VALUE-IN-USE SUSTAINABILITY FACTOR AS A DRIVER FOR ASSET MANAGEMENT OF ROAD TRANSPORT INFRASTRUCTURE

Infrastructure is critical in supporting economic security and societal wellbeing. A sound road network, for instance, is an essential part of any country's socio-economic fabric. However, the development of sustainable road infrastructure has been largely driven by environmental requirements as well as economic necessity. The experiences and satisfaction of users and the consequent value ascribed to the usage of road infrastructure have not been accorded reasonable attention. The current study examines the concept of value attributable to road infrastructure through its usage. A review of related literature was conducted using articles from journals, conference proceedings and from databases including Google, Taylor and Francis, ASCE Library, and Science Direct. Synthesis was done using thematic analysis. The study found that value is attributable to the experience of users and this depends on the condition of roads. Hence, maintenance of roads is paramount to sustain value. A conceptual model for value-in-use sustainability of roads was developed. The study recommends that more attention should be given to the experience of users while making use of the roads, as opposed to the monetary value of the roads only. Moreover, consideration of users' experience will invariably drive demand for travel and bring about increased monetary returns. Therefore, the study highlights the import of the value-in-use concept, and creates more awareness about the conditions that invariably contribute to this value and thus transport managers and policy makers need prioritise asset maintenance and management even during planning.

Keywords: maintenance, management, roads, sustainability, transport, users, value

INTRODUCTION

Much focus has been on economic imperative as the overwhelming driver for road transport infrastructure projects planning, delivery and operations (Stapledon, 2012). However, it has been argued that sustainability issues are vital in achieving full value from investment projects. Although sustainability has been considered, a plethora of studies have focused on environmental sustainability and legislative requirements thereto. This is inadequate since road transport infrastructure planning should embed sustainability concerns related to the physical sustainability of the structure. Sustainability should guide decision-making throughout infrastructure projects to meet wider objectives of durability and performance. Moreover, the potential benefits of infrastructure investments are limited if the assets are not properly refurbished and maintained to maintain durability and performance (Palmer et al., 2013). Surveys show that adequately maintaining road infrastructure is essential to preserve and enhance benefits of durability, modernisation and sustainability; but a backlog of outstanding maintenance causes irreversible deterioration of road networks (Malkoc, 2017). This implies that assets with a long useful life and maximum benefits to the public and community or society should contribute to prosperity, rather than endanger or be allowed to deteriorate and pose a danger, in the long run. This way, value for money can be maximised whilst concomitantly demonstrating positive social and environmental outcomes which justify the use of scarce resources (financial and natural) and for the associated impacts on the community wherein such infrastructure is provided.

A sound transport network is an essential part of a country's socio-economic fabric and as such needs to be in a condition as to continually serve the community and the economy as a whole. Furthermore, poorly maintained roads constrain mobility, significantly increase vehicle operating costs, increase accident rates and their associated human and property costs, aggravates isolation, poverty, poor health, and illiteracy in rural communities (Moleli, 2012). Concurring with these views, Palmer et al. (2013) stated that road transport infrastructure needs to deliver its service over its lifetime, efficiently and reliably. Roads have to be in a continuously good condition for them to be able to command value (Alasad *et al.*, 2012; 2013). This in turn will drive demand and influence the level of satisfaction obtainable from the use of the subject road network assets and related services, as well as the monetary returns accruable. Management of road assets involves the application of engineering, financial and management practices to optimize the level of service outcome in return for the most cost-effective financial input (Malkoc, 2017).

Hence, strategies to sustain road transportation infrastructure to continue to deliver its services over its useful life should include plans for an appropriate and well-managed infrastructure during operation in order to satisfy the users. Users' satisfaction is a paramount consideration since they are the central focus in such developments with regard to the quality of services provided by the system Dhingra (2011). Moreover, considering that the services provided are meant to be paid for by the taxpayers themselves, their satisfaction and experience are important considerations in road infrastructure planning.

