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Regenerative ideas for urban roads in South Africa

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Safer and reliable infrastructure in cities is a necessity for urban dwellers. The question is whether conventional planning practices would provide solutions before urban roads are labelled as unmanageable sources of fatalities, especially in developing economies. This paper presents how smart mobility can be achieved. Using Bloemfontein in South Africa, a case study was performed to examine the causal feedback relations among the factors prompting mobility. The study revealed that: (a) the use of information and communication technology in everyday functions, instead of large-scale physical movement is crucial; and (b) efficient public transportation systems would assist in developing smart mobility in urban areas. In effect, regenerative ideas that are based on prioritised causal feedback relations should bring about smart mobility, which engenders traffic safety in urban areas.

1. Introduction

Urban regeneration targets the well-being of cities by bringing sustainable advances in social, environmental and economic aspects of urbanism (Yu and Kwon, 2011). Urban regeneration, which has allowed the delivery of sustainability targets, is produced with design excellence, economic investment and legislative change (Rogers *et al.*, 2012). Within the context of urban regeneration, the transfer of information has significant implications for the movement of people and goods. Particularly at the city level, it has implications for physical movement of people and the use of different modes of transportation.

However, sustainable and smart mobility is a challenge in most South African cities. The reasons for the challenge are multifaceted. For example, the decline of conventional economic activities, such as mining, has led many cities to embrace multiple economic activities. The shift in economic activities has attracted a higher influx of people to urban areas (Torres and Pinho, 2011). In the absence of an adequate quality public transportation system in South African cities, it is expected that the use of vehicles by single occupants would increase traffic problems (Monni and Raes, 2008). For example, the number of fatalities through increased individual traffic movement could manifest (Handy, 1996).

The paper reports on an evaluation of the parameters that influence smart mobility. The evaluation is based on ideas that should impact the compilation and application of sustainability solutions for safer urban roads in South Africa. To shed more light on these phenomena, the concept of smart and sustainable mobility forms the nexus of the discussion in the next section of this paper. A succinct description of Bloemfontein, a centrally located city in South Africa, then provides the context in which the issues have emerged. The discussion of different linkages that show possible policy options was presented after the methodology and results of the study. The implications of the conceptual models for policy makers and their limitations provide grounds for future exploitation of the ideas of this study.

2. Smart and sustainable mobility

Sustainable mobility is essential for a city to transform to a smart city (Giffinger *et al.*, 2007; Lombardi, 2011a; Shapiro, 2008; Van Soom, 2009). However, before understanding what smart mobility entails, it is necessary to understand what a smart city is. A smart city is a well performing, forward-looking, medium-sized city that is built on endowments and activities of independent and responsive citizens (Giffinger *et al.*, 2007). The use of modern technology in urban life, which includes innovative transport systems, and efficient energy systems are an integral part of a smart city. Factors associated with urban life in the form of safety, cultural heritage, good governance and peoples' participation are essential ingredients of a smart city (Giffinger *et al.*, 2007; Lombardi, 2011a; Shapiro, 2008). Smart mobility refers to local and international accessibility in the form of a sustainable physical transportation system and ICT infrastructure (Giffinger *et al.*, 2007; Lombardi, 2011b). Smart mobility is derived from the concepts of connected city (smart logistics and sustainable mobility) (Nijkamp and Kourtik, 2011).

Various cities across the world have tried to alleviate mobility woes and attain smartness in many ways. Most of the interventions indirectly point to one end, namely the reduction of vehicular traffic on roads. The reduction of vehicular traffic has been pursued with increased taxation, and generated funds have always contributed to new highways projects. However, according to critics, this could improve the short-term efficiency of the traffic system, but it will not contribute to its long-term sustainability because individuals with a small ecological footprint need increased access for liveability. Liveability is the sum of the factors that add up to the quality of life in a community. Such factors include the built and natural environments, economic prosperity, social stability, educational opportunities and other cultural/or recreational opportunities. For this reason, it has been argued that raising taxes on vehicles will not completely alleviate mobility problems (Thynell *et al*., 2010).

In addition, there are arguments that compact on urbanism, which leads to short trip distances that promote walking and cycling and reduce fuel consumption (Monni and Raes, 2008). This argument is made possible with advancements in ICT.

