Proceedings of the 8th North American International Conference on Industrial Engineering and Operations Management, Houston, Texas, USA, June 13-16, 2023

Assessing Spatial Planning Readiness to Accommodate Innovative Transport Systems and Technologies.

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Abstract

Contemporary cities have taken up efforts to decarbonize urban mobility which has led to a growth in electric vehicles and investment in new renewable energy opportunities. The current transport sector contributes to greenhouse gas emissions, air pollution, and traffic congestion. This has led to a growth in studies to develop a reservoir of knowledge on sustainable mobility to address this challenge. The global shift towards electric vehicles has provided greater energy efficiency as part of the global climate change mitigation strategies, however, electric vehicles are not widely adopted in developing countries due to factors such as insufficient charging stations. Globally this shift to electric vehicles and the spatial distribution of charging stations has been informed by the private sector. This has led to city authorities to be reactive to the implementation of electric vehicle and its charging infrastructure. There is hence a need to assess the readiness of spatial planning to facilitate the transition towards electric vehicles and its infrastructure. Given this emerging trend in urban mobility transition, there have been lack of proactive policy initiatives to inform the adoption of electric vehicles. Using a qualitative research approach this study unpacks the adoption of electric vehicles from urban spatial planning perspective. Fifteen participants from the city of Tshwane were interviewed using a semi-structured interview format. The participants were selected using snowball sampling and purposive sampling. Content analysis was used to develop themes. Findings of the study reveal areas where the charging infrastructure is placed, as these can be found in public spaces such as shopping malls and office parks in the city of Tshwane. The implications of the study are creation of a reservoir on knowledge to inform plans for developing countries such as South Africa to integrate spatial distribution of charging stations with sustainable mobility initiatives. Future studies should develop a framework to inform the broader aspects of spatial planning in relation to innovative sustainable transport systems.

Keywords: Electric vehicle, urban mobility transition, spatial planning, charging infrastructure, urban planners.

1. Introduction

Contemporary cities have taken up efforts to decarbonize urban mobility which has led to a growth in electric vehicles and investment in new renewable energy opportunities. Scholars have articulated that emerging challenges in cities result from an increase in urbanization (Bayram and Bayhan, 2020). In developing countries these challenges provide an opportunity for cities to invest in new smart technologies to inform the transition towards sustainable urban growth and sustainable urban mobility (Banister, 2011). The role of technology in urban mobility is concerned with the aspects of sustainable and integrated smart urban mobility systems (Lyons, 2018). The global shift towards electric vehicles is progressing and centered around the concept of sustainable smart urban mobility system (Faira et al. 2014). Electric vehicles include hybrid electric vehicles, plug in electric vehicles and battery electric vehicles (Nealer and Hendrickson, 2015).

Electric vehicles are considered to be smart mobility considered as innovation under the sustainable development goals (Paiva et al. 2021). It is recognized that cities are the centers of innovation that can facilitate the transition towards electric vehicles (Heidrich et al. 2017). Smart cities shape extensive processes of urban transformation through the concept of innovation and the use of technologies, the concept of innovation involves stakeholder engagement to inform new processes of inclusive urban transformation (Lee et al. 2023).

According to Pucci (2021) a technological change in the urban transport system leads to a new spatial formation (Pucci, 2021). The urban spatial framework is not yet fully understood and incorporated in the urban mobility technological changes, it is further weakened by lack of clear integrated policies (Roy and Law, 2022). Furthermore, there is a lack of research to inform spatial planning in relation to future transport planning (He et al., 2022). Without adequate spatial research or knowledge on urban electric mobility, urban planners remain unprepared to respond to the unfamiliar potential of spatial reorganization created by electric vehicles and its charging infrastructure (Yigitcanlar et al. 2019). The spatial form can either facilitate or hinder the energy transition, as such, many countries are using spatial planning to influence the urban form to facilitate aspects of the energy transition and improve the weak relationship between the urban form and urban mobility technologies (Asarpota and Nadin, 2020).