Consequently, there is need to incorporate the views of road users and perception on road quality, which are typically and largely ignored or neglected in road infrastructure planning and management (Dhingra, 2011; Hartmann and Ling, 2016). Dhingra (2011) focused on the quality ascribed to road transport assets by users while Hartmann and Ling (2016) examined the relationship between the physical condition of roads and user experience and subsequent satisfaction or dissatisfaction. However, both studies did not include other sustainability value considerations such as environmental and social values.

Therefore, research on the value of road transport infrastructure as influenced by the users' experience and sustainability-related factors is crucial. The present study investigates the concept of value in use as a sustainability element and identifies factors that influence "value-in-use" in order to inform transport planners, policy makers and asset managers on the critical factors which influence the quality of roads and invariably, value.

METHODS

The approach for the current study was a desktop study. The research was conducted through a detailed review and synthesis. The search for useful literature began by listing the relevant key words and phrases, namely, sustainability, maintenance, management, value-in-use and road transport. Articles from journals, conference proceedings and from databases including Google, Taylor and Francis, ASCE Library, and Science Direct were used. Synthesis was done using thematic analysis. Thematic analysis identified relevant themes from the literature, which were selected bade on their content, that is, focusing on the key words relevant to the current study. The identified themes were thereafter used to develop a framework for value-in-use sustainability of road transport infrastructure assets.

LITERATURE SYNTHESIS

Road transport infrastructure

Roads are of vital public assets and contributors to economic development, bringing important social benefits, providing access to employment, social, health and education services (Malkoc, 2017). Road transport infrastructure, in particular, facilitates mobility of people and specialized products and services which are essential for development and growth, meets the demands for access to working, shopping and travelling, enhances the value of land within the locality in which they are provided and improves the quality of life of citizens (Brown-Luthango, 2011). According to Olamigoke and Emmanuel (2013), road transport investments are beneficial to the development of individual, the community and economy as a whole, directly through savings in travel time and vehicle operating costs, and indirectly through accessibility to employment opportunities and development of the local economy.

A road system comprises the network and its users (driver and pedestrians as well as vehicle loadings of passengers and freight, whose chief role is to facilitate interaction between people and the exchange of goods and services and providing safe, reliable fluidity of movement for people and goods to reach their desired destinations, with the efficiency required to compete in the global economy (Moleli, 2012; Litman, 2016).

Sustainability of road transport infrastructure

According to Stapledon (2012), sustainability is concerned with: "

> ***"'fit for purpose assets',*** *where fitness is a function of an asset's capacity to be: continually useful over its entire life; a consistent and integral part of the wider infrastructure 'jigsaw', fulfilling community expectations by helping to solve sustainability challenges, and resilient and adaptable to changing circumstances."*

The meaning of sustainability was stated by the World Commission on Environment and Development (WCED), which opined that transport infrastructure development is deemed sustainable when the needs of the present are met without compromising the ability of future generations to meet their own needs (Bongardt et al, 2011; Litman, 2016).

Sustainable development is about achieving a balance between several objectives (environmental, economic and social) over dynamic time and spatial horizons" and as such, it should incorporate the useful life of the road asset in so far as it is in existence and should continue to deliver its services as expected or planned, in addition to the returns accruable and benefits enjoyable from the investment (Stapledon, 2012).

Value of road transport infrastructure assets as a sustainability indicator

Road transport infrastructure asset value has to do with how the quality of existing assets is preserved and maintained to fulfil its intended objectives over its useful life (sustainability). In addition, the assets should be maintained to continuously be consistent with set toll fees, and thus leveraging the optimum possible funding (Ramani et al., 2009). This is especially since the quality of transport infrastructure has to be maintained in such a way as to continue commanding revenue and charges as intended.

