

## Built environment and travel behavior in rural areas

### A scientometric literature review

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# Built environment and travel behavior in rural areas: A scientometric literature review

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With the rise of global urbanization, the rural built environment has undergone tremendous changes. As such, the rural built environment impacts on residents' daily travel behavior is getting more researchers' attention. To date, most of the research focuses on urban areas in developed countries. To understand the state-of-the-art of interplay between the rural built environment and travel behaviors and to identify future research directions, this study adopts a science mapping approach to identify the relevant topics, authors, journals, and countries of the research done. This study proceeds through bibliometric retrieval of articles from 2005, followed by scientometric analysis and qualitative discussion. 37 documents are found to compare urban and rural domains, with 28 on the rural built environment. Research gaps and the research trends are discussed, of which the main themes are multi-dimensional correlation comparison of rural transportation service systems and emerging transportation modes, the influence of rural social and cultural factors on travel behavior, and low-carbon sustainable transportation. This review provides empirical foundation for current state-of-the-art and identifies the future research directions, specifically for rural built environment impact on travel behavior.

## KEYWORDS

rural built environment, travel behavior, science mapping, scientometric analysis, literature review

## Introduction

In recent years, with the incessant improvement of people's living standards and the extensive diversification of lifestyles, the travel behavior of residents, along with the traffic problems, attract researchers' attention (Sun et al., 2017). Though studies of urban travel behavior have been performed (Chen and Gan, 2014; Wang and Zhou, 2017; Yang et al., 2021a,b, 2022b), rural areas remain often neglected (Wang et al., 2019; Ao et al., 2020). In the

context of global urbanization, rural conditions have undergone tremendous changes, profoundly affecting the 3.4 billion rural residents worldwide (Doloi et al., 2018; Ao et al., 2021). Therefore, it is necessary to conduct a comprehensive review of the research on the rural built environment and residents' daily travel behavior from relevant authors, topics, and countries' perspectives, to provide a complete and systematic understanding of the studied and emerging topics such that future research can be formulated to support stakeholders in their decision-making processes.

Literature reviews are a good approach to getting a deeper understanding of a research field (He et al., 2017). As such, this study attempts to find out and analyze the relevant research focusing on the rural built environment and residents' travel behavior, to provide a comprehensive and systematic description of research trends. The science mapping approach will be applied which aims to establish bibliometric maps of specific disciplines and research fields (Cobo et al., 2011), including bibliometric literature search and scientometric analysis (Hosseini et al., 2018). Based on the extracted data, the emerging research topics, the most influential journals, scholars, and countries in the domain of rural built environment and residents' travel behavior are presented in the form of a visual network diagram, which reduces subjective bias and makes the analysis objective, and explicit.

The contributions of this study to the research field of the rural built environment and residents' travel behavior are as follows: (1) High-frequency keywords related to the rural built environment and travel behavior are extracted and analyzed from literature samples. (2) High-impact articles and scholars related to the rural built environment and travel behavior are presented. (3) This paper points out the shortcomings and gaps of the existing research and proposes future research trends.

The remainder of this article is organized as follows. Section "Methodology" describes a holistic review approach. Section "Results of scientometric analysis" presents the preliminary findings from science mapping. Section "Discussion" expands the science mapping approach to reason the factors affecting the travel behavior of rural residents, as well as the research gaps and trends in this field. Section "Conclusion" summarizes this study.

## Methodology

This study proceeds through bibliometric retrieval of articles from 2005, followed by scientometric analysis and qualitative discussion. The overall workflow is illustrated in Figure 1, which shows the whole science mapping approach.