In several studies, spatial planning is viewed as a policy tool that can facilitate urban interactions and reorganize the urban form, further research is required to investigate the spatial implications of the transition towards electric vehicles (Zhao and Pendlebury, 2014). The spatial change or the urban spatial transformation is often unforeseen as the result of the actions taken by private sectors or individuals which raises the question of how smart cities are inclusive (Nahiduzzaman et al. 2021). The emergence and adoption of urban mobility technologies takes place through various patterns in space, the local government should have a clear understanding of this urban spatial transformation driven by smart city technologies to facilitate an inclusive and sustainable urban development.

This study will focus on the aspects of the spatial distribution of electric vehicles and its charging infrastructure. It is widely accepted that having the charging infrastructure at areas such as shopping malls promote the transition towards electric vehicles, however, the impacts of the potential spatial change are often not researched.

1.1. Objectives

The study seeks to examine the involvement of urban planners in the transition towards electric vehicles. Through stakeholder value creation the City of Tshwane has sought to implement programs to develop electric vehicles infrastructure. The study utilizes the City of Tshwane as a case study, spatial datasets and policy documents were used to unpack the implementation of electric vehicles infrastructure. Given the limited literature from developing countries, this study seeks to add to the existing body of knowledge to inform development of electric vehicles infrastructure in developing countries.