According to Opara (2011), road asset value can be viewed and defined in different ways, namely:

- mortgage value: depending on the elements of the asset which retain value for a long time, such as the bases and surfaces in the case of roads;
- service value : the income it provides to the users (for instance, where detours are laid to repair closed roads, drivers incur additional costs to of fuel and time);
- social, ecological, or military categories of value: These relate to benefits arising from the road's existence and condition.

The above evaluations, however, depend on the purpose. Nevertheless, it is the cost of replacement or depreciation that is sought in most valuations, in addition to the costs shown in the figure 1.

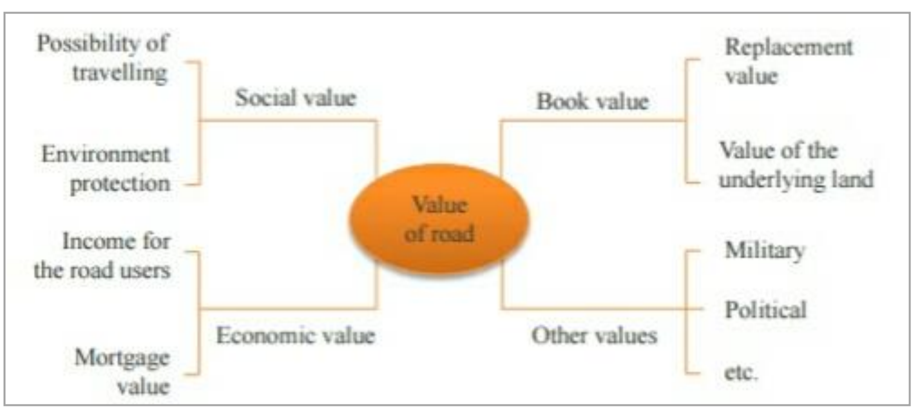

Figure 1: Different road value aspects (Source: Opara, 2011).

Other sustainable value criteria such as reliability value (which encompasses elements of both social and physical aspects), option value (availability of alternatives, which is social in nature), economic value, and environmental value have been indicated as road asset value indicators. These criteria are related to the experience of users and the value attributed to the assets while in use.

The value-in-use concept

Road transport infrastructure has to be in a continuously good-enough condition so that people will be willing to pay for the services related to them (Alasad *et al.*, 2012; 2013). According to Hartmann and Ling (2016), road infrastructure itself does not possess any value, but only incorporates value proposition for its users; thus value that is created whilst the road is being used, termed *value-in-use.* The term “value-in-use” describes value which users attach to their experience while using the road networks. It should be a vital consideration in transport planning and management since the experiences of road characteristics and traffic conditions have an influence on the utility of traveling, the perceived level of satisfaction from services (such as security and delays) is a valid consideration.

Value in use implies that firms and service providers are not able to create predefined value; they can only make value propositions (based on its functionalities or capabilities and significance or intangibles), but the true value is perceived, defined and created through the process and at the moment of consumption of the service (Hartmann and Ling, 2016). However, the extent to which road users perceive value-in-use depends on their experience of maintenance activities, which are manifested in the experienced road condition parameters (Hartmann and Ling, 2016; World Road Association (WRA), 2014). This implies that the experience of the road users and their subsequent satisfaction influences road asset value, and this is in turn influenced by other factors including road condition and quality of service. This was articulated in Hartmann and Ling (2016), as depicted in Figure 1.

