be restricted (Andor et al., 2020). Therefore, we further assume that improving public and active means of transport is the preferred option among the sustainable mobility options. In addition, the provision of easily accessible services and amenities in the neighborhood is an important factor for subjective well-being and quality of life, as it enables participation in activities and the fulfilment of needs (Mouratidis, 2021). The concept of the 15-minute city, for example, shows how important accessibility is for people and modern planning, as greater accessibility within an area will lead to time savings and less traffic (Moreno, 2024). Nevertheless, Brookfield (2017) also found that while local facilities are desirable, they do not necessarily have to be located in the immediate vicinity. High building density and mixed use were largely rejected by residents in her study due to concerns about noise, nuisance, and health effects. We therefore assume that local facilities will be moderately accepted compared to the expansion of public and active modes of transportation.

Shared mobility, i.e., the shared use of cars, bicycles, or other means of transport, is an innovative transport strategy that is becoming increasingly important in the context of the transport transition. As part of the sharing economy, it promotes the sustainable use of resources and can contribute to reducing motorized private transport and environmental pollution (Arbeláez Vélez, 2024).We know that they are becoming increasingly important in urban residential areas and can provide an attractive alternative to car ownership (Jochem et al., 2020). However, the uptake and continued use of sharing services among German residents is generally slow (KANTAR, 2020; Nobis & Kuhnimhof, 2018). While the number of registered car-sharing customers in Germany has steadily increased (Bundesverband Carsharing, 2024), they still represent a small percentage of the total population. The proportion of active car- or bike-sharing users is even lower (Nobis & Kuhnimhof, 2018; Grüner & Kowald, 2025). Overall, shared mobility continues to occupy a niche position, even though the services are widely known (KANTAR, 2020), which is why we assume that shared mobility services are the least preferred mobility alternative.

H_{2a}: The improvement of public and active transport means (walking, and cycling) is preferred over the expansion of local facilities.
H_{2b}: Shared mobility services are the least preferred sustainable mobility alternative, compared to improved public and active transport means and the expansion of local facilities.

Finally, taking into account the mentioned research findings on sustainable mobility offers understood as pull measures, we expect that the expansion of alternative and innovative forms of mobility in the neighborhood will lead to a greater acceptability of car-restrictive land use changes (interactions between car-restrictive land use option and mobility alternative seen):

H_{2c} (interaction): The introduction of sustainable mobility alternatives increases the acceptability of car-reducing land use changes in the neighborhood.

The focus of the study is to determine the effect of specific vignette characteristics on the acceptability of a future land use proposal. At the same time, we know from the literature that the evaluation of mobility-related policies depends also on personal characteristics. When evaluating plans to reduce car use or promote alternative forms of mobility, it is particularly important which modes of transport people mainly use and whether they have had experience with alternative mobility options. This effect seems to be caused by a 'status quo acceptance', tending to increase the support for the current living and mobility situation (Hess & Börjesson, 2017). Accordingly, Ruhrort et al. (2021) showed that car owners tend to reject a redistribution of road space more often. Likewise, Andor et al. (2020) found that multimodal car users had a more positive attitude towards many of the car-restricting measures surveyed than monomodal car users. In contrast, people who regularly cycle or use public transport are more likely to support a reduction in car infrastructure (Buring, 2024; Lanzendorf et al., 2024; Kirschner & Lanzendorf, 2020). Therefore, the third hypotheses block is:

$H_{3.1}$: Car-restrictive space reallocation options are less preferred by frequent drivers.
$H_{3.2}$: The expansion of public and active transport (walking and cycling) is preferred by frequent public transport users and frequent cyclists.
$H_{3.3}$: Participants with experience in shared mobility services prefer the expansion of shared mobility offers.

Studies have also examined how demographic and socio-economic variables influence the acceptability of car-reducing measures. Their impact on attitudes towards transport policy measures is comparatively low (e.g. Lanzendorf et al., 2024; Nilsson et al., 2016). However, research showes that young people support parking space reduction, the increase of green spaces, and improvements to bicycle infrastructure more often than older population groups (Lanzendorf et al., 2024; Buring, 2024). Likewise, gender-specific differences in the evaluation of transport policy measures have been identified. In the survey from Andor et al. (2020), female heads of household were more likely to be in favor of car-free city centers and driving bans for vehicles that exceed emission limits. On the other hand, women were more likely to reject higher parking fees in city centers, the expansion of infrastructure for electric mobility, and higher diesel taxes. Although Kirschner et al. (2020) did not find differences on the acceptability of parking policies between women and men, reasons for gender-related variations may lie in different attitudes, practices and more dynamic mobility patterns (Rosenbloom, 2006; McQuaid & Chen, 2012). Women use public transport more often and walk more. Furthermore, they are significantly less likely to use sharing services or e-scooters than men (Dellenbaugh-Losse, 2024; Krauß et al., 2020).

Income correlates with the evaluation of car-reducing measures, especially if they are accompanied by higher costs. For instance, people with lower incomes are less likely to support parking or congestion charges than higher-income individuals due to perceived unfairness and higher travel costs (Nilsson et al., 2016; Lanzendorf et al., 2024), maybe because higher parking costs would have a relatively greater impact on lower-income than on higher-income households (Andor et al., 2020). Furthermore, it can be expected that shared mobility offers in the neighborhood are particularly of interest for households with comparatively low incomes and that might not have access to a private car. Conversely, researchers found that the 'typical' car sharer – despite being male and young – has a higher income (Prieto et al., 2017; Mouratidis, 2022; Burkhardt & Millard-Ball, 2006). Besides income, respondents with a higher educational background are found to be more likely to accept certain transport policy measures, such as congestion charges, parking fees or an improved sharing supply (Lanzendorf et al., 2024). Accordingly, we hypothesize that particularly age, but also gender, income and education, influence the evaluation of certain vignette levels (H_4).

$H_{4.1}$: Younger age groups are more likely to accept land use options to the detriment of parking spaces.
$H_{4.2}$: Respondents with higher educational qualifications are more likely to accept land use options to the detriment of parking spaces.
$H_{4.3}$: Respondents with lower incomes are more likely to reject land use options that involve the introduction of parking space fees.
$H_{4.4}$: Female respondents are more likely to reject the introduction of shared mobility options.

Finally, research results speak to the importance of attitudinal, psychological factors when evaluating transportation policy measures. Kirschner et al. (2024) showed, that car-owning residents intending to reduce car use evaluated car-restricting policies similarly to individuals in already car-free households, unlike frequent car drivers. Eliasson et al. (2011) found a strong connection between environmental attitudes and support for congestion charges. In a study by Eriksson et al. (2006), the acceptability of measures aiming to change travel behavior is mainly explained by general environmental beliefs and beliefs related to a specific measure. Our last hypothesis (H_5) is therefore as follows:

H_5: The higher the environmental awareness of respondents, the more likely they are to accept land use options to the detriment of parking spaces.

There is a number of studies examining acceptability of car-restrictive land use changes and sustainable mobility alternatives in residential areas. However, the focus is often on interventions in mixed urban areas in general or in completely newly built housing estates.

Research on retrofitted residential areas is less common (Aumann et al., 2023). This is where this study comes in, investigating the process of urban redevelopment. The term refers to the adaptation of existing communities and structures with the aim of maintaining, strengthening, and further developing the functionality and performance of residential areas under changing conditions (ARL, 2025). Additionally, little is known on how residents assess the competition between different forms of land use that result from densification processes. So far, the question of how residents choose between different favored aspects of land use when spatial and ecological restrictions limit their equal implementation has not been studied.

3. Data and method

a. Research area and data collection

The factorial survey experiment was one component of a larger cross-sectional study conducted as part of the *'Wachstum findet InnenStadt'* research project (Kleinekort et al., 2025), that took place in selected post-war residential areas in the German Rhine-Main region and Cologne. In Germany, as in other Western industrialized countries (Baur et al., 2022), these emerged at the beginning of the reconstruction after World War II and can be found in almost every German city (Kleinekort & Schmeing, 2016; Kaufmann, 2024). The residential buildings are characterized by a linear arrangement of three- to five-story houses. These are surrounded by generous green spaces which is why they are said to offer plenty of room for further development.

