

# Public Transport in Rural Areas: Enabler or Disenabler of Mobility?

## Research Paper

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**Abstract.** Public transport can be a sustainable and efficient way to provide mobility. However, its use is declining while the number of car owners is escalating. Previous research overlooks the dual nature of public transport in rural areas, as it can be both a mobility enabler and disenabler, and the question of how digitalisation can influence this is also not sufficiently considered. This paper attempts to fill this gap through a comprehensive literature review, including the consideration of regional characteristics and system design. For this purpose, 21 papers were analysed and the challenges and opportunities for improving public transport in rural areas were identified. The findings underscore the need for holistic approaches integrating technological, organizational, and societal dimensions to maximize the benefits of rural public transport and address mobility challenges effectively.

**Keywords:** public transport, rural areas, mobility

## 1 Introduction

To date, there is no other means of transport that can match the flexibility and comfort of a private car (Brake & Nelson, 2007). Consequently, the number of car owners continues to rise, while the number of public transport users is decreasing (Lieszkovszky, 2018). This creates a “vicious circle” that can only be broken by external intervention, for example by the government, since with increasing car use due to poor public transport, the market for public transportation reduces further (Brake & Nelson, 2007).

This development negatively impacts the environment as public transport could serve as a route towards more sustainable mobility while traditional vehicles have a negative impact on climate because of their high CO<sub>2</sub> emissions (Vanessa Miriam Carlow et al., 2021). In addition, population density in rural areas is steadily decreasing due to urbanization (Brake and Nelson, 2007). On the one hand, this has led to a decline in essential services and therefore an increase in transport needs for those who

remain. On the other hand, the public transport network has shrunk continuously, resulting in more people turning to private cars (Lieszkovszky, 2018). This places residents in rural areas without a driving license or car access at risk of being excluded from participating in everyday activities and regular social interactions, which particularly affects children, elderly people, low-income families and individuals with disabilities (Berg & Ihlström, 2019). That is why in many countries, i.e. in Germany, “Public transportation ... is part of the public service required by law for all regions (German: § 1 Abs. 1 Gesetz zur Regionalisierung des öffentlichen Personennahverkehrs)” (Sörensen et al., 2021, p. 7) to ensure mobility for all residents. This confronts decision-makers in affected areas with the challenge of providing public transport services that serve as a viable alternative to private cars, benefiting all community groups and the environment. Moreover, the evolving transport landscape is closely linked to cultural changes and changing societal attitudes towards mobility. As lifestyles, values, and preferences of communities change, people's transport choices undergo a parallel evolution. These shifts not only reflect individual choices, but also contribute to the overall structure of mobility behavior.

Technological progress and innovation have introduced new approaches to public transport, offering potential solutions to these challenges. Some technologies like transit apps are already being used in everyday public transport, but there are many more promising approaches that have not yet become established and need to be researched further (Bian et al., 2022). These include, for example, Demand Responsive Transport (DRT) and Ride Sharing as specific technology-based methods for optimizing public transport, but also modern perspectives on mobility such as Mobility as a Service (MaaS) or Smart Land approaches.

In essence, the study of public transport in rural areas traverses the interdisciplinary realms of geography, infrastructure, technology, and policy. The following literature review aims to unravel the complexities and contradictions that the role of public transport plays in shaping the mobility landscape in rural communities. By understanding the enabling and disabling factors, it aims to contribute to the discourse on the development of sustainable and inclusive transport systems that empower individuals and communities in rural areas. To delve deeper into these aspects and identify research gaps, a systematic literature review is conducted, as this method provides a comprehensive overview of the existing scientific literature. The review is focusing on the research question:

*Public transport in rural areas: enabler or disabler of mobility?*

Based on this, the current situation of public transport in rural areas will be analyzed and potential improvements highlighted, especially with regard to innovative technologies.

## **2 Research Method**

As a first step a concept map was used to analyze and highlight relationships between the basic concepts of the subject and to collect related key terms (Brocke et al., 2009).

Then Cooper's Taxonomy was applied to define the scope of the work (Brocke et al., 2009). This review focuses on the results of the papers and their possible applications. The primary objective was to offer a comprehensive overview of the current state of public transport in rural areas, followed by an analysis of opportunities and challenges for improvement. To ensure neutral representation, the results obtained are presented in methodological and conceptual terms. This literature analysis does not encompass every published work on the topic; rather, a select subset of the literature was examined to provide a representative overview of the most important factors.