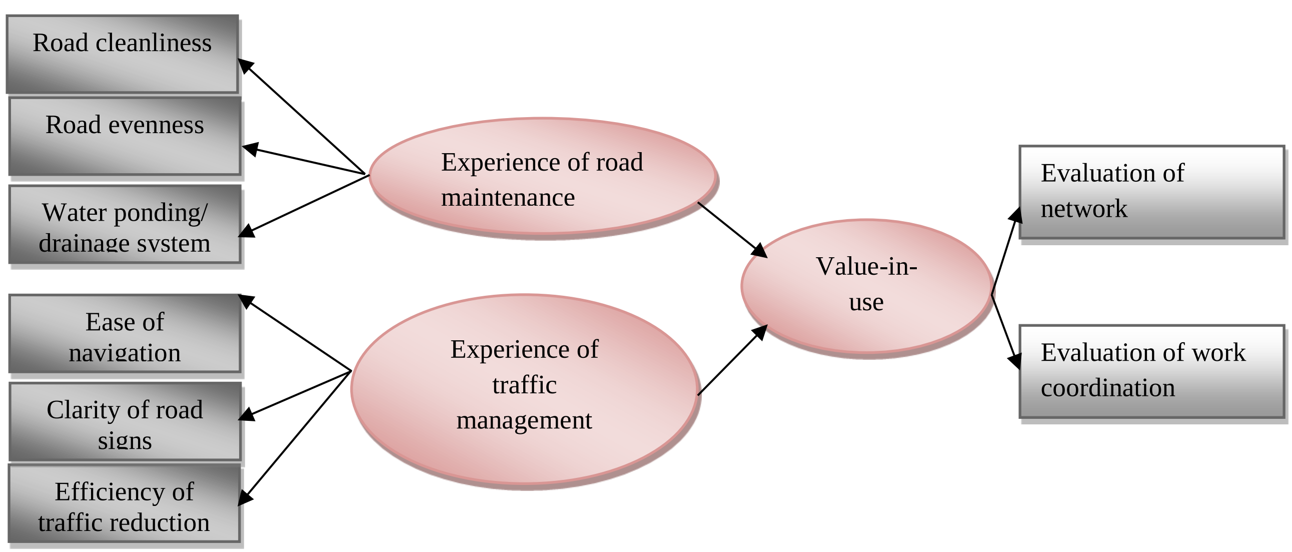

Figure 1: Model of road performance measurement (Source: Hartmann and Ling, 2016)

Hartmann and Ling (2016) found a strong relationship between the physical condition of roads and user experience and subsequent satisfaction or dissatisfaction and advocated the use of the model for road value evaluations. However, the model did not incorporate other value considerations in terms of sustainability.

The current study builds on this model but includes other sustainability criteria including environmental and social components. The current study argues that the value of road transportation network infrastructure depends on a wide range of factors. According to Schiff et al. (2013), these include inter alia, the breadth of coverage, the number and connectivity of networks and the activities/opportunities provided by the network. However, the current study is focused on asset condition and related factors to ensure sustainability of road transport assets in terms of social, economic, and environmental factors. The quality of the network (condition) and the service (by management and/or project actors) also influence the value attributed to transport assets.

VALUE-IN-USE CONCEPTUAL FRAMEWORK

As stated earlier, the current study builds on the views expressed and models developed in Dhingra (2011) and Hartmann and Ling (2016), which did not incorporate other value considerations in terms of sustainability. The current study builds on this model but includes other sustainability criteria discussed hereunder. The study argues that the evaluation of road transportation infrastructure should include more factors beyond the physical sustainability or financial return to investment. It should include social value attributed to the benefits as well as environmental preservation, as depicted in Figure 2. Attention to environmental and social values is important since they relate to the quality of life and environmental preservation are vital in road transportation infrastructure planning and they are related to the quality of the services provided by the subject infrastructure.

The conceptualised model depicts that the value attributed to road assets while in use is influenced by user's experience as determined by quality of service provision and road condition. It is notable that the conceptualised model incorporates environmental and social values which were not included in similar models (Dhingra, 2011; Hartmann and Ling, 2016). The variables are discussed in detail hereunder.