1.2. Study Area

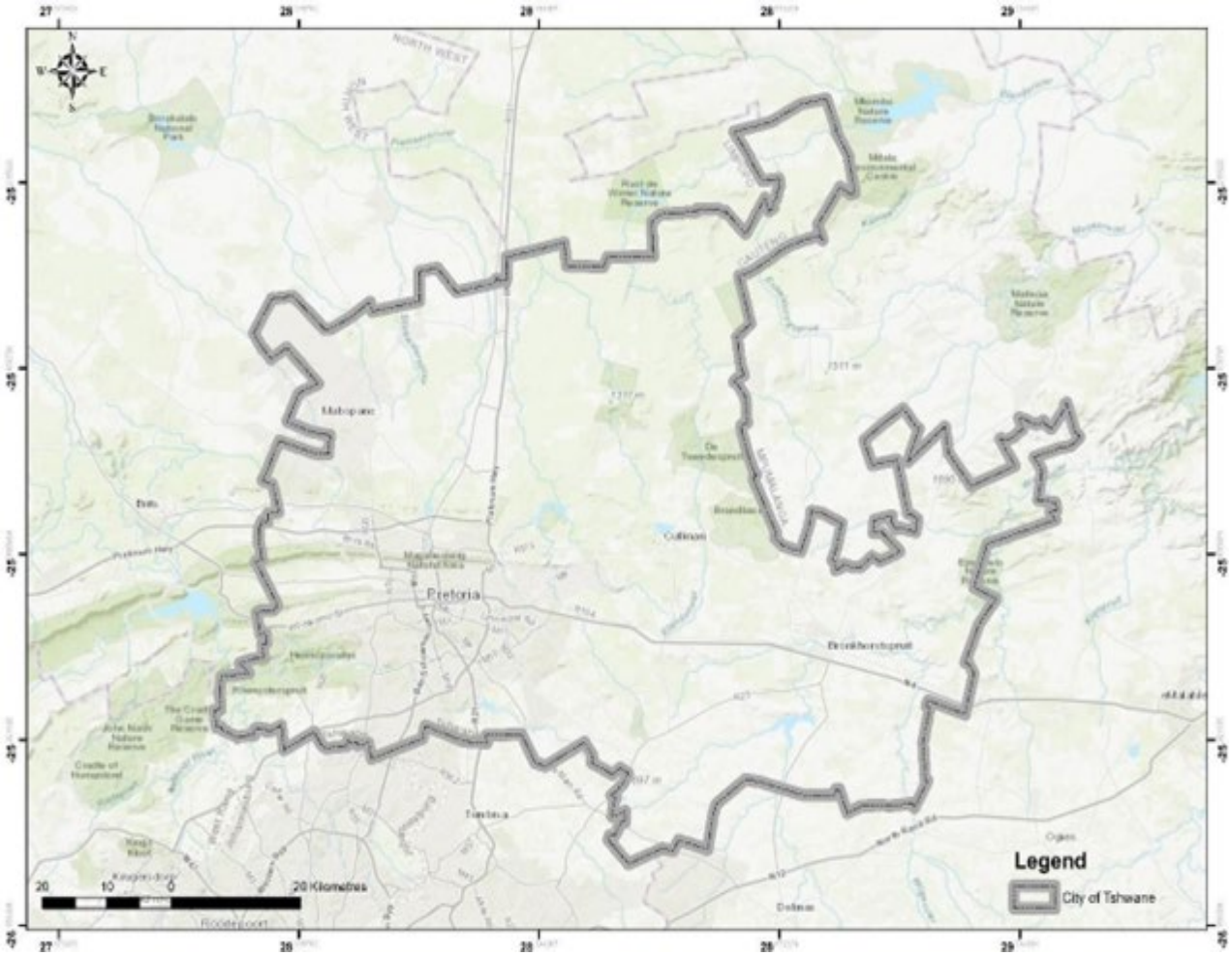

Figure 1: Map of the city of Tshwane

The spatial scope of this study is the city of Tshwane. The city of Tshwane is located in the Gauteng Province, the Gauteng Province is highly urbanized and is the economic hub of South Africa, furthermore, the city of Tshwane has a population of about 2.9 million with a land area of about 6298km^2 (Landman and Nel, 2022). Between 2003 and 2014, the city of Tshwane experienced the most significant growth in population relying on private vehicles, however, these vehicles are contributing towards greenhouse gas emissions and traffic congestion, therefore, it is imperative to transition towards a more sustainable mode of transport, however, there is lack of adequate sustainable urban transport policies to facilitate the transition towards sustainable mode of transport (DURI and Van Zyl, 2019)

Electric vehicles and their associated infrastructure have become prevalent in the city of Tshwane, charging infrastructure for electric cars can be located in areas such as the Menlyn Maine shopping centre situated in the eastern suburb of the city of Tshwane and at areas such as the municipal offices (TMPD logistics offices).

2. Literature Review

The transition theory deals with the systematic changes within the context of technological transformation. This transition is taking place to meet the objectives of sustainable development goals, within the context of "improved vehicle technology" for these vehicles to be recognized as sustainable mobility they need to address broader issues of environmental pollution, traffic congestions and noise pollution (Næss and Vogel, 2012). The framework on sustainable development goals provide the links between broader issues of governance, social, environmental and economic which could be incorporated within the concept of electric vehicles to promote a sustainable urban mobility transition (Omahne et al. 2021). Promoting sustainability require new systematic perspective which involves working with different stakeholders and knowledge components to develop new organizational approaches and new systematic perspective that promote sustainability, furthermore innovation is key aspect of creating new knowledge to support the emerging technologies in the urban mobility pattern (Seebode et al. 2012).

Spatial planning is recognized as a policy tool that has the potential to reorganize the urban form to facilitate the introduction of electric vehicles in a sustainable manner (Zhao and Pendlebury, 2014). The effective role of spatial planning in contributing towards facilitating the transition towards electric vehicles is often doubted due to the weak link between the urban form and urban transport planning. Several studies argue that electric vehicles will influence and change the spatial formation and also influence changes in the urban form (Yigitcanalar et al. 2019). It is argued that the location of the charging infrastructure for electric vehicles will influence and change the urban formation because the availability and the location of the charging infrastructure will encourage or discourage people to use electric vehicles which will result in a new spatial mobility pattern (Pevec et al. 2019). The location of the charging infrastructure has an influence on the urban form and also influence achieving objectives of the sustainable urban transportation system, in this regard, a spatial analysis is required to clearly integrate and link the urban form and the transition towards electric vehicles (Morton et al. 2018).

Socio technical transition such as in mobility occur within the spatial landscape, the transition occurs differently across space and various countries (Fuenfschilling and Binz, 2018). This urban transition in mobility advocates for cooperation and cocreation of solutions to achieve sustainable cities and communities (Schmitt and Wiechmann, 2018). The role of technology in urban mobility will influence how the urban population connects with the urban services and infrastructure through the urban design, another aspect of technology in urban mobility is to provide travel information services to ensure that the urban mobility service is attractive, affordable and accessible to achieve sustainable and integrated smart urban mobility (Lyons, 2018).

