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Developing Green Urban Mobility Policies for Sustainable Public Transportation in Local Communities- A Norwegian Perspective

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Abstract

Purpose

The concept of green urban mobility has emerged as one of the best approaches for promoting environmental-friendly transportation in local communities. Green urban mobility aims to reshaped public transportation system and enhance mobility, with emphasis on deploying digital technologies to promote sustainable public transportation. Therefore, this article aims to analyze existing public transportation policies by exploring how local communities can facilitate green urban mobility by developing a socio-technical urban based mobility model highlighting key factors that impacts regions transiting towards sustainable transportation.

Design/methodology/approach

This article investigates "the role of data for green urban mobility policies towards sustainable public transportation in local communities" in the form of a systematic literature review and insights from Norway. Secondary data from the literature and qualitative analysis of the national transport plan document was descriptively analyzed to provide inference.

Findings

Findings from this study provides specific measures and recommendations as actions for achieving a national green mobility practice. More important, findings from this article offers evidence from the Norwegian context to support decision makers and stakeholders on how sustainable public transportation can be achieved in local communities. Additionally, findings present data driven initiatives being put in place to promote green urban mobility to decrease the footprint from public transportation in local municipalities.

Originality/value

This study presents a socio-technical urban based mobility model that is positioned between the intersection of "human behavior" and "infrastructural design" grounded on the factors that influence green urban mobility polices for local communities transiting to a sustainable public transportation. Also, this study explores key factors that may influence green urban mobility polices for local communities towards achieving a more sustainable public transportation leading to a more inclusive, equitable and accessible urban environment.

Social implications

This study provides factors that would promote public and non-motorized transportation and also aid towards achieving a national green urban mobility strategy. Socially findings from this study provides evidence on specific green urban mobility measures to be adopted by stakeholders in local communities.

Practical implications

This study provides green mobility policies as mechanisms to be employed to achieve a sustainable public transportation in local communities. Practically this study advocates for the use of data to support green urban mobility for transport providers, businesses, and municipalities administration by analyzing and forecasting mobility demand and supply in terms of route, cost, time, network connection, and mode choice.

Keywords: Place management; Urban development; Green urban mobility; Sustainable public transport, Transport policies; Local communities.

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1. Introduction

The mobility of people, goods and services is one of the important elements of city development that characterizes urban space and how the citizens functions (Oleśków-Szłapka et al., 2020). Thus, mobility has an important influence on the liveability and total functioning of municipalities and citizens quality of life (Ribeiro and Mendes, 2013). The increased public transportation issues in local communities, such as emissions of pollutants, increase in the number of accidents, traffic congestions, etc. has become the main reason for establishing new approaches and various strategies to improve public transportation policies in urban areas (Grzelec and Hebel, 2016). Thus, urban mobility has become one of the utmost challenging undertakings not only in densely populated cities but also in local communities, as traffic congestion, air pollution, greenhouse gas emission, and energy consumption are environmental problems daily faced by cities (Holota et al., 2022). Moreover, the number of private vehicles used in local communities are exponentially increasing. However, these changes are pursued by appropriate expansion of public road infrastructures, which has resulted to traffic congestion, waste of time, and expenditure. As such local communities are faced with issues on how to improve livability and decrease environmental impact, minimize energy use, and improve planning of public transportation infrastructures (Szołtysek and Otręba, 2016; Holota et al., 2022).

The topic of sustainable public transportation as well as green urban mobility is presently important for local communities, due to climate changes, global warming, and environmental degradation. Green urban mobility planning and design offers a timely, critical, and succinct exploration of urban development strategies throughout the world (Holota et al., 2022). Green urban mobility aims to decrease the level of air pollution, noise, and dust from traffic in cities. Green urban mobility forms an essential part of an integrated sustainable transportation policy for addressing climatic issues and global warming for achieving sustainable development of local communities (Szołtysek and Otręba, 2016). Green urban mobility has the potential to promote sustainable development of local economies by providing proactive steps to help decarbonize the public transportation systems thereby providing local communities with the prospect to meet their green policy responsibilities in a holistic manner (Bokolo, 2023). Green urban mobility is now not just a trend in cities but over the years has now become a medium for communities to improve the livability and quality of life of an urban area (Grzelec and Hebel, 2016; Ambrosino, 2018).

Therefore, the development of green urban mobility strategies is, thus, not restricted to lowering transport-related adverse externalities, but aims to address bigger goal of supporting economic, ecological, and human development. Local communities and regions rely on efficient, connected public transportation (Oleśków-Szłapka et al., 2020). Thus, cities are now focusing on achieving the aspect of green urban mobilities, however, adopting green urban practices in transport sector is a challenges task as it requires the use of data from digital technologies for changing the planning, design, and use of public space, use of transport infrastructure, integrating different mobility modes along with the change of citizens mindset towards adopting green mobility system (Grzelec and Hebel, 2016; Anthony Jnr et al., 2020). Although local communities

have not yet defined visions and long-term strategies of how they can deploy data for sustainable public transportation planning in the future (Oleśków-Szłapka et al., 2020). Moreover, as pointed out by Oleśków-Szłapka et al. (2020) establishing a data-driven integrated, and environmentally friendly intermodal and multimodal mode of commuting is a key issue for the development of urban regions. Thus, this article aims to investigate the following research questions.

- Which specific measures as recommendations are to be adopted in local communities to achieving a national green urban mobility strategy?
- Which key factors may influence green urban mobility polices for local communities transiting to a sustainable public transportation?
- How can data from digital technologies support green urban mobility measures in local communities?

To address the above research questions, this article aims to investigate how local communities can facilitate green urban mobility. Findings from this study presents measures for green mobility and a socio-technical urban based mobility model grounded on factors to be considered to promote environmentally sustainable, low carbon transport infrastructure in local communities. The findings provide green mobility measures as guidelines for policy makers and municipalities, including public and private actors towards identifying strategies that can be adopted to promote sustainable public transportation. This article is structured as: Section 2 presents the methodology employed in this study. The main findings from this study are described in Section 3. The insights from Norway are presented in Section 4. The discussion and implications are reported in Section 5. Finally, Section 6 presents the conclusions.

2. Methodology

This article employs systematic literature review (SLR) which involves a review of existing literature carried out in a structural way (Maybury et al., 2022). SLR is adopted in this article as a method to make certain that this study is comprehensive, and that all substantial literature published within the study area are included. Given the recent pledge by many countries to decarbonize the transportation sector, this study is well-timed and needed. Similar to prior studies (Anthony Jnr, 2022; Maybury et al., 2022), the review in study was carried out based on the procedure outlined by Kitchenham (2004).

2.1.Data Sources and Search Strategy

A search of online libraries which includes Google Scholar, Scopus, and Web of Science was carryout. The search string comprises of different terms combined with the Boolean operator "AND". Also, key terms were combined in each search string using the Boolean operator "OR". The search process was constructed into search strings for the searches: *"green urban mobility" or "green mobility" or "sustainable mobility" or "sustainable transportation" or "data driven"*

"digital technologies"and "local communities *", and "municipalities" or "green urban mobility polices" and "model*" and "frameworks*" and "strategies*" or "initiatives" and "factors*" and "practice*" or "polices" and "measures*" and "recommendations*".*

2.2.Selection of Sources

In the selection process the searched sources are assessed to exclude possible duplicates and sources that were not well positioned to the role of data for green urban mobility policies towards sustainable public transportation. The selection process is shown in Figure 1 below.