ICT has two significant components in a city. These include physical movement and accessibility (Giffinger *et al.,* 2007; Komninos, 2002; Lombardi, 2011a). The challenge is the integration of these two components to achieve sustainability in terms of striking a balance between benefits to the individual and the society while establishing a smooth and safe movement of people and goods (smart mobility) (Giffinger *et al*., 2007; Komninos, 2002; Lombardi, 2011b; Nijkamp and Kourtik, 2011; Shapiro, 2008; Van Soom, 2009).

The main challenge is to minimise unnecessary vehicular movement. Banister (2008) argues that the idea is not to prohibit the use of vehicles, but rather, the idea is to design liveable cities so that people do not have the need to use vehicles often. In order to create cities with desired liveability, improved access through sustainable transportation systems remains an essential goal. This calls for a new paradigm that sees mobility as a way to create infrastructure that satisfies individual comfort and societal goals.

3. Case study: Bloemfontein, South Africa

The study area was Bloemfontein in South Africa. Bloemfontein is located almost at the centre of South Africa. It is one of the growing medium-sized cities in the country. The city is connected to each part of the country by road, rail and air. Bloemfontein also houses a number of regional centres of organisations. As a result of the availability of adequate basic urban infrastructure, which includes transport and communication services, the availability of skilled manpower and its proximity to Johannesburg, the economic hub of South Africa, Bloemfontein has attracted a number of domestic and multinational organisations. The use of ICT is evident in the city as most of the areas in the city are connected. However, the growth of industrial activities and the influx of people have increased the pressure on urban infrastructure, especially road networks. The major transportation concerns in the study area include the lack of public transportation, access to transport services, cost of fuel, accidents and traffic safety, and the quality of the roads (Burger, 2012; Luke and Heyns, 2013). The research work of Burger in 2012 discovered that more than 40% of urban dwellers in Bloemfontein use personal vehicles and about 35% of the people use shared taxis, whereas only 25% of people use the regulated public transportation system.

4. Data collection, analysis and interpretation

This investigation was conducted by employing survey research, which incorporates discussion with people involved in the urban development process in South Africa. The literature was reviewed to understand the indicators and factors that contribute to smart mobility. Data related to demography, economy, transportation, communication, governance and liveability, which enable the evaluation of the performance of the sectors, were collected from primary and secondary sources.

The primary data were therefore collected at the household level in six representative suburbs in Bloemfontein. Suburbs from different geographical locations and people from various strata of society were included in the study. The criteria used in the selection include geographical distribution, importance of the suburbs in terms of urban functions, population density and availability of transport facilities. The suburbs surveyed were: Heidedal in the east; Universitas and Langenhovenpark in the west; Dan Piennar in the north; Pellissier in the south-west; and the Central Business District (CBD) area of Bloemfontein. The household survey was conducted in the selected suburbs with pretested schedules. The sample strata was 270 selected households (the survey varied from 40 to 50 households in each suburb). A systematic stratified random sampling method was used to identify the participants. The semi-structured face-to-face method was employed for the survey, which was conducted in 2012. In terms of household income, approximately 28% of the surveyed households have a general annual income below US$10 000, 24% of the households are in the income range of US$10 001–20 000, 18% are in the range of US$20 001–30 000, 16% belong to US$30 001–40 000 and 14% earn more than US$40 001.

Initial questionnaires were compiled based on the indicators and factors to be measured in relation to mobility. The indicators and factor were identified in Giffinger *et al.* (2007), Odendaal (2006) and Van Soom (2009). Thereafter, a pilot survey was conducted with a sample size of 30 to test the questions. Based on the feedback from the respondents of the pilot survey, the questionnaires were revised and applied to the sample frame.

Various indicators and factors that generally influence mobility in a city were used for the evaluation of smart mobility. The questionnaire was compiled with 10 indicators, which were categorised under four factors. The factors considered included local accessibility (public transport), international/national accessibility in terms of physical movement, sustainable, innovative and safe transport systems, and availability of ICT. The indicators included public transport network per inhabitant (in terms of network length and available number of buses and taxis in a day), access to public transport, quality of public transport under local accessibility, air transport of passengers, air transport of freight, green mobility share, traffic safety, use of economical cars, computers in households and internet access in households (Giffinger *et al.*, 2007; Odendaal, 2006; Van Soom, 2009). The respondents were also asked to rate their responses on a scale of −3 to +3, where −3 is high negative impact, +3 is high positive impact and zero is considered as neutral (Giffinger *et al.*, 2007). The respondents were asked to assign a weight to each indicator and factor. The ratings show the relative influence of the indicators and factors based on the perceptions of the survey respondents. The questionnaires were physically administered by the researchers to facilitate clarifications if the need arose.