In order to find appropriate literature, suitable databases were identified and search terms were constructed on the basis of the concept map. The results obtained were limited to English-language works. In addition, a temporal restriction was made to the last nine years to exclude outdated works. Then duplicates were eliminated and only freely accessible papers were considered. To check the relevance of the content of the articles found, the abstracts were read. Backward and forward searches were then carried out.

To give an overview over the content of the papers found a concept matrix was created (Webster & Watson, 2002). The columns were organized based on the components outlined in the concept map. Subsequently, these components were further divided into distinct criteria. This structure offers an initial overview of the literature, indicating which sources delve into which concepts.

**Taxonomy.** The basic concepts of this paper are public transport, rural areas, and mobility. Rural area is land far away from large towns or cities "characterized by low population densities and long distances between societal functions such as schools, shops, and healthcare facilities" (Hult et al., 2021, p. 12). This leads to the problem that there is a huge need of mobility on the one hand, but not many users of mobility services on the other hand. These factors contribute to a unique set of challenges that shape the mobility needs and preferences of rural residents. Recognizing the diversity within rural areas due to factors such as geography, demographics and local economies is essential. The Cambridge Dictionary defines mobility as the ability to move freely or be easily moved (mobility, 2023) and "public transport as a system of vehicles such as buses and trains that operate at regular times on fixed routes and are used by the public" (public transport, 2023). These definitions showcase that a connection exists between the concepts, as public transport can provide mobility.

As shown in the concept map, smart mobility is a key concept and strongly interlinked with other approaches. Because of its novelty, there is no official definition of the term yet, but in summary, it is a revolutionary way of thinking about how to move. Ideally in a more sustainable, safe and efficient way (Porru et al., 2020), and often with the help of new technologies.

Demand Responsive Transport is defined by Davidson et al. (2014) as a service that is available to the public, provided by low-capacity road vehicles and responds to changes in demand. The fare is charged on a per passenger and not a per vehicle basis (Davison et al., 2014). A more established approach is ridesharing as one example of shared mobility, defined as "use of the same vehicle by two or more people traveling to a common destination" (Meurer et al., 2014, p. 1923). Shared Mobility itself is not automatically public transport but typically offered as a private service. However, there are more and more approaches in which it is offered by public-transport-providers (Hult et al., 2021). An idea that represents an entirely new perspective on mobility rather than

concrete transport methods is Mobility as a Service meaning “a type of service that through a joint digital channel enables users to plan, book, and pay for multiple types of mobility services” (Hult et al., 2021, p. 2). Another important technology is the Internet of Things (IoT). This encompasses “objects with computing devices in them that are able to connect to each other and exchange data using the internet” (the internet of things, 2023). In terms of public transport, this could mean that the data collected by IoT sensors, for example on the number of public transport users, could be used to optimize routes or plan new routes. These sensors could be located in vehicles or security cameras, for instance. The emerging technology of Vehicular Cloud Networking (VCN) enables the seamless integration of vehicles and nearby infrastructure into conventional internet clouds, facilitating a wide array of applications that span from straightforward to highly sophisticated functionalities (Ahmad et al., 2015). This technology and many other approaches are increasingly being improved or enabled by Artificial Intelligence (AI). AI can be defined as the field of computer science dedicated to creating systems or machines that emulate human-like qualities. These include the ability to interpret and generate language in a manner akin to humans, recognize or generate images, solve complex problems, and learn from provided data (Russell & Norvig, 2016).

In the area of smart mobility and its associated approaches there are still few practical applications and major gaps in research exist, which is highlighted by the fact that there is still no generally accepted definition of smart mobility. For this reason, existing research is analyzed in the following to identify specific research gaps.

