smart cities

MDPI

Article

The Implications of a Co-Created Software Solution for Mobility in Rural Areas

Lutz Eichholz

Fraunhofer Institute for Experimental Software Engineering IESE, 67663 Kaiserslautern, Germany; lutz.eichholz@iese.fraunhofer.de

Abstract: This paper explores the challenges in providing digital services of general interest in rural areas and proposes co-created ride-sharing software solutions to address the specific needs of these regions. This applied research is part of the Smarte.Land.Regionen project, which aims to improve digital public services at the district level. Focusing on rural mobility, the paper introduces ride-sharing benches enhanced with software as a possible low-threshold solution. Via workshops, surveys, and market research, the study identifies barriers to the adoption of ride-sharing benches and investigates factors contributing to their success. The software will be developed in an agile process together with partner counties and applied in a real-world case study. The proposed software solution emphasizes user-centered development, the geographical location of benches, and the prioritization of ride requests over ride offers. The findings highlight safety concerns, a lack of reliability, and the importance of obtaining people who are theoretically interested in solutions to actively participate in them. The paper emphasizes the importance of collaborative development with county stakeholders while also acknowledging the inherent limitations as the overall process becomes more complex and organizational obstacles arise. In addition, the findings suggest that the current state of rural mobility cannot be fundamentally changed by the implementation of ride-sharing software alone. Future research should focus on sustaining and scaling digital solutions, measuring their impact on rural mobility, and ensuring their transferability to other regions. The goal is to contribute to inclusive and sustainable rural development by improving access to digital public services and promoting the adoption of tailored mobility solutions.

Keywords: smart region; shared mobility; rural mobility; ride-sharing benches; co-creation; software development

check for updates

Citation: Eichholz, L. The Implications of a Co-Created Software Solution for Mobility in Rural Areas. *Smart Cities* **2023**, *6*, 2706–2721. https://doi.org/10.3390/smartcities6050122

Academic Editor: Pierluigi Siano

Received: 15 August 2023
Revised: 27 September 2023
Accepted: 5 October 2023
Published: 9 October 2023

1. Introduction

An urban–rural digital divide is a common assumption [1–4]. The implementation of the online access law and digital strategies is also slower in smaller municipalities in Germany, which supports this thesis [5,6].

Additionally, services of general interest are more challenging to provide in rural areas compared to urban areas due to numerous factors such as lower population density, limited infrastructure, longer distances, and a lack of specialized service providers. Digital solutions are seen as having great potential to address these challenges in rural areas. By leveraging technology, digital solutions can bridge geographical gaps and help overcome the limitations of traditional service delivery models [7–11].

When delivering public services, it is necessary to adapt technical solutions to regional needs and contextual conditions so that they can be implemented by local institutions and utilized by the population [12]. Other studies have suggested that many emerging smart city technologies are often contextualized within an urban-centric, particularly neoliberal, development paradigm [13]. This perspective raises the possibility that rural areas may face increased marginalization as a result [4].

Moreover, the digitalization of rural areas faces various barriers, as identified by Ferrari et al. [14], which can be categorized into the following areas: socio-cultural, technical, economic, and regulatory institutional barriers. Socio-cultural barriers involve demographic factors, distrust, fear, values, competence, and complexity, all of which can potentially hinder the adoption of digital technologies in rural communities. Technical barriers encompass connectivity, dependability, usability, and scalability issues related to the application of technology in rural environments. Economic barriers revolve around the high costs of technology and infrastructure modernization, as well as limited financial resources. Regulatory institutional barriers involve challenges in data management and unclear regulations that might hinder access to funds and technology. Overcoming these barriers is essential to ensure the successful implementation of digital solutions and bridge the digital divide between urban and rural areas.

The "Smarte.Land.Regionen" research project, funded by the German Federal Ministry of Food and Agriculture (BMEL), aims to improve digital public services at the county level and develop transferable policies and software. Together with government and industry partners and seven counties, Fraunhofer IESE is designing, implementing, and evaluating digital solutions in the areas of education, health, community, volunteering, and mobility. Each area is worked on with two partner counties to include the local perspectives and to ensure transferability. In addition, a digital platform is being developed as a central 'digital ecosystem' to ensure the widespread adoption of these solutions beyond the model regions and to facilitate the integration of existing digital solutions. For a more in-depth look at the project, see Bartels et al. [15].

This paper focuses on the mobility aspect of the research project. It is applied research aimed at addressing the mobility issues encountered by rural residents.

Improving rural mobility presents a significant challenge for smaller municipalities. In rural areas, low demand for travel creates an economic challenge for transport operators who struggle to provide sufficient services to meet mobility needs. This mismatch between supply and demand leads to a cycle of reduced transport services and dwindling public transport usage, ultimately resulting in a heavy dependence on private cars for transportation [16,17].

While addressing the challenges of rural mobility is crucial in Europe due to the economic constraints faced by transport operators in rural areas, it also aligns with the German government's objectives for rural development, as outlined by the Federal Ministry of Food and Agriculture [18]. These objectives emphasize the need to create equal living conditions, with mobility being a specific area of concern. Consequently, enhancing mobility in smaller municipalities across Europe takes on significant importance.

Moreover, the digital divide between urban and rural areas compounds the limited transport options available, especially in relation to mobility providers that rely extensively on digital tools. This situation exacerbates car dependency and restricts access to mobility-sharing services, which are predominantly concentrated in urban areas [19–21]. Due to the increased emphasis on volunteerism in rural areas [22], self-help initiatives tailored to the specific needs and characteristics of the region can be crucial in addressing these challenges and providing viable solutions for the future.

In addition, existing transport systems are failing to meet climate targets, highlighting the urgency for action [23–25]. Low car occupancy rates [26] (p. 233), coupled with the increasing size and cost of cars, exacerbate the problem. In rural areas, the proliferation of electric cars only benefits those who can afford and operate them.

Travelers consider several criteria, such as cost, travel time, flexibility (the ability to adapt to changes in schedule), convenience (the location of the pick-up and drop-off points, the ability to listen to music, or privacy), reliability, and the perception of security. These factors influence their choice of travel solutions and are important considerations when developing mobility solutions for rural areas [27].

Recent findings indicate that higher car usage is associated with factors such as low urban density, limited local activities, a high percentage of children, and a low percentage of seniors [28].

A report by the International Transport Forum (ITF) [29] analyzed how to improve mobility in rural areas. The study's findings recommend a national accessibility policy and sustainable regional mobility plans, a whole-of-government approach, flexible regulations, combining budgets, funding pilot projects, prioritizing high-impact services over high-tech solutions, innovative financing approaches, increased central government funding, technical assistance, mobility hubs and supporting the development of Mobility as a Service (MaaS). MaaS entails the integration of transportation services via a digital platform. Nevertheless, it is worth noting that while MaaS has gained traction in urban areas, its presence in rural regions, particularly in Finland and Sweden, is characterized by a prevalence of small-scale pilot projects with limited user engagement, often short-lived in their establishment [30,31].

To address these challenges, this paper examines the development of co-created ride-sharing software solutions designed to address the mobility issues encountered by rural residents. Via this exploration, the paper aims to make a meaningful contribution to the advancement of inclusive and sustainable development in these regions by enhancing transportation choices.