The secondary data (statistical and time series data) were collected from the *Integrated Development Plan* (IDP) of the Mangaung Metropolitan Municipality, which is the administrative authority of Bloemfontein (Mangaung Metropolitan Municipality, 2012). The limited data collected from the IDP were used to check the correctness and adequacy of primary data wherever possible. The data collected from the primary survey was checked for its reliability through Cronbach's α test and then analysed through descriptive statistics. The evaluation of the mobility indicators and factors was conducted based on the mathematical models developed using the weighted average index method (Table 1). The mobility characteristic index is the measured parameter for evaluation of the overall smart mobility scenario of the city.

As mentioned earlier, the smart indicators, factors and mobility characteristics were measured on a rating scale of −3 to +3 (Giffinger *et al.*, 2007). This quantitative performance evaluation was followed by a qualitative system dynamics (SD) model for smart mobility of the city. The conceptual models are based on the causal relations between the factors and indicators influencing smart mobility. While developing the causal relations, variables such as information, decision, action and the environment (system) were identified. The variables were then connected with simple one-way causality with their influence and polarity (El Halabi *et al.*, 2012; Olaya, 2012). Once the one-way causalities were established, the feedback relationships were checked and established. The causal feedback models were developed based on the inter-linkage of the indicators and factors obtained from the reviewed literature (see Table 3 below). This approach was adopted to avoid subjectivity from the investigators. The results from the evaluation of the performance of each indicator and factor and their relative influence, as shown in Table 2, were employed to develop the models.

The constructed causal feedback diagrams were then discussed with the professionals and experts in the field of urban development and transportation to check their veracity. These discussions were conducted by using semi-structured interviews in a repetitive, iterative and reflexive manner (Day and Bobeva, 2005; Donohoe and Needham, 2009; Hsu and Sandford, 2007; Jung-Erceg *et al.*, 2007; Pandza, 2008). The discussions were conducted at least four times: (i) before developing the models to know the inter-linkage of parameters in the study area;

Indices	Models	Nomenclature
Smart mobility indicator index (SMII)	$SMII = \sum(P * N)/\sum N$	P = values assigned to each indicator by the respondents N = number of respondents favoured a value for each variable
Smart mobility factor index (SMFI)	$SMFI = \sum(SMII * Z)/\sum Z$	SMII = smart mobility index of each indicator under each factor as calculated above Z = average weightage assigned to each indicator
Smart mobility characteristics index (SMCI)	$SMCI = \sum(SMFI * W)/\sum W$	SMFI = smart mobility index of each as calculated above W = average weightage assigned to each factor

The average weightages assigned to each SMFI and SMCI are calculated from the responses provided by the respondents on weightages for each smart mobility indicator and factor

Table 1. Models used for evaluation of smart mobility in Bloemfontein

Smart mobility indicator	*N*	Cronbach's α	SMII	Standard deviation	Smart mobility factor	SMFI	SMCI
Public transport network per inhabitant	270	0·94	−1·5	0·35	Local accessibility (public transport)	−1·65	0·05
Access to public transport	268	0·92	−1·5	0·42			
Quality of public transport	270	0·94	−2·0	0·43			
Air transport of passengers	251	0·91	1·4	0·15	(Inter)national accessibility (physical movement)	0·90	
Air transport of freight	225	0·90	−1·1	0·25			
Green mobility share	255	0·91	−2·0	0·45	Sustainable, innovative and safe transport systems	−0·45	
Traffic safety	270	0·94	1·2	0·30			
Use of economical cars	248	0·90	−1·5	0·25			
Computers in households	265	0·93	2·0	0·35	Availability of ICT infrastructure	1·25	
Internet access in households	255	0·91	0·5	0·15			

SMII, smart mobility indicator index; SMFI, smart mobility factor index; SMCI, smart mobility characteristic index

Table 2. Smart mobility indicators and factors of the study area

(ii) while developing the model to understand causal feedback relations; (iii) to validate the causal feedback relations and conceptual models; and (iv) during the development of mechanisms for policy interventions. Furthermore, anonymity was maintained to avoid subjective interpretations and prejudice by the experts and professionals. Modifications and amendments to the causal relations and conceptual models and interpretation were made after every stage of the discussion with the experts.