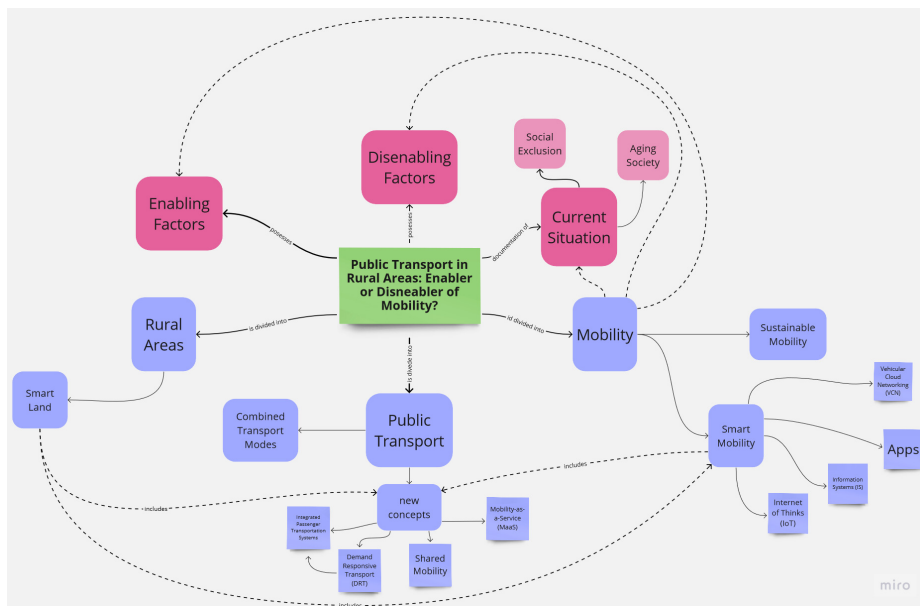


Figure 1. Concept map according to Brocke et al., 2019

**Search Execution and Analysis.** Firstly, the selection of databases for literature analysis was critical. Science Direct, EBSCOhost, and ACM were identified as the most relevant platforms for accessing scholarly works relating to the subject matter. Next,

appropriate search terms were formulated based on the created concept map. The search was divided into two terms focusing on enabling and disabling factors. This approach aimed to capture a comprehensive range of relevant literature. The formulated search terms were as follows:

Search Term 1: ("public transport" OR "mass transit" OR "public transit") AND ("rural area\*" OR countryside) AND (enable\* OR opportunit\* OR accessibility OR possibilit\*)

Search Term 2: ("public transport" OR "mass transit" OR "public transit") AND ("rural area\*" OR countryside) AND (disenable\* OR challeng\* OR limit\*)

After applying the restrictions, like the year of publication, and the forward and backward search, a total of 21 articles were identified that were suitable for the subsequent content analysis of this work. Throughout the search process it was not possible to filter for peer-reviewed papers in the ScienceDirect and ACM databases, but the papers found were taken into account nevertheless. The rapid reduction in the number of papers after reading the abstracts resulted from the fact that many of the papers found did not address the factor of enabling or disabling public transport. Furthermore, many of the papers only briefly touch on the topic of public transport in rural areas and refer more to larger cities. The results were then analyzed and compiled in the concept matrix, with the help of which the results of this work were compiled.

**Table 1.** Search results according to Brocke et al. 2019

Database	ScienceDirect		EBSCOhost		ACM	
	1	2	1	2	1	2
Search Term	1	2	1	2	1	2
Searched in (all fields)	8363	7655	127459	132016	171	173
Searched in (A=Abstract)	34	31	740	1082	—	—
Peer-reviewed	—	—	184	323	—	—
Year of publications (since 2014)	28	22	133	228	138	141
Language (englisch)	—	—	115	189	—	—
Number of results	633					
After elimination of duplicates	28	18	105	185	136	128
Accessible literature	9	9	40	79	92	84
Number of results	321					
After reading Abstract	3	4	3	5	2	2
Number of results	19					
After backward search	2					
After front search	0					
Final number of results	21					



### 3 Results

**Opportunities and Challenges of Public Transport.** One of the biggest advantages and most important functions of public transport is the inclusion of marginalised groups such as the elderly or disabled people. Unfortunately, the current transport network in many rural regions does not fulfil this purpose. For example, Binder & Matern (2020) investigate the connection of mobility and social exclusion in peripheral regions in rural Brandenburg. They came to the conclusion that there are huge public transport deficits, but they also state that “adjustments could be made to public transport schedules to better connect different modes of transport and to offer ride-sharing and demand responsive transport options” (Binder & Matern, 2020, p. 1061) to solve this problem. Furthermore, the use of public transport helps to connect a wide variety of people and thus promote dialogue when they use the same transport mode together (Kjærup & Skov, 2022). Another advantage “for those who regularly travel by public transport is that they can use the time for working, studying, surfing the internet, relaxing, or listening to music” (Berg & Ihlström, 2019, p. 7). The widespread use of public transportation minimizes traffic and consequently environmental pollution, which presents a significant potential in terms of sustainability. Hasselqvist et al. (2016) demonstrate in their study how the utilization of diverse information and communication technologies can foster sustainable travel. Specifically, they highlight the effectiveness of “eco-feedback” – providing travellers with information about the environmental impact of their behaviour – as a valuable tool (Hasselqvist et al., 2016). If using the public transport network is cheaper than owning a car, there is a financial advantage for the users, increasing their motivation to use public transport. This is usually already the case for traditional public transport, but to fulfil the other needs of potential users, it must become more flexible.

