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Decoding Micro-Mobilities Adoption in Rural and Tourist Destinations: A Systematic Review

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Abstract *This study systematically reviews micro-mobility adoption, focusing on e-bikes and e-scooters in rural and tourist areas where limited infrastructure and environmental challenges constrain traditional transportation. Through a bibliometric and content analysis of 79 studies from Scopus database, the study identifies key research themes, including infrastructure readiness, consumer perceptions, and policy support, highlighting significant gaps in the existing literature. Findings suggest that integrating e-mobility into rural tourism can foster Sustainable Development Goals (SDGs) by reducing emissions, enhancing accessibility, and promoting eco-friendly tourism practices. This research also reveals a strong international collaboration on micro-mobility studies, demonstrating that the movement towards sustainable transportation is a global one, with clusters centered on sustainable mobility and rural transport. Insights from this review provide valuable guidance for policymakers, tourism planners, and researchers in advancing e-mobility solutions that foster sustainable rural development. The study concludes with actionable recommendations to enhance micro-mobility infrastructure, regulatory support, and future research directions, establishing a foundation for sustainable and accessible transportation in rural tourist destinations.*

Keywords: *Sustainable Rural Tourism, Infrastructure Readiness, Tourist Destinations, Micro-Mobility Adoption*

INTRODUCTION

The increasing reliance on fossil fuels in urban mobility has significantly contributed to global warming, driven by a massive buildup of greenhouse gas emissions (Bruzzone et al., 2020). Micro-mobility solutions (e-bikes and scooters) have recently gained global attention as sustainable and accessible alternatives to traditional transportation modes (Olabi et al., 2023). In rural and tourist areas, where conventional transportation often faces infrastructure constraints and environmental challenges, these emerging mobility solutions offer valuable alternatives, particularly e-scooters and e-bikes (Mouratidis et al., 2021). The shift towards micro-mobility options, including e-scooters, bicycles, and e-bikes, holds the potential to improve urban mobility and advance several Sustainable Development Goals (SDGs), such as SDG 3, 8, 11, 12, and 13, by reducing air pollution, traffic accidents, and the transportation footprint, while enhancing accessibility and community health (Olabi et al., 2023). Although urban studies on electric mobility adoption are common, research on adoption in rural and tourist settings remains limited, particularly concerning consumer behavior, infrastructure needs, and policy implications (Flores, 2024; Kopplin et al., 2021; Prakhar et

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al., 2024d). Rural tourism has become increasingly crucial for the social and economic development of many regions worldwide (Randelli & Martellozzo, 2019), motivating this study's focus on understanding e-mobility adoption trends in non-urban tourist areas to foster sustainable transportation.

Existing literature mainly explores e-bike and e-scooter use in urban contexts, examining patterns, sharing systems, and usage behavior (Almannaa et al., 2020; Jin & Sui, 2024; Bieliński & Ważna, 2020). While some studies address electric vehicle adoption and entrepreneurial aspects in this sector (Prakhar et al., 2024a; Maybury et al., 2022; Prakhar et al., 2024c) and others focus on sustainable tourism (Prakhar et al., 2024b; Streimikiene et al., 2020), a research gap remains concerning electric two-wheelers and micro-mobility in rural tourist areas. This study aims to bridge this gap through a thematic review, exploring e-mobility adoption in these unique contexts. The findings will support policymakers, tourism planners, and governments in making informed decisions on e-mobility infrastructure, regulation, and incentives, ultimately fostering sustainable mobility in rural tourist areas and enriching academic knowledge. This paper organizes, analyzes, and categorizes research on e-mobility adoption, providing an in-depth field overview. Specifically, it addresses the following research questions:

- RQ1. What are the most influential sources and nations contributing to e-bike and e-scooter adoption research in rural and tourist areas?
- RQ2. Who are the leading studies in this field, and what collaborative networks or affiliations do they have?
- RQ3. What are the primary themes and topics explored in e-bike and e-scooter adoption studies?

The study's primary objective is to systematically review and analyze existing literature on e-bike and e-scooter adoption in rural and tourist destinations, identifying factors like infrastructure readiness, consumer perceptions, and policy support that influence adoption. This study enhances the literature on sustainable rural tourism and micro-mobility, providing a foundation for future empirical studies and guiding researchers to explore remaining gaps. The rest of this study is as follows: the next section describes the study's methodology, followed by a presentation of findings.