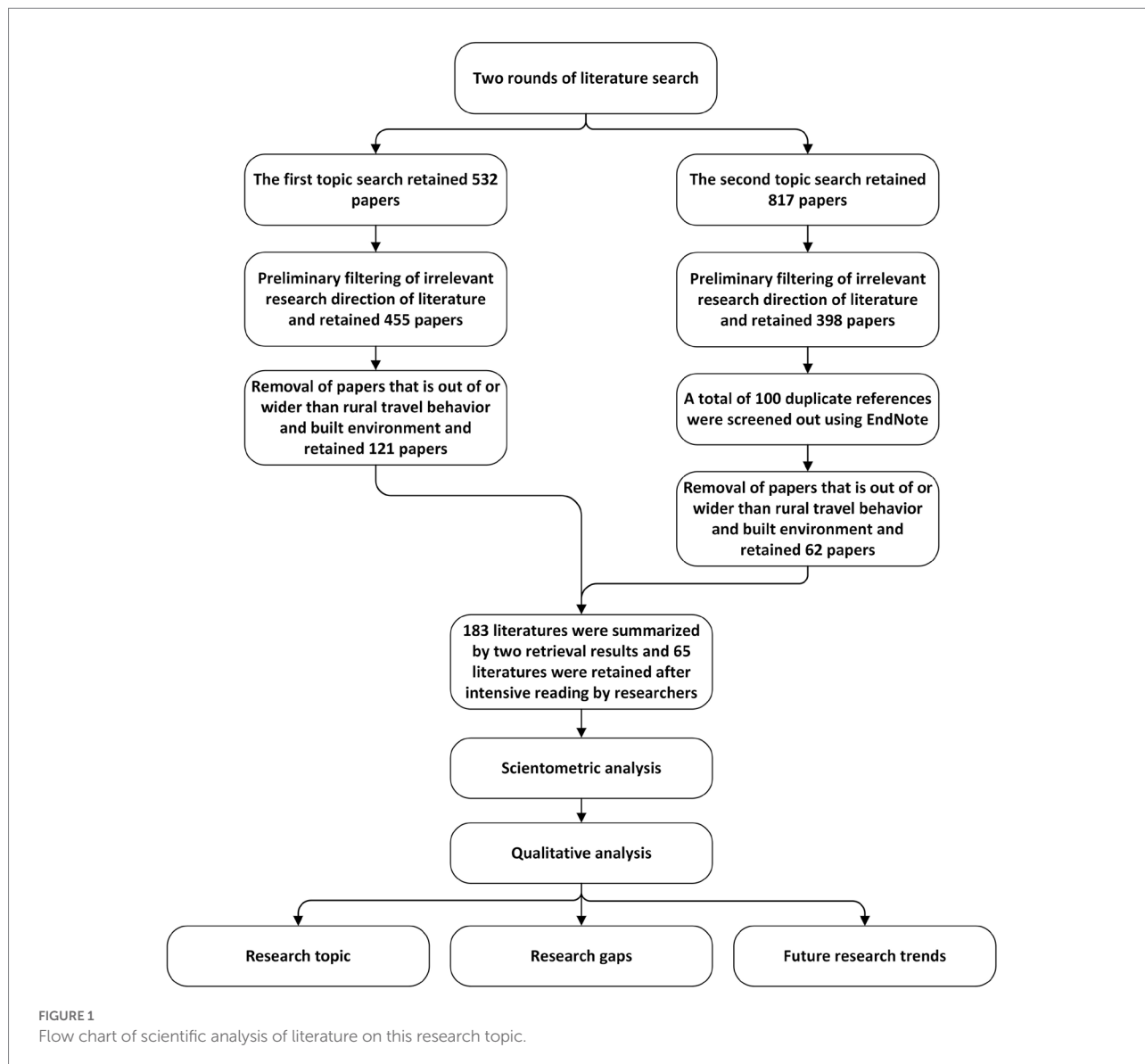
### Bibliometric search

The literature in the domain of rural built environment and travel behavior is retrieved from the Web of Science. It is known that the Web of Science combines a traditional citation index with advanced web technology, along with multiple and unique

functions which accurately retrieve targeted literature. This study conducted two rounds of literature searches using the Web of Science. The rule for the first round is TS = ("built environment" OR "physical environment" OR infrastructure OR neighborhood) AND TS = (rural OR village) AND TS = ("travel behavior" OR mobility OR "travel behavior") NOT TS = ("urban village"). As this review aims to serve the planning and travel behavior field, some irrelevant directions such as Agriculture, Physiology, and Biodiversity were excluded. After that, 455 records were selected. Generally speaking, the first round of search is enough, but considering the comprehensiveness of the search results, TS = ("travel behavior" OR mobility OR "travel behavior") NOT TS = ("urban village") was changed to TS = (travel) and then the second round of search was conducted. So the rule for the second round is TS = ("built environment" OR "physical environment" OR infrastructure OR neighborhood) AND TS = (rural OR village) AND TS = (travel), excluding the research directions of Food Science Technology, Geology, Pharmacology and so on, and 398 records were retrieved. The researchers imported the twice search results into Endnote software and screened out 100 duplicate records, thus the duplication rate was about 13.28%. So using the Web of Science search engine, 753 journal articles were identified by a two keyword-based bibliometric search, with duplicate journal articles being removed. A further detailed reading of the titles and abstracts of the articles resulted in the exclusion of 570 other articles. For example, although two studies by Jiao et al. (2017) and Gieling et al. (2019) focus on rural areas, the former was a study on the livelihood strategies of rural families (Jiao et al., 2017), while the latter explored the influence of different forms of rural attachment on local volunteer services (Gieling et al., 2019). Similarly, while Wolny et al. (2019) and Balestrieri and Congiu (2017) both explored the impact of rural road accessibility on the rural economy, they do so without reference to rural residents' travel behavior (Balestrieri and Congiu, 2017; Wolny et al., 2019). Finally, reading the remaining literature in full resulted in some further eliminations for the theme mainly on the spatial reconstruction of rural areas, the integration of land resources, or utilization efficiency (Wang et al., 2016; Bu et al., 2020), and no reference was made to the rural built environment and travel behavior. Thus, another 118 journal articles were excluded. Ultimately, the final number of journal articles that formed the database for this review study settled at 65.

### Science mapping

VOSviewer is a text-mining tool developed by Van Eck and Waltman for analyzing and visualizing the bibliometric network in this study (Van Eck, 2010). This was done to reach the following goals: (1) Loading the literature samples downloaded from the Web of Science; (2) Visualizing, calculating, and analyzing the influence of core journals, scholars, and countries in the field of the rural built environment and residents' travel behavior research; (3) Researching the mainstream research keywords and their inter-relationships.



## Qualitative discussion

The last step comprised qualitative discussion. As shown in Figure 1, there are three main objectives to be achieved through the in-depth qualitative discussion. This paper summarizes the main research results in the field of the rural built environment and residents’ travel behavior, points out the gaps in the research and puts forward proposals for future research.

## Results of scientometric analysis

### An overview of the literature sample

Overall, scholars pay limited attention to the built environment and travel behavior in rural areas, especially in

developing countries. Before 2011, as shown in Figure 2, we find only a few articles published on the theme of the rural built environment and travel behavior. Research in this area has only gradually increased in the last decade. Since 2010, several articles have appeared every year. Though the volume of publications fluctuates significantly, the trend as a whole is on the rise. (The point of literature retrieval in this study was November 21st, 2021, so the final output for the year can be expected to exceed the previous 6). Compared with previous years, the past 10 years have been the most productive in this research realm.

### Science mapping of journal sources

This study systematically analyzed the source journals of 65 research articles on rural built environment and travel behavior, and the analysis results are shown in Figure 3. In VOSviewer, both the



