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Bridging the Last Mile through Shared Mobility towards an Integrated Mobility System

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ABSTRACT

As the population of urban centers grows, there is a significant challenge of adjusting the transportation needs of urban mobility, as well as pursuing environmental protection strategies and ensuring social inclusion. The major bottleneck of urban mobility includes the constant traffic congestion in major cities because of excessive use of private cars. Developing an accessible, attractive transportation system that caters to people's individual mobility needs and preferences is one possible solution to these problems. It is important to have a coordinated system connecting the various modes of transportation so that people's homes and destinations can be reached with ease. The first and last miles of commuters, which are the weakest linkages in the transportation network, should be developed first before the system can be integrated. Shared mobility which involves using a shared vehicle (car, bike, scooter, etc.) often serves as a first or last mile connection to other modes of transportation such as public transit. Understanding the factors that influence the adoption of shared mobility services is crucial to ensuring that they become a significant component of the urban mobility system. This paper provides an overview of existing and emerging last mile solutions, particularly in the concept of shared mobility. The objective of this study is to add and enrich knowledge in the area of shared mobility in bridging the last mile toward an integrated mobility system.

Keywords: Last Mile, First Mile, Shared Mobility, Urban Mobility, Transportation

INTRODUCTION

Mobility challenges are one of the most serious concerns in urban areas which have resulted in a deteriorated quality of life. Cities face a growing number of motor vehicles leading to air pollution, noise from traffic, environmental degradation, scarcity of green spaces, and a rise in overall carbon emissions. Transportation demand and distance traveled have increased as continuously grow and travel patterns have changed. In India, for instance, continuous urbanization entails rapid urban modernization and a consistent increase in travel demand. As a result, there is more traffic, more consumption of fuel, and more inequality in terms of access to transportation. Moreover, the growth of population in urban areas and vast urban expansions have exacerbated this challenge. Sixty percent (60%) of the world's population will reside in urban areas by 2030. With this, the expansion of the transportation network proves to be a critical transportation objective. People regularly move from one place to another which necessitates a reliable infrastructure that can accommodate multiple mobility options. Urban development must take into account the emerging urban networks that connect residents to the rest of the city. However, expanding and improving transportation networks is a challenging endeavor especially in developing cities and their towns. This is identified as a huge gap in the transportation network. Different companies and startups attempted to address this gap with new technologies and solutions. The challenge for mobility stakeholders is to create a seamless mobility offering that can effectively respond to rising mobility needs while also having a significant impact on traffic congestion, environmental sustainability, and livability in our cities. To do this, it is imperative to reduce the frequency of motorized trips, increase the share of nonmotorized trips (such as walking and cycling), and reduce motorized trip distances. The creation of an easily accessible, attractive, and sustainable transportation system that satisfies people's needs, preferences, and desires for mobility is one possible solution to transportation-related "urban diseases." Moreover, an integrated system connecting the different modes of transportation is likewise significant that must easily connect people's homes with their destinations. Public transportation must be the foundation of any integrated mobility and sustainable transport system. In general, an integrated system promotes safe, effective, dependable, and practical movement of people and goods known as an integrated mobility system. All users—pedestrians, bikers, drivers, professional drivers, transit patrons, etc.—benefit from an integrated mobility system.

Mobility or transport integration is not a new concept although there is no universally agreed-upon definition of an integrated transportation system. Past

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and recent studies have explored this concept as well as strategies to achieve sustainability in transportation. For instance, the study of Potter and Skinner (2000) articulates this concept serves as a guiding principle in developing several transport policies in different countries. The study focuses on the integration of private and public modes of transportation that will lead to a higher level of sustainability. Brand et al. (2017) developed a framework to evaluate multi-modal bus network integration and discusses factors and system variables that influence integration. Additionally, Bruzzone et al. (2021) suggested important performance measures to assess possible improvements in the operational, environmental, and social performance of integrated systems as compared to the existing transportation systems. The ongoing challenge of enhancing public transportation (PT) networks, particularly the first and last mile trips, must be taken into consideration if urban areas are to become more livable and sustainable. However, transitioning to more environmentally sustainable transportation has been challenging, especially in suburban regions. There are a variety of constraints and limitations in traveling sustainably for individuals in society. These roadblocks include a lack of available modes of transportation and routes, public transportation costs, wider cultural norms, and the difficulty of combining long-distance intercity travel with short-distance urban travel, among others. Other problems include lack of sidewalk networks, badly maintained sidewalks, missing curb ramps, lack of crosswalks and crossing lights, inaccessible bus stops, and lack of amenities such as shelters, seats, and lighting at bus stops. Combining these is the 'last mile' problem. The first mile/last mile (FMLM) trips are the biggest challenge for commuters when using public transit.

The first mile is defined as the first leg or trip of a commuter, from starting point to a mass transit station. The last mile, on the other hand, is the last leg of a journey or the distance between a mass transit station and the final destination. The last mile is also defined as the potential distance between a traveler's primary access point for transportation (bus stop, subway station) and their house, workplace, etc. The trips from work to home and vice versa are taken into account. These trips are crucial in the transit planning process because the effectiveness of transient is contingent on adequate access to and from transit stops. Problems in the first and last mile can be a limitation to increasing public transportation usage. For instance, people may not choose to walk or opt to use a direct travel mode such as a personal vehicle because of the distance between transit stations and their origin/destinations. This makes urban areas more inaccessible. The last mile for many cities in Asia and the Pacific is served either by a strenuous walk or by three-wheelers, generally known as rickshaws. In developing countries, the last mile problem is more acute because of the poor connection between public transportation with other modes of mobility. Moreover, pedestrian and bike infrastructure are lacking in these countries. FMLM issues such as these that go unaddressed contribute to unsafe travel situations, which can increase anxiety and reduce mobility. The quality of the first and last mile journey has an impact on the passenger's overall experience in public transportation. Even with high-quality transit service provided, the inability to transport passengers from point of origin to destination discourages transit use. Hence, a commuter's first and last miles should be developed first before the integrated system can be established. It is important to make them more attractive to travelers to encourage the use of public transportation being an important part of a person's journey.

Transit agencies and advocates in cities across the world are attempting to bridge the gaps in the first and last mile toward improving public transportation services, and promoting personal mobility thereby increasing its use and reducing car dependence. Citizens will travel to and from public transportation by car or motorcycle until there is a safe, secure, comfortable, and affordable way to do so. Moreover, researchers and planners of public transportation have recently paid close attention to the coordination of bicycle and transit modes. For instance, the study by Flamm and Rivasplata (2014) surveyed cyclist-transit users (CTU) in the American cities of Philadelphia and San Francisco to define their characteristics and assess their travel patterns and behavior. In European cities, commuting by bicycle has shown to be a viable means of transportation to and from their workplace. Cycling is a first, last, and only mile alternative that can be used to complement train travel that is extremely efficient. While some cities in developed countries have a well-established infrastructure, others, usually in developing countries lack this. Hence, there is less mobility from network to network as well as network congestion. For instance, developing countries in the Latin region such as Bogota, São Paulo, Rio, and Buenos Aires have the worst traffic. Therefore, there is an overlap of multiple and sophisticated systems in these ecosystems to provide people with mobility alternatives.