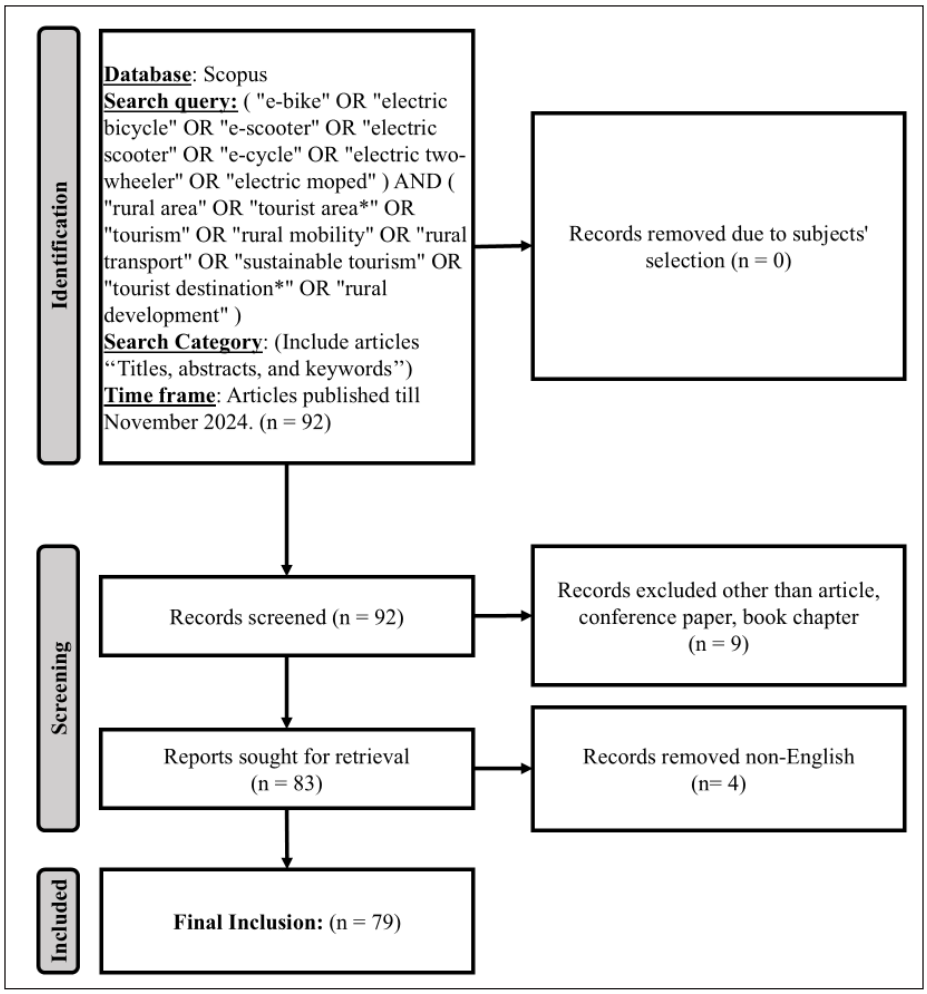

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Fig. 1: Data Inclusion Criteria (Based on PRISMA Guidelines)

The subsequent section outlines future research agendas, implications, and the paper concludes in the final section.

RESEARCH METHODS

This research followed the PRISMA guidelines for data filtration. Fig. 1 illustrates the inclusion and exclusion criteria applied, ultimately resulting in 79 documents selected for further analysis. The Scopus database searches relevant keywords and tracks academic progress (Jaiswal et al., 2024; Jaiswal & Gupta, 2024; Gupta et al., 2024) in e-bike and e-scooter adoption in rural and tourist destinations. Due to the limited database coverage on this topic, exclusions applied (as shown in Fig. 1), narrowing the selection to 79 documents. Furthermore, a bibliometric analysis was conducted using the R Biblioshiny tool, identifying key players and trends in the subject area. The study developed new ideas, themes, and concepts through content and factorial analysis. The paper offers recommendations and implications for future research and practice based on the findings.

RESULTS AND DISCUSSIONS

Bibliometric Landscape

This study found that the top three most relevant journals in adopting e-two-wheelers in rural tourist areas are Sustainability, Transportation Research Part C, and Accident Analysis and Prevention. At the same time, Transportation Research Part d: Transport and Environment has the most productive journal with 45 publications, followed by Sustainability and Tourism Management with 19 publications from 2008 to 2024. Altogether, the most productive year in this domain is 2024, with 31 publications showcasing the increasing interest in research in the area. From 2008 to 2012, only "Transportation Research Part d: Transport and Environment" has 2 publications each year. Moreover, China is the most relevant country based on its highest citations, 338, followed by Italy with 95 and the Netherlands with 87 citations. Based on productivity, China again has the maximum productivity, followed by Germany and the Netherlands with 254, 111, and 94 publications, respectively. China is the only country with publications from 2008 to 2017; other countries started publication in 2019. Notably, Germany started publication in 2020, published drastically, and holds the second rank.

Word Cloud

The word cloud map shown in Fig. 2 presents the most used keywords analyzed using keywords plus illustrates prevalent areas in the academic interest of rural tourists, the electric two-wheeler. E-bike is the most used word with a frequency of 11, followed by cycling and sustainable mobility with a frequency of 4, showcasing the researcher's highest interest in e-bikes. Whereas e-mobility, electric bicycle, micro-mobility, rural built environment, rural transport, Sustainability, and sustainable transport with a frequency of 3 showing moderate interest in research in ecological

Source: Generated through R studio.

Fig. 2: Word Cloud

transportation in rural areas, electric and micro-mobility. Other than that, batteries, bicycles, sustainable tourism, green commuting, renewable energy, rural mobility, electric vehicles, and other highlighted words have less frequency or less explored areas that are to be explored by future researchers.

Treemap

Fig. 3 shows a Treemap based on the frequency with which keywords are used in domain research on electric two-wheelers and tourist destinations. Based on the map, the chart shows the 50 most frequently occurring terms based on keyword plus. A large rectangular area represents a more significant proportion of particular terms, such as bicycles, with 6% frequency, followed by rural areas, with 5% frequency, which are the most used words. Vehicles, travel, transportation system, transportation mode, and motor vehicle are the least used words, with only 1% used frequency.

