Sustainable Urban Mobility in the Context of Smart Cities: How Utilization of Non-motorized Transit Improves Lives in Urban Areas

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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As we are nearing the end of the second decade in the twenty first century, a vast majority of the world's population live in urban areas and especially low- and middle-income countries are undergoing a rapid urbanization trend (UN Environment, 2016). This trend creates an irreversible burden on the local authorities in those countries, who are responsible for building and maintaining the transport infrastructure, as they struggle to adjust to this pace of expansion and building stress on the transportation infrastructure in those cities in terms of social, environmental, and economic challenges (Biyik, 2019). There is ever more increasing interest in improving the lives of people in the urban areas around the world through introducing non-motorized transportation (NMT) alternatives, that are safe and comfortable. Those methods are predominantly comprised of walking, cycling, and public transit in the urban mobility space. This research sheds light on the complex relationships between different stakeholders while promoting the NMT alternatives to achieve sustainable urban mobility. A strong connectivity with Actor-Network Theory (ANT) is established as the main underlying socio-technical framework. According to ANT, different stakeholders; people, city organizations, technologies and infrastructure, nature, and economic activities are the result, or effect of heterogeneous networks (Cressman, 2019). Additionally, the political effects of technology on the society in the context of sustainable urban mobility is explored.

Research Question and Methods

In parallel to the growing interest in improving the lives of people in the urban areas, introduction of non-motorized transportation alternatives, which are safe and comfortable, emerges as a more viable option. Those alternatives, if planned carefully, contribute significantly to the quality of life in the cities by improving the urban mobility along with social and

economic conditions in a sustainable manner. What are the complex relationships between different stakeholders while promoting the non-motorized transport alternatives to achieve sustainable urban mobility, and how the non-technological factors influence the ultimate goal of improving quality of lives in the context of a smart city? A documentary research method organized by the topic is utilized referring to a wide variety of research completed in the area of sustainable urban mobility and its implications in the social, economic, political, environmental, and health context. Actor-Network Theory is employed as the main underlying socio-technical framework.

Background

Technological developments, rapid urbanization, and economic rationale makes urban mobility an inevitable concept for city planners and administrators. In his research exploring the impact of sustainable transport and mobility on social development, Chakwizira (2019) discusses the strong links between transport infrastructure mobility and socio-economic development in South Africa. Properly designed, accessible, and inclusive transport infrastructure alternatives support the people in disadvantaged and marginalized neighborhoods to be able to access to the urban economic development in a stronger way. Better accessibility and increased sustainable mobility give more people access to qualitative urban environments where people meet and participate in the economy. It is critically important for the city residents to be able access to key socio-economic services at a reasonable cost, in reasonable time, and at reasonable ease as discussed in the article “Do Artifacts Have Politics?” (Winner, 1980) with the example of purposefully lowly built overpasses in Long Island, New York.

A smart city is defined as an efficient city, a livable city, as well as an economically, socially, and environmentally sustainable city (Buscher). The increased use of motor vehicles

globally on the back of rapid urbanization, increasing income levels, and formation of a new working class significantly improved the car ownership and caused higher carbon emissions due to the increasing hydrocarbon usage in those vehicles. Efficient ways of urban mobility also contribute to more pedestrian based alternatives, increased bicycle usage and wider public transportation access among commuters, which promotes the social and economic wellbeing of the users of those non-motorized alternatives. The improved mobility of people also helps improved health conditions and reduces cost of living, as well as improving overall comfort of people.

While the non-motorized transport alternatives are the most viable option in terms of sustainable urban mobility within the context of smart cities, there are a number of challenges faced during the implementation phase in reaching the desired level of pedestrian, bicycle, and public transit methods of transportation. In some cases, a more technicist camp of city planning engineers, due to their faith in cause-effect reasoning based on predictable phenomena associated with laws of nature, are likely to disregard the heterogenous aspects of the projects that might require attention to more sociotechnical effects on the society (Faulkner, 2007). Those social barriers are represented by issues related with self-esteem, personal security, and affordability (Chakwizira, 2019). In most parts of the developing world, such as countries in the Middle East, the bicycle usage and transportation by walking is mainly by two different groups. For those who cannot afford a private motorized vehicle, the bicycle or walking are main methods for transportation, while those with time and money for leisure activities, cycling is primarily a recreational activity (El-Geneidy, A., Diab, E., Jacques, C., and Mathez, A., 2013). One of the limiting factors in a social context is that in some of the developing countries, such as countries in Africa, based on habits dating to its colonial past, use of motorized transportation is often