Before data collection, the project team identified typical housing estates in the Rhine-Main region that met the criteria of this post-war urban planning type. Afterwards, the team analyzed the identified housing estates for their densification potential. From the resulting pool of analyzed residential areas, five housing estates in three suburbs of Frankfurt am Main (located in Griesheim, Sossenheim and Preungesheim) were selected as study areas because of their size and proximity to the university. Data collection ran from September 2023 to November 2024. The team members recruited residents via a flyer and a letter containing brief information about registration, the €20 incentive and the survey procedure. All adult household members from 18 years of age, were able to register online or by telephone. As the overall response was low (only between one and two percent of households responded), we employed external service providers specialized in target group recruitment and expanded the potential recruitment area to the Cologne region. The service providers reached potential participants via existing internal databases or through cold recruitment in the residential areas. The direct approach to residents on their doorstep was particularly successful here, albeit with some effort. A recruiter, recognizable as acting on behalf of the university and equipped with survey material, was able to conduct a large number of interviews directly in the residents' homes. All in all, the service providers recruited 182 interested persons, of whom 163 were successfully interviewed (cooperation rate: 89.6 %). It is not known how many potential participants were actually contacted by the service providers, which is why no statement can be made about the response rate. With the recruitment strategies described, a total of 236 residents aged 18 and above were successfully surveyed between September 2023 and November 2024, with more than two-thirds of the respondents being achieved by external service providers.

Due to survey complexity, computer-assisted personal interviews (CAPI) were implemented with Qualtrics (2024) and conducted online or on site. Especially for the vignette study, it was necessary for interviewers to explain the task and be available to answer questions. To enable people without access to a computer or the Internet to participate, rooms close to their homes were requested where the survey could take place. For those who preferred online participation, we used a video tool (WebEx and Zoom) in which interviewers shared their screen, allowing for interaction during the web-based survey and looking at the vignettes together. The survey took an average of 46 min to complete.

b. Design of the factorial survey experiment

To identify residents' preferences for different forms of mobility-related land use and their spatial organization, participants were asked to evaluate a series of prospective land use scenarios (*vignettes*). In vignette studies, participants judge hypothetical scenarios, situations or persons according to perceived fairness, attitudes, or intended actions (Jasso, 2006; Auspurg & Hinz, 2015). To define the scenarios, each vignette contains a discrete number of different predefined dimensions (*attributes*). Each dimension can be described by a certain number of characteristics (*levels*), which are varied by systematically assigning one level to each dimension (Dülmer, 2019). This approach allows researchers to assess the causal impact of the vignette levels on individual responses to the hypothetical vignette context (Atzmüller & Steiner, 2010). This survey method suited our research goal well, as it required respondents to make trade-offs between vignette dimensions.

The vignettes illustrate different ways of reallocating available space in the residential areas when land use intensifies due to the construction of new housing and growing traffic. Their creation was based on several

Table 1
Vignette dimensions and levels.

Dimension	Level	Level description
Space reallocation	(1) Major	• no more parking spaces at all: parking only outside the residential area • rental cars on the outskirts • still space for greenery, recreation & play
	(2) Medium	• collective garages on the outskirts: ten-minute walk away & subject to a fee • residential area is traffic-calmed: cars can only enter in exceptional cases • still space for greenery, recreation und play
	(3) Low	• same amount of parking spaces for residents as before, now subject to a fee • car parking outside the area possible, if free parking is desired • less free space for greenery, recreation & play because of possibly more buildings as part of densification
Sustainable mobility option	(1) Improved public & active transportation	• regular & frequent public transport connections • good and wide cycle and footpaths • sufficient signposting and bicycle parking spaces close to the entrances
	(2) Shared mobility services	• a variety of shared mobility options in the neighborhood, like (electric) cars, bicycles, cargo bikes & scooters • reservation & booking via mobility app • app provides real-time information on public transport services
	(3) Expanded local facilities	• various leisure & care facilities right on the spot (such as a café, doctor's office or places for private or communal use like working or celebrating) • offers can be found on the ground floors of the houses or outside in the green areas

German guidelines on the implementation of car-reducing land use and mobility concepts in residential areas, which we identified in a previous literature review (Verkehrsclub Deutschland, 2020; Aichinger, 2020; Bauer et al., 2022). Table 1 provides an overview of the selected dimensions and levels, including their exact descriptions in the vignette texts. We contrasted two dimensions: (1) the reallocation of space (in terms of parking, green and recreational spaces) and (2) the introduction of sustainable mobility options (aiming at either shifting traffic or avoiding it) (Banister, 2008). We did this, to test their impact on the evaluation of space reallocation options. To reduce the space required for cars, the most common proposals are to reduce the amount of parking spaces, to bundle them at the edge of a neighbourhood (collective garages), and to create traffic-calmed streets or even car-free zones, allowing for a distinction between car-reduced and car-free neighbourhoods (Melia, 2014).

Compared to the current state of land use in the residential areas, the first dimension includes three levels of space reallocation: A *major* reallocation option that involves completely eliminating parking spaces in the residential area, preserving space for green and recreational areas. A *medium* reallocation option in which parking spaces are relocated to a collective garage within walking distance (subject to payment), also preserving space for green and recreation but allowing some car traffic in exceptional cases. And a *low* reallocation option maintaining the same amount of close parking spaces despite densification, with paid residential parking and less free space for greenery and recreation due to possibly more buildings. Since the available space is limited, the expansion of residential buildings and the reorganization of parking facilities affects the proportion and usability of the remaining space in the neighborhood. Therefore, each level within the space reallocation dimension is a fixed combination of possible distributions of space for parking, greenery and recreation.

For sustainable mobility options, we followed the shift and avoid strategies of the sustainable mobility paradigm (Banister, 2008). To shift traffic, common strategies include promoting environmentally friendly means of transport, like walking and cycling, through attractive infrastructure as well as integrating attractive public transport. In addition, innovative mobility solutions, such as shared mobility and mobility stations, are key components of sustainable mobility options. Finally, the expansion of local facilities and services is an option that enables easy access to a range of facilities and services in the area (Moreno, 2024), which aims at reducing the need for cars.

Each vignette randomly combined one level from the space reallocation dimension (in the first paragraph) with one level from the sustainable mobility option (in the second paragraph). As each level of the first dimension could be merged with any level of the second dimension, the complete vignette universe consisted of 9 vignettes (3×3). Since the vignette study was part of a larger questionnaire, we wanted to reduce the response burden. We created three vignette blocks, with each block containing three vignettes. When creating the blocks, we ensured that every participant was exposed to each level of both the space reallocation and the sustainable mobility dimension exactly once. This, however, does not mean that an individual respondent saw every possible combination of levels. Table 2 shows an example for a block.

Vignettes were presented as short texts with keywords highlighted (see Fig. 1), helping respondents to better imagine the situation. Although Shamon et al. (2019) did not find consistent effects of vignette format on decisions, we followed Auspurg and Hinz's (2015) argument and found a short text more realistic, vivid and informative than a tabular format. Before the vignettes were presented, participants read an introductory text explaining the task. After accepting or rejecting a vignette, respondents could give up to three reasons for their decision, including the option to enter additional reasons in a free text field.

Table 2
Example of one possible vignette block.