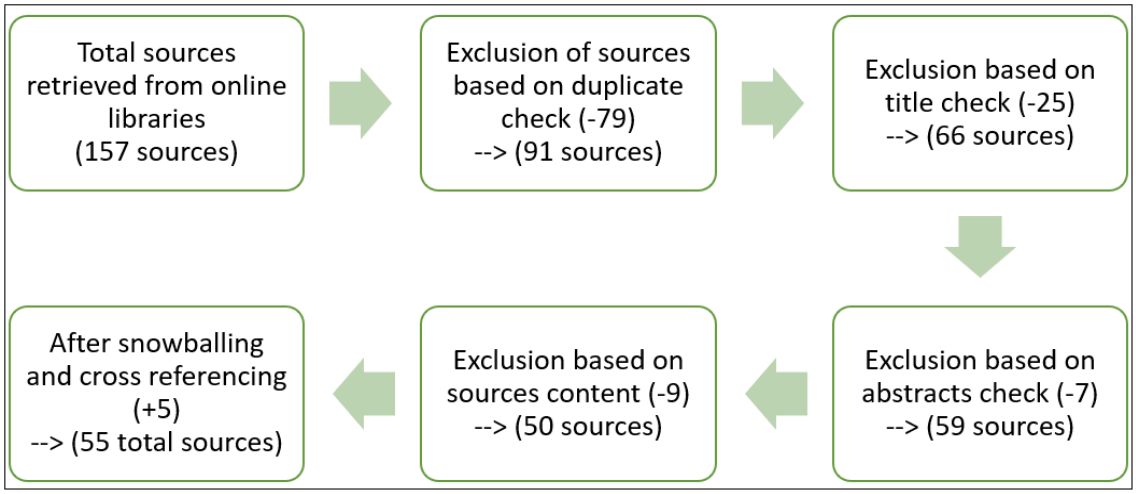

Figure 1. Sources search process carried out in this study (source: designed by the author)

As seen Figure 1 a total of *157 sources* were retrieved from the online libraries. After which a duplicate check was carried out and 79 sources were removed resulting to *91 sources*. Then *25 sources* were excluded based on the source title not fully aligned to the study area, resulting to *66 sources*. Next, *7 sources* were removed due to the abstract not fully discussing data for green urban mobility policies towards sustainable public transportation. Additionally, *9 sources* were removed as the content of the sources was not well linked to address issues related to the research questions. Lastly *50 sources* well aligned to the research questions and further *5 sources* were included through snowballing and cross references resulting to a total of *55 sources*. Next qualitative data was extracted and synthesized from the selected sources. Then descriptive data analysis was employed to present findings related to the research questions which includes specifying measures as recommendations are to be adopted in local communities to achieving a national green urban mobility strategy, identifying key factors may influence green urban mobility polices for local communities transiting to a sustainable public transportation, and lastly exploring how data from digital technologies support green urban mobility measures in local communities.

2.3.Inclusion and Exclusion Criteria

For inclusion and exclusion criteria, this review study is more focuses on sources published in English language. Moreover, sources published in academic journals, conference proceedings,

chapters of books, dissertations, thesis, and technical report. Also, only sources published from 2000 till date (2023) were considered in this study. The sources selected also provide relevant data to provide answers to the research questions presented in this study. Sources that provide evidence on approaches related to green urban mobility policies for sustainable public transportation were screened and if the source were grounded on a scientific method, then such sources were included. Also, if the aim, objectives, and research problem were well explained such studies were included. Studies published in other languages other than English language were excluded. Lastly, this study opted to include technical reports and dissertation as many reports from well-known associations such as European Commission, EU has published technical reports on the research area of sustainable public transportation (European Commission, 2007; European Commission, 2009; European Commission, 2011). Also, a technical report on green urban mobility policies from Norway was also included (regjeringen.no, 2021).

3. Findings

3.1.Green Urban Mobility Measures to be Adopted in Local Communities

To address the first research questions this section presents evidence on specific measures as recommendations are to be adopted in local communities to achieving a national green urban mobility strategy. Accordingly, Figure 2 summarizes the green urban mobility measures to be adopted in local communities towards sustainable public transportation.

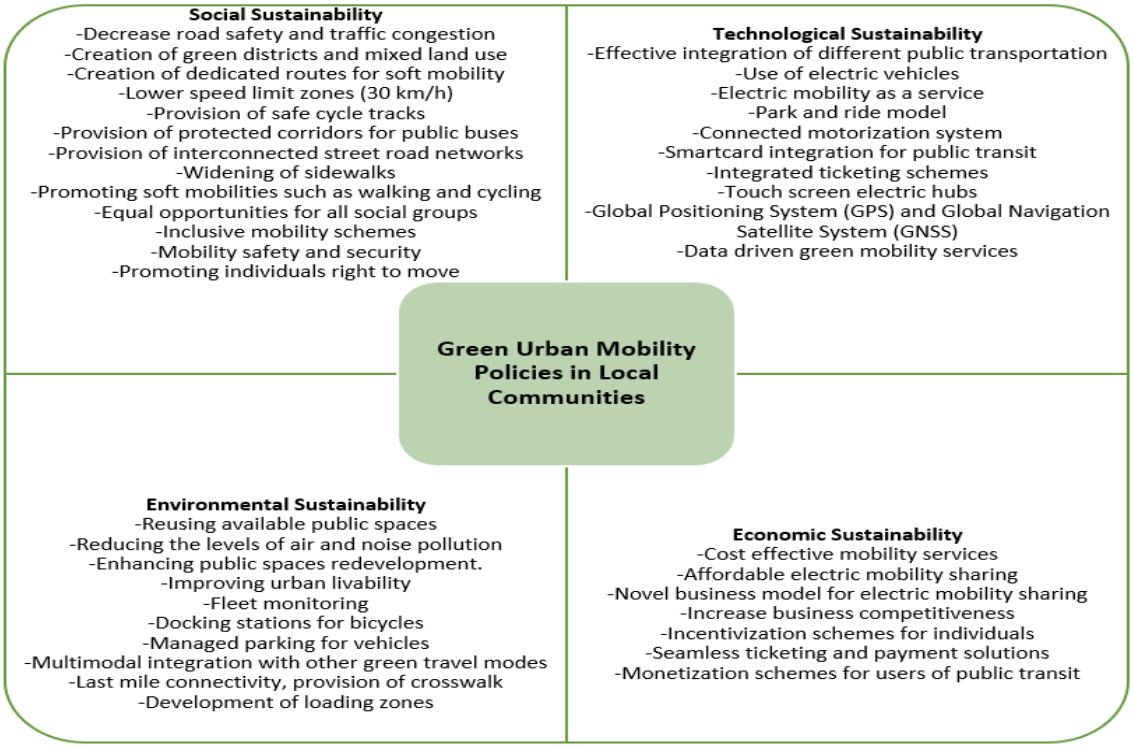

Figure 2 Green urban mobility measures to be adopted in local communities (source: designed by the author)