associated with education, affluence and an elevated status in the society. Therefore, the general attitude towards non-motorized transportation, are often associated with the poor (UN Environment, 2016). Likewise, as per findings of the 2010 research by Roşca E., Ruscă A., Ilie A., and Ruscă F., the use of personal car is equivalent to a social status symbol and are seen as issues related with free movement and free choice in the Central and Eastern European countries. Another important factor is related with safety. Owning a private car is a major aspiration for people in Manila, Philippines as the non-motorized transport is often seen as inadequate and unsafe, which requires consideration of road safety as an important factor to achieve sustainable mobility. (Neyestani, p5).

Actor-Network Theory and Sustainable Urban Mobility

Achieving sustainable urban mobility inevitably requires a high degree of dedication and coordination by city planners and administrators. Despite the highly demanding technical requirements for the proper design and implementation, there are many other implications in the social, economic, political, environmental, safety, and health related space, which significantly outweigh the importance of technology related considerations, requiring a multi-dimensional approach (Speirs). Essentially, a collective and comprehensive approach will be required to understand those human and non-human actors interacting through heterogeneous networks.

In order to identify all the implications of non-motorized transportation alternatives within the context of sustainable urban mobility, this paper employs Actor-Network Theory as the STS framework. ANT is described as the interaction among people, institutions, and organizations. ANT considers both human and non-human elements equally as actors within a network (Cressman, 2019). In other words, the same analytical and descriptive framework is to be employed when faced with either a human, a text or a machine. In this research paper, the

framework between various actors in the context of urban mobility is laid out, while various relationships between the technological change and the behavioral and social practices of all the stakeholders that are closely impacted by those changes, are elaborated. The ultimate goal is improving the quality of life by emphasizing the relationships between the actors such as city planners and administrators, the public through interactions around social, economic, political, environmental, safety, and health factors (Del Pozo, P.B., Benito, P., Serrano, N., Marquess-Sanchez, P., 2016).

The ANT is often criticized for having an exclusive emphasis on empirical observation tools and therefore has methodological limitations in understanding the social experience outside the pre-established models and tools of social research. To remedy this, a more interpretive approach as emphasized by the concept of translation can be utilized (Cressman, 2019). More explicitly, urban mobility strategies can be considered at a broader interactive framework, through which every actor identifies other actors and arranges them in relation to each other to ensure a more heterogenous approach.

Additionally, many of the most important examples of applied technologies with political consequences are those that transcend the simple categories of "intended" and "unintended" altogether (Winner, 1980). These are instances in which the very process of technical development is so thoroughly biased in a particular direction that it regularly produces results counted as wonderful breakthroughs by some social interests and crushing setbacks by others. Therefore, it is of utmost importance to examine how those consequences are perceived by different social groups, in the context of politics related with technology. Societies choose structures provided by technologies that influence how people are going to work, communicate, and travel, over a very long time. As those choices are made, different people are differently

situated and possess unequal degrees of power as well as unequal levels of awareness (Winner, 1980). It is vitally important to give a serious consideration to those multiple factors that work in tandem with the technological solutions to add value in terms of improving the quality of people's lives.

Results and Discussion

Even though the ultimate goal of sustainable urban mobility is to improve quality of life, there are complicated relationships between actors that negatively or positively impact this intricate web. The technological change required to promote the non-motorized transport alternatives is perceived by the actors within social, economic, political, environmental, health, and safety contexts. Actor-Network Theory provides an excellent framework to elaborate those complex relationships between the technological change and the behavioral and social practices of the stakeholders that are closely impacted by those changes (see Figure 1). This methodical approach identifies the stakeholders involved in technological change and explains the relationships between these actors and actants by analyzing the heterogenous factors that are intertwined with this change in regard to the presence of both human and non-human actors.