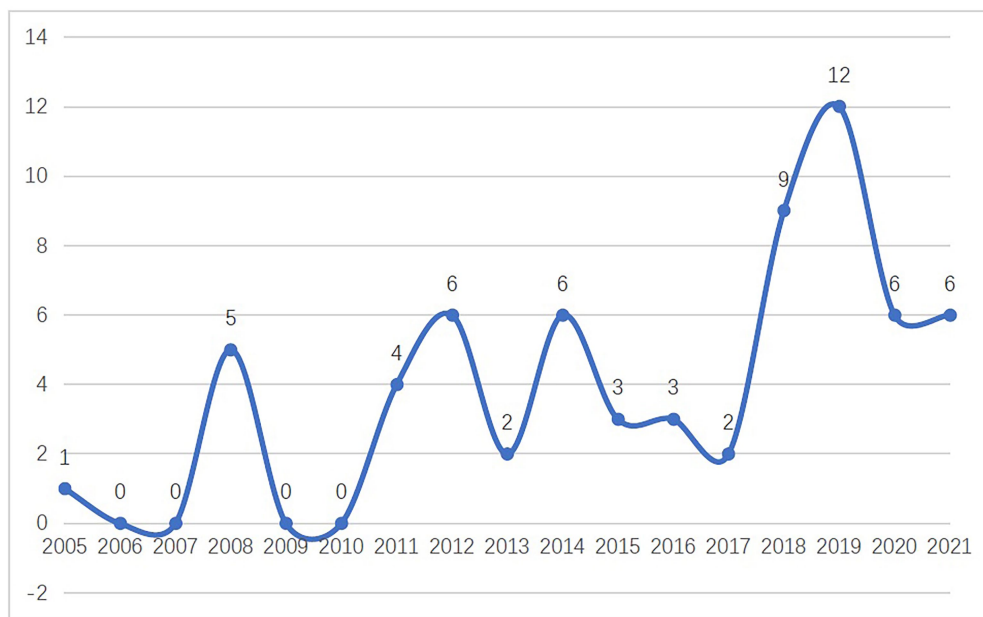


FIGURE 2  
Annual publications from 2005 to 2021 in the research field.

minimum number of published papers and the minimum number of citations were set to 1, resulting in 12 of the 28 journals meeting this threshold. Figure 3 shows the clusters of journal sources and their inter-relationships through connection lines. In Figure 3, the number of publications of a given journal is represented by the font and node size visually, while different colors and connecting lines show the proximity of journals in terms of mutual citations. Citation is the major measure of the influence of academic works, and the use of direct citation is a recognized standard to identify influential research in a certain field (Van Eck and Waltman, 2014). The most influential journals are: *Journal of Transport Geography* has the highest literature output, while *Transport and Journal of Rural Studies* has relatively high literature output and average citation times, indicating the high influence on literature output and research significance. From the perspective of average standardized citations, journals such as *Gender Place and Culture*, *Transportation*, and *Journal of Rural Studies* all share the highest annual average influence. Although the highest number of publications and total citation rate belongs to *Journal of transportation geography*, its average citation rate and average standardized citation rate are not the highest. Appendix 1 summarizes the number of publications, total citations received, average citation per publication and average normalized citations.

## Co-occurrence of keywords

Keywords spotlight the main topics of the research and describe the focused themes in a given domain (Su and Lee, 2010). The knowledge inter-relationship and intellectual organization of

the research themes are shown by the keyword network (Van Eck and Waltman, 2014). In VOSviewer analysis, the minimum occurrence of a keyword was set to 3, using “All keywords” and “Fractional counting.” At first, 44 of the 406 keywords reached the threshold. By combining some keywords sharing the same semantic meaning, such as “neighborhood type” and “neighborhood,” “travel behaviour,” and “travel behavior,” “auto ownership” and “car ownership,” and “impact” and “Impact,” a final body of 40 keywords was selected, as shown in Figure 4.

VOSviewer divides 40 keywords into five clusters with different colors: red green blue purple and yellow according to the connection strength between these keywords. It can be seen that health and walking are closely related and both belong to the red cluster representing aspects related to mobility. Similarly keywords in different clusters are closely related such as gender accessibility and mobility. Generally speaking the main research keywords of rural travel behavior can be classified according to the built environment accessibility mobility and other influencing factors.

Further keywords of quantitative nature are summarized in Appendix 2. In the research domain of rural built environment and travel behavior, the keyword “Self-selection” has been cited as the highest on average. Thus, it may be surmised that this research theme has received the most attention since 2005. The average normalized citation value is calculated by dividing the total number of references by the average number of references published each year. This normalization corrects the misconception that the holder’s literature has more time to be cited than the more recent publications (Van Eck and Waltman, 2014). After eliminating the time error, the average normalized