As shown in Figure 2 each of the green urban mobility measures which comprises of social, technological, environmental, and economic sustainability are being employed by transport planners, urban developers, and other groups of stakeholders to help local communities address urban mobility challenges by identifying management strategies that promote the *effective integration* of different public transportation modes as a means to achieving a greener urban mobility in the future. Accordingly, municipality authorities are commissioning various measures as initiatives to promote green urban mobility to lessen the negative impact of public transportation on urban residents' quality of life (Brandajs and Russo, 2023). Therefore, green urban mobility measures are being implemented in many cities aimed at reducing environmental pollution, road congestion, and uncontrolled urban development (Anthony Jnr, 2020; Balsas, 2023). Green urban mobility measures offer initiatives to increase the efficiency of the public transportation and enhance the attractiveness of the local environment (Jacyna and Kotylak, 2020). Similarly, local authorities and policymakers are continuously striving to find measures that lessen private vehicle use in urban areas towards the green shift. This involves the *use of electric vehicles* which reduces air pollution, eliminates CO_2 emission thereby limiting environmental impact associated with traditional vehicles (Holota et al., 2022).

Green urban mobility measures are part of an integrated transport policy outline for addressing challenges citizens faced in commuting within and across cities and regions (Sheller, 2011; Hobbs, 2018). Green urban mobility measures have the potential to contribute to viable local economies and also provides proactive initiatives to decarbonize public transportation systems giving municipality authorities the opportunity to address their green policy responsibilities in a holistic way (Hobbs, 2018). Thus, more green urban mobility modes such as *electric mobility as a service, walking, cycling, and Electric Vehicles (EV)* are to be adopted, as well as the improvement on public transportation infrastructures (Ribeiro and Mendes, 2013). In addition, most regions have focused on provision of innovative business models for EV sharing schemes which includes electric scooter, electric bikes, electric bicycle, and electric car sharing. Also, other urban mobility initiatives involve *redistributive schemes like park and ride, fleet monitoring, docking stations, smartcard integration for public transit, and integrated ticketing schemes, touch screen electric hubs, and Global Positioning System (GPS) and Global Navigation Satellite System (GNSS)* that provides positioning, navigation, and timing (PNT) services for regional and global transportation services (Majstorović et al., 2014; Sultan et al., 2016). Green urban mobility measures imply shaping local communities' transportation services in a way that guarantees *equal opportunities for all social groups* residing and working in each region and also provides appropriate form of mobility related information and communication to users (Jacyna and Kotylak, 2020).

Green urban mobility initiatives should create a *connected motorization system, not disrupt existing public transport* and non-motorized transportation or soft mobility for pedestrians and cyclists and should *ensure harmony* with its surroundings (Jacyna and Kotylak, 2020). Additionally, green urban mobility measures in local communities should provide *available,*

accessible, acceptable, affordable, and adaptable for inclusion to all groups in the society (Gargiulo et al., 2018), while *ensuring a safe and secure mobility for all individuals*, with a prominence on pedestrians and cyclists as the most vulnerable public road users. For example, for municipality authorities to reduce the use of private vehicles by individuals in local communities within the city center. Green urban mobility measures improve the municipality's spatial order and image, establishing a good quality public space, and *promoting diversity in the development and citizens quality of life* (Jacyna and Kotylak, 2020). Green urban mobility polices requires measures *to lessen the need to travel* (promoting citizens to take less trips), to promote modal shift, to decrease trip lengths, and to achieve more efficiency in the current public transportation system (Oleśków-Szłapka et al., 2020). Accordingly, there is need for the municipality to develop public spaces by *reusing available public spaces* such as adjacent parking areas or pavements, introduce limited traffic areas, and improve existing alternative public transportation services (Campisi et al., 2022). Next the role of *soft mobilities* and *multimodality* to improve green urban mobility is discussed below.

3.1.1. Soft Mobility for Green Urban Mobility in Local Communities

Local communities are faced with high transport demand and associated environmental effects such as noise and air pollution, traffic congestion, increasing shortage of space and traffic jams, which has resulted to additional costs to the society (Dura and Weil, 2014). The increased attention to safeguard the natural environmental concerns due to the increased emission from motorized transportation has motivated local communities towards the development of specific services and infrastructures devoted towards "*promoting soft mobilities"*. Soft mobility which includes all mode of Non-Motorized Transportation (NMT) or human powered mobility that utilize only the human energy is suggested as one of the green urban mobility initiatives (Oleśków-Szłapka et al., 2020). *Soft mobility comprises of pedestrian, cycling, and other non-motorized* displacements that produces zero impact as compared to other alternative mobility modes. Soft mobility supports sustainable mobility aimed at *improving urban livability, promoting individuals right to move*. Soft mobility could enhance urban environment especially *reducing the levels of air and noise pollution, road safety and traffic congestion* (La Rocca, 2009; Oleśków-Szłapka et al., 2020).

Generally, the increase in use of soft mobilities would decrease private vehicle traffic, specifically regarding short trips. This also includes ensuring highest levels of *mobility safety and security enhancing public spaces redevelopment*. Soft mobility should be also integrated with urban and regional planning measures to guarantee the implementation of dedicated facilities and infrastructures (La Rocca, 2009). Moreover, local communities can encourage planning of soft mobility modes (pedestrians and cycling), by adopting measures such as *the creation of green districts and mixed land use.* This will help to improve sustainable urban policies targeted to advance the use of public spaces and to *increase road safety measures* in local communities (Nigro et al., 2021). Additionally, other initiatives can be implemented such as the *creation of dedicated routes* for soft mobility and *lower speed limit zones (30 km/h), provision of safe cycle tracks* beside the road, *provision of protected corridors* for public buses, *provision of interconnected street road*

networks. Also, other initiatives include *widening of sidewalks*, development of street-oriented building, available *managed parking for bicycles and multimodal integration with other green travel modes, last mile connectivity, provision of crosswalk, and development of loading zones* (La Rocca, 2009).

3.1.2. Multimodality for Green Urban Mobility in Local Communities

In local communities one of the aims of the municipality is to facilitate the movement of individuals from location to another in a safe, secure, faster, sustainable, and efficient manner (Anthony Jr, 2023). Presently, local communities and regions face many societal changes that are taking place such as changes in use and ownership of vehicle, new vehicles, novel business models; use of mobile platforms and technologies that empower and facilitate individuals' mobility, etc. (Oleśków-Szłapka et al., 2020). Modern mobility services in local communities comprises of public space and transportation planning aimed at promoting greater use of public transportation as a multimodal means which comprises of electric mobilities such as electric buses, electric bicycles, electric scooters, trams, etc. (Jacyna and Kotylak, 2020). Theses shared electric mobility services offers a *key initiative for lowering fuel consumption, energy use, and pollutant emissions* (Motta et al., 2015). Thus, the integration of *multimodal approach* in public transportation promotes sustainable urban development of local communities (Ribeiro and Mendes, 2013). Multimodality is one of the innovate mobility services provided by municipalities to its citizens to improve their daily travel within and across cities, as it aids urban residents to select from a range of green alternative mobility options. Multimodality as used in different domains and fields is mainly associated with the transportation sector.