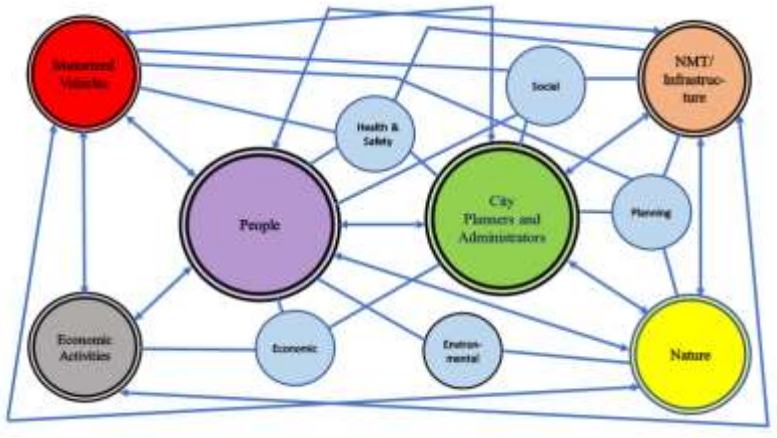

Figure 1: ANT Network for interaction of stakeholders: This network depicts the interactions between different actors and the influential factors as interconnected color-coded circles, where blue refers to the factors and other colors refer to different stakeholders. Two-headed arrows mean that both parties affect each other (Kutay, 2019)

In reaching the non-motorized transport alternatives, technological challenges are faced around infrastructure, information, planning, and time limitation. Enabling proper infrastructure is often seen as one of the most important factors to improve affordability and accessibility for urban communities. Non-motorized transport alternatives should be encouraged not only by providing the right infrastructure but also by ensuring that pedestrians and other users such as bicyclists, feel safe and secure in their environment while utilizing those services. As per the research (Biyik, 2019), the key message is that "switching much of the population to more active forms of transport for many journeys is entirely feasible, if such forms of transport are made accessible, comfortable, and can easily be integrated into the user's daily routine". The proposed technological solutions should be reliable and provide feasible remedies to the existing challenges as those solutions may require relatively radical changes not only in the habits in which people travel but also in the structure and organization of urban development. Therefore, timely user engagement has become an increasingly common practice among city planners, designers and many other professionals to harness the knowledge of communities by opening their processes to different stakeholders. Governments, businesses, civil society and academia work together to tackle complex problems in a more effective way - though often a more resource intensive and time-consuming process - insights are gathered from the concerned parties, besides building trust and gaining support in the solutions proposed. (Taborda, 2017).

Social Factors

Social dimensions are an important concern for sustainable urban mobility (Chakwizira, 2019). Lack of access and mobility prevents people from being able to break out of the cycle of social exclusion. South Africa's NMT Policy (UN Environment, 2016) is explicit that the policy should serve marginalized people, which it defines as women, the disabled, children, rural

communities, and the poor. The policy notes the all-encompassing role of transport in a society as a key indicator in social, political and economic development. Transport is not simply about mobility and infrastructure, but also about socio-cultural roles and responsibilities that impede the development of women and girls, including the impact on women and children accessing health services, educational facilities and employment, as well as participating in key decision-making forums. The public awareness and acceptability of the sustainable urban transportation and in particular of the non-motorized transportation are often biased from the adjustment of the social rules and cultural background as per the 2010 research by Roşca E., Ruscă A., Ilie A., and Ruscă F. Social acceptability is often influenced by the type of implementing various measures on the transportation alternatives, the encouragement measures being more popular than discouragement measures, which emphasize the importance of raising public awareness, ensuring interactive feedback and inclusive planning. The non-motorized transportation supports the social harmonization and inclusion, eases discrepancies and inequalities between actors in the society, and facilitates mobility of disadvantaged individuals to the economic activities in a stronger way employing a heterogenous approach for the actors in the network.

Economic Factors

Sustainable urban transport systems require a dynamic balance between the main pillars of sustainable development, namely economic, social and environmental aspects and considerations. As transportation projects tend to be expensive endeavors, financing of transportation projects becomes increasingly challenging. Whether for capital investments or ongoing operations, the issue of funding is always a concern for transportation authorities. (El-Geneidy, A., Diab, E., Jacques, C., and Mathez, A., 2013). The UK Government announced a £5 billion increase in funding for buses and cyclists recently. The system, which is already used in