	Sustainable mobility option 1	Sustainable mobility option 2	Sustainable mobility option 3
Space reallocation 1	○	●	○
Space reallocation 2	○	○	●
Space reallocation 3	●	○	○

Rows represent levels of the space reallocation dimension and columns represent levels of the sustainable mobility dimension. Filled circles (●) indicate the three combinations (Space reallocation 1–Mobility 2, Space reallocation 2–Mobility 3, Space reallocation 3–Mobility 1).

c. Analytical approach: Extended binary logistic regressions

The dependent variable is dichotomous and indicates whether a respondent accepted (1) or rejected (0) the vignette. Therefore, binary logistic regressions are used to model the association between the dichotomous dependent variable and the independent variables (Kalisch & Meier, 2021). However, with three vignette evaluations per respondents, the data are nested, meaning that the evaluations within the participants are not independent of each other (Hox et al., 1991). Therefore, the data were also analyzed using multilevel (random intercept) logistic regressions, with vignette characteristics at level 1 and respondents at level 2. This allows for the inclusion of a random effect that indicates how much the participants differ from one another in their vignette evaluation (Steiner & Atzmüller, 2006). All other predictors were included in the model as fixed effects across all participants. This model is chosen because it is assumed that although the participants differ systematically in their vignette evaluations, the influence of the predictors is the same across all participants. We first estimated an empty model to check how much the vignette evaluations differ between participants. The random intercept (level 2-variance) in the two-level null model is small and statistically insignificant ($\text{var}(u_{0j})=0.099$, $p = 0.457$) (see appendix), suggesting that there is no significant variability in the chance of accepting a vignette between the participants. The interclass correlation coefficient (ICC) in the null model is close to zero (0.024). This means that only 2,4 % of the total variance in vignette acceptability can be attributed to differences between respondents (Snijders and Bosker 1999: 16f). Conversely, most differences in vignette evaluations are found within respondents (i.e., between vignettes). Based on these findings, we decided to employ the simple (1-level) logistic regression (the results of the multilevel analysis can be found in the appendix).

To test the research hypotheses, the multivariate analysis was carried out in five steps using IBM SPSS Statistics (version 29):

1. First, we tested the influence of vignette levels (see Table 1) on the acceptability of a presented scenario across all respondents in a baseline model (*Model 1*). This allowed analyzing which vignette characteristic is preferred among participants (H_{1a} to H_{2b}).
2. Second, interaction terms between the main effects of vignette levels were used to test whether the sustainable mobility alternatives in the scenarios influence the evaluation of space reallocation proposals (H_{2c}).
3. Next, we examined whether the effects of the vignette levels on the acceptability are moderated by respondent's frequency of transport use ($H_{3.1}$ to $H_{3.3}$, *Model 2*),
4. socio-demographics ($H_{4.1}$ to $H_{4.4}$, *Model 3*), or
5. environmental awareness (H_5, *Model 4*).

If a coefficient for an interaction term is positive, the respective level has a stronger effect on vignette evaluation for respondents with the characteristic under consideration, while a negative interaction

Please imagine the following situation:

New flats are being built in your neighborhood, giving more people a place to live in the city. With more people in the neighborhood, traffic problems may arise, for example, due to increased pressure to find parking spaces. The City has developed a number of proposals to help you make the most of the limited space in your neighborhood, while still ensuring that you can get around.

On the following pages we present **three different solutions. Please read each proposal carefully and decide whether you would accept it or not.**

One proposal is as follows:

Despite the densification, there will still be **space for trees, green areas, seating and play areas for children in your neighborhood**. This has been made possible by the fact that there are **no longer any parking spaces available for private cars in the neighborhood**. If you want to use a car for certain errands, shopping, or transport, there are **cars available for hire at the edge** of the neighborhood. You could then sell your own car or park it in one of the surrounding neighborhoods.	*Text module dimension 1, level 1*
There are **regular and frequent public transport connections**, the stops are quickly accessible on foot and you will find information boards with departure times at the building entrances. There are **good and wide cycle and footpaths**, **signposting and sufficient bicycle parking spaces** near the building entrances, both in your neighborhood and on the connection to the city.	*Text module dimension 2, level 1*

Would you accept this suggestion?

- ☐ Yes
- ☐ No

Which aspects were crucial for your decision? Please select the most important ones (up to three).

- ☐ *list of all aspects from the vignette text seen (that are marked in bold)*
- ☐ *Another reason (please enter below):*

free text entry

Fig. 1. Example of a vignette.

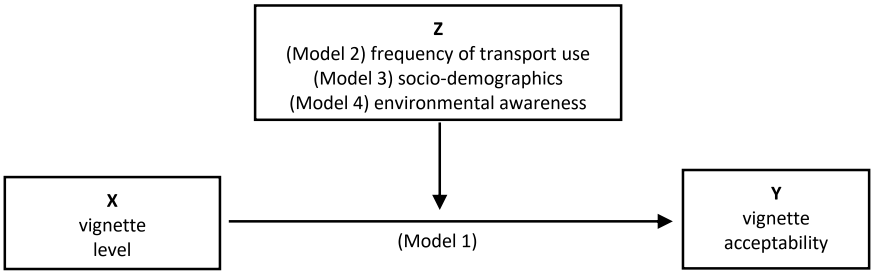

Fig. 2. Conceptual structure of statistical models.

parameter has the opposite effect (Hilbe, 2015). Fig. 2 shows the conceptual structure of the statistical model.

Since vignette levels are categorical variables, they are incorporated as dummies on the independent side of the model. Household net income is available in the dataset as an ordinal variable with ten categories. In order to calculated the equivalized household net income that takes into account the number of household members, we calculated a continuous income variable from the ordinal one by taking the mean of each income category. It should be noted that this approach can lead to measurement errors. The total net disposable household income calculated in this way was divided by the equivalized household size, with the first adult being weighted by a factor of 1, all other persons aged 14 or over by factor 0.5, and persons under 14 by factor 0.3 (Eurostat, 2021). For environmental awareness, a latent factor was extracted from respondent's answers to four items as manifestations of the latent variable using exploratory factor analysis (for results of the items used, including factor loadings, see Table 8 to Table 12 in the Appendix). Both the Bartlett test (Chi-square = 248.8, $p < 0.001$) and Kaiser-Meyer-Olkin measure of sampling adequacy (KMO=0.785) indicate that the items are suitable for a factor analysis (Backhaus et al., 2021). Thus, a principal components analysis with varimax rotation was conducted, explaining 60.7 % of the variance. After conducting reliability analyses, the final factor was saved and included in the model as the mean value from the sum of the four items.

For each dimension, one level was defined as the reference category, treating it as the "baseline" and setting it to zero. For the first dimension, this is the 'low space reallocation' level, because this option to manage increasing land use pressure includes the fewest structural changes and best reflects the 'status quo' in the residential areas today. Similarly, we selected the level of improved environmentally friendly transport modes as the reference for the second dimension, as many residential areas already have quite good transport connections, but lack shared mobility services and local shops and facilities. The associated coefficients describe their estimated effect on the acceptability of a vignette. The coefficients of a logistic regression are reported as odds ratios (ORs). They describe how strongly an independent variable influences the probability of the target event occurring, when all other variables are held constant (Kalisch & Meier, 2021). An OR > 1 makes it more likely

that the vignette will be accepted, an OR < 1 makes it less likely that the vignette will be accepted, and an OR of 1 means there is no correlation.

4. Results

a. Study sample: Descriptive statistics

Table 3 shows the description of the study sample with regard to all variables used in the model (as dummy variables in the interaction terms). Our sample includes 236 respondents from different post-war housing estates in the German Rhine-Main and Cologne region. At 61 %, the proportion of female respondents in our sample is slightly higher than in the population of the selected post-war housing estates, which has roughly equal proportions of women and men (for comparison see Table 7 in the Appendix). Furthermore, our sample tends to be somewhat younger compared to the general population living in the housing estates, with 35 % of respondents being between 18 and 34, and 19% being 60 years old or older. 30 % of respondents are in the high-income group and 35 % have a university degree. While 38 % of the respondents stated that they travel by car (almost) every day, 36 % of the respondents use public transport (almost) every day. Only 11 % say they cycle frequently. A further 11 % have already tried a car-sharing service.

b. Acceptability of the mobility-related land use scenarios

All 236 participants evaluated three vignettes, resulting in 708 observations (=rated vignettes). Each vignette was evaluated approximately the same number of times (708/9 = 78.6 times on average), indicating a balanced design. Roughly half of all vignettes seen were accepted (49 %), and half were rejected (51 %) (see Table 4).