Shared mobility is the short-term use of shared vehicles, bicycles, and other modes of transportation "as needed". It is one of the solutions to the first and last mile problems that help commuters get to and from a location in a safe, convenient and efficient way. It is often connected to other modes such as public transportation. Shared mobility services include carsharing, bike-sharing, scooter sharing, on-demand ride services (e.g. ride-hailing/ ride-sourcing) and ridesharing (i.e. carpooling or vanpooling microtransit), and courier network services (CNS). Shared mobility is an emerging trend that can help reduce traffic congestion, reduce carbon emissions, providing an environmentally friendly mode of transportation. Moreover, it is more economical compared to the use of individual private vehicles.

Travel behavior has changed as a result of socio-demographic trends and recent economic development patterns, which requires a more flexible and accessible public transportation option. Important information to encourage more sustainable travel behavior can come from understanding different perceptions and attitudes of commuters relating to their journeys in the last mile. For instance, poor last mile design may be preventing people from riding public transportation, walking, or cycling. This paper provides a review of the existing and emerging last mile solutions specifically in the context of shared mobility. Moreover, a synthesis of the factors influencing the adoption of these services in different countries will be presented. The paper aims to enrich and strengthen knowledge in bridging the last mile through shared mobility toward an integrated mobility system.

Shared Mobility Services

The mobility industry is undergoing a significant shift in order to improve efficiency, and this evolution has significant economic and societal implications. However, developments in mobility also contribute to global warming and health concerns due to pollution, traffic congestion, and social inequity. With this, more research has been focused on addressing these issues through novel mobility solutions and alternatives, a shift in societal behavior, and autonomous vehicles, among others (Turienzo et al. 2022). These services are essentially different and more advanced than traditional modes of transportation (Calderon and Miller 2020). In most cities, traditional forms of mobility include walking, cycling, and taking a bus, subway, or taxi among others (Hussin et al. 2021). Traditional public transportation, which uses fixed routes and schedules, is designed to serve densely populated urban areas with concentrated travel patterns. Over the last few years, rapid advancements in automated vehicle technology have opened the possibility of new modes of transportation. The self-driving automobile, which was once a futuristic concept but is now being developed in many forms, provides many safety, societal, and infrastructure-related benefits (Zellner et al. 2016). The emergence of new forms of transportation has a noticeable impact on the development and sustainability of urban mobility. New mobility services have emerged providing a range of options for a variety of personal trips. Instead of having only one option, the new modes allow people to select the most appropriate and available mode for them (Hussin et al. 2021). Combined with a well-developed public transportation system, these mobility services enable people to get to work, run errands, and get to places without the use of a personal vehicle (Shared-Use Mobility Center, n.d).

New emerging trends are happening in the sharing economy that shapes the modern world's cultural, economic, and social landscape. The sharing economy has already made an impact on urban mobility, with more city dwellers opting for a car and ridesharing instead of owning a car (Ohnemus and Perl, 2016). In recent years, there have been various definitions of the sharing economy, but no single definition has been widely recognized by researchers and practitioners in the field (Novikova, 2017; Botsman, 2013). Nevertheless, the concept of sharing economy has been used in a variety of contexts including production, consumption, finance, and education among others. With so many variations of the sharing economy concept growing in a variety of fields, the area of shared mobility has emerged as a forerunner of these developments. Shared mobility is the shared use of transportation services and resources, such as a car, bicycle, or other modes that enable users to quickly access different modes of transportation as needed (Novikova, 2017; Shaheen & Chan, 2016). It includes automobile-based modes (carsharing, rides on-demand, and micro transit), micro-mobility (bike sharing, scooter sharing), commute-based modes or ridesharing (carpooling and vanpooling), and e-Hail (taxis). Shared mobility can support cities in reducing the number of private vehicles on the road, conserving energy in the transportation sector, and ensuring the success of the energy transition (Burghard and Scherrer 2022). It has grown in popularity in major cities throughout the world as an innovative transportation mode that improves urban mobility. Aside from this, it is also considered a feasible solution for connecting the first-and-last mile trips with public transportation. It has the potential to expand the reach of public transportation crucial in bridging the gap in the existing transportation network. Moreover, the utilization of shared mobility encourages multimodality for first and last mile trips.

Shared Mobility as Last Mile Solutions

New development of framework and terminologies are required to address the first and last mile connectivity to public transit. Concepts such as Mobility as a Service (MaaS), Mobility on-Demand (MoD) Flexible Transportation Systems (FTS), among others have been developed by the academic communities (Calderon and Miller 2020). For instance, developed countries have conducted studies on MaaS and found that it has the potential to influence the mobility of people toward an efficient and sustainable transport system for the future (Hasselwander and Bigotte 2022). This system organizes, distributes, and integrates both private and public transportation alternatives through the use of intelligent digital technologies. Integration takes place in various physical modes of travel such as public transit, carsharing, ride-hailing, bike-sharing, etc. This is possible by bringing together the services that are often controlled individually, such as scheduling, paying, and booking tickets into a single user interface. At the local and national levels, MaaS aspires to bridge the gap between public and private transportation carriers, shifting away from personally owned modes of transportation toward providing mobility as a service. The primary idea behind MaaS is integrated and seamless mobility providing travelers with mobility options tailored to their specific travel requirements (Kamargianni et al. 2016; Esztergár-Kiss, 2020; Alyavina et al. 2020;). It is a practical mobility option that most likely will be crucial in the reform of urban transportation in the future.

The same concept of mobility is also at the center of the study of Ohnemus and Perl (2016) but their focus is on shared mobility for the last/first mile in suburban and low-density areas where traditional public transport services fail to provide high levels of service. They point out that future mobility in these areas depends much on the extent to which deployment of autonomous vehicle technology is shared or not. Shared autonomous vehicles (SAVs) would keep door-to-door service while eliminating the cost and congestion associated with single-occupant vehicles. Integrating SAVs with public transportation systems might significantly boost synergies between vehicles and transit because of their ability to connect the first and last mile of trips in areas of low density. As SAVs preserve accessibility to auto-dependent sites during times of climate and energy disruption, low-density land use could be protected against climate and oil vulnerability. Some public transit firms in New Cairo, Egypt, are using information and communication technology (ICT) in their operations. The modal share of New Cairo demonstrated the efficiency of ICT integration. The second most popular mode of transportation is ride-hailing apps, which rely heavily on this technology to provide their services. Although they are new to Cairo's mobility system, peak-

only mass transit services and buses like Mwaslat Misr may compete for ridership (Hussin et al, 2021). Moreover, other solutions include implementing shared mobility services like shared bicycles or scooters which can be electric or non-electric. As a first and last mile mode option, 25.9% of poll respondents in New Cairo chose this mobility service. In some circumstances, ride-hailing is also seen as a solution to the first and last mile problem to promote the use of public transportation instead of using private cars. In the Netherlands, the biking infrastructure is already well-developed, hence people have been using this option. In terms of mobility of people, having a last mile solution is a significant factor for people to choose a more sustainable mode of transportation instead of just using a car when traveling.