5. Results and discussion

The analysed survey data shows that 87% of the respondents need vehicular travel to perform their daily urban functions and more than 45% use their own (individual) vehicles for such purposes. The reason is because most of the respondents live in suburban areas, whereas most of the urban socio-economic and civic functions are located across the city. Only about 18% of the respondents regularly use public transportation. The challenges associated with public transportation in the city pertain to crime and safety (73%), inadequacy (68%), lack of quality (67%) and accessibility (57%). These challenges are major hindrances for the effective use of the public transportation system in Bloemfontein.

With regard to ICT, the study shows that more than 55% of the people have access to computers and internet connectivity. Among the people having computers and internet access, the majority (35%), particularly those who are involved in the service and professional activities that do not require regular physical presence in their work, say that they would prefer to work online rather than travel to work every day. So it is shown that there is a clear need for travel in the city, but the condition of public transportation causes people to travel by individual vehicles in the city. However, with effective use of ICT, the need for local travel may be reduced.

In terms of accessibility, it was revealed that about 12% of the respondents use air travel from the city for both national and international travel. The city has an international airport, but more than 40% of the respondents were of the opinion that it is underutilised. About 45% of people who travel abroad use their own vehicles to travel to the international airport in Johannesburg rather than using air travel from the city. The major reasons are associated with the cost of travel and local accessibility to the airport. According to 63% of the respondents, the travel facilities by road to other cities or other parts of the country are very poor. This indicates that although the city is connected by road and air, the national accessibility by road and international accessibility by air from the city is not very good.

The performance of the important mobility indicators and factors and overall smart mobility characteristic of the city are given in Table 2 (smart mobility characteristic is based on various mobility factors and each mobility factor is influenced by a set of indicators). The mobility factors considered are local accessibility, (inter)national accessibility, sustainable, innovative and safe transport systems, and availability of ICT-infrastructure. The mobility indicators include public transport network per inhabitant, access to public transport, quality of public transport, air transport of passengers (national), air transport of passengers (international), air transport of freight, green mobility share, traffic safety, use of economical cars, computers in households and internet access. The high Cronbach's α value against each indicator shows that the data used are reliable and suitable for the evaluation. The evaluation revealed that six of the

Causal variables	Inter-linkage	Use variables	Sources
Urban functions	→	Need for travel	Garmendia *et al*. (2012); Plassard (1992)
Need for travel	→	Public transportation network	Banister (2008); Garmendia *et al.* (2012)
Quality of public transportation	→	Public transportation system	Thynell *et al*. (2010)
Public transportation network	→	Local accessibility	Banister (2008)
Effective use of ICT	→	Reduction in local travel needs	Gennvi-Gustafsson (2013); Van Geenhuizen (2009)
Reduction in local travel needs	→	Low carbon emissions	Dalkmann and Brannigan (2007); Schipper *et al*. (2000); Tiwari *et al*. (2011)
Use of economical cars	→	Low carbon emissions	Cervero and Kockelman (1997); Schipper *et al*. (2000); Schipper et al. (2009); Tiwari *et al.* (2011)
Low carbon emissions	→	Green mobility share	Cervero and Kockelman (1997); Dalkmann and Brannigan (2007); Schipper (2009); Tiwari *et al.* (2011)
Reduction in local travel needs	→	Reduction in travel volume	Ewing *et al.* (2008); Sietchiping *et al*. (2012)
Reduction in traffic volume	→	Traffic safety	Odero (2009); Sietchiping *et al*. (2012)
Green mobility share	→	Sustainable, innovative and safe transportation	Cervero (2009); Dalkmann and Brannigan (2007); Schipper (2009)
Adequacy in public transportation			Thynell *et al.* (2010)
Traffic safety			Badland *et al*. (2008); Daniel *et al.* (2000); Wei and Lovegrove (2012); Miranda-Morenoa *et al*. (2011); Retting *et al.* (1995)
Availability of computers in households	→	Availability of ICT infrastructure	Graham and Marvin (1996)
Internet connectivity in households			Graham and Marvin (1996); Mayer (2007)
Availability of ICT infrastructure	→	Effective use of ICT	Gennvi-Gustafsson (2013); Mayer (2007); Van Geenhuizen (2009)
Effective use of ICT	→	National accessibility	Gennvi-Gustafsson (2013); Giffinger *et al.* (2007)
Availability of flights			
Sustainable, innovative and safe transportation			Garmendia *et al*. (2012); Sietchiping *et al*. (2012)
Availability of ICT infrastructure	→	Local accessibility	Gennvi-Gustafsson (2013); Giffinger *et al.* (2007); Lombardi (2011a); Van Geenhuizen (2009)
Availability of ICT infrastructure	→	National accessibility	Giffinger *et al.* (2007)
Local accessibility	→	Smart mobility	Cervero (2009); Sietchiping *et al*. (2012); Thynell *et al*. (2010)
National accessibility			Giffinger *et al.* (2007)
Availability of ICT infrastructure			Caragliu *et al*. (2009); Giffinger *et al.* (2007)