parts of outer London, typically includes segregated cycle lanes, traffic calming, access-only streets for cars, and so-called pocket parks by the roadside. As per the government, this funding should help to improve air quality and drive down carbon emissions by supporting the transition to zero-emission vehicles; reduce fares and speed up journey times (Paton & Elliott, 2020). While the economic aspects of transportation and mobility related projects should be carefully analyzed before those expensive capital investments, the resulting economic impact on the users of sustainable urban mobility systems should also be considered. The use of private motorized vehicles may cause excessive congestion and carbon emissions, which result in hidden economic burden on the society. Use of non-motorized transportation actually achieves a sustainable social and economic growth by improving inclusion, accessibility and social mobility without forsaking affordability for various segments of society. Additionally, the local government's ability to attract private funding for innovative mobility projects also varies significantly. Establishing close partnerships between the public and private sectors to co-create innovative mobility solutions is a key principle of many cities' mobility strategies. Successful examples include City of Milan where the urban mobility projects have a combination of funding; internal government funding specifically intended for the required investments and grants from external stakeholders, whereby a healthy inclusive process is followed (Taborda, 2017). Ensuring diverse and inclusive sources of funding for the NMT projects increases the effectiveness of economic cooperation between the city administrators, people and economic activities as important actors/actants.

Political Factors

As every successful project, reaching a desirable and sustainable level of urban mobility requires political buy in from public administrators and municipalities (Neyestani). A high level of coordination among various policy makers to reduce motorized vehicle usage is a necessity.

Such coordination will ensure the strong messages to be disseminated to the people as a demonstration of the political will. Weak local governance (Biyik 2019) is usually seen as an obstructive factor for people not to use alternative ways of transportation such as walking, cycling and public transportation due to reliability, awareness or safety concerns. Public acceptability should be consistent with political acceptability in reaching the non-motorized transport alternatives. Shaping a critical mass of non-motorized transportation supporters could trigger support actions from the authorities (Roşça et al, 2010). Most cities have a reactive and passive response to regulatory barriers – particularly towards more disruptive innovations, as these explore new and unknown ground, which city authorities are not familiar with. Given that most regulatory frameworks are designed at a national or federal level, cities should also consider innovative ways to act within the boundaries of their institutional power. Several cities have been working with central governments, advocating for change at a national level. Equally, cities have also been creative in adapting their own rigid and bureaucratic processes (Taborda, 2017). Strong policy and regulation are needed to ensure that equal, if not greater, consideration be granted to vulnerable road users. "Governments need to take into consideration the needs of all road users when making policy decisions that impact road safety" (Speirs). This decisive and inclusive approach cements an effective coordination between the actors such as public administrators both at local and federal levels, people, and the NMT infrastructure as the key stakeholders in the network.

As proclaimed in his article by Winner, all technical artifacts have political qualities. In contrast to using the infrastructure development projects to alienate a certain disadvantaged group of people from accessing some parts of the city as seen in intentionally lowly designed Long Island overpasses by Robert Moses, the master builder of roads, parks, bridges, and other

public works from the 1920s to the 1970s in New York, it is possible to promote accessibility by facilitating dialogue, exchange of ideas, raising public awareness and education. The actions promoting transportation infrastructure such as the highways and bridges built by Moses to favor the use of the automobile over the development of mass transit continued to shape New York City for generations after Moses has gone. Therefore, political will with adequate public coordination and inclusive planning are fundamental requirements of successful sustainable urban mobility solutions.

Environmental Factors

Vehicle emissions are one of the leading sources of pollution. Emissions from cars compromise air quality affecting the health of all who live in cities. This pollution goes beyond harm at the local scale but also contributes to global climate change. The emissions directly harm those who must breathe them while indirectly harming everyone by contributing to air pollution. The heat generated from burning fossil fuels causes urban heat islands and the associated environmental problems. (Speirs) The new capabilities in reaching sustainable urban mobility through non-motorized transport alternatives rely on physical and digital infrastructure whose potential is only beginning to be realized. By supplementing urban planning and management practices with digital technologies, there is an opportunity to improve mobility services for citizens, while managing demand on physical transport networks and generating wider economic and environmental value along with the reduced carbon footprint. In the move towards a more sustainable transport, through a more effective management of demand, lower fuel and power consumption by vehicles and infrastructure can be achieved, leading to reduced transport-related carbon emissions, improved local air quality and related environmental conditions, along with reductions in congestion and traveler frustration. (Buscher) As per European Union Sustainable

Urban Mobility Plans in 2018, there is a great need to invest in new sustainable transport systems that can contribute to achieving Europe's climate targets and increase comfort and convenience for urban inhabitants. The complex relationships between people, nature, motorized vehicles and the NMT infrastructure, as the key actors in the network, need to be taken into consideration to be able to reach to urban mobility in a sustainable manner.