Especially in rural areas, where car ownership rates surpass those in urban areas, and public transport is often insufficient [32,33], ride sharing emerges as a potential solution to address mobility challenges. This notion is supported by studies indicating a strong desire for ride-sharing options among rural residents [34]. Ride sharing can be categorized into two major forms: unorganized and organized.

Unorganized ride-sharing, involving informal arrangements among acquaintances or even strangers, is hindered by inefficient communication methods. Yet, it has occasionally manifested as ad hoc arrangements such as hitchhiking [27].

In contrast, organized ride-sharing, facilitated by agencies, offers a promising scalable solution. These services provide prearranged ride-matching opportunities without requiring prior personal relationships. Various patterns of organized ride-sharing include:

- Dynamic real-time ride-sharing: This option automates the matching, routing, scheduling, and pricing of rides, often at short notice or on the move.
- Carpooling: Primarily for commuters with similar routes and a preference for regular carpooling to work.
- Long-distance ride-matching: For travelers on inter-city, inter-state, and inter-country journeys, allowing users to specify departure regions and times based on ride availability.
- One-Shot Ride-Match: Combines aspects of carpooling and long-distance ride-sharing, offering choices for different types of trips.
- Bulletin Board: Provides ride-share opportunities based on bulletin boards, allowing users to add desired information to offers and requests.
- Flexible carpooling: Coordinates ride-sharing on the spot, without the need for pre-arrangement [27].

While organized ridesharing offers potential benefits for enhancing rural mobility, it continues to face challenges related to safety, security, and limited accessibility due to sparse population densities [24,35]. Furthermore, rapid access to transportation during emergencies is crucial for those residing in rural areas; hence, personal mobility is highly favored by the majority of individuals in these areas [34]. Additionally, a study conducted in rural Sweden revealed persistent problems with limited public acceptance and use, highlighting the difficulty of establishing successful and widely accepted ridesharing initiatives in such regions [21]. These challenges are not unique to rural areas; even in urban regions, similar obstacles hinder the adoption of alternatives. The research underscores that the primary obstacle in introducing alternatives to private car usage is not the technical aspect but rather the social acceptance and the preference for the car over other modes of transportation [36].

In summary, it can be said that the future of rural mobility, supported by digital technologies, can advance the concept of a 'smart countryside' with more mobility options but also faces many challenges [32,37].

2. Research Design and Objectives

2.1. Goal and Research Questions

This paper focuses on collaborative software development to enhance the utilization of ride-sharing benches. These benches are specially designed public seats where individuals express their interest in receiving a free ride to a specific destination, similar to hitchhiking rather than organized pooling via software portals. To signal their intent to be picked up, individuals simply need to sit on a designated ride-sharing bench (see Figure 1), typically indicating their intended direction solely by the bench's location. Ride-seekers further clarify their exact destination in conversation with the driver.

Figure 1. Example of a ride-sharing bench [38].

In Germany, there are currently 190 ride-sharing bench projects under discussion, in planning, or already in operation, where counties or municipalities have strategically placed at least a few benches [39]. While these data provide some insights into their distribution, it is not possible to make clear statements about the impact that these benches have or could have. There are no data available to indicate how many people theoretically benefit from these benches. However, assuming an average of 15 benches per project and considering that each bench is typically located close to at least one village, it becomes apparent that these benches have the potential to significantly benefit the mobility of residents in rural areas across Germany.

These findings highlight the need for further exploration and analysis of ride-sharing benches as a mobility solution. Understanding the factors that contribute to their effectiveness, as well as the challenges that limit their usage, is crucial for optimizing their potential and improving the overall efficiency of carpooling initiatives in rural regions.

This paper aims to address the following research questions:

- What specific challenges arise in the development of co-created mobility software for rural regions?
- To what extent and with what specifics are ride-sharing benches used?

- How can the use of ride-sharing benches be increased via digital solutions?
- Does involving counties in the cooperative development of software in rural areas positively impact effectiveness and user acceptance?

By addressing these research questions, this paper seeks to shed light on the challenges, usage patterns, potential enhancements, and impacts of co-created mobility software in rural regions. Via a comprehensive analysis, the findings will contribute to the development of effective strategies for improving rural mobility and fostering the adoption of digital solutions tailored to the specific needs of these areas.

2.2. Method and Approach

As a first step in our methodology, we selected two partnering counties via an application process in which counties were invited to define their precise digitization goals. To determine eligibility, we considered the Thünen Typology of rural areas index [40], which quantifies rurality based on indicators such as population density, land use, housing, regional population potential, and accessibility to major centers. Rurality in the Index tends to be more pronounced: the lower the settlement density, the higher the proportion of agricultural and forestry land, the higher the proportion of detached and semi-detached houses, the lower the population potential, and the poorer the accessibility of large centers. This index results in a numeric value, with a baseline of zero (0) representing the average rurality of all counties, regions, or local authority areas. Values greater than 0 indicate above-average rurality, while values less than 0 signify below-average rurality. Eligibility for our study was limited to counties whose rurality index value was more rural than -0.25. Compared to the OECD's definition outlined by Fadic et al. [41], the majority of regions classified with a Thünen Index from at least -0.25 would be categorized as "remote regions." This indicates that over 50% of their population resides beyond a 60-min drive from urban areas with a minimum population of 50,000 inhabitants.

We then identified two counties with similar goals and challenges. This matching process provided the basis for a cohesive and productive collaboration in the development of software aimed at improving rural mobility. For further information on the partner counties, refer to Table 1.

Table 1. The partner counties [40,42,43].

Municipality	Population	Thünen Index	Inhabitants per Sqm
Potsdam-Mittelmark	214,000	0.18	79
Bernkastel-Wittlich	112,000	0.96	93

Potsdam-Mittelmark is approximately 1–2 hours from Berlin, the most urban region in Germany, according to the Thünen Index (Thünen Index of -4.5). As a result, transport links improve the closer one is to Berlin. On the other hand, Bernkastel-Wittlich is further away from major cities, with Trier (Thünen Index of -0.5) being the only significant urban center neighboring the district. Both districts are predominantly rural, and outside the major urban centers, the private car is often the main mode of transport.

In this scenario, Bernkastel-Wittlich County was a junior partner. This means that representatives from the county participated in all important meetings, but no additional activities took place within the district for use case identification and development. All activities mentioned in the paper, such as workshops and the survey, took place in Potsdam-Mittelmark.

After selecting the partner counties, our methodological approach involved the following steps, as illustrated in Figure 2.