Planning has shifted from being a technical focused field to being placed within dynamic political institutions where different stakeholders are involved in influencing and informing the decision-making processes focused on the broader aspects of spatial formation (Schmitt and Wiechmann, 2018). According to Seto et al. (2014) successful implementation of spatial planning depends largely on institutional capacity and political will to ensure that there is alignment between different policy instruments (Seto et al. 2014). At the local government level, spatial planning focuses primarily on the land use planning to regulate land use in a manner that contributes and promotes sustainable development and inclusive urban growth (Koresawa and Konvitz, 2001:11). Antoson and Carlson (2018) argues that governmental institutions particularly at the local level face the challenge of responding to the emerging technology of electrical vehicles due to the absence of political will to introduce new planning policies that can clearly link different aspects of the urban form to facilitate the introduction of electric vehicles (Antoson and Carlson, 2018).
City governments are recognized as the main actors in implementing spatial planning frameworks that could be used to facilitate the transition towards electric vehicles and to ensure that there is sustainable development (Asarporta and Nadin, 2020). Institutional arrangement is required to ensure that the role of spatial planning is recognized within the context of the transition towards electric vehicles, this clear institutional arrangement will also enable urban planners to respond collectively to the emerging technology of electric vehicles which has the potential to promote sustainable urban transportation (Zhao and Pendlebury, 2014).

Studies have shown that electric vehicle adoption depends considerably on availability and accessibility of charging infrastructure, in several studies models were used to identify the optimal location for the placement of the charging infrastructure focusing largely on areas that have high demand for charging. The demand aspect of the models projects the distribution of electric vehicle charging stations (He et al. 2022). In countries such as China, the local government has taken efforts to introduce policy measures to guide the deployment of the charging infrastructure where it is a requirement to integrate charging points in commercial and residential areas, the local government is responsible for

the selection of urban space suitable for charging stations and new city areas often act as designated application areas for placing the charging infrastructure (Lauer and Liefner, 2019).

3. Methods

A case study research approach was used to gain a deeper understanding of a complex issue within its natural setting. Furthermore, case study research does not always provide a representative sample and it tends to be researcher focused (Cousin, 2005). Using the city of Tshwane as a case study, a qualitative research approach was applied in this research study. Researchers use qualitative research methods to study the social phenomena in its natural settings, this include and is not limited to focusing on individual perspective or how individuals experience aspects of their lives, furthermore, researchers are the primary data collectors in a qualitative research study (Teherani et al. 2015).

Using non-numerical data, qualitative research attempts to make sense of social life by studying targeted populations or places. The qualitative research approach was adopted to get insights into the transition towards electric mobility from a spatial planning perspective.

4. Data Collection and Data Analysis

The study relied on secondary data from literature review since the concept of electric vehicles is still considered to be new and not fully researched in the broader aspects of the spatial planning field. Primary data was collected in the form of in-depth interviews. Interviews were conducted with 15 participants in which 12 were from the city of Tshwane urban planning department and 3 were private developers. The interviews were conducted mainly via the Microsoft teams platform.

The researcher transcribed the spoken words from the initial interview into written text. The text was subsequently categorized based on emerging concepts to recognize shared patterns and connection, including emerging patterns. The initial interview served as a foundation for extracting significance and gaining insights into emerging thematic key areas which were then further explored through subsequent interviews.

In the literature review, the researcher primarily examined up to date research relating to electric mobility and sustainable mode of transport, the researcher further explored studies investigating the integration of land use planning with transport planning as well as research focusing on electric vehicles and its infrastructure particularly in the urban space. Concepts such as smart city, smart mobility and electric vehicles were explored in this study. Theoretical frameworks covering theories on innovative mobility, spatial planning and socio technical changes were explored in this research.

From a policy perspective, the researcher reviewed municipal spatial planning frameworks and associated urban planning policies to explore how electric vehicles and its charging infrastructure is integrated to provide urban planners with insights and guidance on effectively responding to this emerging technology of electric vehicles. In terms of policy analysis, problem analysis was explored to identify the problem associated with current urban planning policies promoting electric mobility. Currently there is a lack of well-defined national and local policies that can assist urban planners in effectively addressing the sustainable integration of electric vehicles in their planning guidelines, consequently this absence of clear policies has led to a lack of coordinated efforts among urban planners in responding to the emerging technology of electric vehicles.

