INTEGRATING INFORMATION AND COMMUNICATION TECHNOLOGY AS A SOLUTION TO SUSTAINABLE ROAD TRANSPORTATION IN SOUTH AFRICA

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ABSTRACT

Initiatives have long been taken to attain sustainable road transportation system across the world, including South Africa. Despite the various initiatives, sustainable road transportation in South African cities remains as a challenge. Therefore, this study, through a qualitative study, examined how sustainable road transportation can be achieved in South African cities. It is found that strengthening of public transportation system and effective integration of Information and Communication Technology (ICT) in socio-economic activities, and travel needs in particular, would be able to contribute significantly to sustainable road transportation. ICT Integration and its effective use will reduce need for travel, reduce traffic volume, and enable appropriate route planning, which consequently will reduce traffic congestion, traffic collisions, travel distance and travel time. It will also limit environmental pollution caused by carbon emissions from vehicles, thus contributing to sustainable road transportation.

Keywords: Environment; Information and Communication Technology (ICT); Road; Socio-economic activities; Sustainable road transportation; Travel pattern.

1. INTRODUCTION

Sustainable development and sustainable transportation do not have any universally accepted definitions. However, sustainable development can be construed as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It achieves continued economic development without being detriment to the environmental and natural resources (WCED 1987; Themes Sustainable Development, 2004; Center for Sustainability, 2004). Similarly, sustainable transportation can be interpreted as a system that allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and

ecosystem health, and with equity within and between generations. Specifically, it is a system that is affordable, operates efficiently, offers choice of different transport modes, and supports a vibrant economy. Besides, it also limits carbon and other polluting matter emissions and wastes within the planet's ability to absorb them, minimizes consumption of non-renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise (Litman, 2003a; CST, 2001; Transportation Research Board, 1997). Consequently, transportation and sustainable development are inextricably interlinked. Therefore, since the establishment of the concept of sustainability, it has been the planner's priority to come up with innovative ideas that will lead to sustainable development.

Development of sustainable cities is a challenge because they are considered as wicked problems, which does not have any specific solutions (Rittel and Weber, 1973). With regards to sustainability of cities, many look at the concept of sustainability from the environmental point of view. They argue that the system in place may have missed the direction to the world's priorities, consequently resulting in the ecosystem not surviving the depletion of non-renewable resources (Sitarz, 1993; Walters, 2008). However, there are several other attributes of cities that contribute to sustainability, and among those road transportation is one of the major attributes (Thynell, Mohan and Tiwari, 2010). Sustainable road transportation is an imperative and integral part of the sustainable development in a society (Thynell, Mohan and Tiwari, 2010).

Over the years, various initiatives towards achieving sustainable road transportation system that include controlling car use, integrated rapid transit, and increasing the opportunities for cycling and walking, to name few have been undertaken (Thynell, Mohan and Tiwari, 2010; Tiwari, Cervero, and Schipper, 2011). Furthermore, car sharing, congestion pricing, and energy efficient low carbon mobility systems have also been attempted (Adler and Blue, 1998; Bajpai, 2015; Hameri, and Paatela, 2005; Kanninen, 1996; Ng, Barfield, 1995; Thynell, Mohan and Tiwari, 2010). Nonetheless, the question still remains, whether sustainable road transportation can be attained by such policy interventions. In this regard, it is evident that despite such measures, many European and Asian countries are faced with socio-economic, environmental and road infrastructural challenges. For example, cities like Stockholm and Delhi could not succeed in alleviating their mobility anguishes in recent years (Thynell, Mohan and Tiwari, 2010). Similarly, cities of Africa, particularly in South Africa are no exception (Emuze and Das, 2014). So, alternative arguments have emerged that significant use of ICT can contribute significantly to alleviate the road transportation related challenges and contribute to sustainable road transportation in South Africa (Emuze and Das, 2014). Thus, the objective of this paper is to explore the concept of sustainable road transportation from different perspectives, and to assess how sustainable road transportation can be achieved, particularly by integrating the use of ICT in the socio-economic and travel activities of people and in the transportation system in South Africa. The study was conducted by using an enticing mix of literature review and case study analyses from across the globe, as well discussions with experts in the sustainable development, ICT, road transportation and related fields. Findings suggest that there is ample potential for integration of ICT in socio-economic and travel activities of people in South Africa. ICT can engender positive changes in the way

socio-economic activities are performed, and in the travel pattern of people, such as reduction in unnecessary use of privately driven vehicles, reduction in trips generation, and reduction in travel distance and time. In addition, it can also provide real time information to people, which can assist in appropriate trip and route planning and avoid congestion and delay. Consequently, pressure on vehicular transportation, road infrastructure and environment can be alleviated, which can contribute to sustainable road transportation in South Africa