Health and Safety Related Factors

The environmental cost of motorized vehicles and their contribution to climate change is at a global scale. The emissions from the motorized vehicles has an adverse impact on air quality, which affects health, quality of life, and subsequently the attractiveness of cities. Fossil fuel use by motor vehicles generates substantial amounts of heat in the urban areas. Heat islands generate "thermal plumes" – artificial convection currents which suspend pollution and particulate matter creating dust domes over cities. These blankets of pollution, however, exacerbate heat islands by preventing outgoing radiation – particularly at night. Consequently, the ability of cities to cool is diminished (Speirs). The particles from the gas emissions irritate the eyes and ears, causing general annoyance for the lungs as one of the drivers of mortality from cardiovascular, respiratory, and other diseases. On the other hand, bicycle use is considered to be a physical activity of moderate intensity by World Health Organization. Non-motorized ways of transportation alternatives contribute positively to the levels of physical activity. A wide spectrum of research has been produced that demonstrates the encouraging effects of physical activity on individual health (Del Pozo, P.B., Benito, P., Serrano, N., Marquess-Sanchez, P., 2016). Motorized traffic is also noisy and unpleasant. Noise pollution has been shown to contribute to health issues such as sleep disturbance, cardiovascular issues, poor work and school performance, and hearing impairment. Research has exposed a link between noise pollution and

incidence of diabetes and hospital patient readmission rates. Noise pollution from traffic has even been linked to higher incidences of dementia among the elderly (Speirs). Along with health aspects, safety is another important factor that needs to be well coordinated with variety of actors within a sustainable urban mobility system. The design of transportation facilities can significantly affect traffic safety as the segregation of slow from fast traffic, careful design of intersections to maintain good sight distances, to reduce turning conflicts, and to channelize traffic to enhance predictability of flows can all reduce safety problems while improving operational performance. Poorly designed and improperly maintained separate cycle facilities lead to an increase in safety problems, particularly if there are many intersections or driveways crossing the cycle paths and sight distances are poor (Angira, 2013). Health and safety related factors play a critical role in improving quality of lives for people, and hence deserve a careful consideration while introducing technological solutions to the network containing people, city administrators, NMT infrastructure and motor vehicles.

The main goal of this research is to lay the framework between various actors in the context of urban mobility while elaborating different relationships between the technological change and the behavioral and social practices of the actors that are closely impacted by those changes. In line with the methodological norms of the Actor-Network Theory, which is used as the main sociotechnical framework, this paper relies on case studies and empirical observation undertaken by a wide array of research and therefore may not inspire a thorough understanding of the wider social values and norms that account for human experience outside of pre-established categories or models. The other limitation related with ANT is that it pre-assumes all actors are equal within the network and no adjustments for power imbalances were made such as potential domination of bureaucratic norms by the city administrators over the environmental

concerns for the nature, or economic limitations influencing over people's choices for NMT alternatives.

In order to further build on the findings of this paper, a more interpretive approach as emphasized by the concept of translation can be explored including how different entities in the network assign roles onto the others. As ANT relies on a variety of concepts including actors, networks, intermediaries and the elements of translation, the interaction and balances between those key elements are subject to change. Translation is an ongoing process as it is never permanent and may fail in some circumstances. The entry of new actors, the departure of existing actors, or changes in alliances can result in the 'black-boxes' (Rodger). Therefore, further research can be done examining all the strategies through which an actor identifies other actors and arranges them in relation to each other.

Conclusion

Consequently, successful integration of non-motorized transport alternatives as sustainable transport strategies, aimed at creation of a well-balanced transport system to improve the quality of people's lives, requires a thorough consideration of all the social, economic, political, environmental, health, and safety related factors and depends on the development of a sociotechnical construct to understand the complex relationships between those actors (Wallim, 2017). While the provision of physical infrastructure is fundamental to enable mobility at a safe and convenient manner, there are numerous sociotechnical factors that would influence sustainable urban mobility in a broader sense. Technology can provide some solutions to some of the challenges in achieving the results but evaluation of those other factors that work in lockstep with the technological progress will add value to the solutions in terms of improving the quality of people's lives in smart cities.

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