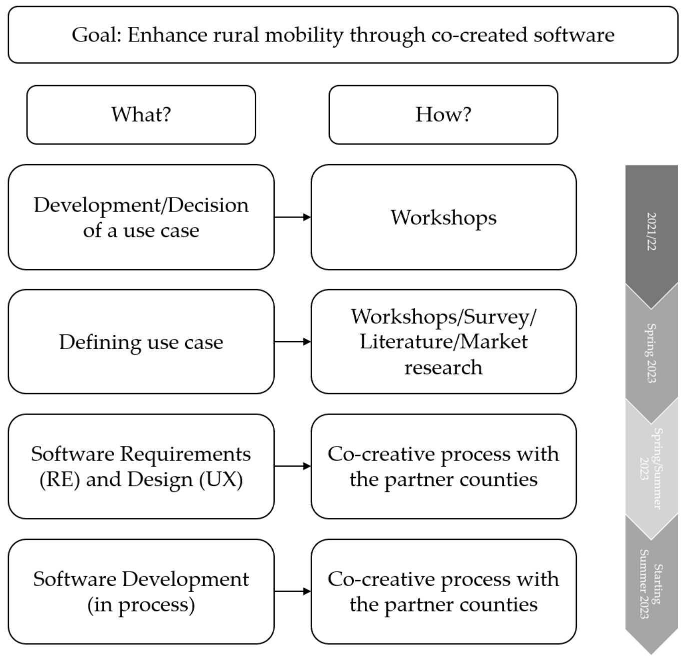

Figure 2. Method.

To develop the use case, two initial workshops were held with stakeholders from the city governments and the mobility sectors from the partner district Potsdam-Mittelmark. Once we decided on a use case, we started to investigate it further. This included another workshop, a literature review, market research, and a survey to further explore how the solution needed to evolve.

This helped define the exact requirements and look of the solution. Feedback from the partner districts played a crucial role in refining the requirements and ensuring user-centric use cases. The final step was to start developing the solution with the close involvement of the districts.

Throughout the solution development process, each step is carefully discussed with the partner district. We use wireframes and clickable prototypes to quickly gather feedback from both district staff and citizens. In line with this, participants who took part in our surveys will be contacted to serve as test users. Additionally, the partner district will engage local citizens and organize public events for real-world testing, ensuring that the solution is thoroughly evaluated in practical scenarios. This iterative process is ongoing at the time of publication, allowing us to refine the technical aspects and user interface of the solution based on real-world testing and user input.

3. Results: Finding and Analyzing a Use Case

3.1. Elaboration of the Use Case

The use case was developed in collaboration with the partner counties, involving participants from various stakeholders in civil society and the industry. The process began with two workshops, each attended by approximately 20 participants. The first workshop focused on representatives from the county, while the second workshop involved stakeholders from the mobility sector. The workshops aimed to assess the current state of mobility and identify problems that could be addressed via digital solutions. Notable challenges included the absence of intermodal routing options, the digital invisibility of smaller mobility providers, a shortage of car rental options, and technical barriers hindering mobility digitalization.

Following the workshops, ideas were further discussed with representatives of the county of Potsdam-Mittelmark. Examples of ideas include the digitalization of small-scale bike rentals, the prevention of empty cabs, and enabling the sharing of vehicles owned by municipalities and clubs to attain better utilization. Another much-discussed idea was the development of a new software interface standard to integrate different mobility services into a multimodal platform. However, after conducting short research within the county and among mobility stakeholders, it was discovered that many of these ideas were already being pursued by other mobility players or were not feasible due to organizational or legal reasons.

Despite this exploration process, a use case ultimately emerged after careful consideration: the implementation of a digital ride-sharing bench.

The reasons for selecting this use case are as follows:

- Ride-sharing benches are already present in both partner counties, providing an existing infrastructure to build upon.
- The use case could be replicated in other districts, making it a scalable solution.
- Digitizing the ride-sharing bench provides an opportunity to bridge digital and analog realms, promoting digital solutions at a physical location.
- The implementation of a QR code-based solution would offer a simple and user-friendly software solution to facilitate digital interactions.

By selecting the use case of a digital ride-sharing bench, the aim is to leverage existing infrastructure, promote digital solutions, enable transferability, and provide a straightforward and purposeful software solution.

3.2. Further Use Case Analysis

3.2.1. Workshops

To gain a deeper understanding of the ride-sharing bench use case, a kick-off workshop was organized with representatives of the county and citizens interested in ride-sharing. A total of 15 people attended the workshop. Only two participants had experience of using ride-sharing benches. However, during the workshop, initial discussions and stories emerged on how the solution could potentially work (see Figure 3).

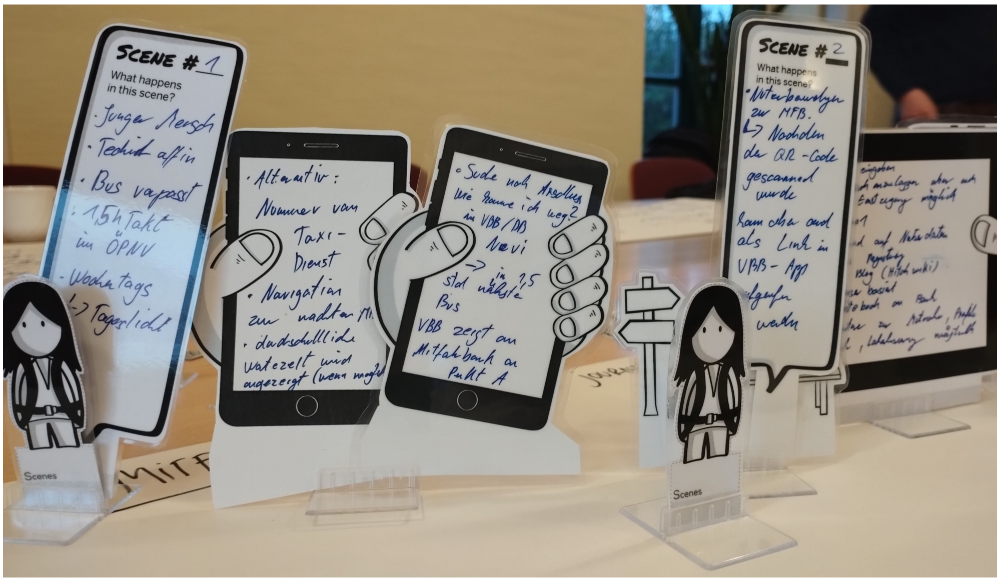

Figure 3. Workshop participants' visualization of how the software could be used.

It is worth noting that county officials expressed concerns about developing software that can be used while driving and where they do not have full control over who uses it and how.

3.2.2. Survey-Based Insights on Ride-Sharing Bench Usage in Existing Literature

An analysis of the existing research literature on ride-sharing benches surveys reveals that there is interest in using ride-sharing benches, but only a small percentage (0–25%) of respondents have reported using them at least once, indicating a lack of regular users. The survey also revealed that there is more interest in being a passenger than in offering rides [44–46]. Participation in fuel cost was found to be relevant for only 3% of respondents. Furthermore, a significant proportion (63–68%) expressed discomfort in giving rides or being a passenger riding with strangers [46]. However, of those who had given someone a ride, 90% reported feeling comfortable [44].

To summarize the usage of the benches, studies suggest that the impact of ride-sharing benches on traffic has so far been minimal. While some projects have reported success stories in newspapers [47], all available data suggest that actual usage is quite low [44,46].

3.2.3. Results from Our Conducted Survey

The survey was distributed and completed online in May 2023, with participants recruited via the partner county's extensive network. The questions were developed from the existing literature on ride-sharing and the information we received from the workshops.