2. STUDY METHODOLOGY

The study follows an inductive explorative qualitative approach with a mix of literature review, case study analysis and qualitative discussions with experts. Relevant literature coinciding with sustainable road transportation in general with particular emphasis on developing countries including South Africa, and other developed cities across the world were collected from peer reviewed journals, books, conference proceedings and research and technical reports. For this purpose, literature data bases such as Science direct, Scopus, Google Scholar, different sustainable development and transportation related websites, research and technical reports, etc., were searched and relevant articles were collected. The literatures were screened based on their relevance to the study and classified under different categories. After classification and categorisation of the collected literature, relevant articles concerning to sustainable road transportation and influence of ICT in road transportation were selected and critically analysed. Furthermore, different case studies that highlight the concept of sustainable road transportation from across the world, specifically from developing countries were also reviewed and analysed. In this context, a number of cities across the world, such as Singapore, Curitiba, Surabaya, Stockholm, Delhi, etc., which adopted the concept of sustainable road transportation were specifically analysed to reflect on the concept of sustainability in road transportation, indicators of sustainable road transportation, implications of sustainable road transportation, challenges against sustainable road transportation, and strategies adopted for attaining sustainability in road transportation. Moreover, a number of experts from the field of urban planning, transportation planning and ICT were consulted to get insights to the challenges and solutions for sustainable road transportation. The experts include academicians, personnel engaged in urban and transportation planning, officials belonging to Municipalities, consultants and ICT professionals. Initially the experts and professionals were identified based on their professional activities and association with sustainable development and transportation activities. They were contacted through personal contacts for their willingness to participate in the discussions. The discussions were conducted with 16 willing participants through non-structured semiformal interviews. The view points and opinions from different experts and professionals were compiled through a snowballing approach over a period of time from the years 2014 to 2016. However, while conducting the discussions anonymity of the identity of the experts and professionals have been kept because of the reservations shown and requests made by some of them to do so.

3. SUSTAINABLE DEVELOPMENT AND SUSTAINABLE ROAD TRANSPORTATION

Sustainable road transportation is considered to be an imperative part of sustainable development and both are complementary to each other. However, difficulty is still evident in attempting to make sustainable development operational. Yet, the concept of sustainable development is important as it arouses central questions, such as: how to define intergenerational equity; how to indicate quality of human life; how to maintain global life-support systems; how to value multifunctional natural resources; how to bring an end to global inequity; and how to design institutional frameworks for change, to name a few prominent aspects concerning sustainable development (WCED, 1987; Gudmundsson and Höjer, 1996). Solving all these questions at the same time is almost impossible; however, they remain vital to attain sustainable development.

According to the literature, three key elements where used to explain what is meant by sustainable development, which include: (1) there is a limit to the scale of the economy, which is set by the need to sustain the cawing capacity of the ecosystems and resources of the globe; (2) a fair distribution of resources and output from the economy within and among generations of humans should be considered; and (3) within the restrictions of the two mentioned elements, analysis should be concerned with a socially efficient allocation of resources, maximising net benefits as is the case in traditional welfare economics (Jansson et al., 1994; Robert, et al., 2002). Besides, according to Haughton (1999), there are five equity principals which are central to sustainable development and among these principals, procedural equity is considered pivotal. This procedural equity is needed to ensure that all people have a legal right, safe and healthy living and work environment that they are treated fairly and more importantly they can engage in the decision making processes concerned with the urban centre they live in (Haughton, 1999). On the other hand, environmentalists also have their view about sustainable development. They emphasise that environmental problems need to be addressed before sustainable development goal can be met. The challenges which need to be addressed include: controlling infectious and parasitic diseases; reducing chemical and physical hazards within the home, workplace and wider city; achieving a high-quality city environment; minimizing the transfer of environmental costs to the inhabitants and ecosystems surrounding the city; and sustainable consumption (Satterthwaite, 1997). With all the elements being highlighted and argued upon to be critical for sustainable development, apparently sustainable development doesn't have any universally accepted definitions. However, it can be interpreted as: it achieves continued economic development without being detriment to the environmental and natural resources (WCED 1987; Connor and Dovers, 2004; Johnson, et al., 2004).