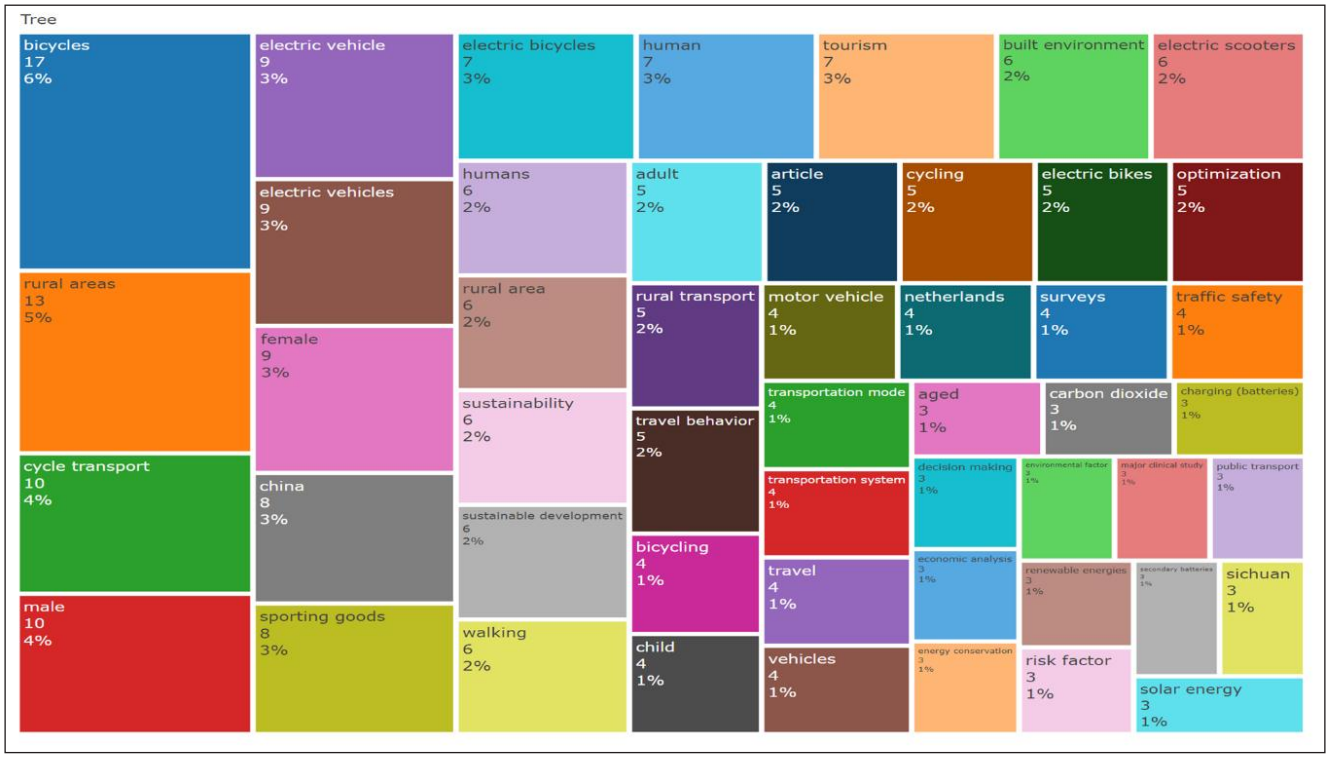

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Fig. 3: Treemap

Co-Word Network

The co-occurrence network between key terms is shown in Fig. 4. The purpose of co-occurrence analysis is to assess the relatedness of items based on the number of documents that occur together. The size of the circle reflects the number of articles in which the term occurs. The proximity of two terms presents the relatedness of the term based on their number of co-occurrences; a total of eight interconnected clusters were observed, including a central cluster of electric vehicles in red, bicycles in blue, Sustainability in green, Vehicles in purple, electric vehicle in orange, Human in brown, cycle transport in magenta, and economic analysis in gray. This figure represents economic analysis; solar energy, renewable energy, public transport, rural transport, tourism, traffic safety, Risk factors, environment, charging (batteries), and electric bikes are the least explored areas that can be explored in future research with the realm of rural transportation.

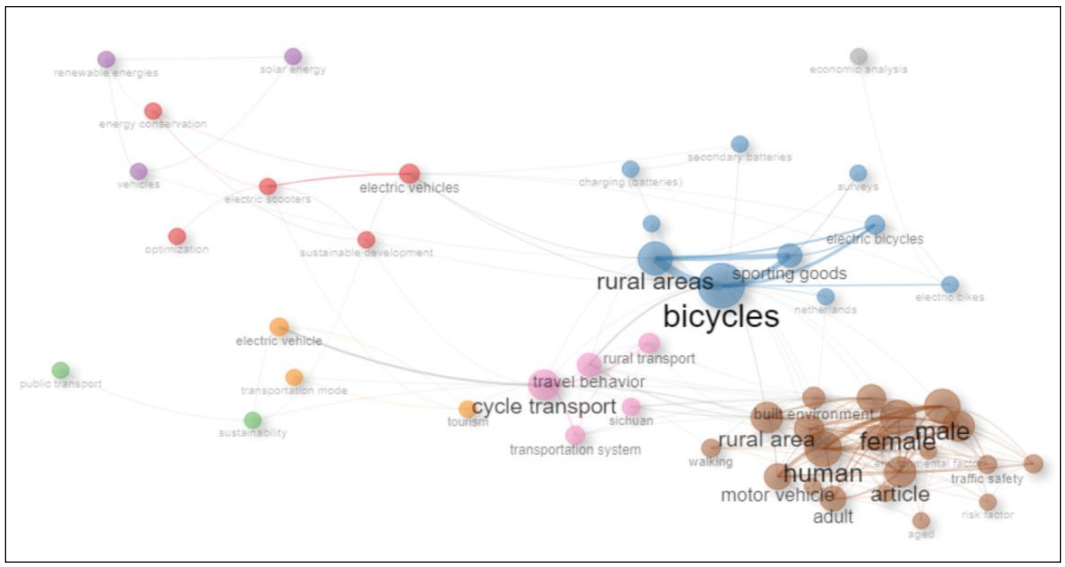

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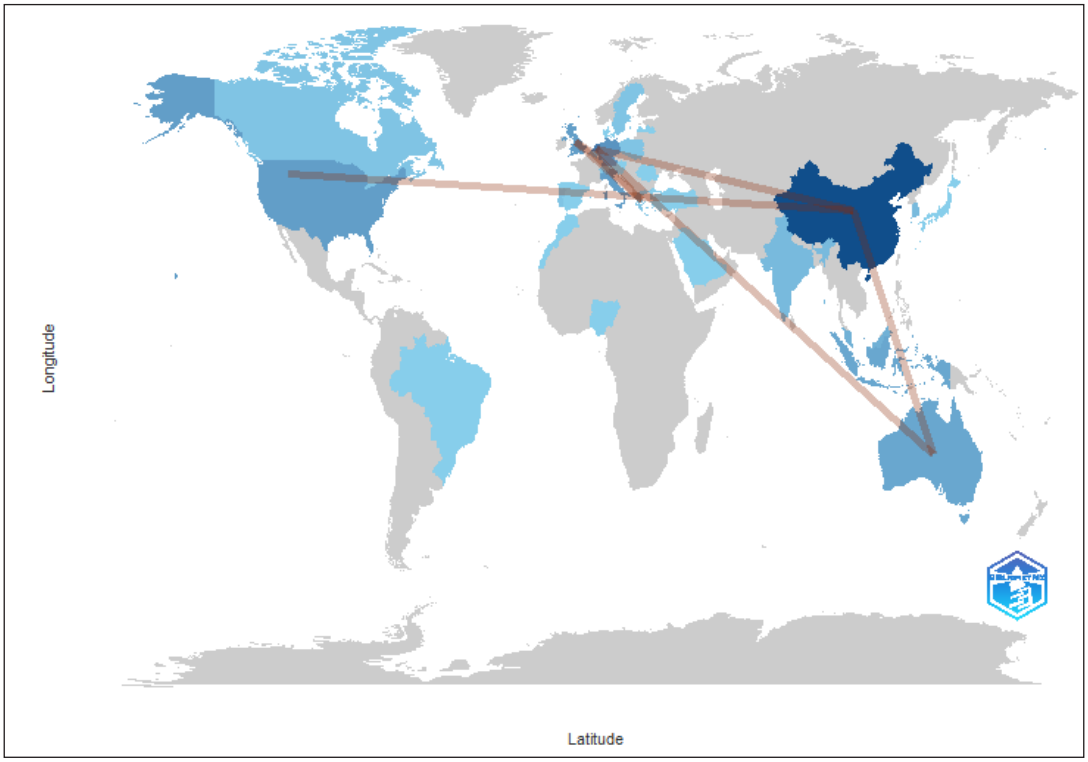
Fig. 4: Co-Word Network