However, the use of new technologies to achieve a high level of flexibility is often expensive and can only be achieved with extensive public funding in most cases (Pavanini, 2023). Consequently, it is a major challenge for public transport authorities to provide rural areas with a higher level of mobility, as this results in higher costs for the respective municipality. According to Sørensen et al. (2021), these costs are not new, but are merely shifted from private households to the community. In rural areas with low population density, increased mobility is costly. Hence, a political or municipal agreement is crucial to decide which mobility services should be publicly accessible. (Sørensen et al., 2021). In addition, people have to use the public transport network to cover the investment costs, so acceptance is crucial. There are many factors that influence potential passengers' acceptance of public transport, such as practicality and influence on social status. One major challenge in this regard is, that modern systems such as DRT or Ride Sharing require the use of tracking and data mining technologies in conjunction with personal information, which raises concerns about trust, privacy, and security among potential users (Meurer et al., 2014). Public transport providers must therefore overcome these concerns so that the expansion of the mobility network is worthwhile. Furthermore, the data needed to implement technology-based approaches is difficult to obtain, analyze and apply (Porru et al., 2020). The conceptualization between stakeholders is also essential for the success of public transport in rural areas. Therefore it must be managed to satisfy the various stakeholders, such as users, regional

politicians, transport network providers and residents, by taking all their different needs into account when planning and implementing the public transport network (Porru et al., 2020). Another important aspect, that must be considered when planning a functional public transport system, is the individual characteristics of a region. This is caused by various factors such as unequal population distribution or the natural characteristics of a region (Šipuš & Abramović, 2017). The so-called “last mile problem” is another challenge that must be overcome to provide good public transport services. It “is a characteristic of the rural public transportation infrastructure, where gaps in service exist as a result of infrequent departures or discontinued routes” (Kjærup & Skov, 2022, p. 124). A possible solution to this issue are micro-mobility services like rentable electric bikes and scooters as a part of a MaaS-concept (Kjærup & Skov, 2022). However, this solution does not work for all population groups. People who are dependent on public transport, such as the elderly or disabled, are often unable to use these means of transport.

From the opportunities and challenges mentioned, decisive factors for good public transport can be identified. Well-functioning public transportation should align with people's travel schedules, offer comparable travel times to cars, maintain cost parity with car usage, and provide satisfactory bus stop locations and routes (Berg & Ihlström, 2019).

**Table 3.** Opportunities and challenges of Public Transport in Rural Areas

<b>Public Transport in Rural Areas</b>	
<b>Opportunities</b>	<b>Challenges</b>
Social Inclusion	Acceptance
Connection between People	Security
Time for other Activities	(Huge) Data Requirements
Reduces environmental Pollution	Conception between Stakeholders
Reduces Traffic	Regional Characteristics
Costs	

**Possible Solutions.** The approaches elaborated in the literature to overcome the stated challenges and promote the benefits of public transport will be explained in more detail in the following.

One possible solution that Porru et al. (2020) discuss in their paper is the use of IoT. They were able to identify three essential factors for the success of public transport, which are: the availability of financial means, the cooperation between stakeholders and the flexible supply of scheduled and on-demand transports. IoT can make a major contribution to the realization of the last point in particular. This includes aspects like adapting services to specific market segments (for example people with disabilities), improving safety and optimizing frequency, journey times and the number of stops (Porru et al., 2020). Thus, they were able to conclude that strong public transport, supported by IoT technologies, has the potential to enhance the prospects of rural areas.



Another promising approach is DRT. According to Davison et al., there are three reasons for the increase in the use of DRT recently, which are: technological improvements, societal trends like the rapidly ageing population, and cuts to public transport subsidy budgets, at least in the United Kingdom, to which their study refers. In some regions, this has already resulted in DRT services replacing conventional bus services due to DRT being a more cost-effective way of meeting local needs. Nevertheless the future of DRT remains unclear, as its implementation remains difficult (Davison et al., 2014).

MaaS also offers promising solutions to the current transport problems. Alyavina et al. (2020) showcase opportunities offered through new public transport approaches for more sustainable mobility by examining the decisive factors for the acceptance and potential success of MaaS. They were able to determine five core issues that are critical determinants underpinning MaaS acceptance and success. These are car dependence, trust, human element externalities, value, and cost (Alyavina et al., 2020). If these points are met, shared mobility services can be integrated with public transport in MaaS products to help citizens put together individualized offers that meet their travel needs (Hult et al., 2021).