Sustainable transportation has long been argued to be a critical and integral part of sustainable development, particularly in cities, as unsustainable transportation can cause both socio-economic and environmental challenges, jeopardising the sustainability of cities. So the attainment of sustainable transportation remains a paramount concern. Sustainable transportation systems can be interpreted as systems that allow the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations. It is a

system that is affordable, operates efficiently, offers choice of different transport modes, and supports a vibrant economy, while limiting emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources to the sustainable yield level, reuses and recycles its components, and minimises the use of land and the production of noise and pollution (Litman, 2003a; Transportation Research Board, 1997). In other words, sustainable transportation reduces short and long term negative impacts on the local and global environments; has economically viable infrastructure and operation; and provide safe and secure access for both people and goods (Beaudoin et al., 2015; Bongardt et al., 2011; Dalkmann and Huizenga, 2010). Thus, sustainable transportation influences spatial configuration, economic vitality and environmental quality of a region or city (Cervero, 2009; Deakin, 2001). Therefore, it is highly imperative to attain sustainable transportation in order to realize the goal of sustainable cities.

3.1 Sustainable road transportation in South Africa

Sustainable road transportation has been observed to be a critical challenge in Africa including South Africa. The challenges of both mobility and accessibility still remain. Some of challenges include lack of public transportation, traffic congestion, vehicular accidents and poor traffic safety, predominant use of privately driven vehicles, high travel time and environmental pollution, because of use of fossil fuel, etc.[1] Similarly, although improved access in urban areas by means of sustainable road transportation remains an essential goal, the question remains: are the current policy measures such as modernisation, creating new and additional road transport infrastructure, bus rapid transit system (BRT), or introduction of energy or congestion tax answers to attain sustainable road transportation in the cities. If it is so, despite the systems available why many European countries are struggling to reduce carbon emission and worried about its impact on climate change and why cities like Stockholm and Delhi could not succeed in alleviating their mobility anguishes (Zanella et al., 2014; Scheiner and Kasper, 2003). Similarly, scholars, like Emuze and Das (2015) argued that challenges of sustainable road transportation in South African cities emanated from multiple factors. For instance, the need to perform urban functions conjoined with lack of ICT use to perform socio-economic functions at a larger scale necessitate the need for travel. The need for travel and lack of adequate public transportation facilities forces for higher volume of individual driven cars on the roads. Higher volume of vehicles on roads cause traffic congestion, traffic collisions and vehicular carbon emissions and pollution, thus leading to unsustainable road transportation. Also, arguments have emerged that land use and urban form and availability of social and economic urban functions influence accessibility through encouraging or discouraging use of vehicles to destinations[2], which could cause traffic collisions as more an individual travel, the higher the chance of being involved in a traffic collision (Handy, 1996). Consequently, traffic safety and congestion remain to be important parameters for sustainable road transportation (Das, 2014).

[1] Experts in sustainable road transportation and transportation planners
[2] Experts in urban development and planning

However, like other parts of the world, the African continent, including South Africa, has also been active in adopting the concept of sustainable development. Consequently, initiatives have been taken to adopt sustainable transport framework for a transition to sustainable road transportation, with a view to boost the use of sustainable fuels, to reduce greenhouse gas emissions through use of low-emission and curb air pollution, to improve road safety, to encourage non-motorised transport, and foster quality of public transport and to invest in clean technologies including the use of ICT (Schneider, 2013). However, the most critical challenge is to change the perception of unnecessary vehicle use[3]. Banister (2008) argues that the idea of discouraging unnecessary use of vehicles is not to prohibit the use of cars, but rather to design cities with quality and with an acceptable scale, so that people do not have the need to use cars very often. It is believed that cities can be improved and emissions can be reduced if other modes of transportation are prioritised and are encouraged, as well as by using ICT to perform urban functions without the need of travel[4]. Local authorities can achieve this by creating dedicated lanes for public transportation, and improving pedestrian facilities to reduce the need of vehicles, thus reducing emissions, as well as reinforcing efficient movement (Grazi and Van den Bergh,2008; Huwer, 2000) and encouraging to use ICT to perform functions without making any physical vehicular travel[5]. Some of the South African cities (e.g. Johannesburg and Cape Town) have adopted some of these strategies. They have accepted the sustainability challenge and have started employing some sustainability guidelines to improve their sustainable road transportation status. For example, they have integrated BRT and attempted to make public transportation reliable and encouraged the use of electronic trains in their public transportation system with the amalgamation of technological solutions (ICT, ITS, etc.) (Venter, 2013).