Last mile connectivity is critical for increased integration and accessibility of public transportation networks to the public. New mobility services have emerged such as shared mobility which is characterized by innovative technologies. The potential integration of these with mass transit allows for bridging the first and last mile gap. For instance, using the opening of a metro station in Bangalore as a case study, Kanuri et al. (2019) found that there is a first and last mile modal shift from the usage of personal cars to the use of new mobility solutions. Moreover, the study revealed that sustainable and seamless urban mobility requires public-private collaboration. This can be done by supporting regulatory frameworks and increasing multimodal integration of transportation. In recent years, the Asian Development Bank (ADB) has brought together some of the world's leading experts on the pedal- and electric-powered vehicles to develop a modern, efficient, and low-cost three-wheeler vehicle that may serve the last mile of trips in Asia-Pacific cities. The team created a concept for an "e-pedicab," a three-wheeler with a pedal and an electric motor. The e-pedicab was first tested in Lumbini, Nepal which aims to attract tourism in a sustainable way that respects local traditions while encouraging the use of low-carbon economic development. E-pedicabs have proven to be an effective way to connect the town with the temple district, which attracts an estimated 1.2 million visitors each year. The ADB Lumbini project also includes an electric bus fleet that will connect the city to a planned new international airport. Other cities and ADB projects have expressed an interest as well. Other ADB-financed BRT projects considered e-pedicabs and bicycle-sharing systems as integrated solutions for last mile connection. Passengers with disabilities will be able to use the updated design.

One of the key solutions in terms of mobility of people in the last mile for urban travel is sharing vehicles, the development of infrastructure for walking and biking, bike/scooter/electric vehicle parking, and a good public transportation system. Infrastructure development encourages active transportation, such as walking and cycling, as a solution to the first and last mile problem. In New Cairo, this is the most chosen mode by 66% of the total survey respondents according to the findings of Hussin et al. (2020). For private-car users, shared mobility services specifically micro-mobility are considered another solution. Because of the financial and environmental benefits, shared mobility is becoming increasingly popular. Hence, it is crucial to understand its integration into urban transportation networks and how to improve it from a social, environmental, and economic standpoint (Machado et al. 2018). Several advantages come from incorporating shared mobility into current transportation infrastructures. The use and ownership of private vehicles have been reduced, which would help to minimize parking congestion and improve road traffic conditions. Another is that it is more environmental-friendly wherein it contributes to a decrease in carbon emissions, fuel use, and transportation costs. With this, policies and measures are crucial to make sharing services more attractive, accessible, and viable for system users.

Shaheen and Chan (2016) categorize shared mobility services according to what is shared: a vehicle, a passenger ride, or a delivery ride. The sharing of a vehicle and sharing of a passenger ride is commonly linked to public transit. Hence, these will be the focus of this study. Sharing a vehicle includes carsharing and bike-sharing. A recent variation of this model is scooter sharing which is included in the study of Shaheen et al (2016). The same study indicated that the sharing of a ride is enabled by

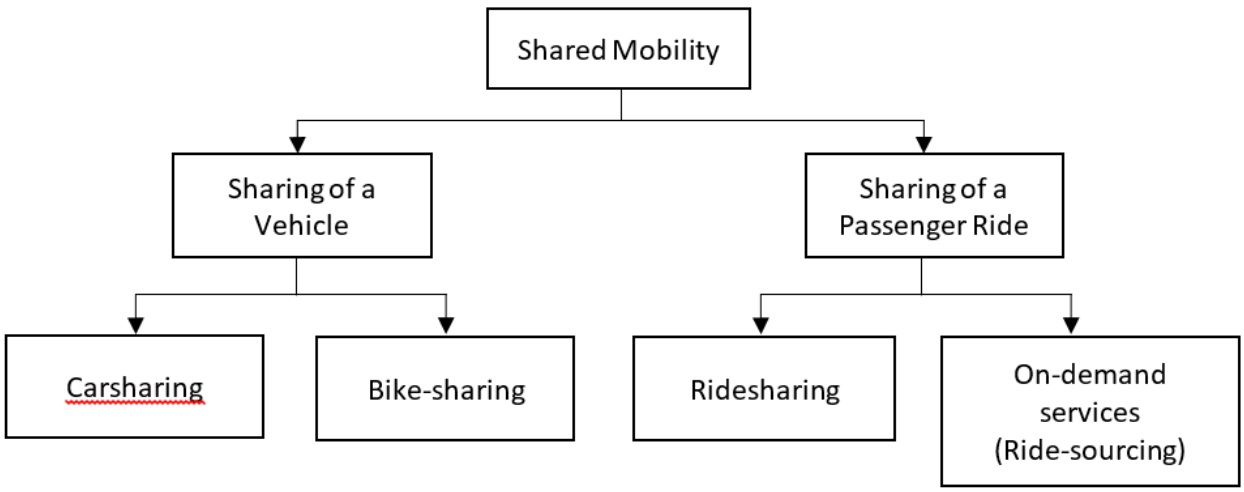

Figure 1. Types of Shared Mobility directly linked to Public Transit

ridesharing, on-demand ride services such as ride-sourcing, ridesplitting, e-hail services, and microtransit. However, this paper will only tackle ridesharing and ride-sourcing under this model.

Sharing a Vehicle

Vehicle sharing services such as bike-share, carshare, and e-scooters, allow for an increase in accessibility and mobility for underprivileged populations (Dill and McNeil, 2021). Using a vehicle sharing system, users can rent a vehicle for a short period. Typically, the length and duration of a trip dictate its cost. The most popular applications of this service include bike-sharing, electric car-sharing, and carsharing systems (Ataç et al. 2021). The establishment of a vehicle sharing system allows keeping the benefits of owning a car while reducing costs. Carsharing is introduced as one of the earliest forms of vehicle sharing system. It has become common, especially in Europe. In 1948, a cooperative in Zurich, Switzerland called "Sefage" (Selbstfahrergemeinschaft) had been one of the earliest users of a carsharing system. This is driven by economics wherein people who cannot afford to buy cars resort to sharing one (Shaheen et al. 1998). Since then, the industry continues to grow over the years.

Carsharing models include two-way/roundtrip carsharing, one-way carsharing, and personal vehicle sharing. Roundtrip carsharing includes giving members hourly access to a shared service fleet. These vehicles must be picked up and dropped off at the same place. On the other hand, one-way carsharing, commonly referred to as free-floating or point-to-point carsharing allows customers to borrow and return vehicles at different locations inside a designated service area. Lastly, personal vehicle sharing allows customers to have short-term access to private vehicles which differs from operator-owned vehicles. Each of these models provides first and last mile connections to other means of transportation (Shaheen and Chan, 2016). A recent variable of the vehicle-sharing model is scooter sharing. It provides roundtrip and one-way short-term vehicle sharing services that come with insurance and helmets. Two scooter-sharing programs existed in Europe in 2015 (Shaheen and Chan, 2016). In 2018, an estimated 38.5 million rides were provided by e-scooters in numerous cities, compared to the 52 million rides on shared bikes. However, there is limited data available on the use of e-scooter (Dill and McNeil, 2021). Lastly, bike-sharing involves the use of bikes for a limited period of time as a means of public transportation. Although the concept has been around since the 1960s, more than 800 cities now offer bikeshare, up from a mere handful in the late 1990s (Fishman, 2016). In general, the main types of this system include public bike-sharing, closed campus bike-sharing, and peer-to-peer (P2P) bike-sharing. Public bike-sharing programs originated in Europe and have become increasingly popular over the last decade. This system becomes more mainstream and is open to the general public and acts as a means of transportation (Parkes et al. 2013). Closed-campus bike-sharing programs are increasingly being implemented at college and corporate campuses; these programs are solely accessible to the specific campus population they serve. Bike owners can use P2P bike-sharing services in urban areas to rent out their unused bicycles to other people. These services are growing as a result of businesses like Spinlister and Bitlock

Table 1. Factors influencing the adoption of a vehicle sharing system

Service	Study	Place	Influential Factors
Carsharing	Luca and Pace (2014)	Southern Italy	Level of service and utility of available transportation; weekly trip frequency, travel distance; familiarity; bus riders
	Becker et al. (2017)	Basel, Switzerland	Greater receptivity to innovative services and societal advancements
	Safdar et al. (2022)	Pakistan	Travel time, cost, waiting time, privacy
	Burghard and Scherrer (2022)	Germany	Psychological factors (perceived compatibility with daily life)
Bike-sharing	Li et al. (2018)	Jiangsu, China	Education, the cost of daily transit, the ease of pick-up, and parking, health contribution
	Bachand-Marleau (2012)	Montreal, Quebec, Canada	Distance of home to docking stations
	Shen et al. (2018)	Singapore	Fleet size, built environment, weather conditions, cycling infrastructure
	Guo et al. (2017)	Ningbo, China	Ownership of household bicycles and e-bikes, trip type, travel distance, location of bike-sharing stations, and user perceptions

(Shaheen and Chan, 2016).