Country Collaboration

The international research collaboration in this area is represented in Fig. 5. The intensity of the blue color indicates the number of published articles. The thickness of the red line indicates the strength of the collaboration based on frequencies. The seven frequent collaborations are between Belgium with Greece, China with Australia, the Netherlands, the USA, the Netherlands with Australia, the United Kingdom with Belgium, and the United Kingdom with Greece with a frequency of 2. The USA and the United Kingdom collaborate the most with other countries, followed by Australia, Belgium, and Greece.



Source: Generated through R studio.

Fig. 5: Country Collaboration Map

Conceptual Map

This study presents a factorial analysis by showing a conceptual structure map (Fig. 6) to visualize the relationship between themes, identify important themes, and understand how much attention research has given to different themes. The map presents five clusters in the figure with different colors. The blue cluster has the highest density by including the identified themes such as bicycles, rural areas, cycle transport, electric vehicles, sporting goods, electric bicycles, tourism, and a few others, as shown in Fig. 6. The red cluster is the second cluster that highlights themes such as male, female, humans, adults, motor vehicles, and traffic safety. Yellow cluster is about transportation, rural areas, and the built environment. Green clusters highlight the travel behavior and transport system. Lastly, the purple cluster is less related to areas such as traffic accidents and clinical studies. With the realm of the subject area, the most relevant areas include multiple documents with different themes. Kaplan et al. (2015) examined factors influencing tourists' intentions to use Copenhagen's bike-sharing system. Utilizing the Theory of Planned Behavior, it found high interest in bike-sharing linked to living in cycling-friendly countries, past cycling experience, and attitudes towards cycling. Electric bicycles appealed to tech-savvy tourists with lower perceived cycling ease. Sun et al. (2020) evaluated e-bike users' modal shift in the Netherlands, revealing significant reductions in conventional bike use and less pronounced decreases in car use post-e-bike adoption. E-bikes offer environmental benefits due to lower emissions, particularly among users under 50 and those in rural areas. Policy recommendations for sustainable mobility are provided. The impact of e-bikes on travel behavior and CO_2 emissions, highlighting their potential to reduce car mileage (Winslott Hiselius & Svensson, 2017), reveals significant emissions reductions in both urban and rural areas from e-bike use. However, the study notes that urban users tend to replace conventional bike trips more than rural users, which may decrease physical activity. It suggests effective e-bike promotion strategies to maximize their environmental benefits in both settings. Ao et al. (2020) investigate how the rural built environment influences travel mode choices among residents in China amidst ongoing rural construction and urbanization. Using on-site measurements and geographic information system technology, building density positively impacts private car usage, while road density increases the use of electric bicycles and motorcycles. Safety perceptions enhance the likelihood of walking, while preferences for safe environments encourage walking over motorized transport. Despite notable road improvements, public transportation usage remains low, highlighting the need for increased investment in public transport facilities during rural urbanization efforts. E-bikes facilitate cycling by overcoming barriers like distance and physical effort, empowering diverse groups to cycle more, especially in suburban and rural areas. While e-cycling expands opportunities beyond conventional cycling, both share similar motivations and challenges, such as inadequate infrastructure, highlighting the need for integrated mobility solutions (Rérat, 2021). Yang et al. (2014) revealed unsafe riding practices among E-bikers, with 70.9% exceeding speed limits and only 2.2% wearing helmets in China. Notably, men showed more violations. These findings highlight the need for improved e-bike safety measures, which are especially important for promoting safe rural tourism and effective transportation solutions. Ao et al. (2019) examine how the rural built environment influences travel-related CO_2 emissions in Sichuan, China, considering factors like car ownership and travel behavior. Findings reveal that accessible markets and higher densities reduce travel distance and emissions, while centralized living increases frequency but not efficiency. The study recommended that improving cycling infrastructure can lower CO_2 emissions. Lin et al. (2022) assess e-bike sharing systems, aiming to enhance accessibility for leisure and tourism, thereby improving resident well-being. Findings suggest classifying e-bikes by battery capacity, charging fees based on distance, and integrating user-friendly software for rentals and information. Promoting cycling can boost physical health and happiness in urban areas. Philips et al. (2022) estimate the potential CO_2 reduction by substituting e-bike use for private car travel, finding a maximum capability of 24.4 $MTCO_2$ per year. The greatest savings occur in rural areas, exceeding 750 kg CO_2 per person annually. The research emphasizes the need for supportive policies for equitable carbon reduction, particularly in car-dependent regions. Ulik et al. (2022) investigated e-scooter-related incidents, analyzing patients injured. The majority of injuries were multifocal, predominantly affecting limbs and the head, with alcohol consumption linked to traumatic brain injuries, and the study recommended stricter E-scooter regulations, helmet use, and technical modifications to improve safety. Broadly, most cited documents highlight the various transportation themes of bicycles, e-bikes, and rural transport, highlighting their impact on travel behavior, emissions, and safety. Research emphasizes the benefits of e-bikes in reducing CO_2 emissions, particularly in rural areas, and recommends improved infrastructure and regulations for safer cycling and e-scooter use.