Table 3. Inter-linkage of causal variables

indicators, namely transport network per inhabitant (−1·5), access to public transport (−1·5), quality of public transport (−2·0), green mobility share (−2·0), use of economical cars (−1·5) and air transport of freight (−1·3) have moderate to high negative values. On the contrary, air transport of passengers – international (1·3), air transport of passengers – national (1·1), traffic safety (1·2), and availability of computers in households (1·6), have moderate to relatively high positive indices. Internet access in households (0·5) has low index value. Consequently, the performance of mobility factors such as local accessibility (−1·65) and sustainable, innovative and safe transport systems (−0·45) are fairly negative, whereas (inter) national accessibility through physical movement (0·95) and availability of ICT infrastructure (1·25) have low to moderate positive indices. Although positive at 0·05, the overall smart mobility index of the city is found to be very low. Thus, the survey results and the performance evaluation of the mobility parameters reveal that the city is limited in mobility from the accessibility point of view; however, the overall positive smart mobility characteristic index indicates the availability of opportunities for development of smart mobility in the city.

5.1 Key causal relations and conceptual SD models

Before conceptualising the models and causal relations for attaining smart mobility in the city, an attempt was made to understand the current status of the mobility and causal relations of the parameters preventing smart mobility in the city. Figure 1 presents causal relationships among the mobility parameters in the current state. In the current scenario, there is a major need for local vehicular travel because of the requirement of daily urban functions (socio-economic activities) and lack of effective use of ICT. However, inadequacy of quality public transportation system causes more individual driven vehicles on the roads, results in high traffic volume, high carbon emissions, and possible vehicular accidents, which in turn contributes to unsustainable local transportation. Therefore, looking at the current status, conceptual models were developed based on the causal relations among the parameters. Table 3 presents the linkages and causal effects of various indicators and factors used for developing the conceptual models.

The results presented in Table 2 were used to observe the relative importance of the various factors and indicators, which influence smart mobility in Bloemfontein. Positive indices show better performance whereas negative indices show disruptions in the performance. High positive values indicate high performance and high negative values indicate greater disruptions. Lower values indicate lesser or marginal influence. The most influential parameters were considered for developing the conceptual models. It was hypothesised that the indicators that showed negative influence, needed to be counterbalanced and augmented and the positive indicators needed to be reinforced. As such, dynamic hypotheses were derived. The dynamic hypotheses form the basis for evolving policy interventions to attain smart mobility.

While developing the SD models, smart mobility was categorised into two significant elements, which included physical movement at the local level and national (regional) accessibility. The conceptualisation for smart mobility was envisaged based on causal relations of the parameters influencing mobility in Bloemfontein. As observed from the survey, urban functions, particularly socio-economic activities necessitate movement of people and goods, from one point to another, in Bloemfontein. If quality and adequate public transportation is available, then the need for local travel will positively influence public transportation and local accessibility will be strengthened. As a result, it will also reinforce the urban functions through feedback causal loop R1 (Figure 2(a)).