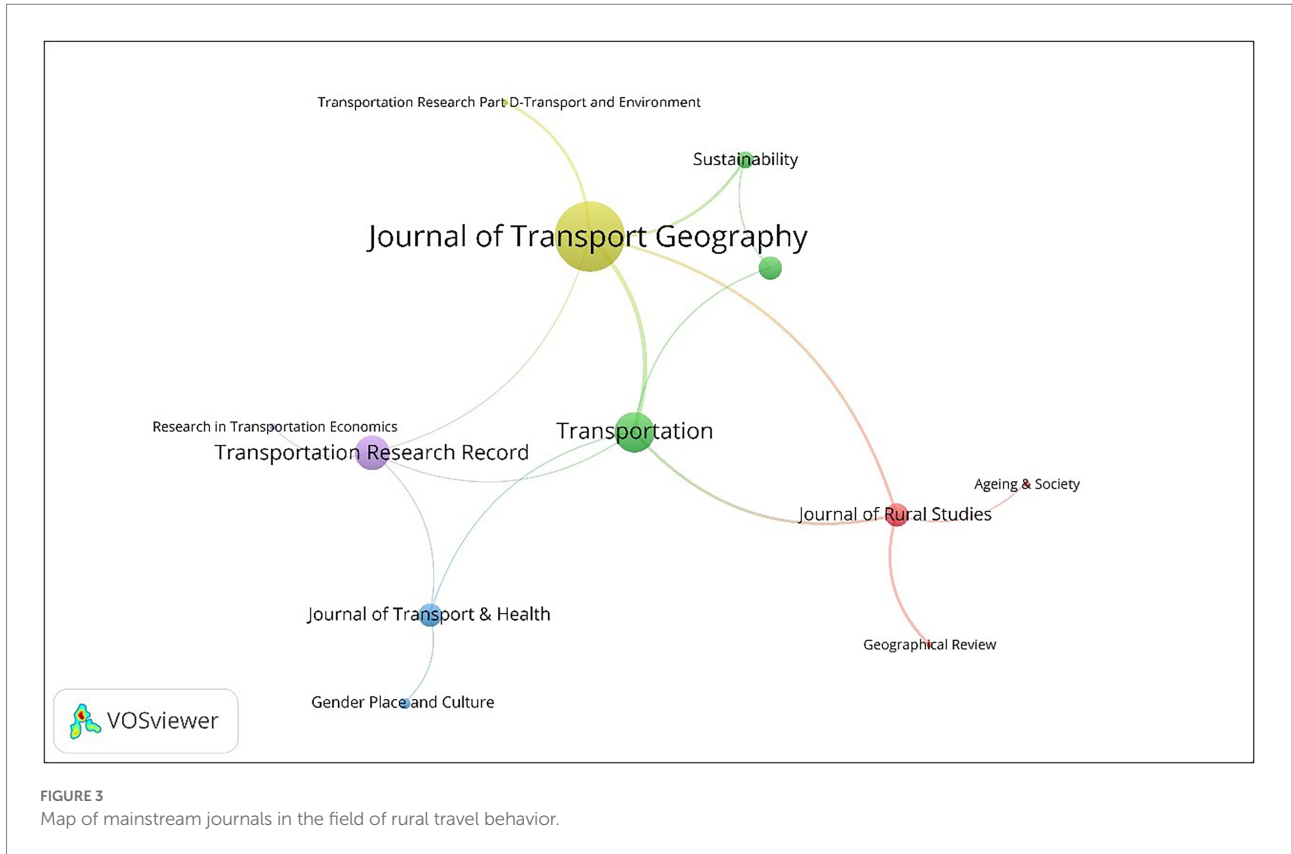


FIGURE 3  
Map of mainstream journals in the field of rural travel behavior.

citation value of the word “Children” is higher than any other keyword, which reveals that rural children’s travel has emerged as a topic of great interest.

### Co-authorship analysis

In VOSviewer, this study screened 65 publications whose authors published two or more papers, with corresponding citations. Literature influence was assessed using Norm. Citations. The visualization is shown in Figure 5. In this field, the series of studies by Ao’s research team are shown to have made important contributions.

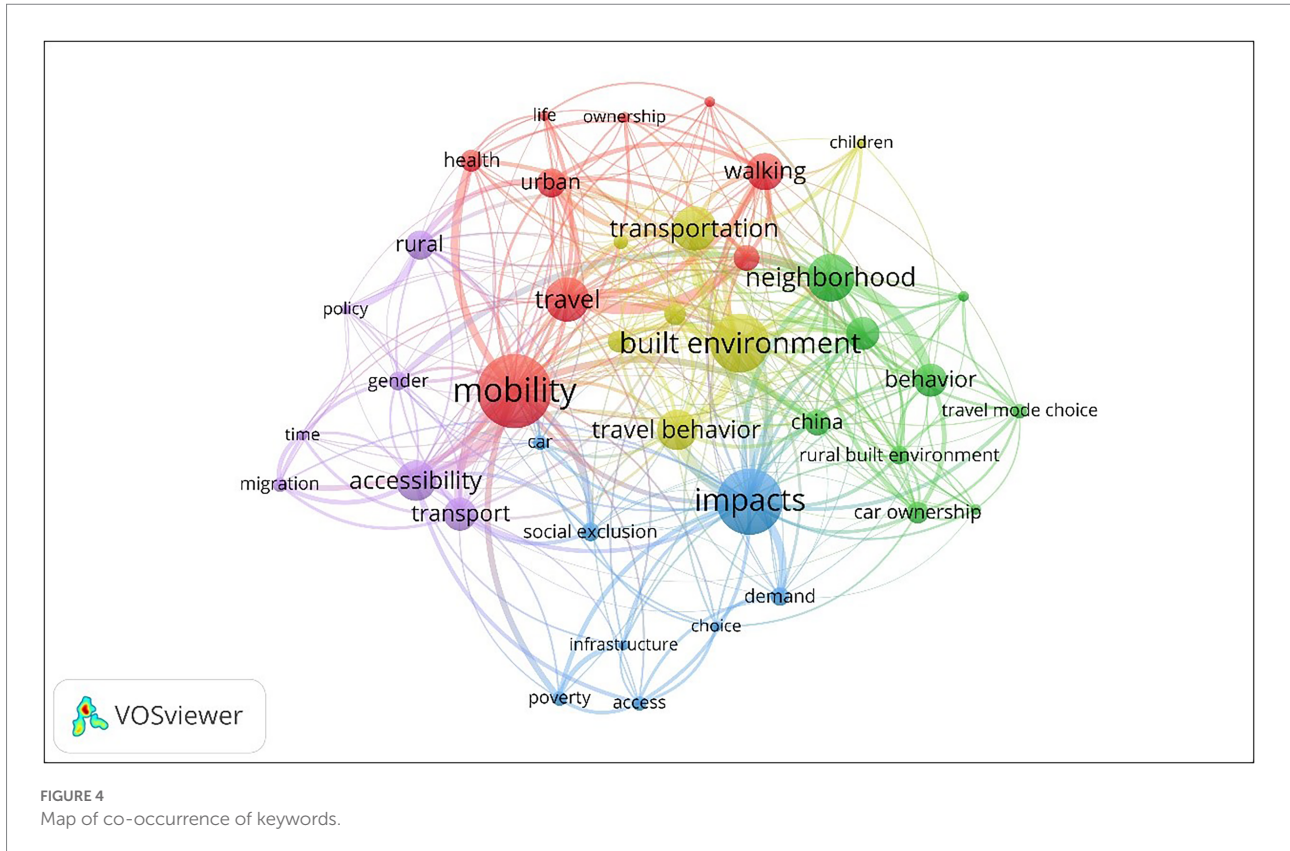
The literature with the highest value of Norm. Citations belong to Ao and Wang (Ao et al., 2018, 2019a,b, 2020; Wang et al., 2019). They explored the influence of the rural built environment in Sichuan, China in regards to the vehicle ownership of rural households. Among them, Ao et al. (2019b) highlighted recent shifts in car ownership in rural areas, analyzing the factors affecting car ownership, and offering a discussion of the characteristics and changes of rural travel behavior. They further expounded on the relationship between travel behavior variables and carbon dioxide emissions, providing a reference for the formulation of transportation policies in rural regions (Ao et al., 2019a). De Vos et al. (2012) explored the relationship between attitude and lifestyle with travel behavior and travel mode choices regarding “soft variables” (De Vos et al., 2012). These researches

analyze the impact on travel behavior from the degree of matching between subjective perception and objective environment and generally conclude that spatial matching has influenced rural residents, especially those residing in built-up settings (Van Acker et al., 2013). Appendix 3 lists further details of these scholars.