4. ENGENDERING SUSTAINABLE ROAD TRANSPORTATION: PLAUSIBLE AVENUES

Since the concept of sustainability has been adopted on a global scale, planners have identified plausible indicators to be assessed in order to achieve the goals of sustainable road transportation. Sustainable road transportation is an ambiguous issue and there is no unequivocal definition. Many international organizations, such as (EU, Eurostat, EEA, UN and WHO) argue that indicators of sustainable road transportation should be based on representative geographical or political systems (Dobranskyte-Niskota et al., 2006). Accordingly, a set of indicators have been proposed and developed based on economic, social, and environmental attributes (Emberger et al., 2008; Haghshenas et al., 2015; Litman, 2007; May et al., 2005; Zhao, 2009). Consequently, the various important indicators to measure sustainable road transportation envisaged include fossil fuel consumption and CO_2 emissions, vehicle pollution emissions, per capita motor vehicle mileage, traffic collision injuries and deaths, transport land consumption, roadway

[3] Experts in transportation planning and urban development
[4] Experts in urban development and ICT
[5] Experts in urban development and ICT

aesthetic conditions, etc., (Litman and Burwell, 2006; Sietchiping et al., 2012; Thynell et al., 2010).

However, it is also implicit that in a city, urban activities, land use and road transportation system are complementary to each other. So, the concept of sustainable road transportation in an urban area is governed by different indicators which include among others, accessibility to- and quality of public transportation, level of congestion, level of carbon emissions and polluting matters, road utilization, facilities for pedestrian movement, traffic collisions, etc., (Haghshenas et al., 2015; Zhao, 2009). Thus, based on these indicators some scholars have advocated that the sustainable road transport policy should tackle rising levels of congestion, noise and air pollution, encourage use of more environmentally-friendly modes of transport, use of higher public transportation, reduction of traffic collisions and use of ICT to reduce travel needs (Dobranskyte-Niskota et al., 2007; Emuze and Das, 2015; Haghshenas et al., 2015). However, in this study two important parameters, such as priorisation of public transportation system and use of ICT are stressed.

4.1 Prioritising public transportation

Public transport has a significant role to play in enhancing urban mobility, reducing road congestion, contributing positively towards our environment by decreasing emissions and improving the living conditions[6]. In many cities, a high proportion of all trips on public transport are provided by informal private sector services. By the end of 1980s, the informal sector had between 40 and 80 percent share in public transport in most capital cities of sub-Saharan Africa (Newman, 1999). The population keeps increasing, and simultaneously car ownership in some South African cities, which simply indicates an investment in roads or adding new infrastructure will not be the only solutions that must be implemented[7].

Evidences from most cities in Africa, Asia and Latin America, revealed that growth in the supply of public transport by the formal sector is slower that the population growth, and the deficit in the supply of services is further widened because the larger the city grows, the greater the average length of travel (Newman, 1996; Walters, 2008). So, the world's wealthiest cities such as Los Angeles, Zurich and Singapore have taken measures to reduce their citizens' dependence on private automobile. Further, public transport in developing countries is also generally characterized by a lack of adequate financial resources, which creates challenges for development of adequate and relevant infrastructure and also for operation of the public transportation system effectively. One of the major reason for the lack of availability of adequate fund for public transportation is that the demands of affordable housing, education and health services are just so great that they limit the amounts that can be set aside for public transport development and support. However, some cities have proved that lack of financial resources must not be the factor

[6] Experts from urban and transportation planning

[7] Experts in urban and transportation planning

that stops cities to develop public transportation (Walters, 2008). Examples from different cities across the world offer evidences of sustainable public transportation that could assist in attaining sustainable road transportation.