These vehicle sharing systems are considered a sustainable transportation alternative, and thus, will likely receive more attention as they continue to expand through technological innovations. Transit agencies and researchers looked more closely at the integration of these systems with transit modes. Carsharing, for instance, has a direct impact on most aspects of urban and transportation planning in terms of modal choice, travel patterns, and vehicle occupancy, among others (Cohen and Shaheen, 2016). Moreover, several studies investigated the factors that affect the adoption of people in using shared mobility, particularly the sharing of a vehicle as a mode of transportation in the last mile. The table below shows some of the influential factors identified in some literatures on carsharing and bike-sharing.

Carsharing

Over the past two decades, carsharing has grown to be one of the most widely used services for facilitating smart mobility solutions, which has helped to minimize traffic and air pollution (Safdar et al. 2022). It is a new type of shared mobility that enables users to access vehicles for a limited amount of time when needed (Degirmenci and Breitner, 2014). With carsharing, people can enjoy the advantages of having a private vehicle without the cost and responsibility of owning one such as the cost of fuel, maintenance, and insurance (Shaheen et al. 1998; Shaheen and Chan, 2019).

Since it was first introduced in the late 1940s, carsharing has existed as a specialized service that has failed to attract a large share of the urban population. This is because carsharing programs are considered to be inflexible and that car ownership has been valued in society. However, due to the advancement of information technology, it has grown to be more user-friendly and has seen an increase in acceptance as a result of social attitudes that value sharing over ownership (Becker et al. 2017). Today, it is one of the most well-known and commonly utilized sharing economy applications in personal mobility (Novikova et al. 2017). Many countries have embraced carsharing services as a solution to social issues such as air pollution, high traffic congestion, and vehicle kilometers/miles traveled (Safdar et al. 2022). Russia, Germany, China, and Italy were the top carsharing countries in the world in 2018. The percentage of users in the mentioned countries for the observed period was calculated to be 3%. By 2018, only 1% of the Japanese population had used carsharing services (Melkadze, 2021). Daimler's Car2Go and BMW's DriveNow have been established as carsharing services in Germany in 2008 and 2011, respectively. In 2018, these two auto manufacturers merged their carsharing business and since then have expanded globally (Guyader, 2021). Between 2004 and 2014, carsharing in the United States grew 2,500 percent from 52,000 to 1.3 million users (Shaheen and Cohen, 2015).

Several aspects of travel behavior that affect the use of carsharing are examined in the review of literature conducted by Degirmenci and Breitner (2014) by way of its implication in the Information Systems (IS) research community. These aspects include carsharing members' attitudes, motivations for using the service, and frequency of use. Results suggest that the Geographic Information System (GIS) is an important domain to consider to further understand the user's travel behavior such as the carsharing motives (e.g. shopping, medical, leisure, work-related). Jain et al. (2020) used a qualitative method to investigate how carsharing affects the mobility and travel preferences of the different user segments. The study categorized car share users into 4 user segments namely: car dependents, car avoiders, car sellers, and car limiters. Car dependents are those who use private cars on most of their trips and only use carsharing services for a specific purpose for a limited period of time such as moving furniture, among others. Car avoiders, on the other hand, are people who did not previously own a private vehicle and do not plan to do so. They are the most active users of active travel or public transportation with connectivity to car share. They also use care share for specific purposes such as out-of-town travels, road trips, and bulk purchases, among others. In the absence of this service, they use ride-sourcing or car rentals. Thirdly, car limiters are those who had some prior access to private vehicles and join carsharing to relieve mobility stress from contextual changes (e.g. change in family size, job location, residential location, etc.). Car share keeps them from purchasing another vehicle in response to these changes. Lastly, car aspirers are those who want to own a car eventually. Carsharing allows them to use a car while they save to buy one.

The attitude of users toward carsharing was examined in the study of de Luca and Pace (2014) conducted in Southern Italy (between Salerno and Baronissi). The study focuses on examining the tendency of users to use a carsharing system which is a unique and understudied component of users' behavior. The satisfaction variable, socio-economic and activity-related attributes were analyzed in order to analyze the interest of residents in carsharing concerning the level of service provided by other modes of transportation, as well as the socio-economic and activity-based characteristics of the users. Results suggest that the tendency for carsharing is influenced by the utility of the available transportation options as well as the quality of those options' service. As is well known, the utility includes socioeconomic and activity-based factors in addition to the level of service features. The weekly trip frequency and the distance traveled together with the satisfaction criterion lower individuals' likelihood to use a carsharing system. Lastly, interest grows among those who are already familiar with the service and those who frequently take buses.

The socio-psychological variables such as perceived usage-related attributes are also examined by Burghard and Scherrer (2022) on how they influence the acceptance and adoption of the use of carsharing. The study revealed that Compatibility strongly affects the attitude and acceptance of the use of carsharing. That is, individuals are more inclined to use new services that complement their existing daily routines and mobility behavior. Therefore, situational and contextual considerations such as the types of transportation that are (or are likely to become) available near a person's home can influence the perceived compatibility. Another factor

is the Ease of use which positively affects attitude but not directly acceptance. The third factor is Triability which has a positive influence on acceptance. This means that it is critical that new mobility services are visible in people's actual mobility experiences and that their first use is both encouraged and made as simple as possible. In terms of socio-demographics, the free-floating carsharing scheme in Basel, Switzerland is mostly attractive to younger and well-educated couples who live in homes with few private vehicles (Becker et al. (2017). It is also attractive to younger men who earn more and whose house is not easily accessible by public transportation. In particular, from the sample selection approach, it is found that there's a high likelihood for university graduates to join carsharing services though they may not use them as frequently. Station-based carsharing is more likely to be adopted by those who are self-employed due to its flexibility. Safdar et al. (2022) however found some contrasting results in their study. For instance, the age factor revealed that those who are aged 39 years old and above are more likely to use carsharing services. Moreover, those who are in high school and below are also more inclined to utilize this service. But in terms of income, the result affirms that of Becker et al. (2017) wherein high earners earning more than 60,000 PKR per month are more likely to use this service. Another finding is that weekly travel is positively significant, showing that those who traveled for longer than 2 days were more inclined to use carsharing services. Furthermore, results in the study of Becker et al. (2017) suggest that carsharing membership correlates with more openness to new services and societal advances in Switzerland. In Lahore, Pakistan, a variety of service characteristics, including trip distance, pricing, waiting time, and privacy, have a big impact on how widely used carsharing services are. This is also one of the findings in the study of Safdar et al. (2022) on the public views and acceptance of the carsharing system. These attributes are negatively correlated with the adoption of the carsharing system. This means that as travel time and costs increase, people are less likely to use the system. The privacy aspect, on the other hand, has a positive correlation, indicating that Lahore residents prioritize the security and safety of their transportation. These findings were aligned with the goal of carsharing, which offers a similar alternative form of transportation for private vehicles without the expense and obligations of car ownership. In addition, Sharma (2020) investigated the role of one-way (free-floating) carsharing in serving the first and last mile to/from public transit in the case of a carsharing platform in Vancouver. This study suggests a possibility of one-way carshare usage for commute trips, which is consistent with earlier studies analyzing one-way carshare journeys. Additionally, it implies that, depending on the likelihood, some of these trips may have involved first or last mile connections to public transportation.