Multimodality involves integrated public transportation system which comprises of different mode of locomotion (Holota et al., 2022). Multimodality provides a low-cost, more efficient, greener and improves citizens quality of life in local communities (Holota et al., 2022). Where, full functioning and effective integration multimodality of public transportation offers solution to tackle especially urban mobility issues in a sustainable way communities. These urban mobility initiatives are now being deployed in various regions have increasingly been integrated to existing public transportation structures, e.g., by provision of information options and availability of multimodal booking (Holota et al., 2022). Multimodality provides several advantages towards sustainable public transportation in local communities. Nevertheless, multimodality lies in *individuals' willingness* to use public transportation as a means of commuting in exchange for use of private car, as multimodality involves the effective combination of different mode of travel which may not necessarily be fast and may not save time for commuters. However, the optimization of public transportation in the context of multimodal urban mobility is progressively gaining traction. As it has the promise to improve the current mode of commuting towards reducing the environmental footprint of public transportation and simultaneously improve the optimal use of urban mobility infrastructures (Holota et al., 2022).

3.2.Factors that Influence Green Urban Mobility in Local Communities

The key factors that may influence green urban mobility polices for local communities transiting to a sustainable public transportation is discussed in this section in line with the second research question. As green urban mobility introduces the concept of modal split can be considered to influence individual's travel mode employed in order to accomplish their physical and non-physical mobility need (Dura and Weil, 2014; Anthony and Petersen, 2020). In the context of this study factors are variables or parameters that influences the performance of green urban mobility measures in local communities. These factors measure the gaps between present and desired performance and further shows the progress in addressing these gaps. Overall, the factors precisely identify where to take action to improve sustainable public transportation performance (Motta et al., 2015). As mobility is considered as a complex *socio-technical system* that is positioned between the intersection of "*human behavior*" and "*infrastructural design*" as seen in the developed socio-technical urban based mobility model in Figure 3.

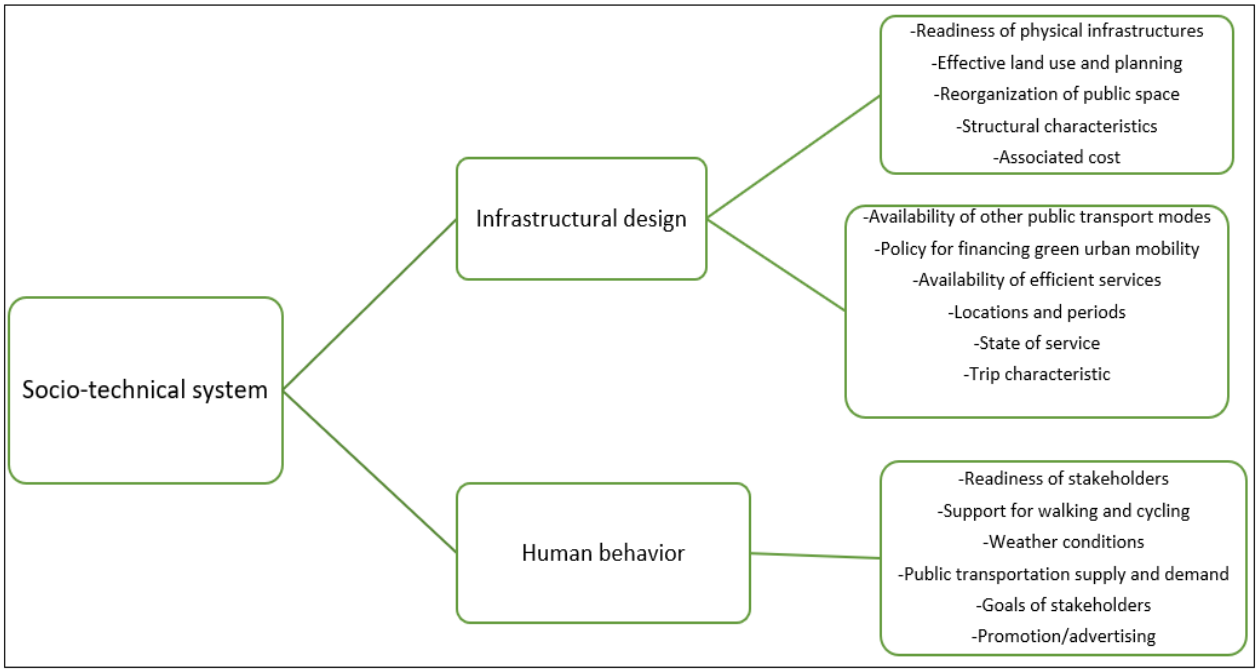

Figure 3 Socio-technical urban based mobility model (source: designed by the author)

Figure 3 depicts the developed socio-technical urban based mobility model which comprises of several factors that influences the adoption of green urban mobility towards improving public transportation in local communities. One of these factors is the *availability of efficient services*, such as charging infrastructures for EVs, mobility accessibility, sustainable land-use, and planning for passengers' movement (Holota et al., 2022). As pointed out in the literature (Dura and Weil, 2014), there are several inherent factors influencing urban mobility choices that are linked to the trip characteristic (e.g., *the trip's distance, purpose*, etc.), and *personal attributes* (e.g., *age, household structure*, etc.). Among these factors the synergy between urban mobility supply and demand heavily depends on the characterization of the *locations and periods*.

Also, the consideration of the aims and *goals of stakeholders* plays a significant role to achieve public participation towards better public transportation solutions for all (Ribeiro and Mendes, 2013). Moreover, the current state of the public transportation will definitely influence the actualization of green urban mobility in local communities as in some instances the bus routes are usually delayed (Ribeiro and Mendes, 2013). Thus, the bus fleet should be regularly updated to provide safe and secure travel for residents. The *state of service* is a factor that measures the time or duration aspects of public transportation service in term of service punctuality, duration, fulfillment, and flexibility e.g., average speed of vehicles, delay at stops, delay forecasting efficiency, path reliability, land use for station/bus stops, and social inclusion (Motta et al., 2015). This should involve measures to *improve traffic control* in sensitive areas and historical centers, improving traffic performance around road junctions particularly in terms of safety for cyclists and pedestrians (Ribeiro and Mendes, 2013).

Effective land use and planning of public transportation are key factors to be considered in achieving a greener urban mobility system. As such there is need for actions that includes *preservation of cultural and historical areas* that foster economic vitality, the *reorganization of public space* in the central part of the city, and consideration of walking and cycling amidst urban transformation of open spaces in local communities (Ribeiro and Mendes, 2013). Researchers such as Dura and Weil (2014) mentioned that *structural characteristics* and *incidental conditions* such as the *availability of other public transportation modes*, *weather conditions*, and parking space availability at the destination can influence green urban mobility. Thus, *parking availability* is an important component that influences green urban mobility, which is based on the fact that the vitality and viability of electric vehicle sharing services depends largely on the availability of the existing parking for supply of these electric mobility assets such as electric scooters, electric, bicycles, and electric cars mainly for commercial purposes (Ribeiro and Mendes, 2013; Dura and Weil, 2014). Provision of *support for walking and cycling* which are soft mobilities as previously stated which are vital to the development of green urban mobility. Pedestrians frequently walk in specific areas in the community, depending on the relative priority and importance that they have relatively to other street users, highlighting the usefulness of the public space near walkable streets, predominantly in pedestrian streets (Ribeiro and Mendes, 2013).