The most supported vignette (68 %) combined the medium space reallocation level (distant, fee-based collective garage, traffic-calmed area and space for greenery, recreation und play) with an expansion of local facilities (*vignette no. 6*). The second most popular option (61 %) was combining the medium reallocation level with improved public and active modes of transport (*no. 4*). In contrast, with 35 % respondents least liked the major space reallocation level combined with shared mobility services in the neighborhood (*no. 2*). The low level of space reallocation (same number of parking spaces, subject to a fee, and a probable reduction in green space due to more buildings) combined with shared mobility offers (*no. 8*) was also only accepted by 35 % of respondents.

c. Estimation results of binary logistic regression models

Table 5 shows the results of all estimated models. *Model 1* includes a constant term and all vignette levels as independent variables in order to test their influence on vignette acceptability (H_1 and H_2). Compared to the reference (with an identical number of parking spaces despite the densification, and the potential loss of greens spaces), respondents were significantly more likely to accept the 'medium space reallocation' option (OR=1.853, $p < 0.001$) with peripheral collective garages enabling traffic calming and green space creation, but requiring payment and a ten-minute walk, confirming H_{1a}. In contrast, the 'major space reallocation' option (no more parking spaces, but lots of space for green and recreation) is evaluated negatively compared to the reference

Table 3
Socio-demographic characteristics of the sample according to the personal variables used in the model.

		Value	%
Gender	female	143	60,6
	male (diverse)	92 (1)	39,4
Age	18–34 years	83	34,9
	35–59 years	110	46,2
	60 years and above	43	18,5
Net household equivalent income	low	90	38,1
	middle	60	25,4
	high	70	29,7
	Missing	16	6,8
Education	University degree	82	34,7
	Other	154	65,3
Frequency of car use	Daily or almost daily	89	37,7
	Weekly, monthly or (almost) never	147	62,3
Frequency of bicycle use	Daily or almost daily	26	11,0
	Weekly, monthly or (almost) never	210	89,0
Frequency of public transport use	Daily or almost daily	84	35,6
	Weekly, monthly or (almost) never	152	64,4
Car sharing experience	Yes	26	11,0
	No	210	89,0
Environmental awareness (factor), mean (SD) (1: not at all, 7: absolutely)		4,95 (1,41)	
	Total	**236**	**100,0**

Table 4
Acceptability rate for each individual vignette.

	Vignette number	Accepted		Total	
		Count	%	Count	%
Major space reallocation &	… promotion of public & active transport modes (1)	38	50,0	76	100,0
	… shared mobility services (2)	28	35,0	80	100,0
	… expansion of local facilities (3)	36	45,0	80	100,0
Medium space reallocation &	… promotion of public & active transport modes (4)	49	61,3	80	100,0
	… shared mobility services (5)	39	51,3	76	100,0
	… expansion of local facilities (6)	54	67,5	80	100,0
Low space reallocation &	… promotion of public & active transport modes (7)	34	42,5	80	100,0
	… shared mobility services (8)	28	35,0	80	100,0
	… expansion of local facilities (9)	44	57,9	76	100,0
Total		**350**	**49,4**	**708**	**100,0**

Table 5
Results of the basic and extended binary logistic regression models.

			Model 1 (vignette level effects only)			**Model 2** (Model 1 + interaction with frequency of car use & sharing experience)			**Model 3** (Model 2 + interaction with socio-demographics)			**Model 4** (Model 3 + interaction with environmental awareness)		
dimension	level	level description	B	p-value	OR	B	p-value	OR	B	p-value	OR	B	p-value	OR
Space reallocation	*low (ref.)*	*Same amount of parking spaces, subject to a fee, less space for green & recreation (ref.)*												
	major	No more parking spaces at all, car rental, still space for green & recreation	−0.074	.692	.929	.359	.094	1.431	−0.042	.875	.959	−0.224	,395	.783
		X frequent car user				−1.251***	<0.001	.286	−1.200***	<0.001	.301	−0.924**	.004	.397
		X young adults (18 to 34)							.520	.076	1.683	.847**	.009	2.332
		X university degree							.577	.050	1.779	.343	.278	1.409
		X environmental awareness										.638***	<0.001	1.892
	medium	Collective garages, 10-min walk away & subject to a fee, traffic-calming, still space for green & recreation	.617***	<0.001	1.853	.620**	0.001	1.858	.577**	.009	1.780	.662**	.004	1.938
		X older adults (60+)							−1.048**	.003	.351	−1.239	<0.001	.290
		X university degree							.699*	.021	2.012	.595	.056	1.812
		X environmental awareness										.302	.004	1.353
mobility alternative	*Promotion of* public and active *transportation (ref.)*	*frequent public transport, wide cycle & footpaths, sufficient signposting & bicycle parking spaces (ref.)*												
	Shared mobility services	Variety of shared mobility options in neighborhood, like (electric) cars, bicycles, cargo bikes & scooters, booking via mobility app	−0.444*	.018	.641	−0.566**	.004	.568	−0.113	.677	.893	−0.046	.870	.955
		X sharing experience				.922*	.035	2.514	.588	.209	1.800	.397	.421	1.487
		X female							−0.698*	.017	.498	−0.810**	.007	.445
	Local facilities	Various leisure & care facilities on the spot, on the ground floors of houses or outside	.229	.222	1.257	.222	.242	1.249	.243	.209	1.275	.305	.125	1.357
		Constant	−0.132	.437	.877	−0.122	.473	.885	−0.128	.455	.879	−0.144	.409	.866
		Number of individuals	236			236			236			236		
		Number of rows in database	708			708			708			708		
		Estimated parameters	5			7			11			14		
		initial −2 Log likelihood	981,406			951,575			928,665			903,901		
		final −2 Log likelihood	951,575			928,665			903,901			865,010		
		Omnibus Tests of Model Coefficients (*p-value*)	<0.001			<0.001			<0.001			<0.001		
		Nagelkerke R^2	.055			.096			.138			.202		

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (two-tailed test).

Table 6
Tested hypotheses and results.

Set	Dimension	No.	Hypothesis	Supported?
1	Space reallocation	H_{1a}	The space reallocation option that allows for traffic calming as well as green and recreational spaces while maintaining parking spaces in the surrounding area will be most accepted.	Yes
		H_{1b}	The space reallocation option that completely eliminates parking spaces in the area will be least preferred, even if it creates a high amount of green and recreational spaces.	No
2	Sustainable mobility alternatives	H_{2a}	The improvement of public and active transport means (walking, and cycling) is preferred over the expansion of local facilities.	No
		H_{2b}	Shared mobility services are the least preferred sustainable mobility alternative, compared to improved public and active transport means and the expansion of local facilities.	Yes
		H_{2c}	The introduction of sustainable mobility alternatives increases the acceptability of car-reducing land use changes in the neighborhood.	No
3	Frequent mode of transport	$H_{3.1}$	Car-restrictive space reallocation option are less preferred by frequent drivers.	Yes
		$H_{3.2}$	The expansion of public and active transport (walking and cycling) is preferred by frequent public transport users and frequent cyclists.	No
		$H_{3.3}$	Participants with experience in shared mobility services prefer the expansion of shared mobility offers.	Yes
4	Socio-demographics	$H_{4.1}$	Younger age groups are more likely to accept land use options to the detriment of parking spaces.	Yes
		$H_{4.2}$	Respondents with higher educational qualifications are more likely to accept land use options to the detriment of parking spaces	Yes
		$H_{4.3}$	Respondents with lower incomes are more likely to reject land use options that involve the introduction of parking space fees.	No
		$H_{4.4}$	Female respondents are more likely to reject the introduction of shared mobility options.	Yes
5	Environmental awareness	H_5	The higher the environmental awareness of respondents, the more likely they are to accept land use options to the detriment of parking spaces.	Yes

(OR=0.929, $p = 0.692$). However, this result was statistically insignificant, meaning that respondents did not reject the major reallocation option significantly more than the reference of keeping the same number of parking spaces, which speaks against *H_{1b}*.

Regarding sustainable mobility options, respondents significantly less preferred shared mobility services to the promotion of public and active transport modes in the neighbourhood (OR=0.641, $p = 0.018$). Also, they evaluated the expansion of local amenities within walking distance more positively than improved public and active transport options (OR=0.1257, $p = 0.222$), but this difference was not statistically significant, suggesting that the two options were similarly acceptable. In line with hypothesis H_{2b}, shared mobility services were the least preferred sustainable mobility alternative.