Bike-sharing

Non-motorized transportation such as cycling, walking, pedicabs, and other human-operated vehicles are most commonly used as a means of transportation in many developing countries, particularly in Asia and Africa. In general, bicycles are more popular in developing countries than in developed countries (Pojani and Stead, 2015). With the growing globalization, social modernization, and economic boom, a bicycle is not a top choice as a mode of transportation in most countries (Yao et al. 2019). Despite this, the usage of bicycles has increased globally during the last 30 years (Shaheen et al. 2010). Cycling is becoming more widely recognized as a clean, sustainable means of transportation that has the potential to replace cars for short-distance travel in cities (ECMT, 2004). In the Philippines, the Metropolitan Manila Development Authority (MMDA) encourages cycling as a mode of transportation as part of its commitment to promoting urban mobility through sustainable transportation, particularly in regions with the potential to generate tourism-related income. Hence, bicycles are widely acknowledged as a solution to urban problems such as traffic congestion, high cost of living, land use, and environmental and health issues (Vassi and Vlastos, 2014). Public transit planners and researchers have paid close attention to bicycle and public transit integration which has been a subject in many recent studies. With this, the term 'cycle-transit users' (CTUs) have emerged (Flamm and Rivasplata, 2014) – those who travel by bicycle and public transportation in one trip (Meenar et al. 2019). In North America, transit authorities have made significant expenditures in the coordination of bicycle and public transportation services since the 1990s. Moreover, several European countries such as the Netherlands, Denmark, and Germany mostly have integrated cycling with public transport, recognizing the key role of the bicycle in improving the efficiency of public transportation (Pucher and Buehler, 2008). One of the main objectives of this integration is to improve the number of users of public transportation by expanding the geographic region from which riders may reach transit stops and stations easily and quickly (Flamm et al. 2014).

Bike-sharing is a new mode of transportation that is gaining popularity in cities all around the world (Parkes et al. 2013; Zhang and Mi, 2018; Shang et al. 2021). It has expanded across four continents since 1965, including Europe, North America, South America, Asia, including Australia (Shaheen et al. 2010). Bicycle sharing systems (BSS) have recently been introduced into urban areas as a new on-demand transportation option providing reliable, practical, and sustainable urban mobility (Faghih-Imani et al. 2017). By integrating the flexibility of cycling with the reliability of public transportation, bike sharing is generally acknowledged to have the potential to encourage sustainable travel (Radzimski and Dzięcielski, 2021). In general, the term "bike-sharing" refers to a service that serves as a form of public transit by allowing users to share bicycles for a certain amount of time (Parkes et al. 2013; Goodman et al. 2014). Bike-sharing allows people to ride bicycles "as-needed" without having to own one completely, avoiding the expense and maintenance that comes with ownership. In general, bike-sharing provides environmental, social, and transportation-related benefits to its users (Shaheen et al. 2010; Zhang and Mi et al. 2018; Cheng et al. 2021). For instance, in their study of BSS in Shanghai, China, Zhang, and Mi (2018) revealed that there is a significant reduction in the consumption of petrol by 8,358 tonnes. Consequently, there were significant reductions in carbon dioxide and nitrogen oxide of 25,240 and 64 tonnes, respectively. Bike-sharing systems can become an everyday travel mode in low-cycling areas

that provides a safe, practical, and sustainable mode of transportation. The use of bike-sharing systems can be complementary to other modes of public transportation and the benefits of the integration can be higher than using either one. Furthermore, bike-sharing can be used to supplement transportation needs in case of a complete transit shutdown enhancing the resiliency of urban transportation systems (Cheng et al. 2021).

Bicycle on-train policies, among other things, have been established by transport agencies all over the world, along with the increasing installation of bicycle racks on transit vehicles. These initiatives are also geared towards integrating bicycle and transit modes to address the first mile and last mile gaps (Flamm and Rivasplata, 2014). Theoretically, bicycle-metro integration is considered to be an excellent solution to improving the efficiency of the last mile of public transportation in cities (Zhang et al. 2019). Hence, it is expected that bike-sharing extends and integrates cycling into transportation systems enabling it to become a more common means of transportation (Shaheen et al. 2010). As part of its Sustainable Transport Initiative, the Asian Development Bank (ADB) is actively promoting bicycle sharing in different locations in the Asia Pacific. In the Philippines, ADB launched a bike-sharing initiative in 2012 called Tutubi ("dragonflies" in Tagalog). Tutubi provides a solution to the growing demand to make cities greener and more livable, and it offers numerous potential solutions to Manila's smog problem (Inquirer. net, 2012) This initiative is hoped to be implemented on a wider scale such as in the whole Metropolitan region of Manila. Students of the University of the Philippines Diliman in Quezon City launched a bicycle sharing system in 2016 wherein students in the university can use the system in traveling around the campus. Recently, Caponga et al. (2021) explored the feasibility and practicality of operating a hybrid BSS at the University of the Philippines Los Baños (UPLB). The study presented a preliminary design for the system for free-floating and station-based systems which served as a basis for large initiatives involving bike-sharing systems in the university. The study's findings indicated that the middle campus should be provided with a free-floating system, while the upper campus and the animal science department at UPLB should be assigned a station-based system. Additionally, it was determined that 35 station-based bikes and 301 free-floating bikes are needed to satisfy the identified demand.

In recent years, China's bicycle-sharing systems (BSS) have grown significantly which were seen as viable answers to the first/last mile problem. Fan et al. (2019) conducted an empirical study in Beijing China and it was found that the most important factors prior to the implementation of BSS are gender, bicycle availability, and trip frequency. Since it was introduced, BSS has become the preferred mode of transportation for first and last mile trips with a 45.9% mode share. Gender, the availability of bicycles, and accessibility are significant determinants for the middle-aged group. These factors are not important for either young people or the elderly. In Ningbo, China, Guo et al. (2017) found twelve variables that are statistically significant in the usage of bike-sharing services. These variables include trip mode such as public transit, bicycle; familiarity with bike-sharing; location of bike-sharing docks; encouragement of sustainable traveling; significant effort in introducing the system; travel time, gender, flexible route, time wasted by bike-sharing, bicycle and e-bikes ownership; satisfaction with bike-sharing fees. A dockless bike-sharing service also called free-floating bike-sharing (FFBS) was the focus of the study of Li et al. (2018). It was found that the usage of FFBS in Jiangsu province in China was influenced by several factors such as education, daily transportation cost, the convenience of pick up and parking, and contribution to the user's health. That is, higher education levels, higher daily transportation costs, ease of pick-up and parking, and benefits to users' health might encourage the use of FFBS, whereas broken bicycles and a lack of rules were key roadblocks to its expansion. In Singapore, the usage of dockless bike-sharing is influenced by fleet size, built environment, and weather conditions. According to the results, bike use is favorably correlated with the dockless bike fleet. However, as the fleet size increases, the marginal impact drops, meaning that each additional bike may result in fewer additional trips. Another important factor is the built environment. Greater economic diversity, narrower street blocks, and more densely populated commercial areas all have a beneficial impact on the adoption of dockless bikes. Bike use is also encouraged by favorable cycling infrastructure and improved transportation systems. Unsurprisingly, reduced bike use may be caused by rain and extreme heat (Shen et al. 2018). In the survey conducted by Bachand-Marleau et al. (2012), for users of the system in Montreal, Quebec, Canada, the proximity of one's home to docking stations is of greatest impact on the likelihood of usage of the shared bicycle system.