A total of 221 participants completed the survey. The survey consisted of 31 questions, 11 of which were open-ended. The questions covered various aspects, including general information about the participants, the types of technical devices they owned, their mobility patterns, inquiries about the concept of ride-sharing benches, and digital solutions supporting them.

In terms of participant demographics, it was observed that 67% of the participants identified as females. Regarding age distribution, 46% of the respondents fell within the 35–49 age group. In addition, 99% of participants were of German nationality, and 90% used their own car regularly.

Our survey findings show that the majority (69%) of the participants are familiar with the concept of ride-sharing benches, demonstrating a reasonable level of awareness regarding this mobility solution. Furthermore, a significant number (76%) of participants expressed their openness to using a digital ride-sharing solution, suggesting a receptiveness to digital platforms for facilitating mobility (Figure 4).

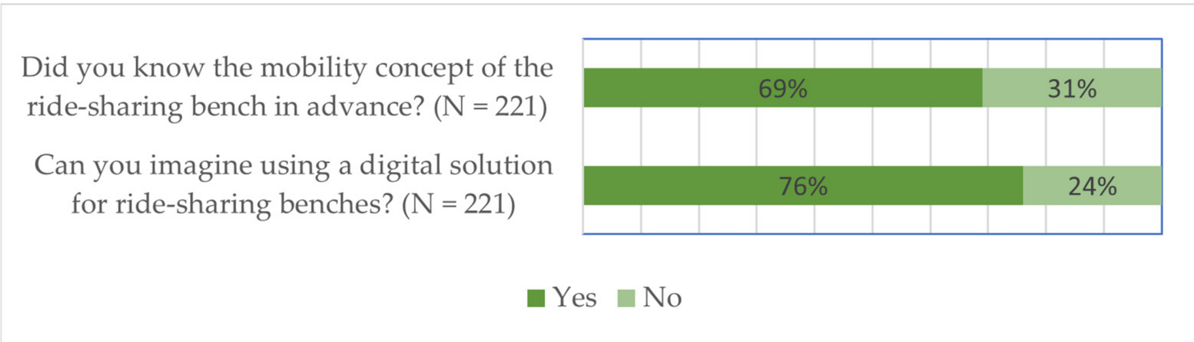

Figure 4. Familiarity with ride-sharing bench concept and willingness to adopt digital ride-sharing solutions.

The willingness to give rides (73%) surpasses the desire to use car-sharing benches (44%), suggesting a greater interest in offering rides among participants (Figure 5).

These findings reveal a positive inclination towards technology adoption and a general interest in ride-sharing concepts among the target population. However, it is evident that there is a gap between the willingness to adopt such solutions and the actual usage rates. Addressing this gap via targeted interventions and strategies could help bridge the divide and increase the uptake of ride-sharing benches among potential users.

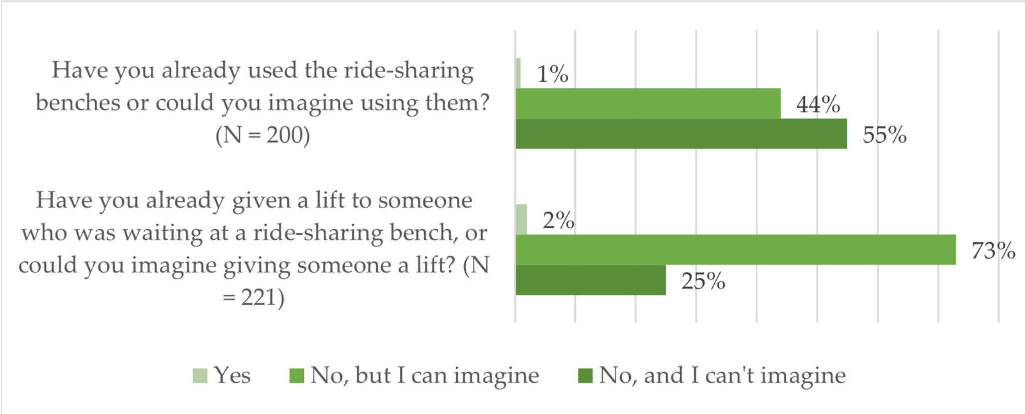

Figure 5. Ride-Sharing bench usage and willingness to offer rides.

In addition, open questions in the survey provided valuable insights into the factors that prevented participants from using ride-sharing benches and their specific concerns. When interpreting the results, it is important to note that we used Chat GPT 3.5 to group the questions. When using Chat GPT 3.5 to group questions, we prioritized time efficiency and resource constraints, recognizing that the primary aim of our study was to identify common software requirements and develop the software rather than to achieve perfect interpretation of individual responses. As the software is still prone to error in this area, the results are presented here in terms of the most frequently mentioned, without knowing the exact number of responses in each category.

The results of the open questions are presented in Tables 2 and 3.

Table 2. Concerns and factors hindering usage (*N* = 86).

Title	Description
Safety concerns	Most of the participants expressed safety concerns as a primary reason for not utilizing ride-sharing benches. These concerns included a reluctance to ride with strangers and fear of criminal activity.
Reliability and uncertainty in usage	Some participants mentioned concerns regarding the reliability and uncertainty associated with using ride-sharing benches.
Lack of need or existing alternatives	A few participants stated that they did not perceive a need for ride-sharing benches or already had alternative transportation options available to them.

Table 3. Reasons for not riding despite interest (*N* = 90).

Title	Description
Absence of ride-sharing benches	Many participants mentioned the lack of available ride-sharing benches in their area as a significant barrier.
Ownership of personal vehicles and preferred transportation method	Some participants indicated that they had their own cars and preferred individual transportation methods, which discouraged them from using ride-sharing benches.
Uncertainty regarding return trips or reliability of ride offers	Some participants expressed concerns about the uncertainty surrounding return trips or the reliability of ride offers.

In particular, the results of the two open questions show the obstacles that a software solution must overcome. They are consistent with the results of the other surveys and the workshop.

3.2.4. Market Research

According to our market survey, there are already around 74 digital portals in Germany that aim to facilitate car-pooling [48].

Despite the availability of many car-pooling solutions, a random sample did not reveal any cases of these solutions being used for short distances or in areas outside the scope of long distances between large cities and that they focus on ride offers. Statistics from the German Federal Statistical Office support these results. According to them, only 2% of the citizens in Germany use carpooling tools [49].

In addition, there are only three software products in Germany that explicitly target ride-sharing benches. These are barely different from other carpooling portals, except that they show the ride-sharing benches on maps [50–52]. In addition, two of the solutions look unused, and one of them has bugs that make it unpleasant and difficult to use. The only solution with visible use in their app had around 120 registered users and three successful rides in the first weeks after implementation [52,53].

Nevertheless, the poor usability of many car-sharing software solutions is confirmed in a study by the Fraunhofer Fit [54], which shows that despite a large number of solutions available, there is still room for improvement.

During the use case workshops, messenger groups were repeatedly mentioned as a best practice solution for digitally connecting ride-sharing benches. However, only one of these groups could be found when interviewing stakeholders related to ridesharing and ridesharing benches. In this group, about 25 residents of a village arranged to carpool without explicitly using the benches [55].