Overall, considering only the vignette levels (*Model 1*) explains only a very small amount of variance in the data (Nagelkerke R^2=0.055). In a second step, we added interaction terms between space reallocation-levels and the levels of sustainable mobility options, to test whether offering alternative mobility options increases the acceptability of car-disadvantaging land use changes (H_{2c}). The sustainable mobility alternatives presented in the vignettes did not influence the acceptability of the space reallocation levels and are therefore not displayed. All interaction terms were statistically insignificant, indicating that H_{2c} does not apply.

Model 2 shows that support for the major space reallocation level depends strongly on car use frequency, confirming $H_{3.1}$. Respondents who travel by car (almost) every day are significantly less supportive of a major parking space reduction compared to the low space reallocation reference (OR=0.286, $p < 0.001$). Those who do not use a car daily, evaluate the option of no parking spaces at all, with space for green and recreation more positively (OR=1.431, $p = 0.094$). For the medium space reallocation level with distant, fee-based collective garages, the interaction effect with car use frequency was statistically insignificant. We also found no differences in space reallocation preferences based on frequent use of public transport or bicycles. The negative effect of shared mobility services on vignette acceptability, compared to promoting public and active transport modes, remained consistent regardless of whether respondents mainly used cars, public transport, or bikes. However, among those who had used car sharing at least once, the negative baseline effect is significantly weaker (OR=2.514, $p = 0.035$), confirming $H_{3.3}$. Conversely, participants with no car sharing experience were significantly less likely to accept a vignette that included information on shared mobility services (OR=0.568, $p = 0.004$). Adding interaction terms between vignette levels and car use frequency or sharing experience increased the Nagelkerke R^2 to 0.096. The Omnibus test of model coefficients indicates a significant improvement of the model with these variables.

After including interaction terms between socio-demographic characteristics and vignette levels (*Model 3*) the Nagelkerke R^2 increases significantly to 0.138. For young adults (aged 18 to 35), the negative effect of a major spatial reallocation on vignette acceptability is less pronounced (OR=1.683, $p = 0.076$). Conversely, for participants aged 60 and over, the positive effect of the medium reallocation strategie is significantly reduced (OR=0.351, $p = 0.003$). These findings confirm $H_{4.1}$: young respondents are more likely to accept the extensive space reallocation option in favor of green spaces, while older respondents are more likely to reject the medium, distant garage-based solution. No significant interaction was found between age group and sustainable mobility alternatives in relation to vignette acceptability. Female respondents showed a significantly stronger negative response to expanded shared mobility offers in the neighborhood (OR=0.498, $p = 0.017$) than male/diverse respondents, confirming $H_{4.4}$. The negative base effect of sharing services is now no longer significant for men with no car sharing experience, suggesting that gender explains the differences in the acceptability of shared mobility services at this point. No significant gender interactions were found for the other vignette levels.

Household net income did not interact with any vignette level effect, indicating that in our data the relevance of the mobility-related land use levels for vignette evaluation is income-independent. However, we found significant effects relating to education, confirming $H_{4.2}$: Respondents with a university degree showed a weaker negative response to the major space reallocation option (OR=1.779, $p = 0.050$) and significantly stronger support for distant and paid collective garages with traffic calming than those with a lower level of education (OR=2.012, $p = 0.021$).

Finally, we tested whether respondents' environmental awareness moderates the effect of vignette levels on acceptability (*Model 4*). Environmental awareness strongly predicts vignette acceptability, increasing Nagelkerke R^2 to 0.202. With increasing environmental awareness, the negative base effect of the major space reallocation level on vignette acceptability is significantly weaker (OR=1.892, $p < 0.001$). For the medium reallocation option, the positive base effect increases with higher environmental awareness. The evaluation of sustainable mobility alternatives, in contrast, is independent of environmental awareness, confirming H_5 only for the space reallocation levels. Table 6

summarizes all tested hypotheses and results.

We used a Chi-square test (omnibus test of model coefficients) to assess whether each model explained the data better than the null or previous model. By comparing the −2LL values, we found significant improvements at each step. The Hosmer-Lemeshow test was not significant in any case: the observed cases do not deviate from the predicted cases, which indicates a sufficiently good model fit (Hilbe, 2015). Overall, the model fit remains moderate. Vignette levels alone explain little variance in acceptability. One likely reason is that each space reallocation level combines several elements together (such as the parking situation, green space, recreational areas, and car rental options) which may affect respondents' evaluations differently. To explore which aspects were most relevant for the respondents' decisions, we will look at the descriptive distribution of the reasons given for a decision.

e. Supplementary description of the reasons for a decision

The option to let respondents give comments on their choice clarifies the reasons for either accepting or rejecting a scenario, which enriches understanding of the acceptability of the scenarios. Nearly 48 % of respondents rejected the *major* space reallocation option due to the complete absence of parking spaces (see Fig. 3), making it the most cited reason for a decision. 24 % disliked the idea of renting a car on the estate's outskirts. In contrast, 36 % accepted the proposal because it creates ample space for trees, greenery, recreation, and play. Since car use frequency and age group significantly influenced evaluations in the multivariate model, the reasons given are additionally split up according to those two variables. Among frequent drivers, 64 % cited the lack of parking spaces in the area as a reason for rejection, compared to only 37 % of infrequent drivers. Similarly, 38 % of frequent car drivers (versus 16 % of less frequent car drivers) rejected the proposal due to reliance on rental cars. When frequent drivers accepted the major reallocation option, 21 % did so because of free space available for other uses, compared to 45 % of less frequent drivers. Age also shaped responses: 57 % of respondents aged 60 and over rejected the proposal of major spatial reallocation due to the entire parking space removal, compared to 49 % of middle-aged adults and 41 % of young adults. For young adults (18–34), the most common reason for acceptance (45 %) was the increased space for greenery and other uses. Among over-60 s, just 23 % cited this as a reason. Young adults also mentioned the option to rent cars on the outskirts slightly more often (23 %) as a reason for acceptance.

Most respondents accepted the *medium* level of space reallocation, with 41 % justifying their decision by the traffic-calmed neighborhood and available green and recreational space (see Fig. 4). In contrast, about 22 % rejected this level due to the 10-minute walking distance to and the cost of the collective garage. Especially among frequent drivers (34 %) and respondents aged 60 years and more, the walking distance was the main reason for rejecting the peripheral garage. The introduction of costs was mentioned equally often across age groups and driving frequencies (around 22 %), indicating that the most decisive factor for decision is not the costs but the distance of the parking spaces.

Interestingly, for 28 % of the frequent car drivers (and middle-aged adults) a collective garage on the outskirts of the residential area is not a problem, but a reason to accept the vignette. This could be a reason for the significantly higher approval of this medium land use level in the multivariate model among all respondents compared to the low redesign level: This solution allows traffic calming (41 % general approval), preserves space for green and other uses while still offering parking possibilities nearby – making it acceptable also for many frequent drivers. Even if it means a ten-minute access and egress walking distance and additional costs, it guarantees a parking space for those who cannot imagine having none.