Though, for soft mobilities such as walking and cycling to contend with motorized vehicles for instance cars, bikes, public transportation must be developed with the *readiness of physical infrastructures* that supports the use of electric mobility assets for the easiness of travel and to promote first-to-last mile mobility services to commuters in local communities (Singh and Singh, 2018). The application of green urban mobility practices within the planning and management of local communities, involves addressing different expectations and *needs of all stakeholders* and must consider the measures that may influence the sustainability of the public transportation of the city (Ribeiro and Mendes, 2013; Nikolaeva et al., 2019). The quality of available public transportation is another factor that assess the consistency of the input and output of the mobility process in relation to compliance, travelers' satisfaction, and availability of space, e.g., existence

of overcrowding in public transportation. This factor comprises of the perceived quality and public transportation network condition (Motta et al., 2015). Also, there is need for *managing public transportation supply and demand* through the use of *economic plans and instruments* for behavior change and urban mobility management (Mateescu and Popa, 2017).

To improve urban mobility the public transportation should always be accessibility to residential areas, schools, workplaces, business, parking, and communal services (Ribeiro and Mendes, 2013). Measures to improve urban mobility towards achieving higher standards of sustainable transportation need to include *the promotion/advertising* of an active use of public transportation in local communities for commuting. Moreover, *associated cost* is a factor that evaluate the unit costs of input and output as well as the utilization rate and productivity of public transportation resources, such as average commuting time and average cost to commuters (Motta et al., 2015). Additionally, *financing* green urban mobility towards a sustainable public transportation is undoubtedly one of the most critical factors in local communities towards achieving sustainable development. The development of *policy for financing green urban mobility* in local communities requires a comprehensive and consistent strategies which are in line with the city`s sustainability *vision and mission* (Oleśków-Szłapka et al., 2020). Green urban mobility measures are put in place to ensure that the population regularly uses public transportation instead of private vehicles. This involves the *provision of investments and the upgrading of public transportation systems adapted* to the needs of residents (Jacyna and Kotylak, 2020).

3.3.Data Driven-Green Urban Mobility Services in Local Communities

This section aims to provide answer to third research question "How can data from digital technologies support green urban mobility measures in local communities?" Presently, urban mobility is on the edge of a technological transformation brought on by the convergence of sharing, electrification, and digital technologies. The adoption of digital technologies such as blockchain, digital twins, internet-of-things, artificial intelligence, cloud computing, radio-frequency-technologies, systems, digital tools, devices, and resources that produce, store or/and process, and manage data (Anthony Jnr and Abbas Petersen, 2021). Advances in digital technologies such as data is enabling real-time electric mobility assets sharing to improve the efficiency of people moving across the city and reducing cars within and across cities (Green et al., 2019). As such digital technologies such as big data have significantly increased the range of urban mobility solutions provided in local communities. This has enabled a proliferation and uptake of on-demand shared electric mobility as a service (such as electric car-sharing, electric car-pooling, electric scooter sharing and electric bicycle rentals) (Green et al., 2019; Anthony Jnr, et al., 2021). Such green urban mobility-on-demand schemes have increased mobility accessibility for individuals, including for persons who had challenge accessing existing modes of public transportation or in local communities that were beforehand underserved by shared transit services (Green et al., 2019).

Additionally, increasing urban mobility needs of individuals in local communities will challenge existing public transportation system and subsequently increase traffic congestion and carbon emissions (Schrank et al., 2019). Satisfying the mobility expectations and requirements for both people, services and goods is needed for the liveliness of local communities, and a proper functioning public transportation system is important for citizens quality of life (Oleśków-Szłapka et al., 2020). Nevertheless, the acceleration of digital transformation is instantly changing urban mobility much faster than previous years (Oleśków-Szłapka et al., 2020; Anthony Jnr, 2021). However, there is significant uncertainty regarding how digital technologies using data will be employed to promote green urban mobility in local communities and regions. Therefore, this study provides evidence on the potentials of data from digital technologies to support green urban mobility measures in local communities. Hence, data from different sources such as *open data, real time data from sensors and metering devices, social data, historical data, and crowd data* can be collected, cleaned, processed, analyzed, saved, and used to support green urban mobility strategies in local communities (Motta et al., 2015; Anthony Jnr, et al., 2020; Bokolo, 2023). The analyzed and used data sources can be utilized by public transportation providers to *monitor and improve their mobility services provided*.

Also, the processed data can provide a d*eeper insight on urban traffic context, flow, conditions, and movement of people and vehicles* within a particular area of the municipality (Motta et al., 2015). Data can be applied to facilitate green urban mobility for sustainable public transportation, where data driven applications can provide *smart services such as intelligent parking management and support, real-time information during travel, real-time urban traffic management, multi-modal journey planning, and seamless integration of shared green transports* (Motta et al., 2015). The data can also be used to support advanced journey planning services for travelers and also aid multimodal and intermodal mobility options by routing commuters' trip into cheaper and faster sub-routes via different public transportation modes. Access to *open data of timetables, static data, and real-time data from public transportation modes* (buses, ferries, flights departure/arrival, trains, underground and trams, real-time data of vehicles from taxis, buses, trains, etc.), *real-time data from sensors* (e.g. traffic camera), in shared electric mobility assets (electric scooters, electric bicycles, electric bikes, electric cars, electric taxi, etc.), to be used to promote and manage sharing of electric mobility assets, *real-time data from parking lots, real-time data from traffic management systems*. Also, *crowdsourcing data* from individuals and/or their devices within and across cities. Moreover, there are *social data gotten from location based social networks* (Motta et al., 2015; Anthony Jnr, 2022).

For crowdsourcing data individuals identify or confirm issues during their trip by providing a short description and an image as evidence provided via their mobile. When these feeds are uploaded to the available social platforms the geo-location are stored. Also, feeds can be tagged in relation to a prepared list of public transportation issues (e.g., delays not conveyed to commuters, unexpected strike which was not reported and unavailable or damaged mobility infrastructure). Another data collection medium similar to crowdsourcing is social mining which

defines activity areas within or across a region that can be employed to model crowds via density clustering of tweets which are geo-tagged, and then further narrowed down according to different data granularity or scales. Social mining can also be used to model crowds close to a public transit stops as it comprises of event detection which utilizes public transportation models simulated from crowdsourcing data (Motta et al., 2015). Data generated from public transportation infrastructures can be shared to the public as part of the municipality`s open data initiatives as data from public sector are to be freely made available to everyone. These open data from public transportation infrastructures as stated by the EU comprises of *geospatial data* (e.g., bus routes, bus stations/stops, etc.), *fare cost, timetables, road closures* (if any within the city), *private/public road network with metadata* (comprising of addresses via geocoding engine, speed limits, etc.), real-time or batched/historical of *accident data, traffic data, layout/pictures of cultural heritage and historical reports*. The historical, online, crowdsourcing, social, and real-time data produced can be in different formats, analogue and digital, temporal, and spatial, image or alphanumeric, moving, or fixed.