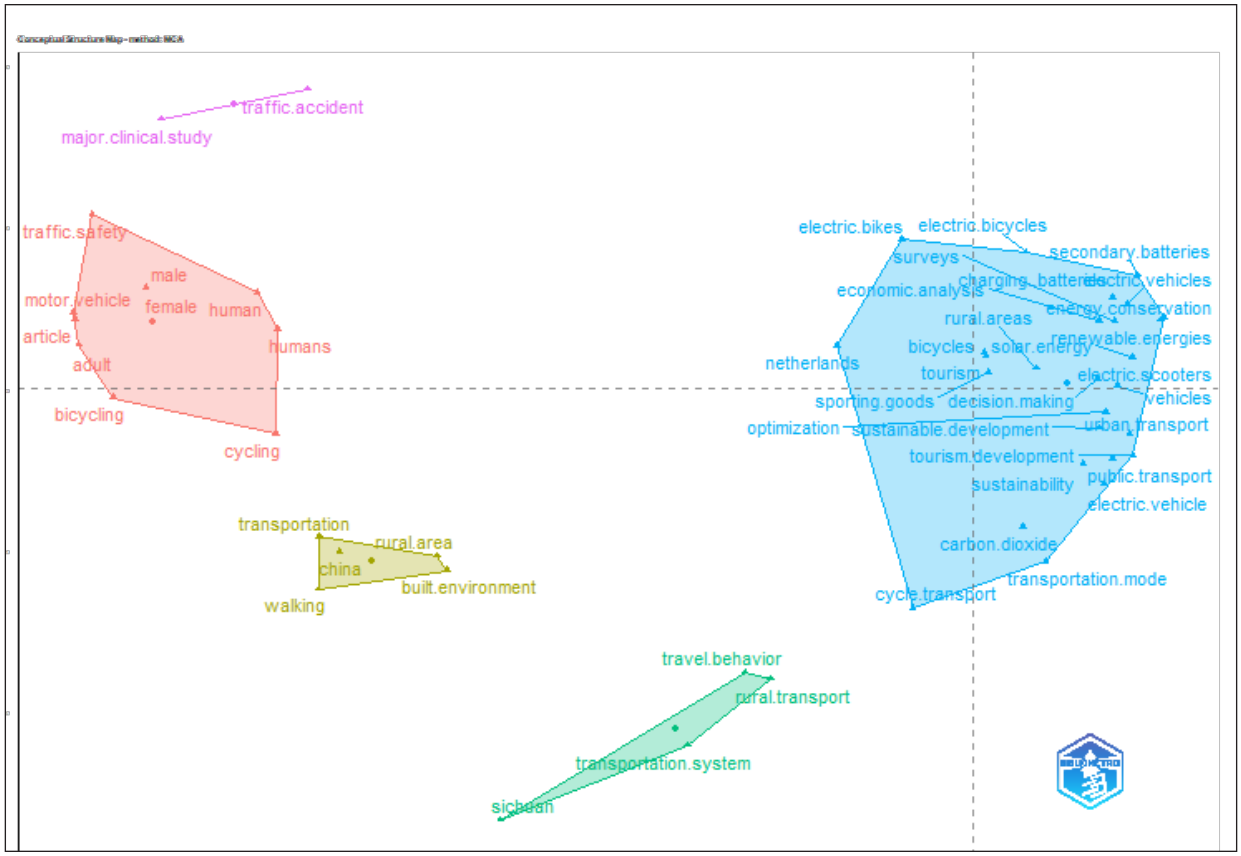


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Fig. 6: Conceptual Map

Thematic Map

Fig. 7 is a visual representation of the distribution of research themes, trends, and patterns in the previously available literature to gain insights into the spatial distribution of research activity, identify activity hotspots, and explore the relationships between research topics. Based on the analysis, this thematic map is divided into four themes, including eight clusters.

Niche themes in the top left quadrant in Fig. 7 with low centrality and high density are specialized and well-developed but lack a solid connection to the subject area. This section includes one cluster and topics like charging, batteries, and charging stations. Documents highlight that E-bike sharing systems can enhance rural tourism by providing convenient, enjoyable transportation. However, challenges like inadequate online charging systems, limited battery accessibility, and underutilization hinder their effectiveness. Improving these features can promote healthier lifestyles and foster a safe, happy environment for both users and the communities they visit (Lin et al., 2021). Yan et al. (2021) address the complex issue of locating electric scooter battery swapping stations and battery deployment, considering variable costs and travel demands. It employs a network flow model and heuristic algorithms, evaluating accurate data to optimize station placement and battery management for reliability in service time, with future stochastic modeling suggested. Pirolo et al. (2024) highlight that bicycle tourism is increasing due to e-bikes, enabling longer rides with recharging stations essential for battery autonomy. The installation of charging stations optimally minimizes distances while adhering to budget constraints. Qiu and Li (2022) present an electric fire safety device for electric bicycle chargers, addressing fire risks in ancient villages with timber and brick structures. The device uses anti-electrode reversal technology to prevent fires caused by overcharging and battery reversal during charging, enhancing fire safety and managing battery charging effectively.