4.1.1 Singapore and Hong Kong

Cities such as Singapore and Hong Kong had challenges of dependence on individual privately driven automobiles. However, they focused on providing public transit. Consequently, these two cities have a successful transit system and very low car usage. These cities have fixed transit systems, which are rapid and comfortable and flexible, supplemented by non-motorised means of transport such as walking and cycling reinforced sustainable road transportation (Newman, 1999).

4.1.2 Curitiba

This city in Brazil has proved that it is possible to minimise the cost of public transit, while investing to make it a preferred choice over private automobile use. Evidences suggest that prioritising public transit has brought several advantages, which include lowest collision rates per vehicle, considerable savings for inhabitants on expenditure on transport, and low cost fares across the city, thus contributing to sustainable road transportation in the city (Newman, 1999).

4.1.3 Surabaya

Surabaya has focused on providing non-motorised transportation facilities, which include bi-cycling and walking. For this purpose, the city developed a program aimed at improving housing, and infrastructure, with the emphasis on improving pedestrian facilities (Newman, 1999).

Thus, the success stories' evidence is that the public transportation system is a major driver for sustainable road transportation. In South Africa, based on the White Paper on National Transport Policy of 1996 (Walters, 2008; Newman, 1999) and the 20-year Moving South Africa Strategy (Department of Transport, 1998), significant interventions should have taken place and are being accelerated to improve public transportation in the country, which is in fact a relevant and essential step towards attaining sustainable road transportation in its cities.

4.2 Integrating ICT with road transportation

There is a consensus among professionals that ICT can contribute significantly to sustainability improvement in cities. Various attributes of ICT- extensibility, trackability and intelligence, will enable to speed up and expand spatial interaction, develop tracks and steers on vehicles and goods and also speed up data retrieval, processing and steering (Kenney and Curry, 2001; Black and Van Geenhuizen, 2006). Use of ICT in public transportation systems for scheduling, route changes and logistics information can change service quality for the better, resulting in increased public transport customers and ridership, due to cost effectiveness of public transportation. ICT solutions will also solve mobility problems experienced by the public transportation operators and their clients (Masinde, Bashingi, and Hassan, 2015). Further, Das (2014) emphasised that mobility in a

city is largely influenced by local accessibility, and travel needs. Availability and effective use of ICT infrastructure can reduce travel needs, as a large portion of the urban functions can be performed by use of ICT without the requirement of physical travel. Consequently, there shall be less trips and vehicles on the roads, which will contribute to reduce in vehicular volume and consequent reduction in congestion, environmental pollution and traffic collisions, thus assisting in attaining sustainable road transportation (Das and Emuze, 2014; Lombardi ,2011; Nijkamp, and Kourtik, 2011; Shapiro, 2008). Experts also believe that, with the stress on incorporation of ICT in the cities of South Africa, in particular, there is ample scope and opportunity for integration of ICT with road transportation, its higher use to perform socio-economic activities and during travel[8]. The experts opine that use of ICT during travel can assist in travel decisions, allow route planning, and optimise distance travel through real time information, which essentially will assist in reducing travel time and travel distance as well as environmental pollution[9], which is in line with the findings of different scholars as mentioned previously (Das and Emuze, 2014; Lombardi, 2011; Nijkamp, and Kourtik, 2011; Shapiro, 2008). Thus, if ICT is integrated with road transportation and socio-economic functions effectively in cities of South Africa, it will significantly contribute to sustainable road transportation.