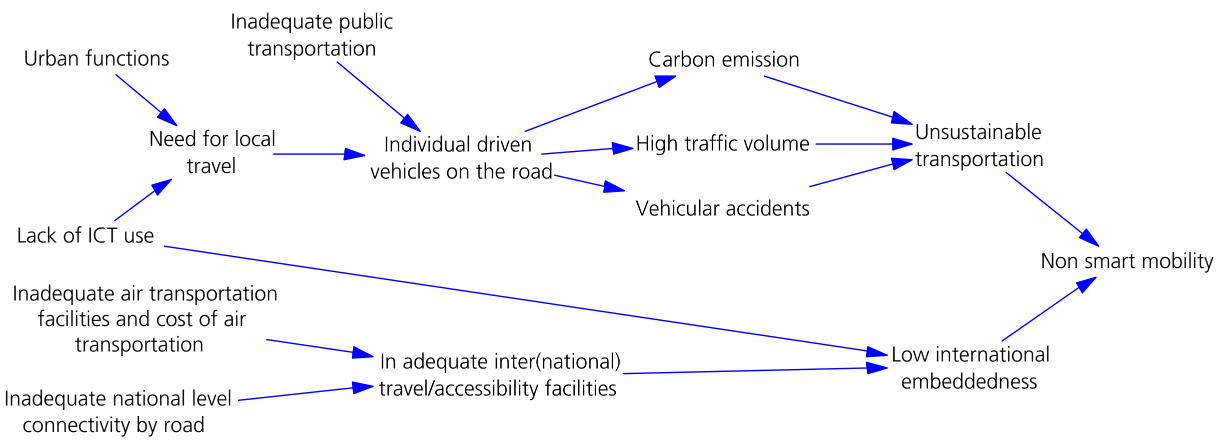

Figure 1. Current status of mobility in Bloemfontein

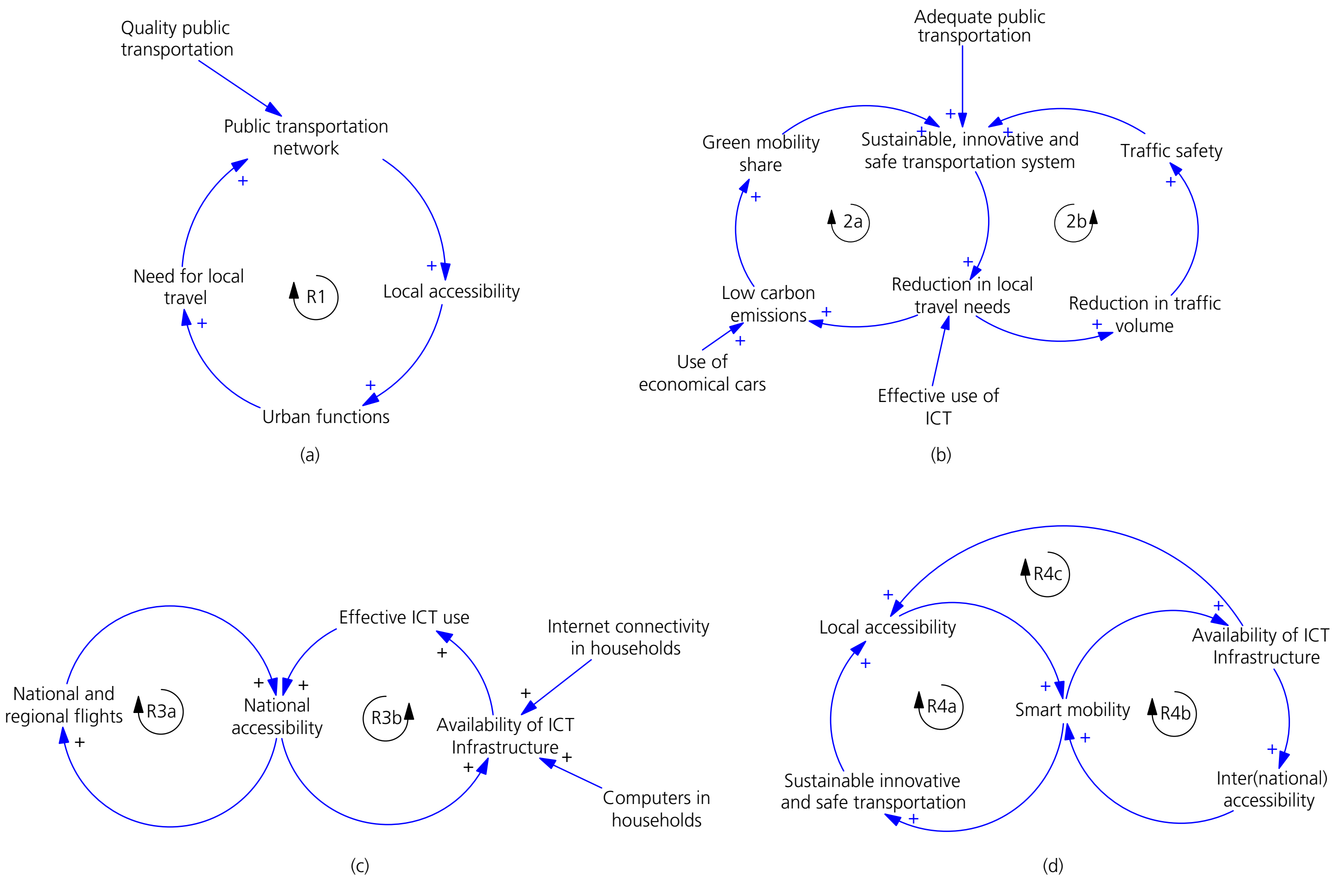

Figure 2. (a) Causal feedback loop for local accessibility; (b) causal feedback loop for sustainable, innovative and safe transportation system; (c) causal feedback loop for national and regional accessibility; (d) causal feedback loop for smart mobility in Bloemfontein