In addition to predefined reasons, participants were able to give free-text responses as to why they did (not) accept a certain vignette. Some respondents, for example, opposed the removal of parking spaces near their front doors, citing difficulties for older or mobility-impaired individuals to walk 10 minutes to their car. Some participants also stated

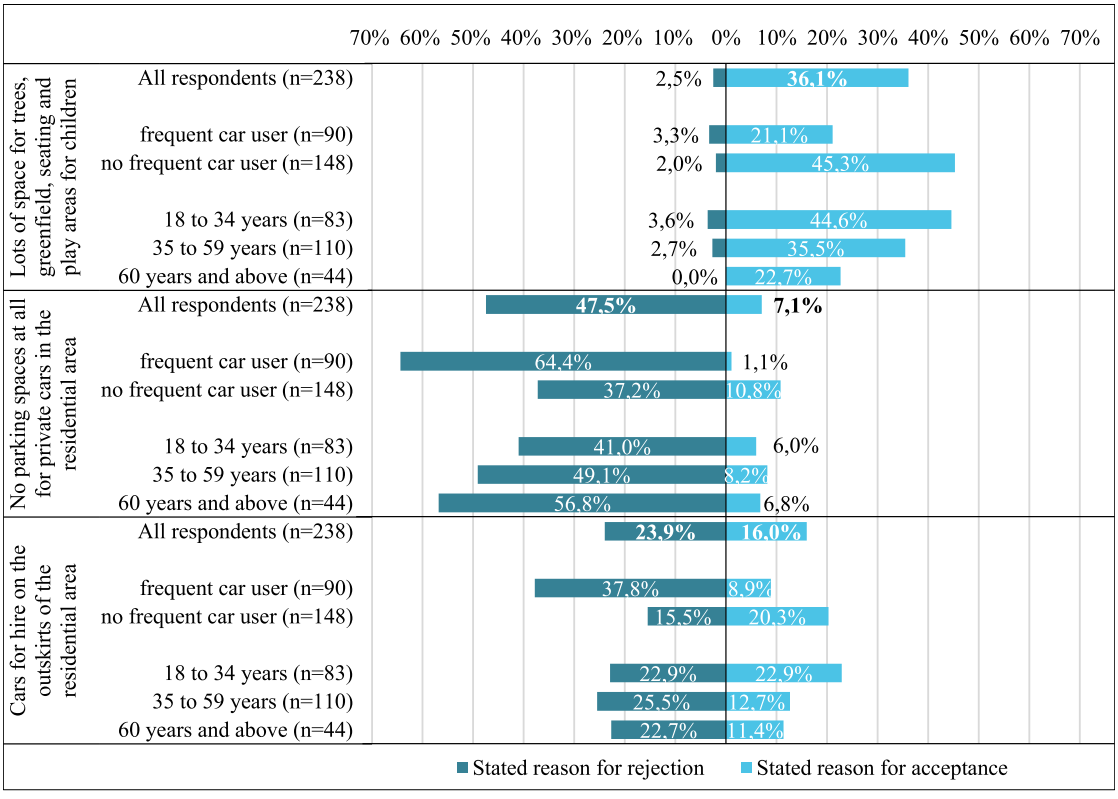

Fig. 3. Stated reasons for major redesign level evaluation by frequency of car use and age group.

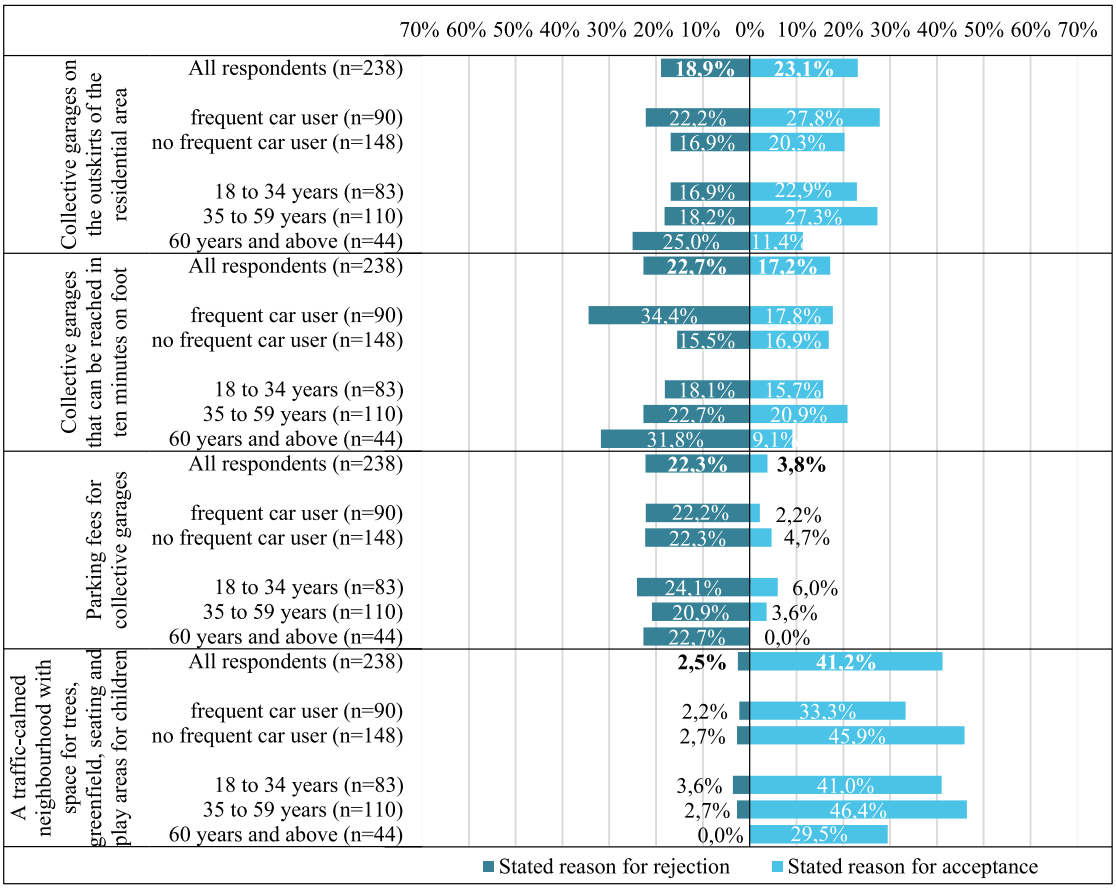

Fig. 4. Stated reasons for medium redesign level by frequency of car use and age group.

that completely getting rid of their own car was not an option, especially since they need to transport children or go shopping. There were also concerns about shared mobility services, such as the potential for e-scooters to be damaged or the lack of available child seats in shared cars.

5. Discussion

The extended logistic regression models show that the space reallocation option that relocates parking spaces to collective garages on the outskirts and creates space for greenery, recreation and other uses in the residential area was the most accepted – regardless of how frequently respondents use their cars and even at the sacrifice of a quick access to private cars and the introduction of costs for a parking space. The most frequently cited reason for this decision, at 41 %, was that the neighborhood is traffic-calmed with space for trees, greenery, seating, and play areas for children. This result shows a relatively broad desire for green spaces, alternative uses, and traffic-calming measures among respondents in the event of densification, which is consistent with the results of other studies (Wicki & Kaufmann, 2022; Ruhrort et al., 2021). Another 23 % of respondents accept the proposal precisely because there is a communal garage, and therefore parking spaces, even if only on the edge of the residential area and subject to parking fees in future. Therefore, the reason for the popularity of the medium space reallocation option is probably that it offers a combination of parking spaces and green spaces. This result reflects the idea formulated by Lanzendorf et al. (2024) in their study: Measures appear to be particularly successful when car restrictions are accompanied by improvements for other land uses. In terms of planning implications, this result highlights that acceptance of neighborhood redesigns depends on finding a balance between competing spatial needs. Both green and parking spaces are valued, and residents appear most supportive of solutions that maintain this equilibrium – such as relocating parking to collective garages while simultaneously preserving greenery. This underlines the importance of designing and communicating changes as tangible and locally visible improvements that demonstrate concrete benefits rather than pure restrictions.

However, participants remained somewhat skeptical towards extensive parking space reductions, even when compensated with green space and sustainable modes of transportation. The major space reallocation option that involves completely eliminating parking spaces in the residential area and creates space for greenery and other uses was least accepted, albeit similarly low to the option of retaining all parking spaces despite densification, thereby risking the loss of green areas due to potentially more buildings. The main reason for rejecting the major reallocation of space in the area is the complete absence of parking spaces. 48 % of respondents stated this. In contrast, 36 % of respondents are in favor of completely removing parking spaces in this area *because* it creates plenty of space for green and leisure activities. In relative terms, however, this is still quite high, as other studies have also found (Andor et al., 2020; Ruhrort et al., 2021; Lanzendorf et al., 2024). Yet, this illustrates varying interests regarding land use and parking among residents and again highlights that planning for car-reduced neighborhoods involves balancing competing priorities. Dialogical, participatory planning can serve as a means to reconcile these perspectives and foster mutually accepted outcomes (Innes & Booher, 2004). Empirical methods and findings like used in this study may effectively support such planning approaches.