### Countries active in rural built environment and travel behavior research

In the chart analysis of countries, this study identified countries pursuing active indagation on the rural built environment and residents’ travel behavior. VOSviewer was used to further identify and evaluate the contribution of these countries to the field. Due to the small number of related journal articles in this study, the thresholds for the minimum number of documents and the cited number were both set to 1 when constructing the national cooperation map of cited documents, with 14 of the 23 countries meeting the requirements. Figure 6 displays the countries that have been actively engaged in research on the rural built environment and travel behavior in the last decade.

It clears that the scholars studying the United States, the Netherlands, Britain, and Canada have published a large number of documents, while a growing number of developing countries have also become active in the research of the rural built environment and travel behavior, such as China, India, Ecuador,



and Ethiopia. [Appendix 4](#) further provides relevant quantitative measurement data, including the number of publications, the average publication year, the number of citations, the average citations, and the average normalized citations. As shown in [Appendix 4](#), it is evident that studies for the United States, China, and the Netherlands have the largest number of publications. From the point of total cited times, American, British and Australian literature were cited the most frequently. According to the average normalized citations, China, Britain, Canada, and Australia are the most studied countries in this research field.

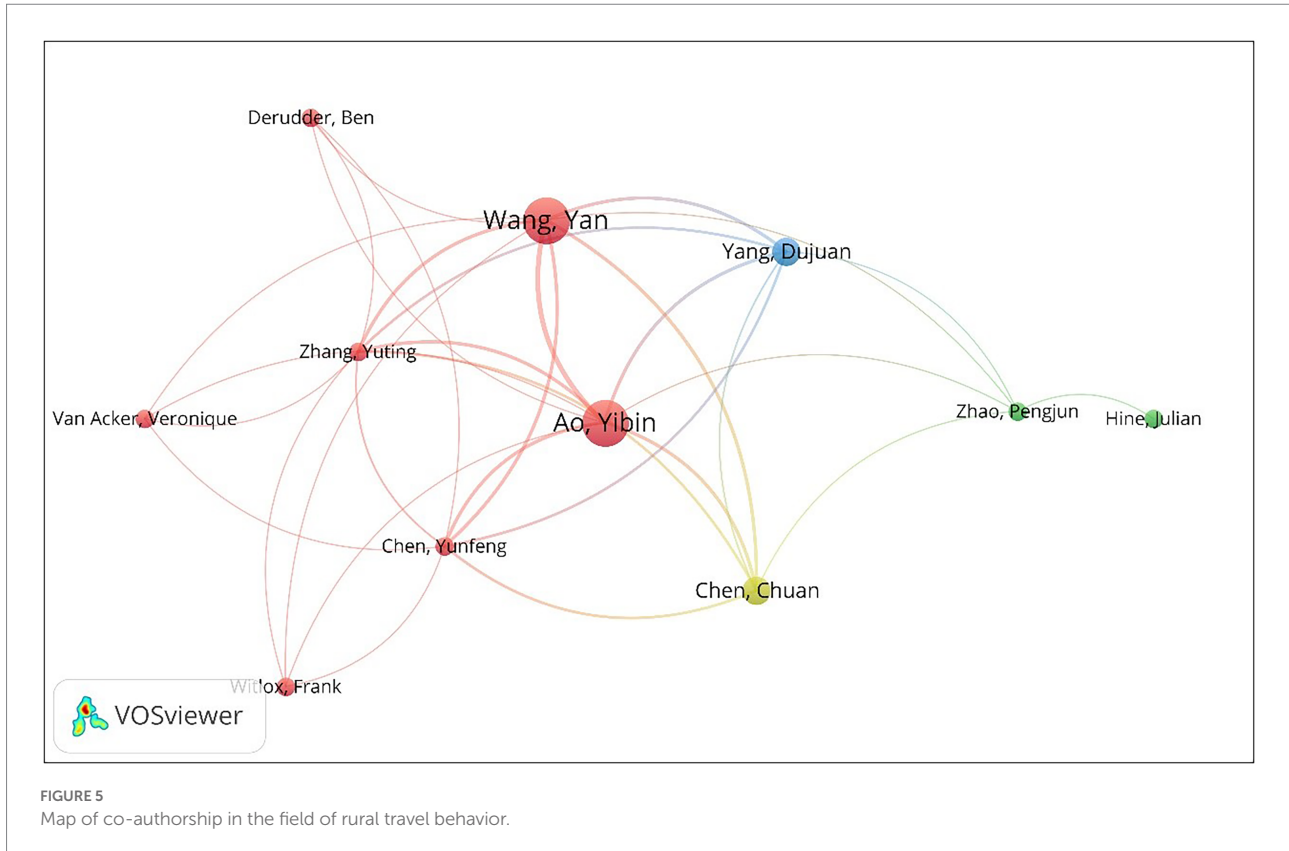
## Discussion

### Comparative study of urban and rural areas

Of the 65 papers studied, 37 have drawn conclusions based on comparative studies between urban and rural areas, while the other 28 have carried out more in-depth research on rural areas.

Overall, the relevant conclusions of the urban–rural comparative study on the relationship between the built environment and travel behavior are more macroscopic. For instance, a study in the Netherlands discovered that the difference in travel behavior between urban and rural areas was determined by the location and the accessibility of transport infrastructure ([Kasraian et al., 2018](#)). [Zhou and Kockelman \(2008\)](#) also attributed

the changes in household Vehicle Miles Traveled (VMT) of families moving between cities and rural areas to differences in the built environment ([Zhou and Kockelman, 2008](#)). Certain scholars have proposed incentivizing residents to use active travel modes (such as cycling and walking) through improvements to the built environment ([Stewart et al., 2016](#); [Tribby and Tharp, 2019](#)). In urban areas, the existence of bicycle-friendly streets seems to be important in promoting active transportation, while in rural areas, access to trails is significantly associated with active travel ([Grabow et al., 2019](#)). [Kamargianni and Polydoropoulou \(2014\)](#) also drew a similar conclusion that the presence of wide sidewalks significantly affects rural residents' choice of active travel modes ([Kamargianni and Polydoropoulou, 2014](#)). In addition, evidence from the Household Mobility Survey in the Baltimore–Washington area of Maryland, United States, shows that increasing the number of retail and recreational locations increases bicycle use among urban residents, while in rural areas, improving traffic accessibility may increase residents' bicycle use ([Cui et al., 2014](#)). In China, people living in rural areas are more likely to choose public transportation when commuting to workplaces located in dense commercial zones, while urban residents with shorter commuting distances tend to walk to work ([Hu et al., 2021](#)). Another study on the influence of the built environment on the use of public transportation by the elderly in urban and rural China indicates that the location of rural bus stops should be optimized while the density of rural bus stops should be increased in urban and rural developments. This would



encourage the elderly in rural areas to use public transportation (Zhang et al., 2018).