Bike-sharing is a carbon-free solution to the last mile problem (Yao et al. 2019). It has the potential to help bridge the gap in existing transportation networks while also encouraging people to use different modes of transportation (Shaheen et al. 2019). Its various features make it an appealing alternative for first and last mile trips. When used in combination with public transportation, private bicycles have a variety of drawbacks. For example, they may not be permitted to use public vehicles at peak hours or even throughout the day. Shared bicycles, on the other hand, could be a viable solution to this problem if they are available at the terminal station (Radzimski and Dzięcielski, 2021). In the study of Parkes et al. (2013), the interview responses revealed that the bike-sharing systems help in solving the last mile problem. Cities such as Antwerp, Dublin, Cardiff, and San Francisco saw that the system helps in the integration of their transportation systems by connecting a rider's last mile with the existing public transit infrastructure. In New Cairo, the study by Hussin et al. (2021), 370 responses or 66% of the survey respondents chose bike-sharing systems as the most suitable solutions for the first and last mile problems. As bike-sharing continues to grow, new program entries, possible program mergers, continuous technology innovation, and policy advancements will continue to define bike-sharing in the coming years. Furthermore, as a result of growing gasoline prices, public health concerns, smart-growth programs, and climate-change worries, public bike-sharing will certainly garner more attention as a sustainable transportation alternative (Parkes et al. 2013).

Sharing a Passenger Ride

Sharing a passenger ride is relatively new than vehicle sharing. Innovations in this area have just recently emerged, hence, the term is still unclear (Shaheen and Chan, 2016). Traditional ridesharing includes vanpooling and carpooling. Vanpooling involves the use of a van where a group of 7-15 people commutes together, while in carpooling, there are only groups of 7 or fewer traveling together in one car (Shaheen and Chan, 2016). Another type is the on-demand ride services wherein passengers book rides through a mobile device and applications such as ride-sourcing and ridesharing services. The rapid growth of these services has been made possible by the recent integration of mobile internet technology into our daily lives. Companies such as Uber, Lyft Grab, Didi, Careem, and Ola were able to leverage internet-based platforms to provide e-hailing services in different cities around the world. For instance, the largest ride-sourcing company, Uber has attracted more than 50 million riders since its creation in 2009. In 2016 alone, it recorded more than 3 billion trips (Yan et al. 2018). Moreover, it has expanded to provide a one-stop mobile transportation platform that offers a variety of services in over 700 urban areas across 65 countries (Wang and Yang 2019).

Early ridesharing company growth was fueled by personal rides, which were traditionally provided by private cars, taxis, and rental cars. Ride-sourcing services stand out from more established transportation options like taxis and paratransit because they can instantly identify, match, and accommodate individual travelers' needs (Yan et al. 2018). Different studies have explored the socio-economic and demographic variables characteristics of the users of these services that affect the usage of these systems. For instance, Habib (2019) identified in his study that there is a significant difference in the socio-economic profiles of the users of the traditional taxi and ride-sourcing services (Uber, in particular). That is, older people prefer taxis while younger ones prefer Uber. This is also one of the findings in the study of Dias et al. (2017). Aside from the younger population, users of these services are typically well-educated working adults with high incomes who live in densely populated areas. According to Alemi et al. (2018), older millennials who are highly educated also have a greater likelihood of using on-demand ride services.

Ridesharing or pooled rides has recently drawn a lot of attention as is considered a sustainable mode of transportation because of its contribution to reducing carbon emissions, congestion, accessibility, and parking in urban areas. The advantages of shared rides will, however, only become a reality if enough people are willing to use them (Alonso-Gonzáles et al. 2021). Wang et al. (2020) identified several factors that are associated with the user's intention to use ridesharing services. Positively correlated factors include perceived innovativeness, environmental consciousness, and perceived usefulness while the perceived risk is negatively correlated with the consumer's intention to use ridesharing services. Moreover, the fare discounts, the extra travel time required, and the (un) willingness to share the journey with other passengers are the three key factors that influence whether someone chooses a pooled transport over an individual alternative (Alonso-Gonzáles et al. 2021).

To effectively market these services, it is critical to recognize the factors that influence user intent. The following table shows the factors that affect the choice of ride-sourcing and ridesharing systems as a mode of transportation.

Ride-sourcing

Ride-sourcing (transportation network companies) is evolving and is becoming more popular. This mode of transportation offers car access without car ownership, reducing transit use by encouraging people to hail rides

Table 2. Factors influencing the adoption of sharing a passenger ride as a mobility option

Service	Study	Place	Influential Factors
Ride-sourcing	Aguilera-García et al. (2022)	Spain	Tech-prone behavior; socio-demographic variables (age, income, education, and residential location)
	Yan et al. (2018)	Michigan, Ohio, USA	Waiting time, in-vehicle travel time
	Alemi et al. (2018)	California	Greater land-use mix, regional auto accessibility; willingness to adopt new technologies
Ridesharing	Stoiber et al. (2019)	Switzerland	Cost, time, and comfort
	Alonso-Gonzáles et al. (2021)	Netherlands	Current travel patterns, personal income, time, cost, number of co-riders
	Amirkiaee and Evangelopoulos (2018)	United States	Economic benefit, time benefit, transportation anxiety, trust
	Sarriera et al. (2017)	United States	Travel time, travel cost, comfort

instead of having to ride transit. Moreover, it makes public transportation more accessible to current or potential riders since getting to and from stations becomes easier (Brown et al. 2021). In recent years, it experienced significant growth in urban mobility as it provides a convenient, on-demand door-to-door service through app-based real-time trip information with flexible prices (Aguilera-García, et al. 2022). Ride-sourcing firms have been able to use internet-based platforms to offer e-hailing services in numerous cities across the world (Wang and Yang, 2019). The rapid growth and popularity of mobile and wireless communication technology have allowed for the emergence of this new mode of transportation. Uber, Lyft, Didi, Grab, Careem, and Ola are among the companies that connect riders and drivers in real-time disrupting the transportation industry, as it competes directly with the traditional taxi industry in providing door-to-door trips (Wang and Yang, 2019; Yan et al. 2018; Aguilera-García, 2022).