5. Results and Discussion

This section will focus on summarizing the key findings of the research paper without going into excessive details. The findings are presented based on key thematic areas and figures to present the data effectively.
In this section, the primary focus is on analyzing the spatial context of electric mobility and its charging infrastructure, furthermore, the study examined the associated policies related to electric mobility using the city of Tshwane as a case study. The research findings indicate that there is inadequate attention given to spatial aspects when planning for electric mobility and its charging infrastructure, this affects the effective coordination of efforts among urban planners.

5.1. Policy as one of the instrument promoting innovation

In the case of the city of Tshwane, it was revealed that the city's spatial planning frameworks are not clear on electric vehicles and its impact on the spatial formation, in the absence of clear policies, the city of Tshwane urban planning department plays a minimum role in facilitating the transition towards electric mobility which might result in unintended consequences such as lack of inclusive access to the charging infrastructure and lack of inclusive access to electric mobility for all residents of the city.

Without clear policies on the aspects of spatial planning and electric mobility, urban planners remain unprepared to respond collectively to the emerging technology of electric vehicles and to manage its impact on the urban form. The private sector is currently installing charging stations without clear regulations from the city of Tshwane, in this case the private sector is ahead of the planning policies. Given the emerging technology of electric vehicles, new ways of thinking and engaging need to inform the development of proactive policies to provide clear guidelines and mandates to assist the city of Tshwane to achieve the objectives of smart city and inclusive city. One of the interviewee mentioned that " Currently there is lack of national policy frameworks on electric vehicles which affects the respond at the local government level to the emerging technology of electric vehicles, the lack of national policy framework also affects the officials of the city of Tshwane to respond to the emerging technology in a coordinated manner".

5.2. Spatial knowledge

The emergence of electric vehicles is considered to be new and there is little knowledge about it from a spatial planning perspective. Focus on future mobility is not yet a mainstream subject in the discipline of urban planning, therefore there are no clearly defined objectives, principles and regulations for the emerging future mobility. Spatial planning is one of the key policy instrument that could assist in transitioning the urban transport system through recognizing urban interactions and promoting sustainable transport systems to effect sustainable and inclusive urban communities, however, the role of spatial planning in transitioning urban mobility transport system is often doubted and worsened by the weak relationship between the urban form and the transport planning, furthermore, several studies indicate that it is not clear enough whether changing the urban form through integrating the transport planning will result in the desired sustainable urban transport system (Storme et al. 2021).

The manner in which the transport network is developed and operated will have an impact on the spatial formation. The spatial formation connects the urban infrastructure and urban activities, the connection between the spatial formation and the transport network needs to be clear in the emerging technology of electric vehicles, this connection and knowledge will inform the spatial planning frameworks to facilitate and manage the transition towards electric vehicles in manner that is inclusive and sustainable.
The new spatial formation to facilitate the transition towards electric vehicles should be centered on public transport systems which is considered to be more sustainable mode of transportation than private vehicles. During the interview, one of the participants highlighted that "there is limited understanding regarding the efficiencies and the spatial connectivity of newly developed electric vehicles, however, it was mentioned that it is important to organize the spatial layout in a way that supports the transition towards electric public transport systems to assist the city of Tshwane in achieving the objectives of inclusive and sustainable city". The transition towards electric mobility can be a catalyst to support sustainable spatial development because the transport system cuts across the objectives of social, economic and environmental aspects of the urban environment.

5.3. Spatial distribution of electric vehicles and its charging infrastructure

The spatial distribution of electric vehicle charging stations is often unforeseen as the result of the actions taken by private sectors. The private sector individuals select the areas where the charging stations should be placed without clear guidelines or regulations from the city of Tshwane urban planning department. Figure 2 presents the areas where there is an emergence of electric vehicle charging infrastructure, charging infrastructure for electric cars can be found in the areas of the Lyttleton Municipal Offices and the TMPD logistics offices in Bosman Street (the Cities Green Transport Programme, 2015). Currently, the exact number of charging stations is not clearly defined since these areas are considered experimental grounds for deploying electric vehicle charging infrastructure.