It is clear from these studies that compared with urban areas, the destinations of daily activities in rural areas are highly dispersed, while rural residents have to travel further to get the services they need, such as for medical care, education, and postal services (Shergold and Parkhurst, 2012). It is for this reason that they rely more on cars and convenient transportation.

## Research in rural areas

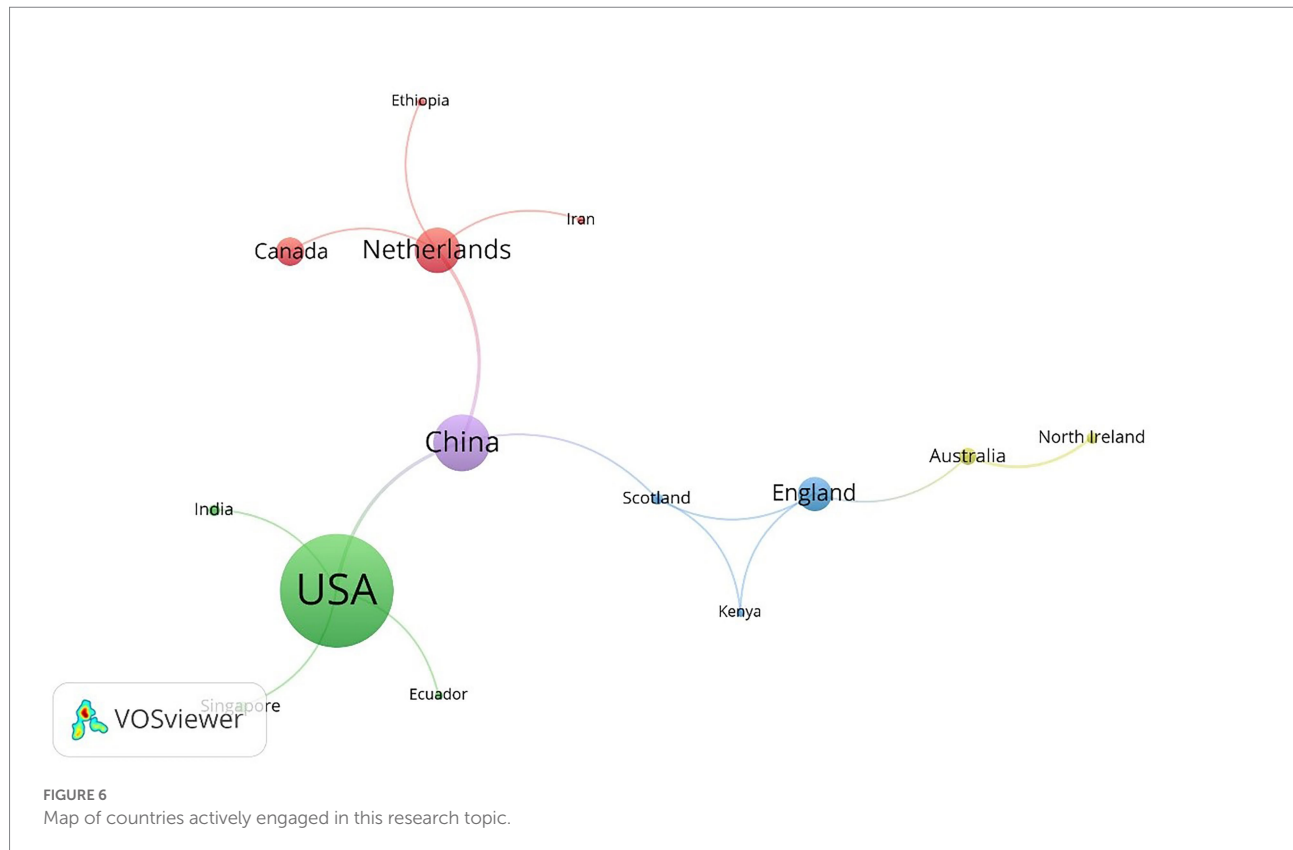
The influence of the five recognized factors of the built environment, such as density (Cui et al., 2014; Ralph et al., 2016), diversity (Kamruzzaman and Hine, 2013), design (Hu et al., 2021), destination accessibility (Hough et al., 2008), and traffic accessibility (Zhang et al., 2018) on residents' travel behavior has been consistently demonstrated across many urban studies in various countries. In recent years, research on rural areas has gained more interest. Scholars' research on rural areas is more microscopic and specific. Subjective and objective aspects of the built environment in rural areas are known to have a prominent impact on the daily travel behavior of rural residents.

In terms of density, rural residents living in high-density areas experience shorter travel distances (Ao et al., 2019a). Rural building density and road density have a meaningful impact on the incidence of car ownership across rural residents' families

(Ao et al., 2019b). Households located in higher building and road density areas prefer to own high-carbon cars (Ao et al., 2018). At the same time, an increase in road density can stimulate the travel frequency of electric bicycles and motor vehicles used by rural residents (Wang et al., 2019).

In terms of diversity, the land use in rural regions is relatively uniform (Ao et al., 2019b), leading to problems such as fewer opportunities for residents to work along with poor access to medical care. For this reason, rural residents choose long-distance travel more often, which makes the mobility level in rural regions usually higher than that in urban places (Pucher and Renne, 2005).