The two fundamental components of the ride-sourcing market are passenger demand and driver supply. On the demand side, potential passengers evaluate ride-sourcing services depending on their attributes and behavior such as the value of time, and willingness to pay, with temporal and spatial characteristics. In making travel decisions, passengers evaluate service quality such as waiting time, and fare, and compare these against other travel modes such as traditional taxis and other public transportation services. Suppliers of ride-sourcing services, on the other hand, decide on whether they work on the platform, and how long (if so) based on their attributes, qualifications, and behavior (e.g., vehicle operation, cost of fuel, and reservation wage as an opportunity cost) in response to many variables and factors unique to each platform. Another critical factor, the level of income is also being compared with other job options. Other comparative factors are terms of the working environment and working hours, job security, comfort, work pressure, and risk exposure, among others (Wang and Yang 2019). In terms of

In recent years, TNCs have vigorously competed with for-hire vehicle and taxi services in most cities, introducing a radically different business model. Companies such as Uber or Lyft offer smartphone apps where riders can 'source' rides by connecting with available drivers using their phone's GPS and getting a for-hire ride to their destination (Ngo, 2015). Following the success of private companies such as Uber and Lyft, transit agencies have started to consider integrating ride-sourcing services with public transit providing on-demand, app-driven ridesharing services to enhance the transit system. The advent of these services has addressed the first-last mile problems (Brown et al. 2021). Ride-sourcing has the potential to improve the transportation system in two ways: by replacing underutilized routes and by providing last mile connections to expand the service area. These services can complement public transportation by improving last mile transit access (Yan et al. 2018). In some circumstances, this mode of transportation can be employed as a first and last mile solution to persuade private-car users to refrain from using their cars and use public transportation. In New Cairo, ride-hailing is found to be the second most used mode in moving across the city. Using a multinomial logit model, results revealed that gender is a significant factor that affects the choice of main mobility mode. That is, females are more inclined to use ride-hailing services than males. Moreover, they prefer to use ride-hailing services than public transportation services. Moreover, the distance between destinations affects the usage of this type of service. Users prefer to travel using ride-hailing modes over public transportation for medium-length trips, with the benefit diminishing as the trip goes shorter or longer (Hussin et al. 2021).

A large-sample survey was conducted by Yan et al. (2018) to investigate how commuters felt about MTransit, a proposed integrated transit system at the University of Michigan Ann Arbor campus. An RP-SP mixed logit model was used to assess the primary factors influencing the selection of commuting mode from the data gathered on revealed preferences (RP) and stated preferences (SP). The model's findings demonstrate that transfers and additional pickups are significant barriers to MTransit adoption. Another significant finding in this study is that ride-sourcing can significantly increase the use of public transportation if employed to provide convenient last mile connections between a traveler's points of origin/destination and transit terminals. A survey campaign was also conducted in Spain in 2018 by Aguilera-Garcia et al. (2022) where they investigated the individual's preferences when selecting between ride-sourcing and conventional taxi services. The roles of individual sociodemographic and household variables, mobility-related characteristics, user perspectives, and psychological attributes were examined as influencing factors in an individual's decision to choose ride-sourcing. It is found that those who are open to technological innovation are more likely to use ride-sourcing services more often than traditional taxis. Findings also point to a larger propensity for ride-sourcing among women, young people, and individuals who use hailing services for social, recreational, or leisure activities. It's interesting to note that those who have used both taxis and ridesharing in Spain prefer to rate ride-sourcing's performance in terms of quality of service (driver and/or vehicle fleet) higher than that of taxis. The study of Alemi et al. (2018) also found that technology-oriented individuals are more inclined to use on-demand services. Aside from this, it is found that the built environment where a person lives and the land-use mix affects this decision. The study confirms that people who are younger, more educated, and of non-Hispanic origin are more likely to use on-demand ride services.

Ridesharing

Another type of shared mobility is ridesharing. It is not the same as carsharing wherein carsharing individuals typically charge a fee in exchange for the use of a single car among multiple drivers. In ridesharing, users share a route rather than a vehicle. Multiple passengers get to their destination using a single vehicle such as a car or van going to the same route or direction. In this way, there is less need for cars on the road reducing traffic congestion level. This system is also similar to carpooling and vanpooling in which it makes multiple stops along a route to pick up and drop off passengers with little or no added

mileage. However, ridesharing is a more flexible kind of transportation that doesn't require the kind of advanced arrangement that carpoolers make with one another. Unlike most kinds of carpooling, ridesharing involves a price, although it's usually reasonable.

Ridesharing is now easy to access because of the availability of smartphone apps. For instance, most recently, Trinity Metro in Texas introduces ZIPZONE as a first/last mile solution. It aids workers in the Mercantile region traveling to work. This is accomplished by linking commuters to take the bus and TEXTrail to the Mercantile Center Station (APTA, 2019). Alonso-Gonzáles (2021) designed a stated preference survey to quantify the willingness to share rides of Dutch urban individuals towards ridesharing services. Results revealed that less than one-third of respondents have strong preferences against sharing their rides. This suggests that the use of ridesharing can still grow significantly and those who currently rely heavily on a car are less likely to switch to more shared modes of transportation. Those who prefer to share ride primarily considers the time-cost trade-off rather than the discomfort associated with ridesharing. Current travel patterns and personal income affects the preference of individuals to share rides. Findings also suggest that the number of additional passengers affects people's willingness to share rides. In Switzerland, sixty-one (61%) of the respondents in the study of Stoiber et al. (2019) preferred pooled rides than using private cars. According to the stated preferences, comfort, cost and time are major considerations in the likelihood of usage of this service. Sarriera et al. (2017) confirmed this finding in which time and costs are primary considerations. In contrast to walking and using public transit, the majority of dynamic ridesharing users are driven by ease, speed, and comfort; (e) safety in shared rides is a crucial problem, especially for women, who frequently report feeling unsafe and prefer to ride with other women. Lastly, social factors such as social interactions such as a networking opportunity or having a good conversation with other passengers are one of the study's most significant findings.

Some psychological and emotional considerations in choosing between ridesharing and driving alone are examined in the study of Amirkiaee and Evangelopoulos (2018). Transportation anxieties such as a feeling of worry, uneasiness, nervousness because of heavy traffic, a long trip, or a lack of parking space are examined. These are commonly called "commuting stress" or "traffic anxiety" and have been acknowledged to have motivated ridesharing or carpooling. The study revealed that a person's attitude toward ridesharing is positively correlated with economic advantage, time benefit, transit anxiety, and trust. Additionally, there is a strong correlation between reciprocity and the desire to use ridesharing.

SUMMARY AND CONCLUSIONS

In the context of ongoing urbanization, private car ownership poses issues in terms of pollution, high energy costs, and limited and expensive parking. Companies are creating innovative mobility alternatives to private car ownership in response to these negative effects (Degirmenci and Breitner, 2014). The emergence of new forms of transportation has a noticeable impact on the development and sustainability of urban mobility. Instead of having only one option, the new modes allow city people to choose the most appropriate and available mode for them. Many recently developed mobility options shared one of two fundamental characteristics. Technology-based solutions, including ride-hailing services like Uber and Careem and carpooling, are the first feature. Another is having privately-owned buses that operate side-by-side with the public buses, like SWVL and Uber Bus, or micro-mobility options like sharing electric bikes and electric scooters, etc. (Hussin et al. 2021). Low-cost technologies like on-demand transportation or parking payments already exist in developing countries and might be employed more frequently to promote new inventive types of urban transportation services. (Pojani and Stead, 2015).

People will typically walk by public transportation if it is close enough. However, the origin or destination on either end of a public transit route could be challenging or impossible to reach by a short walk. The distance from public transportation to the last destination is known as the last mile connection. The concept is broadly relevant to improving access to public transportation for everyone who wants to use it, regardless of whether they live within a mile of a station. An alternative mode of transportation is needed in order to solve the first and last mile gap. This can be through multimodal trips that are facilitated by conventional or new and shared mobility options such as micro-transit, carpooling, cycling, bike-sharing, on-demand shuttle services, and ride-hailing, among others (Sharma, 2020). Shared mobility involves the use of a vehicle, bicycle, or other low-speed means by a group of people to provide short-term access to transportation modes when needed. This is usually connected to public transportation as a first or last mile connection. This paper focuses on shared mobility, particularly the key areas of shared mobility such as carsharing and bike-sharing (sharing of a vehicle) and ridesharing and on-demand services such as ride-sourcing (sharing of a passenger ride) as the last mile solution. Several factors that influence the adoption of shared mobility services in different countries were reviewed and presented.