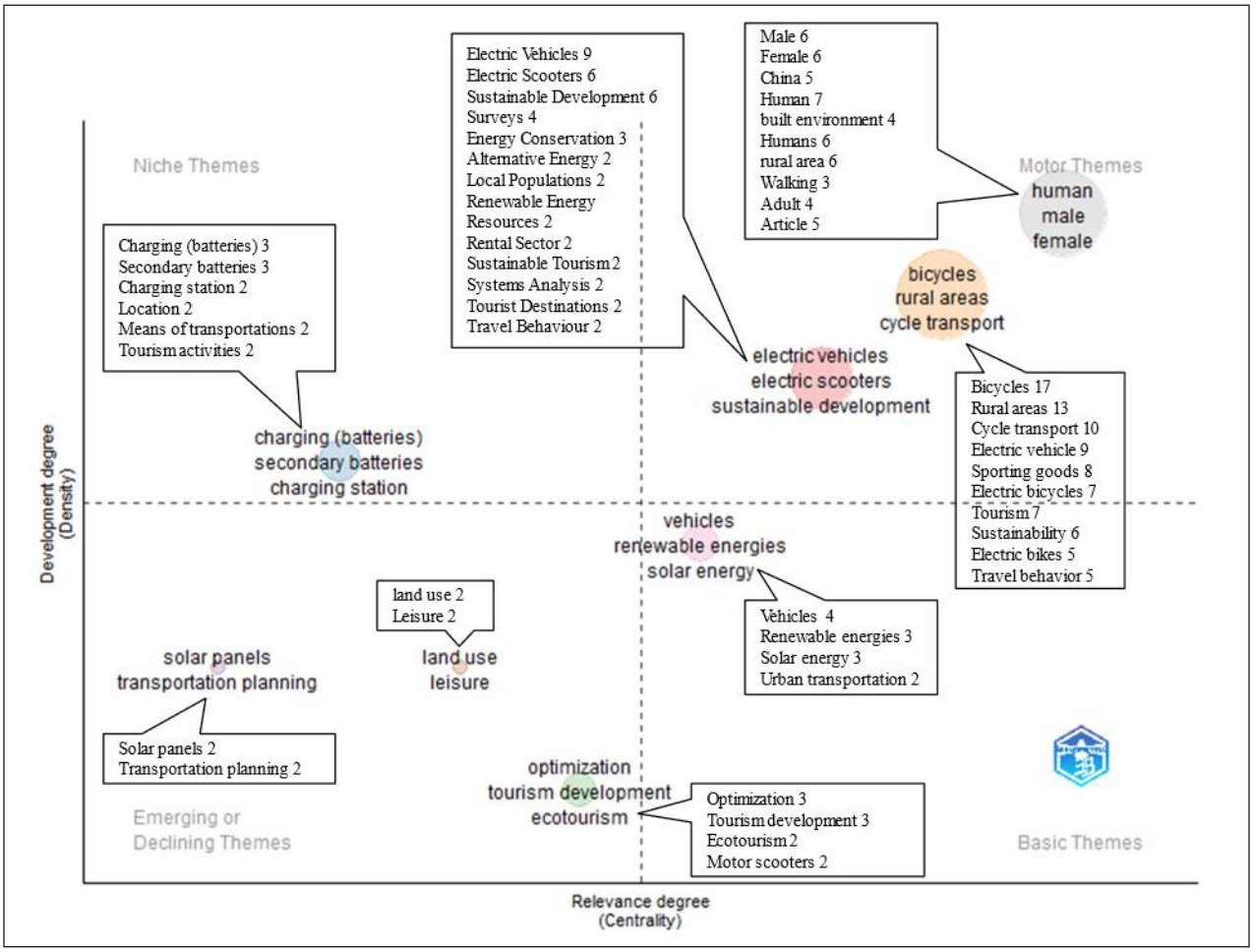
Emerging or declining themes are located in the bottom left corner of Fig. 7, with low centrality and low density. These themes need to be well-developed and central to the field, which may represent early-stage research areas with potential to grow (emerging themes) or previously central topics that are losing relevance (declining themes). Documents involved in this section studied solar panels, transportation planning, Land use, leisure, optimization,

tourism development, and ecotourism. Kothawala et al. (2024) jointly model e-scooter use frequency and purposes, analyzing factors like sociodemographic, lifestyle, and location users. Critical factors of the study include gender, income, and vehicle ownership. The study finds that policy on usage, perceptions, Sustainability, equity, and land use integration are the critical factors. Wang (2008a) explores how electric scooters can mitigate tourism transport's environmental impact, focusing on optimizing the location and number of battery exchange stations using integer programming. It also conducts sensitivity analyses regarding service capacity at each site, highlighting the importance of recharging facilities for effective e-scooter use. Bardi et al. (2019) evaluate e-bike sharing for cruise tourism to enhance Sustainability and reduce pollution at cruise ports. Using a revealed preference survey and an ordered probit model, it analyzes factors affecting tourist satisfaction with e-bike services. Wang (2008b) develops a simulation model for deterministic location analysis of electric scooter recharging systems in tourism and recreation contexts, which identifies service capacities and performance levels at various station locations while addressing demand variability. Senese et al. (2023) examine the challenges and benefits of developing a long-distance cycleway in high mountain areas to enhance eco and geo-tourism. The study highlights the role of e-biking in promoting local geodiversity and identifies and facilitates access to natural and cultural heritage for mountain bikers. Amritanand et al. (2016) address the issue of unelectrified villages in India by proposing an energy cycle that harnesses energy during cycling to light rural households. It integrates solar panels for additional energy generation and reveals that a single bicycle can provide lighting, offering an affordable solution for rural electrification. Colombo et al. (2023) propose an integrated urban mobility plan powered by a solar microgrid, including e-buses, e-minibuses, e-taxis, and e-bikes. A photovoltaic plant is designed to support sustainable electric mobility, providing energy and aiming to enhance transport services. These themes mainly focused on sustainable transportation and solar energy integration, focusing on e-scooter and e-bike systems, energy cycles for electrification, and solar-powered urban mobility plans to enhance ecotourism and reduce environmental impact.