Furthermore, it is important to note that many of the analyzed solutions in this market research are available in multiple European countries, suggesting that the trends observed here are likely transferable to other countries.

3.2.5. Location of the Benches

In the partner county, 18 benches are strategically placed along routes to the Michendorf main station. The distance to the station ranges from 100 m to around 10 km. (Figure 6).

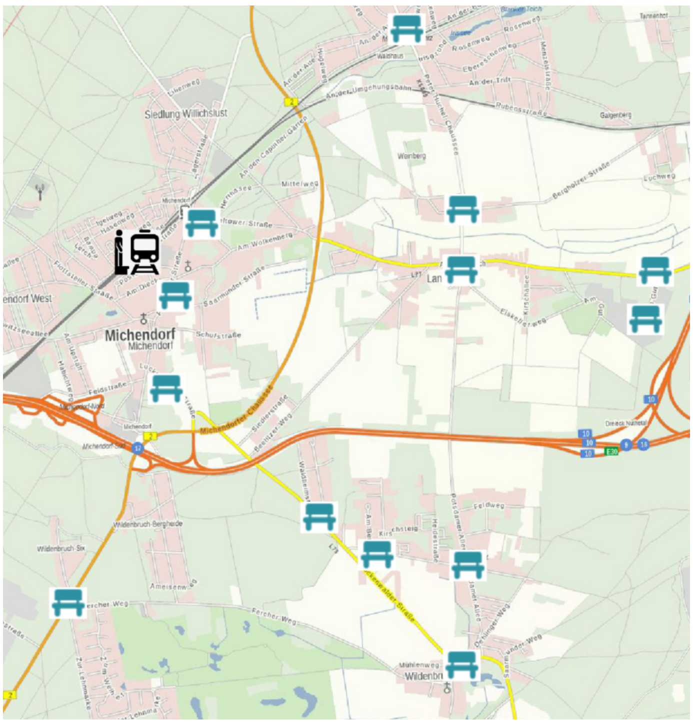

Figure 6. Selected locations of ride-sharing benches in Michendorf.

However, a random examination of other bench locations reveals that many of them were installed without a clear concept. The likely reason for this is that each municipality decides on its own, and there is little evaluation to determine where the benches are best received. Additionally, legal constraints often restrict the placement of benches in areas that would make the most sense. Nonetheless, a recurring pattern emerges, with most benches situated within 1–3 km of each other, aimed at facilitating transportation to the nearest city center or train station.

Despite the limited information available about bench placement, it does provide valuable insights for software development. The data suggest that the software should aim to facilitate short-distance trips to locations with more mobility options.

3.2.6. Summary Use Case Analysis

Overall, the findings from the use case analysis highlight the importance of addressing safety concerns and managing reliability and uncertainty in use to improve the effectiveness and user acceptance of ride-sharing software solutions in rural areas.

By addressing these challenges, the development and adoption of digital solutions tailored to the specific needs of these areas can be a small step toward improving rural mobility. While it may be challenging to quantify the extent to which a working solution can enhance mobility, especially considering factors such as bench placement and the limited usage of analog benches, it is evident that such solutions can serve as a valuable alternative, particularly when other options are unavailable. The motivation exhibited by the counties and the willingness of over 70% of survey participants to use a digital ride-sharing bench solution or offer rides to others highlight the potential for changes in mobility patterns, particularly for the last mile to places with more mobility options.

4. Results: First Insights in the Solution

The existing software solutions mentioned in Section 3.2.4 show that it is important to try to differentiate from them, to avoid the same mistakes, and to make ride-sharing usable over shorter distances.

The aim of the proposed solution is therefore to simplify the process of matching drivers and passengers, incorporating both digital and analog elements, without charging for the software. We aim to stay as close as possible to the classic hitchhiking or ridesharing bench process, avoiding the development of high-tech matching software. Instead, we intend to provide a straightforward digital equivalent of the hitchhiking experience. In this system, passengers only need to go to the bench and send out their ride requests. The most significant difference from the traditional analog ride-sharing bench is that not only drivers passing by at that moment can see the ride request but also drivers who are still at work or home yet planning to leave soon.

By incorporating the geographical location of the benches into the digital platform, users can easily identify and access relevant ride-sharing requests along their desired routes. This feature enhances the efficiency and convenience of the carpooling experience, especially for short journeys within the county.

Furthermore, our solution prioritizes matching passengers seeking rides over drivers offering rides. Additionally, we will implement push notifications for all local users, making people waiting at ride-sharing benches more visible. This concept aligns with our study, which revealed a higher number of available drivers compared to individuals seeking rides, prompting us to explore a different approach to address this disparity. For an insight into the design of the solution, see Figure 7.

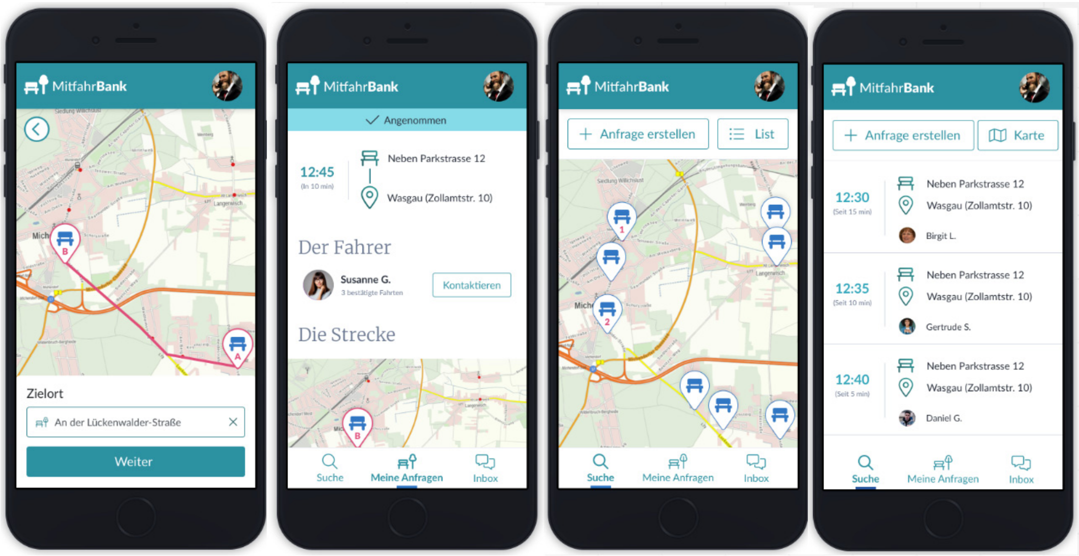

Figure 7. First insights into the design of the solution.

In terms of technical implementation, our solution is a simple, browser-based platform with minimal features. Its primary focus is to provide a user-friendly interface for drivers and passengers to connect with each other and coordinate rides.

The key components of the solution are presented in Table 4.

Table 4. Key components of the solution.