The traditional transportation sector is evolving due to shared mobility services. Through the application of technology, shared mobility has paved the way toward social environmental, and economic efficiency (Machado et al. 2018). This alternative mode of transportation has grown in popularity in major cities throughout the world as an innovative transportation mode that improves urban mobility. Aside from this, it is also considered a feasible solution for addressing first and last mile connectivity with public transit. It has the potential to expand the reach of public transportation crucial in bridging the gap in an existing transportation network. Incorporating it into the current transportation infrastructure will allow for a decrease in private ownership of vehicles which will help in minimizing parking congestion and improve traffic conditions. The utilization of shared mobility services promotes multimodal travel for first and last mile trips. Another benefit is that it is more environmentally friendly as a result of lower carbon emissions, less fuel consumption, and lower transportation expenses (Burghard and Scherrer, 2022). Therefore, the

adoption of shared mobility programs has the potential to improve urban efficiency, competitiveness, social equity, and quality of life (Machado et al. 2018). To increase the attractiveness, accessibility, and sustainability of sharing services for system users, policies and measures are essential. The topic of what factors influence the adoption of individual services is crucial if the objective is to make shared mobility an important component of the mobility system (Burghard and Scherrer, 2022).

Some of the most common factors that are crucial in choosing a mobility solution include time, cost, and perceived convenience or comfort (Novikova et al. 2017; Sarriera et al. 2017; Stoiber et al. 2019). Safdar et al. (2022) added waiting time and privacy as influential factors in choosing carsharing as a mode of transportation. In China, where bike-sharing is popular across the country, familiarity with the service, and accessibility/convenience of docking stations increases the likelihood of its adoption (Guo et al. 2017; Li et al. 2018). Several different factors also affect the use of ride-sourcing and ridesharing services. In terms of attitudinal factors, familiarity with and willingness to adopt new is found to be a primary influence in ride-sourcing adoption (Aguilera-García et al. 2022, Alemi et al. 2018). In the study of Amirkiaee and Evangelopoulos (2018), it is found that there's a positive relationship between economic benefit, time benefit, transportation anxiety, and trust in a person's attitude towards ridesharing. Moreover, there is a positive relationship between reciprocity and the intention to participate in ridesharing. In the use of public transport, it is generally acknowledged that socio-demographic factors, such as income, gender, and marital status; transit network characteristics, such as network size, wait times, and ride costs; built-environment factors, such as accessibility and availability; infrastructure design factors, such as the size and qualities of transit infrastructure, influence modal choice. Transit networks and the built environment surrounding public transportation can either promote or hinder more sustainable travel behavior especially in choosing the modes for the first/last mile (Tilahun et al. 2016).

Transportation planners, policymakers, shared mobility service providers, and marketers who are interested in investing in this industry can all benefit from this review paper. For instance, with trust being the main influencing factor to consider in ridesharing, providers and policymakers should focus on building and maintaining it. They should provide a reliable system that ensures consumers feel safe and secure in using the system. This study aims to contribute to the extensive body of knowledge on shared mobility that will help in the successful adoption of these systems for a sustainable urban transportation system. Future research in this area can include more review of related literatures on other modalities of shared mobility services and on how they can be integrated with other traditional modes of transportation. Lastly, the effects of the adoption of shared mobility as a last mile solution in reducing traffic congestion, and pollution, among others can also be explored.

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Gall Rust Disease Incidence and Severity in a Falcata (Falcataria moluccana (Miq.) Barneby & J.W.Grimes) Plantation Grown from Select Mother Trees in Mindanao, Philippines

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ABSTRACT

It remains unknown whether there are available gall rust resistant seed sources of Falcata (Falcataria moluccana (Miq.) Barneby & J.W.Grimes) in the country or elsewhere. This study was conducted to obtain baseline data for future progeny selection of gall rust resistant clones of Falcata in the region. The objectives were to determine whether there are available seed sources or mother trees in the region that are resistant to gall rust, and whether gall rust infection has negative effects on the growth of Falcata. The trial (with 130 mother trees as treatments and four replications) was assessed in November 2020- or five-years following establishment in 2015. Mean percent incidence (15.0 ± 5.0% to 80.0 ± 14.1%) and severity (3.75 ± 1.25%) to 35.0 ± 16.95%) of gall rust varied significantly among treatments indicative of genetic diversity among mother trees. The incidence ranged from 'occasional' to 'widespread' while severity ranged from 'low' to 'high' with mother trees 99 (Mutia, Zamboanga del Norte) and 106 (Magsaysay, Baliangao, Misamis Occidental) emerged as the most resistant of all. Height and diameter were positively related to gall rust incidence and treatments only, although none of the mother trees with resistant traits had superior growth. There was however indication of growth and disease tolerance tradeoff where trees with higher gall rust incidence tend to grow bigger perhaps to compensate for any negative impacts from gall rust infection.

Keywords: Falcataria moluccana, gall rust, incidence, severity, seed sources

INTRODUCTION

Commercial tree plantations, commonly referred to as Industrial Tree Plantations (ITPs), are important sources of wood and income for wood industries and tree farmers in the Asian region beside other important functions for the environment such as carbon sequestration and soil protection. However, the monoculture-type of planting of commercial tree plantations often expose them to disease infestation or outbreak especially from disease-causing parasites that are usually restricted to parasitizing a few or single host family, genus, or species. Falcata (Falcataria moluccana (Miq.) Barneby & J.W.Grimes), for instance, is the only known host plant to falcataria gall rust fungus (Uromycladium falcatarium sp. nov. Doungsa-ard, McTaggart & Shivas) (Doungsa-ard et al., 2015). This fungus is identified as closely related to acacia gall rust fungus (U. tepperianum (Sacc.) McAlpine), which has over 100 known host plants although mostly from Mimosoideae clade (Morris, 1987). Uromycladium falcatarium is distinguished from other Uromycladium species by the presence of three one-celled fertile teliospores on the pedicel (McAlpine, 1905 as cited by Doungsa-ard et al., 2015). The germination percentage of U. falcatarium spores was observed to reach up to 100% just within three hours from infection (Rahayu et al., 2020). The typical symptoms of rust fungus include a "rust-coloured" (often orange or yellow) pustule on plant shoots or leaf, petiole and rachis deformation, die-back of seedlings, stunting of affected trees or death in more extreme cases (e.g. massive defoliation of tree crowns) (McKenzie, 1998; McTaggart et al., 2015; Rahayu et al., 2018). The devastating impact of U. falcatarium infestation in Falcata plantations has been reported in Malaysia and Indonesia (Rahayu et al., 2010), and Timor-Leste (Old & Dos Santos Cristovao, 2003). The disease was first detected in the Philippines in 1988 and since then the control measures are limited to removal of infected trees or cessation of planting of Falcata in high elevation areas (i.e., >250 m above sea level) (Anino, 1994; Braza, 1997) as incidence/severity of the disease is known to increase with elevation.

Like other countries in the south-east Asia, the Philippines is heavily dependent on commercial tree plantations for wood, which means that the impact of disease infestation on wood production has wide-

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