Motor themes are located in the top right quadrant in Fig. 7 and have high centrality; motor themes highlight well-developed and essential topics in the subject area that are central to the research field. Documents highlighted in this section represent established knowledge. Zhang et al. (2013) examine the relationship between the built environment and household e-bike ownership. The study finds that denser urban areas with mixed land use and accessible transportation links correlate with lower e-bike ownership and suggests that policymakers should tailor e-bike and transportation policies based on built environment variations. Nakamura and Abe (2016) analyzed user decision-making concerning rental modes such as ultra-lightweight vehicles, electric bicycles, and scooters. Studies highlight that most users preferred rental services for tourism, prioritizing safety, convenience, and joy over mobility. Ultra-lightweight vehicles were deemed the most preferred option for alternative transportation to private cars. Twisk et al. (2020) compared conventional bicycles, peddles, and speed peddles, finding significant speed differences, with speed peddles being faster and exhibiting more significant speed variability and harsh braking. This study showed that the role of gender influenced mean speeds above the speed limit, while personality traits were not linked to speed behavior. McKenzie and Romm (2021) introduce a method for assessing regional similarity in cities using human mobility patterns from e-scooter trips. This research models dimensional and temporal movement variability by analyzing trip origins and destinations. Lin et al. (2022) examine intelligent traffic management systems post-epidemic as key to fostering a sustainable urban environment for relaxation tourism. The study highlights the need to improve service quality and fare structures, enhance travel convenience, and promote health safety in public transport to support sustainable urban tourism. Kusuma et al. (2019) propose a redesign of electric scooters for use in remote tourist islands, focusing on compatibility with less developed infrastructure. The new design aims to promote ecological, socio-cultural, and economic Sustainability in ecotourism while fostering interaction between tourists and locals. Lee and Tang (2021) investigate the shared electric scooter service, focusing on enhancing customer loyalty and satisfaction through excellent service. This research used regression analysis to identify critical factors affecting Net Promoter Score and qualitative interviews to address issues. The study proposes an optimized tourism service model for shared electric scooters. Genikomsakis et al. (2021) explore the potential of hotel-based e-bike rental services as a sustainable transportation option for holiday cycling, mainly powered by renewable energy. Conducting a stated preference survey among hotel guests analyzes user profiles and preferences. The finding shows positive returns on investment across all scenarios, indicating that the service is a viable business opportunity that enhances guests' perceptions of environmental quality and friendliness. Ikeh and Yuen (2022) investigate first-mile transportation modes and emphasize their role in sustainable transportation. It identifies critical determinants such as age, status, profession, monthly income, travel distance, and contextual factors influencing individual travel behavior. The findings mitigate traffic congestion and enhance transit connectivity. This study suggests expanding public transportation networks to rural areas, introducing free shuttle buses to encourage public transport use, and promoting e-scooters and e-hailing services for short-distance commuting. Brüchert et al. (2022) examine how

older adults' perceptions of the built environment influence cycling and e-biking for transportation in rural areas. The study highlights the importance of street connectivity and proximity to destinations, while traffic safety had mixed associations. Li et al. (2022) explore how changes in rural built environments affect school travel mode choices among children. Utilizing field measurements and questionnaires, it finds that age positively influences the use of bicycles and buses, while improved road conditions encourage electric bicycle use. Increased distance to school leads to a higher likelihood of using motorized transport. Using police-reported cases, Chang et al. (2022) analyze factors affecting injury severity in e-bike crashes. Key influences include road features, lighting conditions, and rider demographics. The study informs about targeted safety measures to enhance e-bike traffic safety. This section mainly highlights e-bike and transportation dynamics studies, highlighting relationships between the built environment, user preferences, and safety.

Primary themes in the bottom right quadrant in Fig. 7, with high centrality and low density, highlight fundamental themes to the subject area with less development and maturity. These themes are central but need further exploration or more in-depth study. Only some relevant documents are included in this section. Bugaje et al. (2021) explore integrating electric two-wheeler vehicles into an off-grid photovoltaic Water-Energy Hub in rural Kenya. It was found that photovoltaic generation exceeded power consumption, reducing electricity deficits and enabling the daily charging of additional e-bike batteries through load optimization techniques. Roger and Omari (2019) developed a solar-powered tricycle, the Solar-e-Cycle, to enhance mobility and provide electricity in off-grid communities. The prototype needs commercialization and infrastructure support yet needs venture capital interest. According to the study, this innovation could significantly reduce CO_2 emissions and support essential services in rural areas. Themes such as solar energy, renewable energy, and urban transport need further exploration.



Source: Generated through R studio.

Fig. 7: Thematic Map

Table 1: Future Research Direction Based on Thematic Analysis

Themes	Key Areas	Research Gap	Future Research Direction
Niche Themes	Charging (batteries)	Limited research on efficient battery charging solutions in rural areas	Investigate innovative charging infrastructure designs suitable for rural regions with low grid access
	Secondary batteries	Lack of focus on secondary battery systems for extended e-mobility range in remote areas	Examine the potential of secondary batteries to improve the range and usability of e-mobility in remote areas.
	Tourism activities	Limited studies on the impact of e-mobility on rural tourism activities	Explore the role of e-mobility in enhancing rural tourism activities and attracting eco-conscious tourists
Motor Themes	Gender (Male/Female)	Insufficient demographic studies on gender-specific adoption patterns of e-mobility	Conduct gender-focused studies to understand unique adoption challenges and motivators for e-mobility
	Cycle transport in rural areas	Lack of research on the feasibility of cycle transport in rural e-mobility ecosystems	Evaluate cycle transport systems' logistical and environmental benefits in rural mobility networks.
Emerging/Declining Themes	Solar panels	Limited exploration of solar panel usage to support e-mobility in tourist areas	Research how solar panels can be deployed in tourist regions to sustain e-mobility services
	Transportation planning	There are few studies on strategic transportation planning for e-mobility integration in tourist destinations.	Develop strategic models for integrating e-mobility in transportation planning of rural tourist destinations.
Basic Themes	Bicycles in rural areas	Limited research on bicycle adoption in rural areas and its impact on sustainable tourism	Assess the impact of bicycle usage on environmental Sustainability and tourist satisfaction in rural areas.
	Electric Vehicles and Sustainability	Limited understanding of how electric vehicles can enhance Sustainability in rural tourism	Analyze electric vehicle adoption in rural tourism as a pathway to sustainable development.
	Travel behavior in tourism destinations	Lack of insight into travel behavior patterns influenced by e-mobility in tourism destinations	Study the shifts in travel behavior due to e-mobility options in tourism-centric locations.

Source: Author's own.