Public transit data platforms such as the General Transit Feed Specification (GTFS) can be used by local communities. The GTFS offers data specification that helps public transportation organizations to publish their route/transit data in an understandable format that can be utilized by different digital platforms and applications. At present, the GTFS data format is consumed by thousands of public transportation providers across cities and regions. And more than 400 transportation organizations are publishing their public transportation schedules and other mobility related information employing the GTFS format (Motta et al., 2015). It is hosted via https://gtfs.org/ and managed via https://developers.google.com/transit/gtfs by google transit to provide an open, interoperable, and common data format for spatial data and temporal schedule to be used for public transportation itinerary planning. The GTFS is categorized into a schedule and real-time components. The schedule component comprises of geographic transit, fare, and schedule information whereas the real-time component provides information on the vehicle positions, arrival predictions, and service advisories. GTFS has become the standard de facto due to its widespread use and its capability to provide real-time information that supports commuters journey updates (i.e., changed routes, cancellations, delays, etc.), urban mobility service alerts (stop point moved, unexpected events affecting a particular station, route, or the entire route network), traffic congestion level and vehicle positions. Thus, individuals can benefit from the information provided from real-time data concerning location of vehicles, disruptions, expected and delayed arrival times (Motta et al., 2015).

4. Insights from National Transport Plan in Norway

Public transportation in regional and local communities are becoming one of the main contributors of greenhouse gas (GHG) emissions (Curiel-Esparza et al., 2016; Anthony Jnr, 2021). In 2017, a total of 27 percent of total EU-28 GHG emissions was produced from the transportation sector,

excluding 22 percent of maritime and international aviation emissions. This result recorded 2.2 percent increase in CO_2 emissions from transportation sector as compared to 2016 (Oleśków-Szłapka et al., 2020). Due to the high importance of urban mobility in environmental, social, and economic terms, particularly in regional and local communities, governmental actors are progressively developing polices, and action plans (Dura and Weil, 2014; Majstorović et al., 2014). These plans range from *incentivization* to promote a more sustainable public transportation which should principally promote green urban mobility and mitigate, global warming, climate change, and environmental degradation as well as relieve municipal areas of extremely congested transportation (Dura and Weil, 2014; Balaban and Puppim de Oliveira, 2022). Presently, in Norway "The National Transport Plan 2022–2033" was submitted to the Storting in March 2021. The plan presents policies and priorities within an economic, technological, social, and technological frame for a twelve-year period and provides perspectives towards 2050 as seen in Figure 4.

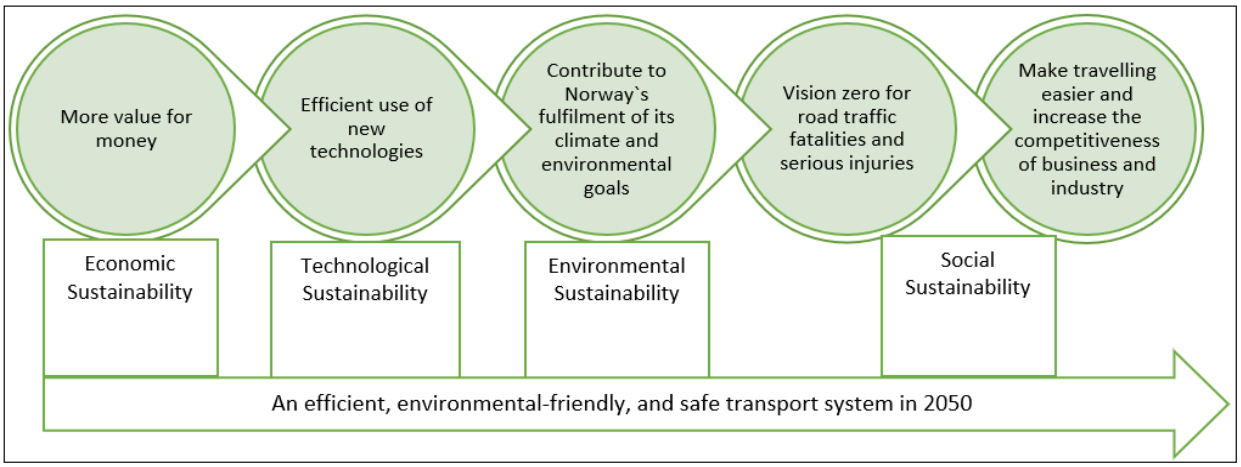

Figure 4 The National Transport Plan 2022–2033 adapted from (regjeringen.no, 2021) (source: designed by the author)

Figure 4 The National Transport Plan 2022–2033 proposed in Norway. The plan will underpin the global Sustainable Development Goals and Norway's climate and environmental goals. The overriding objective for the National Transport Plan 2022–2033 is an efficient, environmental-friendly, and safe transport system in 2050 (regjeringen.no, 2021). Overall, the National Transport Plan aims as seen in Figure 4 aims to efficiently use new technologies such as data (as discussed in previous section), that can contribute to Norway's fulfilment of its climate and environmental goals. The "use of data from digital technologies support green urban mobility measures in local communities" in this study is well positioned within "the use new technologies and research to obtain more efficient and safe transport with lower emissions". Thus, findings from this study facilitate the development of new technologies and contribute to mobility solutions and services that will help us achieve the national green urban mobility strategy.

Hence, there has been many discussions and debates about urban and/or public transportation strategies and planning revolving around the term urban mobility (Majstorović et al., 2014). To improve urban mobility in 2007, the European Commission (EC) presented the green paper report titled `*Towards a New Culture for Urban Mobility*` which marked the initial start of a broad discussion on the need for policies related to urban transport-related issues (European Commission, 2007). Subsequently, the EC published another report as an `Action Plan on Urban Mobility` in 2009 (European Commission, 2009), with 20 definite EU-level strategies to be realized by 2012. Afterwards, several plans were suggested to improve urban transport in another transport white paper `Towards a single European Transport Area` (European Commission, 2011). Over the years the EC have provided supports such as action plans for the realization of sustainable urban mobility within the European Union Member States as this is in line with the goals of the White Paper published in 2011, towards improving coordination between decision makers of transport policy, transport businesses, and transport coordinators in communities (Grzelec and Hebel, 2016; Oleśków-Szłapka et al., 2020). Furthermore, over the last decades, several strategies have been suggested to decrease the acoustic and environmental impacts from the transportation sector. One of these strategies is the policies of the European Green Deal and Agenda 2030 which have been suggested to incentivize decarbonization measures to promote shared and sustainable forms of mobility (Campisi et al., 2022).