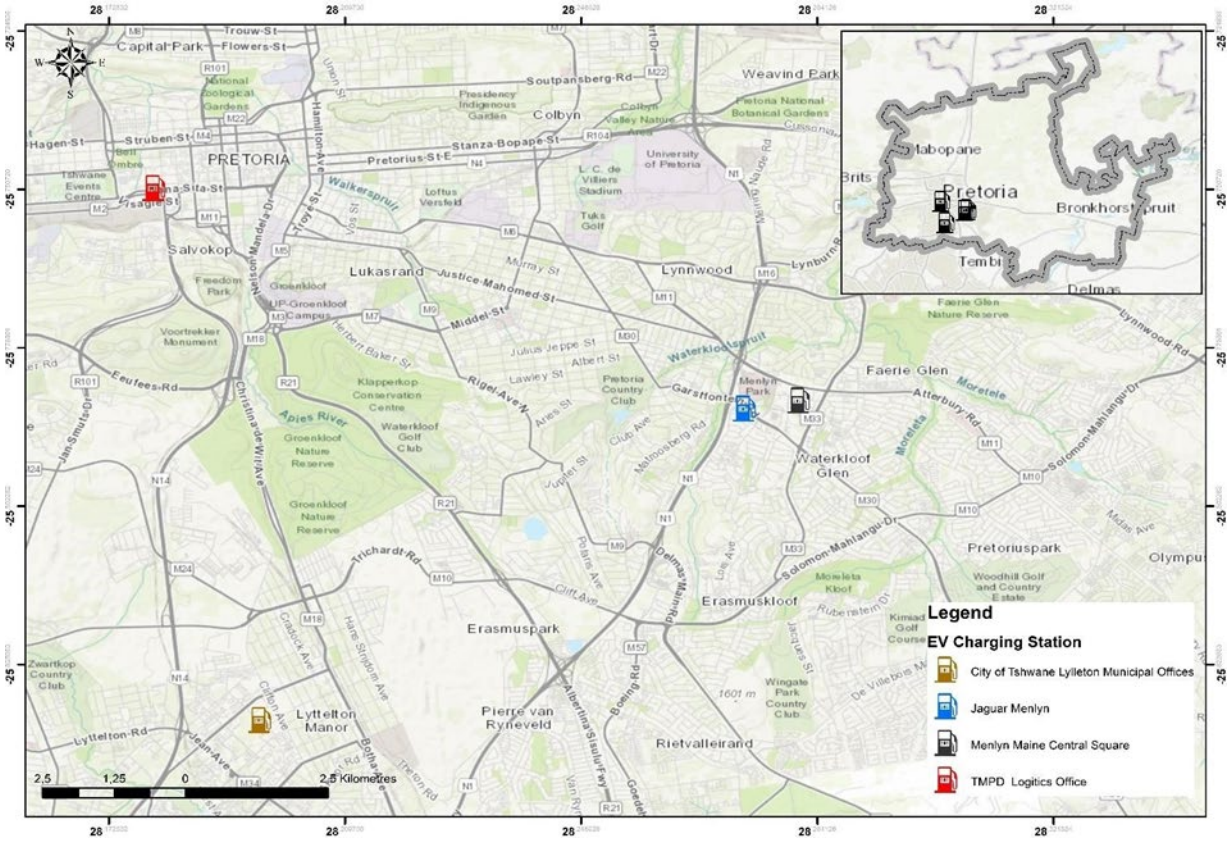

Figure 2: Areas in the city of Tshwane with access to charging stations

The above figure 2 illustrates the areas where the charging infrastructure is placed in the city of Tshwane. The charging infrastructures can be found at public areas such as parking lots and municipal offices. The placement of the charging infrastructure forms part of the city of Tshwane sustainable mobility initiative. There is an optimistic view that the city of Tshwane will utilize these charging stations to stimulate additional investments ultimately benefiting the public as a whole.

The number of charging stations are still limited at the moment given that the technology of electric vehicles is still considered to be new in the city of Tshwane, however, the placement of charging stations should encourage inclusive and sustainable adoption of electric mobility.

Arc GIS mapping tool was employed to cluster the charging stations and provide an overview of the areas where charging infrastructure is placed using secondary and primary data from the city of Tshwane online newspaper article, inputs from certain individuals in the study and on-site visits. The aforementioned map can be improved by incorporating additional insights on charging station areas and further deployment of electric vehicle charging infrastructure.