IMPLICATIONS AND LIMITATIONS

Theoretical Contribution

The theoretical implications of this study extend the understanding of micro-mobility adoption in rural and tourism-oriented contexts, areas that still need to be explored in existing transportation and sustainability literature. By systematically analyzing factors such as infrastructure readiness, consumer perceptions, and policy support, the study provides a nuanced view of the unique adoption dynamics of e-mobility solutions in non-urban settings, diverging from the urban-centric focus that typically dominates micro-mobility research. This approach enriches the theoretical foundation of sustainable transportation by emphasizing the applicability of existing frameworks in rural environments and highlighting new variables and contextual factors critical to these settings. This study also bridges gaps in technology adoption theories, such as the Theory of Planned Behavior (TPB) and Diffusion of Innovations (DOI), by testing their relevance in rural tourism contexts. For instance, it demonstrates how attitudes, perceived accessibility, and environmental values influence micro-mobility adoption, adapting these theories to fit rural-specific challenges like limited infrastructure and lower population density. Additionally, this research underscores the importance of policy frameworks, contributing to theoretical discussions on how regulatory support and local policy can drive sustainable behavior change in rural areas.

The study's findings encourage future theoretical exploration of sustainable transportation systems in other non-urban contexts, such as remote communities or protected areas. By advancing the discourse on rural micro-mobility and its interplay with sustainability, this research calls for re-evaluating technology adoption models to accommodate diverse geographic and socio-economic factors, promoting a broader application of these theories across varying environmental settings and mobility needs.

Policy Implications

The policy implications of this study highlight actionable steps for governments, tourism authorities, and local planners to promote sustainable micro-mobility in rural and tourist destinations. By adopting e-mobility solutions such as e-bikes and e-scooters, these areas can reduce fossil fuel dependence, lower greenhouse gas emissions, and support environmental sustainability. Policies that provide financial incentives, like subsidies, tax breaks, or grants for infrastructure development, are essential to facilitate adoption. This approach would encourage local stakeholders to invest in e-mobility options and improve transportation access in rural regions where conventional modes may face challenges due to limited infrastructure.

Furthermore, developing and maintaining supportive infrastructure, including charging stations, dedicated pathways, and parking facilities for e-mobility vehicles, would make these options more attractive to tourists and accessible to local communities. Integrating micro-mobility solutions into regional tourism policies aligns with Sustainable Development Goals (SDGs) focused on climate action, sustainable cities, and economic growth, particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). By creating regulatory frameworks prioritizing eco-friendly transportation, policymakers can foster eco-conscious tourism, support local economies, and attract environmentally responsible travelers. These initiatives would enable rural and hilly tourist destinations to become competitive and resilient, providing enhanced mobility options that improve tourist experiences and benefit residents through reduced emissions, improved air quality, and a higher quality of life.

Social Implications

The social implications of this paper are substantial, particularly in promoting sustainable and accessible transportation in rural and hilly tourist destinations. By advocating for e-mobility solutions like e-bikes and e-scooters, this study highlights how micro-mobility can help reduce carbon emissions, decrease air pollution, and foster eco-conscious tourism. These outcomes benefit local communities by protecting natural landscapes and enhancing the quality of life through improved air quality and reduced traffic congestion. Additionally, the adoption of sustainable transportation options can drive rural economic growth by making tourist destinations more accessible, attracting environmentally conscious travelers, and supporting local businesses reliant on tourism. This research provides policymakers and tourism planners with actionable insights to make informed decisions about infrastructure development, fostering a more inclusive tourism environment that aligns with Sustainable Development Goals (SDGs), particularly those related to climate action, public health, and economic growth in under-resourced areas.

Limitations and Future Research

This study, while comprehensive, faces several limitations that future research can address. First, the reliance on existing literature limits the generalizability of findings, as contextual factors such as cultural differences, economic conditions, and specific geographic characteristics in rural areas may vary widely and impact micro-mobility adoption differently. Additionally, this study primarily focuses on rural and tourist areas, leaving potential insights into micro-mobility adoption in other non-urban settings, such as suburban or protected natural areas, underexplored. Future studies could conduct empirical research to validate the findings across diverse regions and include quantitative assessments to understand specific adoption drivers and barriers.

Future research should also explore the behavioral aspects of users in rural and tourist contexts, considering factors such as willingness to adopt, perceived benefits, and safety concerns. Moreover, examining the long-term environmental and economic impacts of micro-mobility adoption in these areas would provide valuable data for policymakers. Research could also investigate emerging technologies like solar-powered charging infrastructure or shared e-mobility systems tailored to rural and tourist areas. Finally, interdisciplinary approaches integrating insights from environmental science, economics, and urban planning could offer a more holistic view, helping to create tailored solutions that effectively promote sustainable mobility across various non-urban settings.

CONCLUSION

This study systematically reviews micro-mobility adoption in rural and tourist areas, highlighting the crucial role of e-bikes and e-scooters in promoting sustainable tourism and eco-friendly transport. The bibliometric analysis revealed that countries like China and Germany lead in research productivity on e-mobility in non-urban settings, demonstrating their strong interest and investment in sustainable transportation. Analysis of frequently used keywords, such as “e-bikes,” “sustainable mobility,” and “rural tourism,” emphasizes the academic focus on environmentally conscious travel modes and the need for better infrastructure. The co-word network showed clusters around terms like “electric vehicles,” “Sustainability,” and “transportation systems,” signifying interconnected themes central to the research field. The country collaboration

analysis indicates strong international partnerships, especially between the USA, the Netherlands, and Australia, highlighting global interest in micro-mobility solutions. Conceptual mapping revealed distinct thematic clusters, suggesting areas ripe for further exploration, including infrastructure, environmental impact, and user perceptions. Through this review, the study underscores the necessity of targeted policy interventions, including financial incentives, infrastructure improvements, and regulatory support, to foster sustainable micro-mobility in rural areas. Integrating e-mobility into sustainable tourism policies aligns with several Sustainable Development Goals, fostering climate-friendly tourism practices and enhancing accessibility in remote areas. Furthermore, the study contributes theoretically by extending established urban mobility theories to rural contexts, encouraging future research to examine adoption behaviors and long-term impacts in non-urban environments.

While this study provides valuable insights, it is limited by its reliance on existing literature, which may only partially capture region-specific factors. Future research should employ empirical methods to validate these findings, explore the behavioral aspects of rural e-mobility users, and assess emerging technologies like solar-powered charging stations. This work establishes a foundation for ongoing exploration of sustainable transportation in rural and tourist areas, advocating for a more resilient, accessible, and environmentally responsible approach to mobility.

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