The experimental design enables an analysis of interaction effects between the two dimensions, providing insights into which sustainable mobility alternative might increase the acceptability of parking space reductions. Participants generally welcomed the idea of expanding local facilities as well as improving public and active modes of transportation.

However, the sustainable mobility options offered in the scenarios did not significantly affect the overall vignette evaluation in our study, indicating that they might play a subordinate role. Our findings therefore do not support the assumption that sustainable mobility alternatives – understood as 'pull measures' – automatically increase the acceptability of parking space reduction, despite the positive effects on other, non-traffic-related land uses highlighted in the vignette texts [see the discussion of Lanzendorf et al. (2024)]. Instead, participants seemed to base their evaluations primarily on the imaginable land-use changes – the immediate spatial and aesthetic qualities of the neighborhood – rather than on potential changes in everyday mobility practices. This suggests that many residents do not (yet) envisage a change in mobility practices, but rather prioritize maintaining a familiar balance between green areas and accessible parking, even if parking is relocated to the neighborhood's edge. From a planning and sustainable mobility perspective, this indicates that simply introducing innovative mobility solutions such as shared mobility or improved public and active transport alone is unlikely to change residents' mobility practices. This underscores the need for supportive strategies that bridge the gap between planning intentions and users' lived experience in practice (Selzer, 2021). In particular, communicative and informative interventions (Aichinger, 2020; Verkehrsclub Deutschland, 2020) and "enabling measures" that foster competencies, reduce uncertainties, and help integrate new mobility options into daily routines (Albers et al., 2025) are essential. Sustainable mobility transitions thus require not only infrastructural innovation but also social and communicative processes that make new mobility practices both feasible and meaningful in the local context.

Our analysis also revealed differences in vignette evaluations based on individual characteristics of the participants. While frequent car drivers in particular reject the option of completely eliminating parking spaces in the neighborhood, this option is particularly popular among young adults aged between 18 and 34 and among respondents with a high level of environmental awareness. This result is consistent with the results of earlier studies (Lanzendorf et al., 2022; Andor et al., 2020). Older residents were also significantly less likely to approve a collective garage on the outskirts, mainly due to the longer walking distance. This illustrates the necessity to take a target group-specific approach in the interest of demand-oriented transport and land use planning. A one-size-fits-all solution risks overlooking the diversity of group specific needs and constraints. For instance, it can be particularly difficult for older people (who tended to reject the collective garage due to its access and egress distance) to imagine changing daily habits of car use and explore new transport options (Aguilera & Cacciari, 2020; Lanzendorf et al., 2022). Sustainable mobility and the creation of livable urban environments require planning approaches that enable individuals across all age groups to move safely, comfortably, and independently. This perspective urges urban planners to account for the diverse range of physical abilities, needs, and everyday practices present within the population, rather than designing primarily for an assumed 'average' resident (Colmenero Fonseca, 2021). At this point, the inclusion of the specific perspectives of minors would also highlight the need for differentiated and inclusive planning that account for the needs of vulnerable road users. This dimension was not taken into account in our study, but should be examined more systematically in future studies.

Also, in line with other research findings, shared mobility offers were particularly rejected by women. The reasons for this reluctance require further investigation but are crucial for understanding how services can be adapted to make them more acceptable. It should be noted, that when identifying different target groups, it is not enough to consider solely socio-demographic characteristics. As Dangschat and Millonig (2023) argue, attitudes, values, and interests of different social groups are crucial in determining mobility needs and may help to better identify homogeneous groups with particular interests and behavioral patterns. Our study supports this conclusion, showing that a pro-environmental attitude is a strong predictor for the acceptability of a change in land use toward parking space reduction and relocation. The decision to conduct a vignette study means adopting the approach of methodological individualism, which has and individual-deterministic view of behavior. The authors are aware of other methods that produce rich insights, such as biographical (Miles et al., 2016; Müggenburg et al., 2015) and practice theoretical approaches (Schmidt, 2022). However, the idea was to get an impression on respondents' preferences on land use. To better approach this complexity, we also conducted a stated preference experiment as part of the study. This experiment examined preferences for specific redesigns of buildings, green spaces, offerings, and parking, while also accounting for individual rental costs. Together with attitudinal and normative measures, this will support the development of an integrated choice latent variable (ICLV) model that incorporates both utility-based evaluations and the influence of latent attitudes (Vij & Walker, 2016)

A key advantage of our vignette study design is its ability to experimentally measure preferences for different space allocation strategies and sustainable mobility options, both compared to and *combined* with each other. This is a decisive advantage over item-based queries (Auspurg et al., 2009), enabling us to identify which land use scenario as a whole was generally accepted and can also hope for approval in a real world context. The proposal to relocate parking spaces to the outskirts of the neighborhood convinced the majority of respondents, especially if local facilities in the neighborhood (68 % approval) or public and active transportation (61 % approval) were strengthened at the same time. Other studies have found that neighborhood garages are generally welcomed by residents, as are the expansion of public and active transportation and mixed use in residential neighborhoods (Wicki & Kaufmann, 2022; Brookfield, 2017). Yet, these studies did not examine combinations of land use and mobility measures. Another advantage is the ability to capture individual reasons for accepting or rejecting proposals, either through predetermined response categories or free-text responses. The option to let respondents give comments on their choice, clarifies the reasons for a decision, which generally enriches understanding of scenario acceptability. These free-text answers provided input to the planning perspective, suggesting for instance the need to generally better introduce and explain the shared mobility services to potential users. A better explanation of these aspects in the vignettes, like confirming the availability of child seats, might have improved acceptability. However, the vignettes were already quite detailed, and it is unclear whether adding more information would have affected comprehension.

Finally, our approach benefits from the fact that all respondents live in similar residential areas and have a comparable starting point for evaluating the vignettes. While previous studies have shown that participants' assessments depend on expected personal impact (Schuitema et al., 2010; Andor et al., 2020), this issue might be less significant here. Still, it should also be noted that response behavior might differ if densification in the immediate neighborhood becomes a concrete reality (Wicki & Kaufmann, 2022). With regard to the 'attitude-behavior gap' people might not always act in line with their attitudes and claimed answers (Weyer & Hoffmann, 2023).

Accordingly, the study design also has limitations. First of all, each vignette level on space reallocation describing future land use options contained multiple aspects, such as parking management and charges, a car rental option, and finally the associated effects on the remaining land for recreation and green space to a different extent. This bundling means that the influence of each vignette level can only be interpreted as a whole; the multivariate model does not allow us to isolate which individual aspect (e.g., the loss of parking space or the gain in green space) most influenced respondents' decisions. As a result, our conclusions for planning and policy can only address these bundled options, not their individual components. Our intention was to present a realistic and comprehensive scenario, showing that relocating parking facilities inevitably frees up space for other uses – and vice versa. This is a decisive advantage of the vignette technique (Auspurg & Hinz, 2015). The

vignette design presented multiple explanatory and contextual factors simultaneously, offering residents a more realistic scenario with more detailed descriptions of possible solutions for emerging conflicts (Atzmüller & Steiner, 2010). This adds realism and nuance to the scenarios and reflects the fact that the redesign of public spaces is usually associated with simultaneous 'losses' and 'gains' in terms of quality. These affect people in different ways, depending on what individuals consider to be worth living for. Viewing scenarios as integrated packages rather than isolated elements is more in line with real-life decision-making and thus enriches the study's contribution. Additionally, we included descriptive analysis of stated reasons for a decision in order to gain an understanding of the relevance of individual reasons within each level that were important to respondents. Although they could not be integrated into the multivariate model due to multiple responses per vignette and problems compromising the experimental design, these reasons provide deeper insight into the background of the decisions. Nevertheless, a more differentiated vignette design with separate dimensions for parking spaces and green spaces might be preferable for future studies.