In terms of destination accessibility, existing research shows that individuals living in rural areas with higher accessibility are more likely to integrate into local communities (Hine et al., 2011). As an important place for rural residents' daily activities, rural residents can sell crops and get daily necessities at the market. Studies have shown that the time it takes for rural residents to get to the market or downtown is negatively correlated with their travel frequency (Shilpi and Umali-Deininger, 2008; Yu and Zhao, 2021). Thus, it is important to improve market accessibility. In addition, medical facilities are closely related to the healthy travel of residents (Hine et al., 2011). In a study on the effects of distance from personal residence to medical facilities on the choice of medical treatment, researchers found that people tend to prefer immediate emergency care nearby rather than high-quality medical care much farther away



(Idei and Kato, 2019). Generally speaking, the space available for rural activities is limited (Chen and Akar, 2016), while proximity to the destination promotes more walking (Nathan et al., 2012). The farther away the service distance is, the more residents are likely to own cars or other means of transportation (Wiersma et al., 2017; Zhao and Bai, 2019). Especially nowadays, the elderly in rural regions rely more on cars to meet their travel needs (Hanson and Hildebrand, 2011). However, unfortunate economic conditions combined with poor road facilities in rural areas combine to restrict rural residents from owning cars, resulting in burdensome inconveniences.

In terms of transportation accessibility, transportation infrastructure construction is considered to play a crucial role in the development of residential areas (Dalkmann et al., 2008; Yang et al., 2020, 2022a). For rural residents, their daily travel destinations are limited and scattered, and the corresponding transportation services lag due to the dearth of bus stops and scheduled bus travel frequencies in rural regions (Abhishek et al., 2020). At present, the accessibility of daily activities of residents in rural areas is generally poor and inconvenient (Van Acker et al., 2013). Studies have shown that the distance to the public transportation stations directly correlates with the mobility of rural residents (Yu and Zhao, 2021), especially for rural non-agricultural women (Ranković Plazinić and Jović, 2014). Rural women cannot drive motor vehicles or electric cars often, and they rely almost solely on walking to get to places (Miralles-Guasch et al., 2015). Where the distance to destinations is too

great to walk, public transportation is left as the only alternative mode of transportation.

In terms of design, the barrier-free performance of roads in rural areas increases the probability of residents using cars. At the same time, better road connectivity can promote residents' inclination to walk (Nathan et al., 2012; Shergold and Parkhurst, 2012). Yu and Zhao (2021) considered that residents in small rural towns with limited local services, residing far away from transportation infrastructure, have relatively more travel needs. Thus, rural towns with inadequate local services and less transportation infrastructure are the priority recipients of investment in road infrastructure optimization that would be needed to support such peoples' travel needs (Yu and Zhao, 2021).

Regarding the subjective built environment or rural residents' perception and evaluation of the rural built environment, existing research found that perceived accessibility had a positive influence on residents' walking habits (Shergold and Parkhurst, 2012). When rural residents perceive that the rural roads are in good condition, the accident rate in residential areas is low, the degree of security is high, and the road infrastructure such as sidewalks and traffic lights is complete, the probability of rural residents choosing to travel by walking or cycling will increase significantly (Nathan et al., 2012; Wang et al., 2019). In addition, rural residents living in a harmonious neighborhood, all else being equal, are more probably to choose to walk (Wang et al., 2019). Therefore, improving rural residents' feelings about the accessibility of



destinations, travel safety, neighborhood environments, and road infrastructure can promote more active travel.

## Research gaps and trends

The body of indagation literature on rural built environment and travel behavior is limited. Nevertheless, broad research gaps can be identified, pointing to key research priorities in subsequent research endeavors. Based on the discussion of mainstream research topics and gaps, the framework of near-future directions on rural built environment and travel behavior is proposed and shown in [Figure 7](#).

### Comparative research can tease out similarities and differences

In comparative studies between developed countries and developing countries, some scholars have explored the differences in the relationship between the rural built environment and travel behavior in terms of family income ([Zhou and Kockelman, 2008](#)) and transportation choice ([Delclòs-alió and Miralles-guasch, 2019](#)), yet these comparisons remain limited. In urban–rural comparison studies, the main problem is that indicators used in making comparisons between the urban and rural contexts should remain consistent ([Ao et al., 2019b](#)). Studies of different groups such as children, women, young people, and the elderly are relatively common ([Ryser and Halseth, 2012](#)), but other demographics remain neglected, such as those with disabilities, the critically ill, and those who have lost their ability to care for themselves. Thus, a more comprehensive and in-depth comparative study investigating these deficiencies is called for, and certainly needed so as to develop a profound theoretical understanding regarding the development of rural infrastructure.

### Forward-looking attention to rural transportation service systems and emerging transportation modes

Compared with urban areas, the rural public transport system has much scope for improvement ([Ao et al., 2020](#)). This would include research on public transportation accessibility, types of public transportation facilities, public transportation route planning, station setting, and similar concerns ([Zhou et al., 2019](#)). The development of innovative transportation modes, such as shared cars ([Illgen and Höck, 2018](#)), shared (electric) bicycles, and carpooling services, also require more attention. Further research in these two directions would directly and effectively help improve rural residents' travel accessibility, providing faster and more convenient travel modes and, consequently, improved quality of life.

### Rural local culture and residents' subjective experiences cannot be overlooked

Rural regions cover a large area, and there are great cultural differences between jurisdictions ([Farmer et al., 2012](#)). Rural

residents' feelings of belongingness to the local community, neighborhood relations, and other locationally associated emotions vary widely ([Jain et al., 2018](#); [Blondin, 2020](#)). Considerations of local culture and rural residents' subjective experiences are therefore necessary to be taken into account when researching the rural built environment and residents' travel behavior. Such subjective considerations are an effective mechanism by which to maintain local characteristics associated with village life ([Yu and Zhao, 2021](#)), while also preserving cultural heritage and diversity through the inclusion of diverse stakeholder views.