Figure 3: Charging station found at the parking lot of the Menlyn Maine shopping mall

Above charging infrastructure can be found in the parking space of the Menlyn Maine mall, located in the eastern suburb of the city of Tshwane. The spatial distribution of charging stations is not yet mapped, however, it is often argued that placing the charging infrastructure at strategic locations such as shopping malls parking lots promote awareness about the transition towards electric vehicles (see Figure 3). During the interview, one of the participants mentioned that "the issue of electric mobility is not yet prioritized by both the local and national government, therefore in the absence of regulations and associated policies, the placement of the charging infrastructure is based on mutual agreement between the private developer and the owner of the property".

In previous studies, access and placement of electric vehicle charging stations is not fully researched and understood within the context of spatial analysis. What seems to be emerging in recent studies is an attempt to address the spatial distribution of electric vehicle charging stations to ensure that there is equitable infrastructure placement. A fair distribution of electric vehicle charging station require a holistic, integrated spatial analysis that involves clear understanding of different socio-economic factors at different geographical scales to ease the process of electric vehicles infrastructure planning across all sections of the cities. The concept of spatial justice is important to inform policies that promote sustainable development in the transition towards low carbon energy (Wójcik and Jeziorska-Biel, 2023).

The private sector is taking the lead in installing charging infrastructure without clear engagement with the urban planning department and without clear regulations, some of the urban planners have limited awareness of the charging station locations.

5.4. Lessons learnt from the study

Electric vehicles are acknowledged as sustainable mode of transport and should be integrated into urban planning guidelines and associated policies to facilitate the shift towards electric vehicles, these vehicles are gradually replacing internal combustion vehicles. A systematic approach to transport planning is necessary, this approach should consider the integration of transport planning and land use planning, transport planning in relation to land use planning should be clearly connected to facilitate inclusive and sustainable urban environment.

The primary emphasis on electric mobility lies in its environmental benefits of climate action, while the social and economic dimensions are still under exploration, however, it is recognized that the social aspect which entails providing equitable access to opportunities can be attained through integrating urban and land use planning with transport planning, electric mobility can act as a catalyst to facilitate spatial sustainable development. The arrangement of the physical space can be redesigned in a way that facilitates and supports the deployment of technological changes

in urban mobility, there should be a clear integration of transport systems with urban activities in the transition towards electric mobility.

At present, the technology and infrastructure for electric vehicles is advancing faster than government regulations, creating uncertainty regarding the impact of this technology on urban spatial structure and interactions. The integration of electric vehicle technology with land use planning should be aligned with the goal of promoting sustainable mode of transportation and fostering inclusive and sustainable communities.

Urban planners can play a crucial role in facilitating the adoption of electric vehicles and its charging infrastructure by designating appropriate areas for charging stations, the designated areas should support and promote the sustainable mode of travel. Urban planners can support the incorporation of electric vehicle charging infrastructure into existing transport networks. Urban planners can also use data on transport patterns and charging behavior to collaborate and inform policymakers to develop regulations that promote the adoption of electric vehicles and its infrastructure in an inclusive and sustainable manner. Transitioning towards electric mobility necessitates a shift away from transport planning that primarily favors private vehicles to planning that favors public transport mobility networks, public infrastructure should for public transport planning should be the starting point for transitioning towards electric mobility.

Urban planners can potentially work with private companies to establish partnerships to co create new planning approaches for the installation of charging stations, this partnership can assist in the successful deployment of charging infrastructure and contribute towards sustainable and low emission transport systems.

6. Conclusion

This study has sought to examine the involvement of urban planners in the transition towards electric vehicles. Technological change in urban mobility has the potential to influence or change the urban form and the urban interactions. The link between the urban formation and the transition towards electric vehicles is often not recognized due to lack of research which is also worsened by lack of clear planning policies. The spatial formation can potentially facilitate the transition of new urban mobility systems by connecting the new urban infrastructures and urban interactions through the use of advanced public transport systems, furthermore, having spatial knowledge has the potential to inform urban planning policies to ensure that the city of Tshwane meets the objectives of being a sustainable and inclusive city. Sustainable transport systems form part of sustainable urban cities, the transition towards innovative transport systems must be clearly integrated with the objectives of the city of Tshwane being an inclusive and smart city.