Another issue of concern relates to the order in which vignettes were presented. Items appearing at the beginning or end of a sequence are more likely to be remembered than those in the middle (Krosnick, 1992). Furthermore, priming effects can occur, where earlier content creates a cognitive reference point that shapes the interpretation of subsequent information (Auspurg & Jäckle, 2017). To avoid such ordering effect, it is recommended to randomly vary the order of vignette presentation within each set (Jasso, 2006). Due to an error in the survey instrument following modifications after the pretest, respondents in our design always saw the land use proposals (first paragraph, see example vignette *Fig. 1* in section 3b) in the same order, each with randomly assigned sustainable mobility alternatives. Although we explicitly instructed respondents to evaluate each vignette independently and not to compare them with each other, the sequential presentation may have led to comparisons between vignettes. Nevertheless, we do not expect substantial bias due to the lack of randomization, as Sauer et al. (2020), for example, arrived at similar results using randomized and sorted vignettes in which extreme cases were given priority.

All in all, the housing estates studied are very homogenous in terms of building and green space structure (Kaufmann, 2024). The composition of our quantitative sample is comparable with the resident structure of other post-war estates in Frankfurt, in terms of age, average number of people per household, and duration of residence (Stadtplanungsamt Frankfurt am Main, 2019, see Appendix). To this extent, a certain external validity of the measured preferences can be assumed. At the same time, there are limitations regarding sample composition. Our sample includes slightly more women and family households than statistics on comparable housing developments report. The migration background of the participants was not recorded, which is why no statements regarding generalizability can be made here. Also, residents from different housing estates participated in the survey, because the initially selected estates had a very low response rate, which prompted us to expand the survey area. The infrastructure or the extent to which certain sustainable mobility measures have already been implemented in each housing estate may differ. To examine location-based variation, we compared the assessments of vignette levels between residents of the housing estate with the highest number of participants (Frankfurt-Griesheim) with those from the other estates, revealing no significant differences in response patterns.

Despite the use of a variety of recruiting strategies, it was difficult to motivate residents in the selected post-war residential areas to take part. This resulted in a small sample size, which may have been at the expense of significance levels of the estimated coefficients (Schönbrodt & Perugini, 2013). The different recruitment methods used were helpful in approaching participants in different ways. At the same time, this may have led to a selective choice of study participants and thus to a bias. Such a bias could limit the representativeness of the sample and thus reduce the validity of the analyses Recruiting difficulties are not new, but have been reaffirmed and may be particularly pronounced in the post-war housing estates studied, which are often characterized by subsidized housing and overlapping and concentrated social problems (Stadtplanungsamt Frankfurt am Main, 2019). We were aware of this in advance and expected recruitment to be difficult (Hanslmaier et al., 2022; Gebhardt & König, 2021). Nevertheless, we were surprised by the extent of the rejections. This points to feelings of being left behind and isolation in these areas, which should be given special consideration. In future studies, recruitment resources should be carefully calculated during the initial project planning phase. Also, conducting the survey exclusively in German likely excluded some potential participants due to language barriers, especially given the above-average proportion of foreign residents in the study area. This should be addressed in any future iterations of the survey. Another reason for the low response rate could be that the project was designed as a purely hypothetical survey, without any actual changes to shared open spaces or plans to introduce sustainable modes of transport. The prospect of measures actually being implemented is considered an important motivating factor for engagement in research and participation processes (see for example Bavarian Ministry of the Interior, for Building and Transport, 2019). It can therefore be assumed that a higher number of participants would be achieved if a densification project were actually implemented, as it would bring real changes to their immediate living environment that have a direct impact on them (Meetiyagoda Lakshika et al., 2023). Moreover, collaborating with housing associations, other planning stakeholders and neighborhood offices in a real project could help to gain better access to residents. At the same time, a real project means additional (recruitment) efforts, as it must be ensured that a diverse range of resident groups living in the housing estates are involved and addressed properly (Bager et al., 2021).

Yet, this study provides empirical insights into how residents of the same type of housing area respond to various land use scenarios, taking into account different demands on space. This allows the organization of increasing utilization of urban space and transportation to be more closely aligned with the actual preferences of residents from the outset – in the sense of socially acceptable, evidence-based, and user-centered planning (Schwedes et al., 2023). Rather than favoring one perspective over another or imposing top-down solutions, the key is to develop solutions collaboratively, particularly with those who will be most affected by potential changes. In practice, participation is often reduced to a formal requirement that functions more as information provision than as the genuine integration of residents' perspectives (Pappers et al., 2020). However, meaningful participation would mean finding solutions that take local needs into account while also considering broader goals in terms of quality of life and sustainability. Such an approach requires a longer-term participatory process that goes beyond one-off consultations. Various methods can be considered for this purpose, such as experimental or mixed-method designs, as well as participatory methods and co-creative approaches (Voorberg et al., 2015). This would enable evidence-based and socially grounded decision-making in the planning of sustainable land use and mobility solutions. In this line, our findings can complement participatory and collaborative planning approaches (Innes & Booher, 2004). By systematically capturing residents' preferences and potential areas of resistance *prior* to participatory processes, they can help to focus subsequent dialogues on issues of genuine local concern. Integrating such preference-based evidence early in the planning process can thus strengthen both the legitimacy and the practical feasibility of car-reducing urban strategies (Defila & Di Giulio, 2019).

6. Conclusions

The article provides empirical insights into residents' preferences regarding space reallocation strategies combined with sustainable

mobility options in densifying urban residential areas, a topic that will become increasingly important in the future due to the ongoing trend of urbanization. The factorial survey identified which car-reducing land use options that free up space for other purposes to different degrees can hope for broad acceptance. The vignette study demonstrates that experimental empirical methods can be used to capture areas of conflict regarding the use of open space in densifying residential environments and allow residents to directly evaluate these. Our results show that measures to reduce car traffic that highlight the advantages for other possible space uses are certainly accepted. The evaluation of space reallocation variants depends, however, on the extent and on individual characteristics – most notably on the frequency of car use. In addition, the findings reveal that residents differ in their priorities and needs regarding land use and sustainable mobility, and that acceptance of car-reducing measures cannot be achieved through infrastructural or technical solutions alone. These differences highlight the need for careful and more systematic deliberation in order to balance competing spatial and mobility-related interests.

The key implication for planning is that citizens should be involved in planning and negotiation processes from an early stage on and continuously. Such participation makes it possible to reveal the complexity of local conflicts and to integrate diverse perspectives and expertise into decision-making (Defila & Di Giulio, 2019). Even if existing conflicts cannot be fully resolved in this way, dialogue with citizens helps to develop more sustainable and comprehensible solutions. It also strengthens trust in planning processes and can enhance the acceptance of resulting decisions. Planning procedures should therefore not only strive for consensus, but also deliberately create spaces in which conflicting positions can be expressed and negotiated in the sense of an agonistic planning paradigm (Kühn, 2021). A dialogical planning practice that incorporates experimental empirical methods thus understands participation not as a formal obligation, but as a central resource for socially and ecologically sustainable urban development.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT and DeepL in order to improve the readability and language of the manuscript. After using the tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Data availability

Data will be made available upon request.

Funding

This study was part of the '*Wachstum findet InnenStadt*' project funded by the Federal Institute for Building, Urban Development, and Spatial Planning (BBSR) on behalf of the Federal Ministry of Building, Urban Development, and Housing (BMWSB) [grant number 10.08.18.7-22.39].

CRediT authorship contribution statement

Julia Pohle: Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation, Conceptualization. **Vivien Katharina Albers:** Writing – review & editing, Methodology, Conceptualization. **Matthias Kowald:** Writing – review & editing, Methodology, Funding acquisition, Formal analysis, Conceptualization. **André Bruns:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank the three anonymous reviewers for their detailed and constructive comments, which contributed to improving the quality of the manuscript. We would also like to thank all survey participants and our funding agency BBSR for making the project possible. Many thanks also to Dr. Margarita Gutjar and Hauke Reckermann for their valuable comments on data analysis and presentation of results.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.urbmob.2025.100182.

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