### Low-carbon travel-oriented rural planning

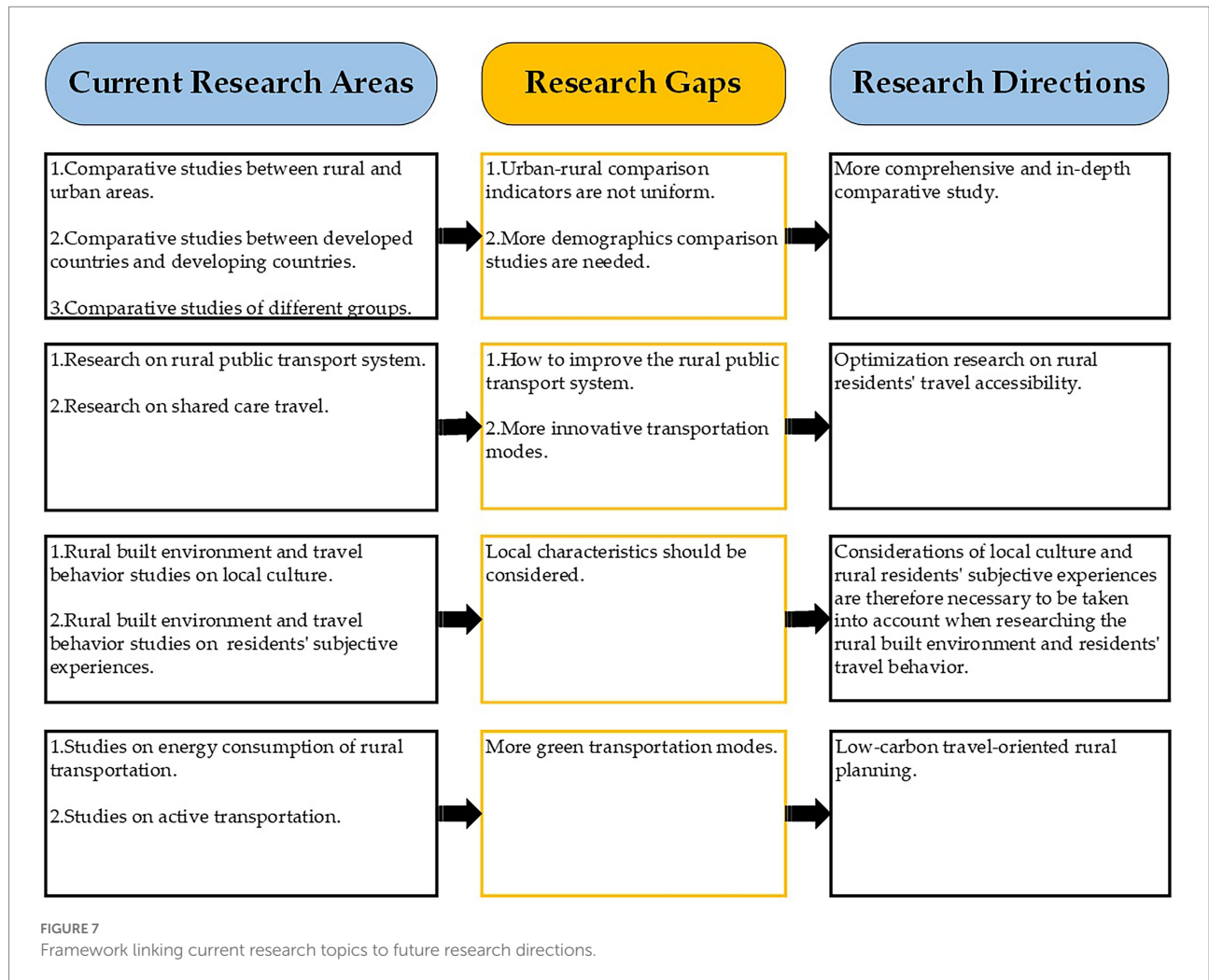
Nowadays, the energy consumption of rural transportation is extremely high and rising ([Zhou et al., 2021](#)). Thus, it needs to pay attention to the sustainable development of rural transportation planning and rural residents' travel. Green transportation modes, such as active transportation (walking, cycling; [Wang et al., 2019](#)), more private transportation utilizing low energy consumption (public transportation, 'green energy' vehicles), are beneficial to the rural residents' physical and mental health as well as in favor of the sustainable development ([Hiselius and Rosqvist, 2018](#)).

## Conclusion

This research explores the influence of the built environment on travel behavior by a holistic bibliometric search, scientometric analysis, and qualitative analysis. In considering the number of studies published each year, it is only relatively recently that the field has gained traction, coming into its own around the years 2018 and 2019. The results of the quantitative analysis are as follows: (1) The influential journals that publish research results on the rural built environment and travel behavior include *Journal of Transport Geography*, *Transportation* and *Journal of Rural Studies*. (2) The keyword analysis reveals the main keywords related to the built environment, which are transportation, accessibility, infrastructure. In regards to travel behavior, the keywords are travel behavior, walking, and travel mode choice. In respect of vehicle ownership, the keyword is car ownership; while for regional studies, the keywords are: rural, urban, and China. (3) Citation analysis reflects the most frequently cited articles, among which Ao et al. deliver the highest Norm. Citations value, with research content mainly discussing the relationship between the rural built environment and travel behavior in China. (4) The countries that have been actively and consistently researched in rural built environment and travel behavior are principally the United States, China, and the Netherlands.

Beyond the results of the scientometric analysis, this study further identifies research deficiencies in this field and puts forward a systematic framework and outlook for further research. The future research outlooked notes the following: (1)





there are few multi-dimensional comparative studies, and more attention should be paid to comparisons between developed countries and developing countries, between urban built environment indicators and rural built environment indicators, and between special groups such as the disabled; (2) Compared to urban transportation systems, rural transportation has much more room for development and improvement, and both the government and private enterprise should actively encourage innovative research on rural transportation; (3) Rural local culture is a factor that cannot be ignored in conducting research in the field of the built environment and travel behavior, requiring an emphasis on empirical research that takes into account local characteristics; (4) Low-carbon travel is a global priority and research related to urban transportation is needed, yet such studies are lacking in the rural context, being limited by such factors as the poorer economy and environmental conditions.

This study focuses on the research progress made to date regarding the rural built environment and travel behavior. The results are, however, limited by the research literature samples: (1) The samples used in this study were sourced from the Web of

Science only; (2) In the literature selection stage, only journal articles were selected, excluding documents in the form of conference proceedings, which may have additional pertinent findings; (3) Finally, this literature review's samples only English language literature, and does not analyze the research output published in other languages. Again, this may result in the omission of additional insightful findings. Notwithstanding, the findings are robust and substantially summarize the state of play regarding research within the domain of the rural built environment and travel behavior.

### Author contributions

YA: supervision, methodology, and draft writing. ML: methodology, formal analysis, draft writing, and visualization. XD, JZ, SX, DS, and ZZ: methodology, formal analysis, and draft writing. YW: supervision and revision. TW: draft writing, supervision, resource, and revision. IM: draft writing and revision. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fevo.2022.1018581/full#supplementary-material>

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