Component	Description
Browser-based solution with quick access	Users can access the platform directly via their web browsers, eliminating the need for additional app installations or complex setup processes. This approach ensures easy and widespread accessibility.
Map-based overview of benches and ride requests	The platform presents a visual map that displays the locations of the ride-sharing benches as well as available ride requests. This map-based overview enhances the visibility and understanding of the available options for both drivers and passengers.
Profile to step out of anonymity	Users have the option to create profiles, which allows them to provide relevant information about themselves and their preferences. This step encourages transparency and trust among participants, fostering a sense of social connection within the carpooling community.
Two levels of verification	Users must verify their mobile phone number, ensuring valid contact information. Additionally, the municipality conducts a verification process to enhance trust and security. Even without completing the second level of verification, users can access essential information such as available rides and current bench occupancy.
Pre-registration view	This view is specifically designed to encourage users to register by showing basic information about rides without revealing personal information about the user.

Specifically, our approach aligns with the 'flexible carpooling' pattern [27]. It offers ride-sharing opportunities without prearrangement, fostering on-the-spot coordination between users. While our concept retains the analog process of ride-sharing benches, we enhance it by sending ride requests to prospective drivers, increasing the visibility of passengers seated at the bench, even for those not passing by, and making the ride-sharing process more organized. In terms of pricing, we made a joint decision with the county to exclude a payment function. This decision was driven by legal and formal complexities and the fact that our survey respondents did not express a preference for monetary incentives. In cases where payment is desired, it is still possible to discuss it verbally between drivers and passengers.

Our approach also aims to gather valuable data generated by the benches to determine their usage patterns and optimal placements. While the development is ongoing, user feedback will be crucial, and if well-received, we plan to continue refining and expanding the solution. Importantly, the solution will be made open source to encourage others, whether individuals or institutions, to contribute to its improvement.

Our priority is to release it as a minimum viable product as soon as possible to benefit the community.

5. Discussion

While there is potential for ride-sharing bench solutions, there seems to be a lack of practical implementation. This gap between theory and practice hinders progress in adoption. Looking at the criteria that travelers consider when choosing their travel options (cost, time, flexibility, convenience, reliability, and perceived safety [27]), it is clear that ride-sharing, with or without a bench, does not excel compared to motorized private transport in most aspects, except for cost.

Safety and reliability are fairly certain criteria that a digital ride-sharing solution can only address effectively if it has been in place for a long time and a significant proportion of the county's population participates. Overcoming these fears and building trust is crucial for successful implementation. In addition, the county's sparse population remains a significant challenge to achieving critical mass [24].

Enhancing the matching process via AI technologies can offer improvements [56]. However, particularly in rural areas, the feasibility of implementing a specialized matching system may be in doubt, given the limited availability of shared-riding options.

Evaluating the proposed solution with the Mobility as a Service (MaaS) Maturity Index, which assesses readiness factors such as operator openness, citizen focus, policy and regulatory support, transport system readiness, and ICT infrastructure adoption [57], it is clear that the ride-sharing bench solution can only be one component of a comprehensive MaaS approach. To develop a complete MaaS ecosystem, different services such as bike sharing, car sharing, taxi, and ride hailing need to be integrated. In this context, the ride-sharing bench solution serves as a convenient, low-threshold option for people who lack alternatives or need flexibility to reach their destination without strict time constraints.

In the context of cooperative development with counties, the motivation of county stakeholders plays a critical role in the success of mobility initiatives. While collaboration with stakeholders, citizens, and counties is often pursued to harness their valuable input and insights, it is important to recognize that such cooperation does not guarantee the identification of an innovative solution that will have a profound impact on mobility. Additionally, it should be noted that the process of finding a use case becomes relatively complex when involving citizens, administration, and stakeholders. Furthermore, legal and organizational obstacles arise.

These issues, which would probably be less problematic in a less collaborative development approach, were evident in the emergence of promising use case ideas prior to the decision to implement the ride-sharing bench. In particular, ideas such as the development of an intermodal routing solution involving all local mobility options proved unfeasible within the timeframe of the project due to difficulties in coordinating and motivating individuals to digitally provide their mobility options on a single platform. Such an approach could have been instrumental in realizing a comprehensive MaaS approach for the county [31].

Nevertheless, cooperative development has more advantages than disadvantages. The main advantage is the identification of the population and administration with the solution and the alignment with the specific problems of a region.

Whether the solution can address a digital divide is difficult to determine. However, it is evident that parts of the population are learning and appreciating the cooperative approach and understanding how a digital solution can be developed. Discussions between county representatives and citizens, as well as initial media coverage of the project [58], indicate a notable interest within the county for a solution that is specifically designed for and with the county.

If the solution were to be adopted by a significant portion of the population and replicated in many other ride-sharing bench projects, the project could have an impact on climate goals in the transportation sector. However, without incentive systems to promote ride-sharing, the likelihood of citizens embracing this change and altering their travel patterns via a new digital solution remains low.

6. Conclusions

In conclusion, the development of co-created ride-sharing software for rural areas is both promising and challenging. While the discussion highlighted the barriers to adoption, safety, and critical mass, it is important to recognize that collaborative development and user motivation can be drivers of success but can also present challenges and slower development. To move forward, we recommend fostering greater collaboration between stakeholders and exploring incentive schemes to encourage ride-sharing. Furthermore, future research should investigate the factors that contribute to the long-term success of such solutions. This includes developing sustainable business models for financing beyond the initial research project funding, implementing effective scaling methods, and assessing their broader impact on rural mobility.

Funding: This research was funded by the Federal Ministry of Food and Agriculture in Germany (BMEL) under the Funding reference number 2818SL001.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions.

Acknowledgments: The author would like to thank the entire smarte.land.regionen team, especially the project managers and the Mobility Solution team.

Conflicts of Interest: The author declares no conflict of interest.

References and Note

1. Fraunhofer IESE. *Strategiepapier für Smarte Landkreise*; Fraunhofer IESE: Kaiserslautern, Germany, 2021; Available online: https://www.toolset-landkreise.digital/wp-content/uploads/sites/12/2023/05/Strategiepapier-fuer-Smarte-Landkreise.pdf (accessed on 25 July 2023).
2. Dubois, A.; Sielker, F. Digitalization in sparsely populated areas: Between place-based practices and the smart region agenda. *Reg. Stud.* **2022**, *56*, 1771–1782. [CrossRef]
3. Stein, V.; Pentzold, C.; Peter, S.; Sterly, S. Digitalization and Civic Participation in Rural Areas. A Systematic Review of Scientific Journals, 2010–2020. *RuR* **2022**, *80*, 251–265. [CrossRef]
4. Cowie, P.; Townsend, L.; Salemink, K. Smart rural futures: Will rural areas be left behind in the 4th industrial revolution? *J. Rural Stud.* **2020**, *79*, 169–176. [CrossRef] [PubMed]
5. Halsbenning, S. Digitalisierung öffentlicher Dienstleistungen: Herausforderungen und Erfolgsfaktoren der OZG-Umsetzung in der Kommunalverwaltung. *HMD* **2021**, *58*, 1038–1053. [CrossRef]
6. Initiative Stadt.Land.Digital. *Wie Smart Sind Deutschlands Kommunen?: Studie im Auftrag des Bundesministeriums für Wirtschaft und Energie*; Initiative Stadt.Land.Digital: Berlin, Germany, 2022; Available online: https://www.de.digital/DIGITAL/Redaktion/DE/Publikation/stadt-land-digital-update-digitalisierung.pdf?__blob=publicationFile&v=1 (accessed on 25 July 2023).
7. Hildner, A.; Stutz, D.; Teuteberg, F. Sorgenetzwerk: Digitalisierung unterstützt rurale Versorgung. *Pflegez* **2018**, *71*, 44–47. [CrossRef]