The efficient management of the large volumes of data and the coordination of different transport options can be facilitated by AI and VCN. Ahmad et al. (2015) illustrate even more capabilities of VCN. Temporary clouds prove effective for low-sized applications like traffic management, safety features, and sharing traffic conditions. Meanwhile, the resources of traditional clouds can be harnessed for more intricate tasks, such as delivering in-vehicle entertainment to users within the vehicular network (Ahmad et al., 2015).

The integration of the aforementioned innovative solutions for enhancing rural public transport could contribute to the realization of smart mobility, fostering a public transport system that actively promotes enhanced mobility (Van Kasteren & Vredenburg, 2023).

## **4 Implications**

This review thoroughly presents the landscape of rural public transportation, extracting crucial insights and challenges. It becomes evident that public transportation in rural areas can be considered a pivotal influencer on mobility. Prior research endeavors have concentrated on various dimensions of rural public transportation, ranging from the integration of modern technologies to the adaptation of services to cater to the needs of diverse population groups. The findings underscore that public transportation holds the potential to enhance the quality of life in rural areas by promoting mobility.

However, research gaps persist, especially concerning concrete implementation approaches and the efficient integration of the mentioned technologies into practice. The sought improvements should not solely occur on a technological level but also consider political and societal aspects. Consequently, further research is needed to develop concrete solutions that not only boost the efficiency of rural public transportation but also foster sustainable and inclusive mobility. Only through the collaborative effort of academia, policymakers and local communities can rural public transportation become a true enabler of mobility that sustainably enhances the quality of life in rural areas.

## **5 Limitations**

The limitations of this literature analysis include first and foremost, the fact that the literature search was limited to three databases. However, these databases allowed access to relevant journals, which ensured that the literature with the greatest scientific influence was examined. Furthermore, the search was limited to English literature exclusively. However, the literature analysis carried out provides a true reflection of the current state of research on public transport in rural areas. Furthermore, this literature review only considered work from 2014 onwards. It could therefore be argued that a longer time period would allow for further relevant studies to be found, but these could also be outdated and no longer reflect the current state of research. In addition, the comparison to urban regions or what could be learnt from public transport in these regions is not addressed. Furthermore, not all aspects that can influence public transport or are part of it were taken into account. For example, the spread of electric cars and their influence was not considered. Similarly, public air transport was not included in the literature research, as this would have gone beyond the scope of the study.

## **6 Conclusion and Future Work**

There are many opportunities and challenges in relation to public transport. Accordingly, there are just as many enabling and disabling aspects for mobility. The predominant aspect depends on various factors such as the region and the design of the public transport concept.

The combination of insights from the analyzed papers underscores a significant potential for public transport, particularly with the integration of emerging technologies into existing public transport systems. The adoption of novel approaches, such as DRT, MaaS, and AI, holds the promise of elevating public transport to a pivotal role as a mobility enhancer. However a detailed examination of the concept matrix reveals that the use of concrete modern technologies for public transport is only rarely and rather superficially dealt with. Accordingly, to ensure public transport becomes an enabler of mobility in rural areas there should be more research focusing on these technologies.

In rural areas public transport often still falls short of being a true mobility facilitator. The challenges posed by factors like low population density, limited service frequency, and gaps in infrastructure underscore the inhibiting aspects of public transport. The potential for it to emerge as a mobility booster hinges on the effective implementation of innovative solutions, the alignment of policies with community needs, and the adaptation of technological advancements to the unique context of rural areas. Furthermore, the widespread adoption of public transport depends on overcoming the allure of car ownership. Consequently, future research efforts should delve into the organization of public transport in a manner that not only competes with but surpasses the attractiveness of owning and using a car in rural areas. A comprehensive exploration of this issue can pave the way for transformative solutions that make public transport a preferred and sustainable choice for rural mobility.

As societies move forward, it is imperative to view public transport not merely as a means of transportation, but as a dynamic system that can shape and enhance mobility experiences. By fostering a collaborative approach among stakeholders, embracing

technological innovations, and tailoring strategies to regional nuances, public transport has the potential to play a transformative role in advancing inclusive and sustainable mobility for rural communities. This calls for continued research, policy innovation, and community engagement to bridge the gap between the current inhibitions and the envisioned potential of public transport in rural areas.

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