5. CONCLUSION

Road transportation in cities of South Africa is observed to be a challenge. The challenges include the need for traveling long distance to perform socio-economic functions, congestion, traffic collisions, increased travel time, and environmental pollution on the wake of carbon emissions. So, there have been concerted efforts to achieve sustainable road transportation in the cities of South Africa. However, despite various initiatives, sustainable road transportation remained as a challenge. Therefore, this study explored the concept of sustainable road transportation from different perspectives, and examined how sustainable road transportation can be engendered in cities of South Africa. The study was conducted by using an inductive explorative method through qualitative literature reviews, case study analysis and discussion with experts. It was revealed that strengthening of public transportation system and integration of ICT in socio-economic and travel activities of people in South Africa are the two major avenues, which could assist to attain sustainable road transportation in South African cities. Particularly, it is revealed that there is a potential for integration of ICT in both socio-economic and travel activities and if it is integrated and used effectively it can change the way the functions are currently performed. Consequently, the travel pattern of people, such as reduction in unnecessary use of privately driven vehicles, reduction in trips generation, and reduction in travel distance and time can be attained. It can also through real time information to people, can assist in appropriate trip and route planning and avoid congestion and delay. Thus, pressure on vehicular transportation, road infrastructure and environment can be alleviated, which in turn can contribute to sustainable road transportation in South Africa. However, the study has certain limitations as it is based on purely qualitative study and

[8] Experts in ICT and urban development
[9] Experts in transportation planning and urban planning

opinions of experts. A more quantitative study would provide greater insights to the challenges and establish the interlinkage between sustainable road transportation and ICT use and public transportation, which is the further scope of this study and is being undertaken.

REFERENCES

Bajpai, JN, 2016. Emerging vehicle technologies & the search for urban mobility solutions. Urban, Planning and Transport Research, 4(1) p. 83-100. DOI: 10.1080/21650020.2016.1185964.

Banister, D, 2008. The sustainable mobility paradigm. Transport policy, 15(2) p.73-80.

Black, W. and van Geenhuizen, M. 2006, ICT innovation and sustainability of the transport sector. European Journal of Transport and Infrastructure Research, *6*(1) p.39-60.

Connor, R, and Dovers, S, 2004. Institutional change for sustainable development. Edward Elgar Publishing.

Das, D, 2014. Evaluation of Control Parameters for Smart Mobility in the Context of a South African City-A Case of Bloemfontein City. Proceedings of Planning Africa Conference 2014, p.138.

Das, D, and Emuze, F, 2014. Smart city perspectives of Bloemfontein, South Africa. Journal of Construction Project Management and Innovation, 4(2) p.930-949.

Department of Transport. 1998, *Moving South Africa Transport Strategy*.

Dobranskyte-Niskota, A., Perujo, A, and Pregl, M, 2007. Indicators to assess sustainability of transport activities. European Commission, Joint Research Centre.

Emberger, G., Pfaffenbichler, P., Jaensirisak, S. and Timms, P, 2008. “Ideal” decision-making processes for transport planning: A comparison between Europe and South East Asia. Transport Policy, 15(6) p.341-349.

Emuze, FA, and Das, D, 2015. Regenerative ideas for urban roads in South Africa, Municipal Engineer, 168(4) p. 209–219, http://dx.doi.org/10.1680/muen.14.00041.

Grazi, F, & Van den Bergh, JCJM, 2008. Spatial organization, transport, and climate change: Comparing instruments of spatial planning and policy. Ecological Economics, 67 p.630–639.

Gudmundsson, H, and Höjer, M, 1996. Sustainable development principles and their implications for transport. Ecological Economics, 19(3) p.269-282.

Haghshenas, H, Vaziri, M, and Gholamialam, A, 2015. Evaluation of sustainable policy in urban transportation using system dynamics and world cities data: A case study in Isfahan. Cities, 45 p.104-115.

Handy, S, 1996. Methodologies for exploring the link between urban form and travel behaviour. Transportation Research Part D: Transport and Environment, 1(2) p.151-165.

Haughton, G, 1999. Environmental justice and the sustainable city. Journal of planning education and research, 18(3) p.233-243.

Huwer, U, 2000. Let’s bike – The 10 point pedalling action programme to support cycling. World Transport Policy & Practice, 6 p. 40–45.

Jansson, A, 1994. Investing in natural capital: the ecological economics approach to sustainability. Island Press.

Johnson, K., Hays, C., Center, H. and Daley, C, 2004. Building capacity and sustainable prevention innovations: A sustainability planning model. *Evaluation and Program Planning*, *27*(2) p.135-149.

Kenney, M, and Curry, J, 2001. The Internet and the personal computer value chain. BRIE-IGCC E-conomy Project (eds.) Tracking a Transformation: E-Commerce and the Terms of Competition in Industries (Washington, DC: Brookings Institution.