8. Pfannstiel, M.A.; Krammer, S.; Swoboda, W. (Eds.) *Digitale Transformation von Dienstleistungen im Gesundheitswesen IV*; Springer Fachmedien Wiesbaden: Wiesbaden, Germany, 2018.
9. Simon, R.; Garthaus, M.; Koppenburger, A.; Remmers, H. Dorfgemeinschaft 2.0—Altern und Digitalisierung im ländlichen Raum. Zur Entwicklung eines Instruments zur ethischen Fallbesprechung in der ambulanten Gesundheitsversorgung. In *Digitale Transformation von Dienstleistungen im Gesundheitswesen IV*; Pfannstiel, M.A., Krammer, S., Swoboda, W., Eds.; Springer Fachmedien Wiesbaden: Wiesbaden, Germany, 2018; pp. 293–315.
10. Williger, B.; Wojtech, A. Digitalisierung im Ländlichen Raum: Status Quo & Chancen für Gemeinden. Available online: https://www.scs.fraunhofer.de/content/dam/scs/DE/download/studien/Digitalisierung_im_L%C3%A4ndlichen_Raum_WhitePaper_FraunhoferSCS.pdf (accessed on 25 July 2023).
11. Gilroy, P.; Krimmer, H.; Priemer, J.; Kononykhina, O.; Pereira Robledo, M.; Stratenwerth-Neunzig, F. *Vereinssterben in Ländlichen Regionen: Digitalisierung als Chance*; Stifterverband: Berlin, Germany, 2018; Available online: https://www.ziviz.de/sites/ziv/files/vereinssterben_in_laendlichen_regionen.pdf (accessed on 25 July 2023).
12. Janacek, E.; Margarian, A. *Digitalisierung Sozialer Dienstleistungen in Ländlichen Regionen: Eine Analyse Feldkonfigurierender Diskurse*; Johann Heinrich von Thünen-Institut: Braunschweig, Germany, 2020.
13. Cardullo, P.; Di Feliciantonio, C.; Kitchin, R. *The Right to the Smart City*; Emerald Publishing: Bingley, UK, 2019; ISBN 978-1-78769-139-1.
14. Ferrari, A.; Bacco, M.; Gaber, K.; Jedlitschka, A.; Hess, S.; Kaipainen, J.; Koltsida, P.; Toli, E.; Brunori, G. Drivers, barriers and impacts of digitalisation in rural areas from the viewpoint of experts. *Inf. Softw. Technol.* **2022**, *145*, 106816. [CrossRef]
15. Bartels, N.; Koch, M.; Schmitt, A. Digitale Ökosysteme im Ländlichen Raum: Herausforderungen bei der Gestaltung eines Digitalen Ökosystems und Zugehöriger Geschäftsmodelle. Available online: https://www.informatik-aktuell.de/management-und-recht/digitalisierung/digitale-oekosysteme-im-laendlichen-raum-i.html (accessed on 9 January 2023).
16. Mounce, R.; Beecroft, M.; Nelson, J.D. On the role of frameworks and smart mobility in addressing the rural mobility problem. *Res. Transp. Econ.* **2020**, *83*, 100956. [CrossRef]
17. Zachäus, C.; Meyer, G. (Eds.) *Intelligent System Solutions for Auto Mobility and Beyond*; Springer International Publishing: Cham, Switzerland, 2021; ISBN 978-3-030-65870-0.
18. BMEL. Das Land Lebt!: Dritter Bericht der Bundesregierung zur Entwicklung der Ländlichen Räume. 2022. Available online: https://www.bmel.de/SharedDocs/Downloads/DE/_laendliche-Regionen/regierungsbericht-laendliche-raeume-2020.pdf?__blob=publicationFile&v=5 (accessed on 25 July 2023).
19. Nobis, C.; Kuhnimhof, T. Mobilität in Deutschland. 2019. Available online: https://www.mobilitaet-in-deutschland.de/archive/pdf/MiD2017_Ergebnisbericht.pdf (accessed on 25 July 2023).
20. Schaefer, C.; Stelter, A.; Holl-Supra, S.; Weber, S.; Niehaves, B. The Acceptance and Use Behavior of Shared Mobility Services in a Rural Municipality. *Smart Cities* **2022**, *5*, 1229–1240. [CrossRef]
21. Hult, Å.; Perjo, L.; Smith, G. Shared Mobility in Rural Contexts: Organizational Insights from Five Mobility-as-a-Service Pilots in Sweden. *Sustainability* **2021**, *13*, 10134. [CrossRef]
22. Simonson, J.; Kelle, N.; Kausmann, C.; Karnick, N.; Arriagada, C.; Hagen, C.; Hameister, N.; Huxhold, O.; Tesch-Römer, C. Volunteering in Germany: Key Findings of the Fifth German Survey on Volunteering (FWS 2019). 2019. Available online: https://www.bmfsfj.de/resource/blob/184604/a7cd006da6aed57d6d0dfab4a38e4212/5-freiwilligensurvey-englisch-data.pdf (accessed on 25 July 2023).
23. Höhne, N.; Fekete, H.; Wong, J. Klimaschutzpolitik im Deutschen Verkehrssektor Entspricht etwa 3 °C Globaler Erwärmung. 2023. Available online: https://newclimate.org/sites/default/files/2023-04/temperaturpfad_verkehr_2.pdf (accessed on 25 July 2023).
24. Bokolo, A.J. Examining the Adoption of Sustainable eMobility-Sharing in Smart Communities: Diffusion of Innovation Theory Perspective. *Smart Cities* **2023**, *6*, 2057–2080. [CrossRef]
25. Vega Naranjo, J.M.; Jiménez-Espada, M.; Martínez García, F.M.; González-Escobar, R.; Cortés-Pérez, J.P. Intercity Mobility Assessment Facing the Demographic Challenge: A Survey-Based Research. *Int. J. Environ. Res. Public Health* **2023**, *20*, 1163. [CrossRef] [PubMed]
26. Deutsches Zentrum für Luft- und Raumfahrt e.V. Verkehr in Zahlen 2022/2023. 2022. Available online: https://bmdv.bund.de/SharedDocs/DE/Publikationen/G/verkehr-in-zahlen-2022-2023-pdf.pdf?__blob=publicationFile (accessed on 25 July 2023).
27. Furuhata, M.; Dessouky, M.; Ordóñez, F.; Brunet, M.-E.; Wang, X.; Koenig, S. Ridesharing: The state-of-the-art and future directions. *Transp. Res. Part B Methodol.* **2013**, *57*, 28–46. [CrossRef]
28. Alonso, A.; Monzón, A.; Aguiar, I.; Ramírez-Saiz, A. Explanatory Factors of Daily Mobility Patterns in Suburban Areas: Applications and Taxonomy of Two Metropolitan Corridors in Madrid Region. *ISPRS Int. J. Geo-Inf.* **2023**, *12*, 16. [CrossRef]
29. ITF. Innovations for Better Rural Mobility. Paris. Available online: https://www.itf-oecd.org/sites/default/files/docs/innovation-rural-mobility.pdf (accessed on 25 July 2023).
30. Mulley, C.; Nelson, J.D.; Ho, C.; Hensher, D.A. MaaS in a regional and rural setting: Recent experience. *Transp. Policy* **2023**, *133*, 75–85. [CrossRef]
31. Amaral, A.M.; Barreto, L.; Baltazar, S.; Silva, J.P.; Gonçalves, L. *Implications of Mobility as a Service (MaaS) in Urban and Rural Environments: Emerging Research and Opportunities*; IGI Global, Engineering Science Reference: Hershey, PA, USA, 2020; ISBN 9781799816164.
32. Porru, S.; Misso, F.E.; Pani, F.E.; Repetto, C. Smart mobility and public transport: Opportunities and challenges in rural and urban areas. *J. Traffic Transp. Eng. (Engl. Ed.)* **2020**, *7*, 88–97. [CrossRef]