4.1.Recommendations for Achieving Green Urban Mobility

Local communities call for a new change in public transportation that considers green urban mobility strategies towards meeting the present and future needs of inhabitants for comfortable and efficient travel while considering the natural environment. Sustainable urban development can help to improve the accessibility for all residents, ensuring *the democratization and use of public transportation* and reinforcing the importance of soft mobility mode of travel for green urban mobility polices (Ribeiro and Mendes, 2013). The need for more greener means of urban mobility is also necessitated by the fact that public transportation is one of the world's emitters of greenhouse gases. Globally, public transportation accounts for almost a quarter of CO_2 emissions (Holota et al., 2022). Green urban mobility measures help to understand the economic and social dimensions without negatively affecting the natural environment and its resources. Thus, there is need to adapt urban mobility policies by improving the mobility accessibility conditions for pedestrians and commuters of public transportation (Ribeiro and Mendes, 2013). For example, soft mobilities measures such as walking as pedestrians and cycling using bicycles which are part of the public transportation within municipalities can be employed as main forms of green urban mobility (Situmorang, 2019). Therefore, local communities are investing in walking and biking initiatives which provides benefits for local economy to local companies, providing space for venues such as restaurants, shops, and other public centers in the local communities (Majstorović et al., 2014).

In addition, *campaigns and promotions* should be provided to the society on the needs and benefits of green urban mobilities including minimizing use of private vehicles and promoting

walking, cycling, and use of public transportation as important to promote sustainable urban development policies. Similarly, *promoting the use of green energy sources* (e.g., such as electric buses), and biogas-fueled public transport (Mateescu and Popa, 2017). It is significant to highlight that it takes time to involve stakeholders in participating in the implementation of green urban mobility initiatives. As such it is imperative to increase the efforts required to *engage all stakeholders* (local government, residents, private enterprises, and public organizations, universities, research institutions), including non-profit, non-governmental, unions, associations, and more (Oleśków-Szłapka et al., 2020). Accordingly, an *active participation of all stakeholders* is needed in order to adapt and realize the principles of sustainable public transportation in local communities. Furthermore, digital technologies such as *"data"* also foster favorable travel conditions for individuals within and across cities by implementing innovative green urban mobility solutions for management of public transportation processes (Grzelec and Hebel, 2016). The use of data supports local communities and regions to deploy innovative solutions for green urban mobility, exploring multimodal and intermodal mode of travel between conventional travel modes of transportation and soft mobility modes (pedestrians and cyclists) towards adopting policies that promotes sustainable urban development aiming at strengthening the environmental and socioeconomic dimensions.

Overall, for local communities to improve green urban mobility planning and development of the entire public transportation system different data is needed such as statistical data which describes the economic and social activities of the designated area, spatial data which describes public transportation offers and traffic indicators describing the traffic supply and demand continuously collected in an integrated, openly, historical, publicly available database (Majstorović et al., 2014). The continuous use of data in urban mobility offers *high-tech and innovative solutions ensures an optimal (sustainable, accessible, quality, efficient, inclusive, safe, and secure)* public transportation system (Strohmeier, 2016). Simultaneously, use of data has resulted to novel business models, involving the proliferation of *on-demand, seamless, door-to-door* electric vehicle sharing services which promises to change urban mobility landscape (Green et al., 2019). In local communities this has been attained via the deployment of data driven mobility solutions and the integration of electric mobility assets as a mode of transportation with zero emissions (Maternini et al., 2014). These data driven approaches continuously ensure the reduction of harmful emissions, provision of economical transportation services, and the adoption of alternative mode of transport (Majstorović et al., 2014).

Results of a survey conducted by Oleśków-Szłapka et al. (2020) revealed that the most common adopted means of urban mobility in cities is public transportation. Electric mode of transportation such as electric bicycles, electric scooters, and electric cars are just being adopted, and consequently, it can be estimated that in the future, their usage share will increase. Furthermore, results from Oleśków-Szłapka et al. (2020) highlighted that most residents prefer to use their own vehicle as a means of transport. The results further stated that a significant proportion of residents has never used green mobility schemes such as electric bicycles or electric

scooters. This is based on the lack of electric mobility sharing services in local communities, or as a result inadequate marketing, promotion, and campaign encouraging individuals to use electric mobility sharing services. The result also cited complex procedure for renting sharing mobility services as a factor that limited uptake of these services. Thus, there is need to simplify such services (Oleśków-Szłapka et al., 2020). Most residents prefer using public transportation based on the reduced price which is seen as a main advantage. Also, the availability of data driven services such as transport service information, ticketing and timetables, and interchanges can improve the adoption of shared mobility services (Oleśków-Szłapka et al., 2020).

5. Discussion and Implications

5.1.Discussion

According to UN predictions, as much as 68 percent of the world's inhabitants will reside in urban areas as compared to 55 percent increase in 2018. This suggest that the population in urban areas will increase. Mobility is one of the many issues that rapidly increasing urban areas are expected to face, especially due to increase levels of traffic congestion, urban pollution, and growing concerns regarding energy consumption around the world (Green et al., 2019). In Europe the development of urban mobility is different, especially in local communities, where policies of green urban mobility, including public transportation planning is mainly the responsibility of municipalities who at times are confronted with insufficient legislation, inadequate funding, or limited expertise on issues related to green urban mobility measures. Findings from Holota et al. (2022) mentioned that cities unsustainable transport situation mainly stems from the unwillingness of policy makers to initiate new innovative solutions and approaches. This issue has affected most of the urban inhabitants. But, planning for green urban mobility in local communities takes long time, as it requires several requirements and an inclusive mobility policy. This plan is in line with the European Commission that proposes the adoption of green urban mobility plans that supports sustainable development of public transportation (Holota et al., 2022). Where sustainable public transportation aims to ensure the effective and safe movement of people, services, and goods within and across cities while reducing traffic costs and damage to the natural environment (Jacyna and Kotylak, 2020).

Likewise, green urban mobility is defined as mobility that is in accordance with the overall goals of sustainable development, including, among other things, physical public transportation assets, a multimodal/intermodal mode and transportation infrastructures that address basic mobility needs in an efficient, safe, and secure way, preserve the integrity of the natural ecosystem, and lessen CO_2 emissions in an environmentally sustainable way, and considers the health of humans. Green urban mobility system provides basic transportation access to the society, and also promotes the travel needs of individuals, societies, and businesses to be safely met in a manner consistent with promoting the ecosystem and human health. Secondly, it provides an affordable, efficiently, and operates fairly, by offering a choice of transport modes, and facilitates a

competitive economy as well as balanced regional urban development (Mateescu and Popa, 2017). The goals of green urban mobility include meeting the transportation needs through an integrated and more efficient use of existing public transportation and urban infrastructure to lessen traffic congestion. This can be achieved by minimizing the length and number of travels by personal vehicles and decreasing the trips demand, reducing air pollution, noise, and GHG emission via the adoption of energy efficient vehicles and alternative fuel/energy source (Grzelec and Hebel, 2016). Findings from this study advocates that to achieve green urban mobility measures it is required to improve the affordability, availability, accessibility, accessibility, adaptability (Ribeiro and Mendes, 2013). Research carried out in the France in Paris region revealed that the use of personal car contributes to about 33 percent of total journeys, consumes 94 percent of road space/hour, while public buses, amounting to about 19 percent of total journeys consumes only 2.3 percent suggesting that buses in transit uses 24 times less space per passenger as compared to a single private car (Camagni et al., 2002).