It was observed that ICT infrastructure was available in the city to a certain extent and people were willing to use it for their socio-economic activities. If the availability of ICT infrastructure is strengthened and they are used effectively, the local travel needs by vehicles will be reduced. The reduction in travel needs along with the use of hybrid cars (cars with high carbon emission efficiency) could lead to green mobility. Green mobility will strengthen sustainable and innovative transportation system. As a result, sustainable and innovative transportation induced by both the public transportation system and ICT will reduce local travel needs (loop R2a). Similarly, a reduction in travel needs will reduce traffic volume and there will be enhanced safety, which leads to sustainable and safe transportation system (feedback loop R2b). Thus, the feedback loops R2a and R2b reinforce the sustainable, innovative and safe transportation (Figure 2(b)).

Bloemfontein has an international airport. It connects to most of the major cities of the country directly or indirectly. However, according to the data, only 12% use the airport because of high cost and accessibility challenges. The majority of the people use roads for national and regional travel needs. In the absence of an adequate and efficient public transportation system, people use their own vehicles, a situation that potentially contributes to road accidents. When national and regional flights are augmented, national and regional level accessibility will be strengthened and vice versa (feedback loop R3a). Thus, single-occupant vehicular movements for national and regional travel will be reduced. Potentially, the reduced traffic will reduce the likelihood of fatalities on the road. The use of ICT through augmentation of connectivity in households will cause faster information transfer at the regional and national level, thereby enhancing regional and national accessibility (feedback loop R3b). Augmentation of flights that enable the transfer of people and freight, and effective use of ICT at both city and household level, will reinforce accessibility in the city (Figure 2(c)).

From the causal feedback relationships of the feedback loops R1, R2 (a and b) and R3 (a and b), it is observed that a sustainable, innovative and safe transportation system will enable effective local physical accessibility; availability and the effective use of ICT will reinforce accessibility. Thus, a sustainable, innovative and safe transportation system and local accessibility through feedback loop R4a, and availability of ICT and international accessibility through feedback loop R4b, should reinforce mobility in the city (Figure 2(d)). Moreover, as availability of ICT infrastructure and local accessibility are interwoven, feedback loop R4c will reinforce both the loops R4a and R4b and consequently strengthen smart mobility in the city.