33. Fiorello, D.; Martino, A.; Zani, L.; Christidis, P.; Navajas-Cawood, E. Mobility Data across the EU 28 Member States: Results from an Extensive CAWI Survey. *Transp. Res. Procedia* **2016**, *14*, 1104–1113. [CrossRef]
34. Richter, A.; Waidelich, L.; Kölmel, B.; Bulander, R.; Glaser, P.; Proske, M.; Brügmann, S. Digitalisation and Future Challenges in Rural Areas: An Open Innovation based Research. In Proceedings of the 16th International Conference on e-Business, Prague, Czech Republic, 26–28 July 2019; SCITEPRESS—Science and Technology Publications: Setúbal, Portugal, 2019; pp. 147–153, ISBN 978-989-758-378-0.
35. Deakin, E.; Frick, K.T.; Shively, K.M. Markets for Dynamic Ridesharing? *Transp. Res. Rec.* **2010**, *2187*, 131–137. [CrossRef]
36. Corazza, M.V.; Carassiti, G. Investigating Maturity Requirements to Operate Mobility as a Service: The Rome Case. *Sustainability* **2021**, *13*, 8367. [CrossRef]
37. Bosworth, G.; Price, L.; Collison, M.; Fox, C. Unequal futures of rural mobility: Challenges for a "Smart Countryside". *Local Econ.* **2020**, *35*, 586–608. [CrossRef]
38. Linis Neugebauer. Mitfahrbank. Picture. 2023. Available online: https://qimby.net/LinusNeugebauer (accessed on 30 August 2023).
39. Renner, N. Mitfahrbänke als Mobilitätskonzept in Ländlichen Regionen: Eine Analyse von Best Practise Beispielen. Master's Thesis, Technische Universität Kaiserslautern, Kaiserslautern, Germany, 2020.
40. Thünen-Institut Forschungsbereich Ländliche Räume. Available online: https://karten.landatlas.de/ (accessed on 30 August 2023).
41. Fadic, M.; Garcilazo, J.E.; Monroy, A.M.; Veneri, P. *OECD Regional Development Working Papers*; OECD: Paris, France, 2019.
42. Potsdam Mittelmark. *Vollantrag Smarte.Land.Regionen*; Potsdam Mittelmark: Werder, Germany, 2020.
43. Bernkastel Wittlich. *Vollantrag Smarte.Land.Regionen*; Bernkastel Wittlich: Wittlich, Germany, 2020.
44. Blees, V.; Becker, J.; Freyer, L.; Löw, G. Erfolgsfaktor Mitfahrbank?!: Wissenschaftliche Untersuchung der Akzeptanz und des Nutzens von Mitfahrbänken. 2019. Available online: https://www.frankfurt-university.de/fileadmin/standard/Hochschule/Fachbereich_1/FFin/Neue_Mobilitaet/Veroeffentlichungen/2020/Schlussbericht_Mitfahrbaenke_19-12-09.pdf (accessed on 25 July 2023).
45. B.A.U.M. ConsultGmbH. *Umfrageauswertung Mitfahrbänke: Im Landkreis Ebersberg und der Region.* 2021. Available online: https://www.energieagentur-ebe-m.de/data/dokumente/sonstige/2021-07-14_Umfrageauswertung_Mitfahrbnke.pdf (accessed on 25 July 2023).
46. Wolfrum, L. "Lift-Sharing Benches" as Additional Low-Threshold Mobility Service for Rural Areas: An Evaluation of Their Use in Selected Communities in Lower Austria and Recommendations for Actions. Master's Thesis, Universität Graz, Graz, Austria, 2021.
47. Holzapfel, D. Wie Die Mitfahrbank zum Exportschlager der Eifel Wurde. Spiegel. 25 April 2023. Available online: https://www.spiegel.de/auto/wie-die-mitfahrerbank-zum-exportschlager-der-eifel-wurde-a-9a61f287-2dd6-4925-b2fb-a5dc8bcc7999 (accessed on 26 July 2023).
48. Mitfahrverband e.V. Mitfahrportale. Available online: https://mitfahrverband.org/projekte/mitfahrportale/ (accessed on 26 July 2023).
49. Statistisches Bundesamt. *Press Release No. 356 of 13 September 2019*; Statistisches Bundesamt: Wiesbaden, Germany, 2019.
50. FELGO Gmbh. *Mitfahrbänke*; FELGO Gmbh: Vienna, Austria, 2021.
51. Boben op Klima- und Energiewende e.V. Available online: https://www.bobenop.de/images/Downloads/BO-Praesentation-03-2022.pdf (accessed on 26 July 2023).
52. DevLabor. *App-Durch-Die-Eifel*; Eifelkreis: Eifelkreis Bitburg-Prüm, Germany, 2023.
53. Borens, S. Vorstellung App Durch Die Eifel, Berlin, Germany. 7 July 2023.
54. Fraunhofer FIT. Mitfahrzentralen Erschweren das Finden Passender Mitfahrgelegenheiten durch Unnötig Minimalistische Funktionalität! 2022. Available online: https://www.fit.fraunhofer.de/content/dam/fit/de/documents/easy2use%20Studie-Mitfahrzentralen-2022.pdf (accessed on 25 July 2023).
55. Hennemann, A. Gartenbauverein Oberleiterbach, Oberleiterbach, Germany. WhatsApp Gruppe Mitfahrbank; Personal communication. 2023.
56. Kubik, A. The Use of Artificial Intelligence in the Assessment of User Routes in Shared Mobility Systems in Smart Cities. *Smart Cities* **2023**, *6*, 1858–1878. [CrossRef]
57. Goulding, R.; Kamargianni, M. The Mobility as a Service Maturity Index: Preparing the Cities for the Mobility as a Service Era. In Proceedings of the 7th Transport Research Arena TRA 2018, Vienna, Austria, 16–19 April 2018.
58. Hauptstadt TV. Die Mitfahrbank. 2023. Available online: https://www.hauptstadt.tv/sendeformate/130/Zuhause_in_Brandenburg/8012/Zuhause_in_Brandenburg_Die_Mitfahrbank.html (accessed on 26 July 2023).