Green urban mobility measures strive to increase citizens use of public transportation and also recommends the development of newer mobility schemes for the society, including sharing electric vehicles pooling and sharing as well as walking on foot and using bicycles. In addition, green urban mobility policies aim at reducing the problem of traffic congestion faced in local communities by increasing the share and number of commuters using public transportation (Grzelec and Hebel, 2016). The findings presented in this article focused on identification of key factors that may influence green urban mobility polices for local communities towards achieving a more sustainable public transportation leading to a more inclusive, equitable and accessible urban environment. The factors would promote public and non-motorized transportation and also aid towards achieving a national green urban mobility strategy. Findings from this study also suggest that local communities need to primarily invest in infrastructures that promote the use of public transportation, intermodality, and multimodality between motorized forms of travel, as well the promotion of green forms of travel. To promote public transportation as the main mobility source municipalities, need to upgrade existing intermodal hubs, transform parking areas into pedestrian walkway and cycling green corridors and provide alternative parking space (Majstorović et al., 2014). Moreover abandoned, and unorganized areas should be regenerated, there should be construction of public spaces (Majstorović et al., 2014).

5.2.Implications for Society and Theory

Population growth in urban areas can have extremely negative effects on the environment and society. Globally, cities (urban areas) occupy only 2 percent of the world's territory, but they contribute 70 percent of all greenhouse gases produced (Ilenič et al., 2021). Global problems, such as warming and negative environmental impacts, also affect trends in mode of transport. As such, over the last decades, concern and interest has been pivoted towards promoting sustainable public transportation in cities globally (Sultan et al., 2016). Emphasis lies on the provision of pedestrian walkways, cycling paths, and better public transportation for improved health, security, and safety, with a specific focus on improving residents' quality of life (Holota et al., 2022). Also, local

communities are now making use of available public space, promoting the adoption of soft mobility or active modes of transportation (walking and cycling), improving safety, decreasing traffic congestion, lessening visual nuisance, air pollution, and noise while deploying digital technologies such as data for maintaining a healthy and wealthy urban economy while ensuring transport opportunities and social equity for all community. Nowadays, data is employed to promote multimodality and intermodality in public transportation across different mode of travel.

Theoretically findings from this study presented a socio-technical urban based mobility model that is positioned between the intersection of "human behavior" and "infrastructural design" grounded on the factors that may influence green urban mobility polices for local communities transiting to a sustainable public transportation. This study provides evidence on specific green urban mobility measures to be adopted by stakeholders in local communities. These measures are meant to increase the level of intermodality and multimodality towards improving regional and urban mobility and encourage environmentally friendly public transportation systems, which will indefinitely lessen CO_2 emissions and encourage the use of public transportation and shared electric mobility services. More importantly, findings from this study provides evidence from Norway highlighting the national transport plan by providing specific strategies to be adopted as best practices in local communities to achieving a national green urban mobility.

5.3.Implications for Policy and Practice

Mobility is important to human wellbeing as it provides access to opportunities and promotes quality of life, prosperity, and social connections (Green et al., 2019). Urban mobility is not mainly a necessary need but is also a key element for the economy (Costa, 2014). Local communities are faced with the challenges of planning and designing public transportation systems that will equitably, affordably, sustainably, efficiently, and safely meet the urban mobility needs of their increasing residents. This has resulted to many municipalities struggling with air pollution, traffic congestion, and other negative externalities of public transportation systems (Green et al., 2019), such as increase in carbon emissions, noise, and concerns of road safety, health of citizens resulting in environmental, social, and economic costs (Badiora et al., 2020). Due to associated economic, social, and environmental issues faced in local communities, municipalities have the responsibility to adopt green urban mobility measures to satisfy sustainable public transportation needs, but at the same time reducing carbon emission and protecting the natural environment. Therefore, there is need for green urban mobility measures such as practices to promote a more rational use of private vehicles and encouraging energy efficient, clean, quiet, vehicles powered by renewable energy source or alternative fuels (Mateescu and Popa, 2017).

Green urban mobility promotes economic, social, and environmentally friendly public transit (Sultan et al., 2016). Findings from this study provides green mobility policies as mechanisms to be employed to achieve a sustainable public transportation in local communities. Additionally, local communities are witnessing changes in the way urban mobility is evolving, enforced by new mode of operation of public transportation systems, progresses in technological

advancements in transport, digital technologies, and use of data (Oleśków-Szłapka et al., 2020). Practically, the green urban mobility measures suggested in this study can be employed for improving the availability of public transportation by using digital technological solutions, improving multi-modality and inter-modality for different travel mode, and enhancing the travel connections, improving the economic productivity of the available public transportation system as suggested by Grzelec and Hebel (2016). Findings from this study is expected to impact the society, natural environment, and businesses by providing real-time information to ease congestion and decrease pollution levels, by supporting commuters in using shared and public transportation. Findings from this study advocates for the use of data to support green urban mobility for transport providers, business, and municipalities administration by analyzing and forecasting mobility demand and supply in terms of route, cost, time, network connection, and mode choice.

6. Conclusion

Mobility is an important part of the society and cities at large as it provides access to different events, such as social, employment, civic, education, and leisure activities. Additionally, mobility aids entry to different facilities and changes in location of individuals. Urban mobility systems are now faced with different challenges which significantly varies from one region to another as well as country to country. As they directly impact the way of life of inhabitants and the surrounding environment. Green urban mobility polices is relevant in sustainable public transportation studies as it has the potential to significant impact the local economy, alongside its capability, if appropriately developed, to address resource consumption, environmental pollution, and climate change issues. On a national level, green urban mobility polices has the potential to resolve a number of core areas related to climate, energy, and mobility as stipulated by the European commission. To provide a method for examining current and future green urban mobility polices in local communities, this study performs systematic literature review and a descriptive analysis using data from the literature and evidence from the national transport plan in Norway. Green urban mobility polices play a key role in the development of the society and cities.

Presently, the demand for sustainable public transportation is increasing every year. Thus, local communities need to adopt strategically oriented and targeted action plans that will improve the affordable, available, accessible, acceptable, adaptable, and use of public transportation while simultaneously contributing to minimize traffic congestion, lesser accidents, and lower pollution in urban areas (Ilenič et al., 2021). Although, the transition to sustainable public transportation in the society and cities will require different strategies, and a "one size fits all" approach will not be adequate (Hobbs, 2018). This current study presents the specific measures as recommendations that are to be adopted in local communities. Moreover, key factors that may influence green urban mobility polices for local communities transiting to a sustainable public transportation are presented and lastly, evidence is provided on how data from digital technologies can support green urban mobility measures in local communities. This study has a few limitations as only secondary

data was employed. Further research will involve collecting data using survey questionnaire to validate the identified factors that may influence green urban mobility polices form different stakeholders in local communities.

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