Through clear stakeholder engagement, new ways of thinking is required to respond to the emerging technology of electric vehicles, currently there is lack of coordination between various departments in the urban planning field which has the potential of resulting in poor planning for electric mobility. The private sector is emerging as the main actor facilitating the transition towards electric mobility. Since the technology of electric vehicles is still considered to be new, it is not yet clearly examined from a spatial form perspective. Urban planners are not yet prepared to respond to the emergence of electric vehicles and to respond to the potential spatial formation caused by these new innovative vehicles, furthermore, urban planners have unclear mandates in the transition towards electric mobility. The local government needs to have a clear understanding of this urban spatial transformation driven by smart city technologies to facilitate an inclusive and sustainable urban development. Proactive urban planning policies are required to manage the spatial patterns of electric mobility in a manner that is aligned with the objectives of sustainable urban planning and development.

The findings of the study can foster strong collaboration between private companies and urban planners, while also providing support for the establishment of regulations. These regulations would ensure that the deployment of charging stations follows the principles of stakeholder engagement to co create new innovative regulations that foster inclusive distribution of technological advancement.

Further research can build upon the findings of this study to identify and precisely articulate the challenges associated with the current urban planning approaches and policies promoting the progress of the electric vehicle deployment,

furthermore, the spatial implications of introducing the electric vehicles should be clearly defined to inform the policymaking processes.

Research can additionally examine the travel behavior of the electric vehicles and the geographical distribution of charging stations to assist urban planners in formulating clear future planning guidelines informed by the current existing charging behavior and location of charging stations. The current spatial distribution of electric mobility infrastructure can inform the connection between future land use planning and transport planning to shift away from private vehicle-based planning.

The study primarily concentrated on understanding the spatial readiness towards electric mobility within the context of the urban environment, paying less attention to the travel behavior of existing electric vehicles and charging stations, this limitation highlights the need for further investigation, additionally the research focused on electric mobility in terms of private electric vehicles.

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Biography

Desmond Nkopodi is a master's student at the Department of Urban and Regional Planning.

Trynos Gumbo is a Professional Planner and currently a Professor at the Department of the Urban and Regional Planning within the Faculty of Engineering and the Built Environment in the University of Johannesburg (UJ). He Holds a PhD from Stellenbosch University, South Africa as well as masters and honours degrees from the University of Zimbabwe (UZ), Zimbabwe. He has previously worked in the Africa Institute of South Africa of the Human Sciences Research Council as a research specialist and Acting Head for the sustainable development programme. Prof Gumbo has also worked as an international instructor in the urban management masters programme within the Ethiopian Civil Service University College (ECSUC) in Addis Ababa in Ethiopia. Before, Prof Gumbo had worked as lecturer and Head of Department at the National University of Science and Technology (NUST) in Zimbabwe. He has attended and presented at several national and international conferences and has published widely in a variety of research areas that include informality, housing, urban planning, development and management. His research interests include urban transportation planning and management, sustainable and smart cities development, housing and economic informality, green economy and renewable energy generation from waste and innovative building technologies and materials.

Thembani Moyo is an Urban Planner and currently Post-Doctoral Research Fellow at the Centre for Applied Research + Innovation in the Built Environment (CARINBE), within the Faculty of Engineering and the Built Environment at the University of Johannesburg (UJ). He holds a Phd in Urban and Regional Planning, as well as a Masters in Operations Management from the University of Johannesburg, South Africa. He has extensive experience in public policy formulation, transport planning, intergovernmental relations (IGR), local economic development (LED), and urban and regional planning practice and plan-making processes. He has served on various forums and scientific committees as a reviewer, facilitator, keynote speaker, and panel discussant. His recent academic publications leverage a combination of experimental and empirical approaches to study complex problems in the field of urban planning at the interface of Geographical Information Systems and Remote Sensing. His main areas of expertise include machine learning, digital twins/3D modelling, image data acquisition and processing techniques (satellite, aerial, and UAVs), automatic feature extraction for cadastral mapping and urban planning, among others. More specifically, his research focuses on the implementation of innovative geospatial and machine learning methods in support of urban modelling and cadastral applications.