Litman, T and Burwell, D, 2006. Issues in sustainable transportation. International Journal of Global Environmental Issues, 6(4) p.331-347.

Litman, T, 2003. Transportation cost and benefit analysis: Techniques, estimates and implications.

Litman, T, 2007. Developing indicators for comprehensive and sustainable transport planning. Transportation Research Record: Journal of the Transportation Research Board, 2017 p.10-15.

Lombardi, P., Giordano, S, Farouh, H and Yousef, W, 2012. Modelling the smart city performance. Innovation: The European Journal of Social Science Research, 25(2) p.137-149.

Masinde, M., Bashingi, N. and Hassan, MM, 2015. Possible Challenges of Integrating ICTS into The Public Transportation System in The Free State.

May, AD, Karlstrom, A., Marler, N., Matthews, B., Minken, H., Monzon, A., et al., 2005. Decision Maker's guidebook. <http://www.ivv.tuwien.ac.at/fileadmin/ mediapoolverkehrsplanung/Diverse/For-

Newman, P, 1999. Transport: reducing automobile dependence. *The Earthscan Reader in Sustainable Cities*, p.173-198.

Newman, P, 1996. Reducing automobile dependence. Environment and urbanization, 8(1) p.67-92.

Nijkamp, P & Kourtik, K, 2011. Joint Programming Initiative (JPI) on Urban Europe. Global challenges and local responses in the urban century. A scoping document, VU University Amsterdam.

Rittel, HWJ. and Webber, MM, 1973. Dilemmas in a general theory of planning, Policy Sciences, 4 p. 155-169.

Robèrt, KH., Schmidt-Bleek, B., De Larderel, JA., Basile, G., Jansen, JL., Kuehr, R., Thomas, PP., Suzuki, M., Hawken, P and Wackernagel, M, 2002. Strategic sustainable development—selection, design and synergies of applied tools. Journal of Cleaner production, 10(3) p.197-214.

Satterthwaite, D, 1997. Sustainable cities or cities that contribute to sustainable development? Urban studies, 34(10) p.1667-1691.

Scheiner, J and Kasper, B, 2003. Lifestyles, choice of housing location and daily mobility: the lifestyle approach in the context of spatial mobility and planning. International Social Science Journal, 55 (176) p.319-332.

Schneider, RJ, 2013. Theory of routine mode choice decisions: An operational framework to increase sustainable transportation. Transport Policy, 25 p.128-137.

Shapiro, J. M. 2008. Smart cities: quality of life, productivity, and the growth effects of human capital. *The Review of Economics and Statistics,* 88 (2) p. 324-335.

Sietchiping, R., Permezel, M.J. & Ngomsi, C, 2012. Transport and mobility in sub-Saharan African cities: An overview of practices, lessons and options for improvements. Cities, *29*(3) p.183-189.

Sitarz, D, 1993. Agenda 21: The earth summit strategy to save our planet.

Thynell M, Mohan D. and Tiwari G, 2010. Sustainable transport and the modernisation of urban transport in Delhi and Stockholm. Cities, 27(6) p. 421–429.

Tiwari, R., Cervero, R., and Schipper, L, 2011. Driving CO_2 reduction by integrating transport and urban design strategies, Cities, 28(5) p. 394–405.

Transportation Research Board, 1997. National Research Council (US). Committee for a Study of Transportation and Sustainable Environment, 1997. *Toward a sustainable future: addressing the long-term effects of motor vehicle transportation on climate and ecology* (Vol. 251). National Academy Press.

Venter, C, 2013. The lurch towards formalisation: Lessons from the implementation of BRT in Johannesburg, South Africa. Research in Transportation Economics, *39*(1) p.114-120.

Walters, J, 2008. Overview of public transport policy developments in South Africa. Research in Transportation Economics, 22(1) p.98-108.

WCED, U, 1987. Our common future. World Commission on Environment and DevelopmentOxford University Press.

Zanella, A, Bui, N., Castellani, A., Vangelista, L. and Zorzi, M, 2014. Internet of things for smart cities. IEEE Internet of Things journal, 1(1) p.22-32.

Zhao, P, 2009. Sustainable urban expansion and transportation in a growing megacity: Consequences of urban sprawl for mobility on urban fringe of Beijing. Habitat International, 34 p.236-243.