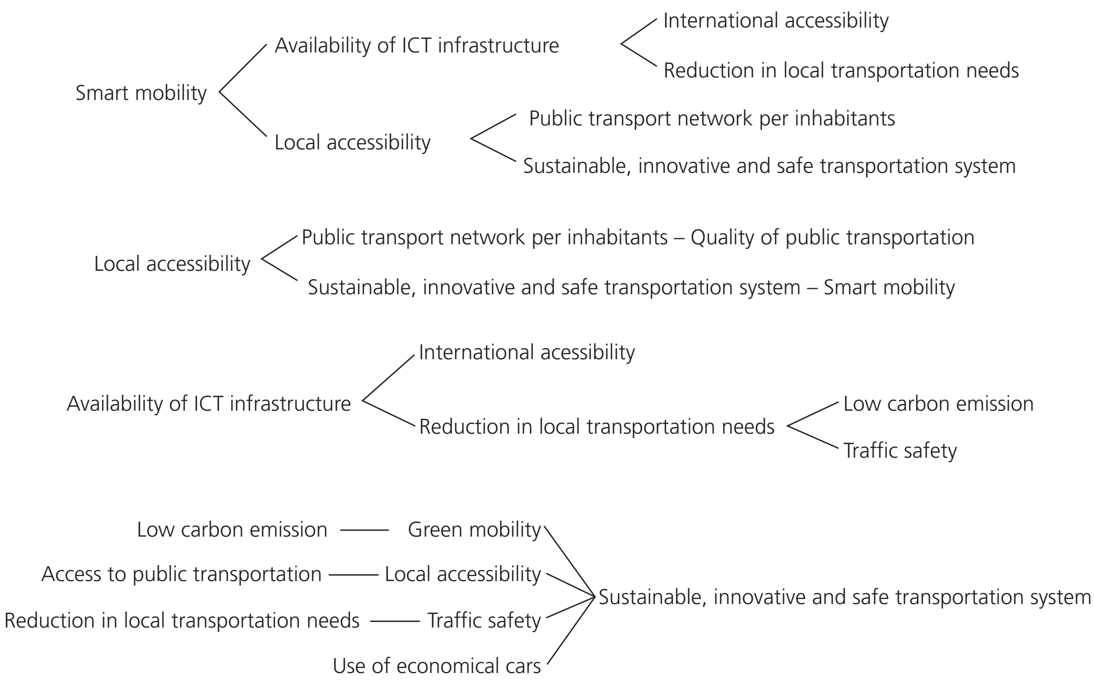

Figure 3. Mechanisms for the development of policy interventions

5.2 Mechanisms for the development of policy interventions

The results from the study suggest that Bloemfontein is severely limited in its public transportation system (public transport network per inhabitant, access to public transport, quality of public transport), green mobility, the use of economical cars and air transport of freight (Table 2). Although ICT is available in the city to a certain extent, it is not reducing constant physical movement of goods and people and so policy interventions are needed in these aspects to attain smart mobility in the city.

The causal relationships are the dynamic hypotheses on which the policy interventions can be developed. As seen from the causal relations discussed, there are four major dynamic hypotheses: R1, R2, R3 and R4. The dynamic hypotheses R1, R2 and R3 lead to the final dynamic hypothesis R4. Therefore, policy interventions need to be developed based on these four hypotheses, which can work as the mechanisms (Figure 3) for the development of policy interventions. When analysing the causal relations, it is observed that reinforcing local accessibility and availability of ICT can lead to smart mobility in the city. Local accessibility can be reinforced through provision of adequate quality public transportation as well as a sustainable, innovative and safe transportation system. ICT will enhance accessibility and reduce local transportation needs, which in turn will increase traffic safety and reduce carbon emissions. As a consequence of low carbon emissions, traffic safety, use of economical cars and access to public transportation, a sustainable, innovative and safe transportation system can be achieved.

The feedback loops show how the parameters that affect smart mobility of a city are interlinked in certain mechanisms and how the mechanisms work. As a result, when a problem occurs at a stage of the mechanism or when a link is broken, it can be diagnosed for intervention purposes. The causal relations also show that if a link in the mechanism is broken or disturbed, not only will it influence the mechanism to which it belongs, but its effects can also be felt on the other mechanisms and even on the whole mobility system of the city. Therefore, the mechanisms based on the causal feedback relations need to be clearly understood and used to evolve policy interventions in order to attain smart mobility in the city.

6. Conclusions and the way forward

The literature shows that urban development through either the provision of new transport infrastructure or the introduction of congestion tax are isolated efforts that will not yield smart mobility. A holistic approach that is underpinned by regenerative ideas is needed to meet the challenge. The delivery of the sustainability agenda through urban regeneration thus need to be promoted by using design and implementation mechanisms, which involve social, economic and environmental responsibilities alongside required legislation and regulations.

This paper used Bloemfontein in South Africa, which has smart mobility challenges, to make a case example. The study examined the status of mobility in Bloemfontein to assess the factors and indicators (variables) affecting mobility. The linkages between the variables were established through causal loops based on SD modelling principles. It was observed that local accessibility in the form of adequate and quality transportation is a major challenge. Although the city has ICT infrastructure, there is a major scope for its full utilisation to optimise physical movement in the city.

The contributions of this article are threefold. First, it explicitly shows the causal feedback relations among the variables in terms of their influence on mobility in a city. A comprehensive understanding of these variables and their dynamic attributes could be used to evolve policy interventions. Second, through its causal feedback relations, the study shows that public transportation that is aided by effective ICT use can bring efficient mobility in developing countries without increasing the pressure on the roads, particularly in Africa, where ICT and road networks are limited. In any case, this study is insufficient when the benefits of quantitative modelling are considered. Future studies should examine the extent of smart mobility that would be engendered through the holistic exploitation of the variables of the study in practice. Despite its limitations, this study can assist urban and transport planners and decision makers to analyse and diagnose the challenges of smart mobility in a city as well as to develop mechanisms based on which policy interventions can be evolved.

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