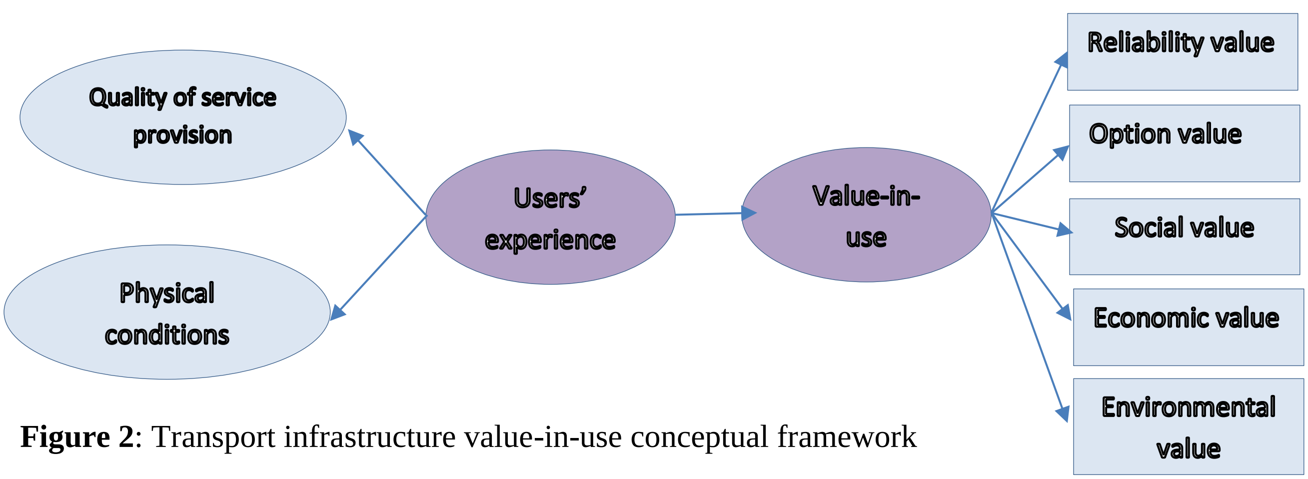

Figure 2: Transport infrastructure value-in-use conceptual framework

Quality of service provision by the transport system

Service provision has to do with traffic control and management systems, safety management systems, security of life and property while travelling, and so on. The level of service provided by the transport system in the management of traffic, congestion, response to incidents and ease of navigation influence value attributed to road networks in terms of performance (Hartmann and Ling, 2016). For instance, rerouting (as a result of efficient traffic control) can create value by preventing road users from being caught in traffic jams and causing stress and unpleasantness.

Dhingra (2011) supported this view and opined that consumers' or users' positive or negative impressions or perceptions are borne out of their feelings about quality, which comes in different forms (Figure 3). These include expected quality (the level of quality demanded by the user), targeted quality (the level of quality that the transport system aims to provide for its passengers or users; also defined based on the level of quality expected by the users, as well as external and internal pressures, budgetary constraints and competitor's or alternative modes' performance); delivered quality (level of quality achieved on daily basis in normal operating conditions); and perceived quality (level of quality as perceived by users during travel).

Figure 3: Different forms of quality associated with transport performance (Source: Dhingra, 2011)

Physical conditions

The physical conditions of the road infrastructure have to do with the state of maintenance, repairs, road cleanliness, road evenness, water ponding or drainage rate and systems, as well as the comfort and convenience of travelling on particular road networks. An uneven road surface is the outcome of a deterioration process (Hartmann and Ling, 2016). Deformations in road structure can be seen on roads as different forms of rutting and vertical imbalance or differential settlement of road structure (Roadex Network, 2017). Water ponding/logging or hydroplaning, which is the presence of excess amounts of water or moisture within a roadway will adversely affect the engineering properties of the materials used in construction (Mukherjee, 2014). For instance, water acts a lubricant reducing the effectiveness of tyre grip on the roads which can increase stopping distances and reduce travelling speed, which can be disconcerting or cause skidding. Additionally, high amounts of water under bituminous layers can cause high hydraulic pressures and distress and can penetrate into the road structure through cracks, and thus lead to reduction in bearing capacity of the road structure and further, to raveling (which is the premature loss of aggregates, and thus resulting in the formation of potholes (Roadex Network, 2017). Hence, if drainage is poor, water will build on the road surface and affect ride quality. The reduction in the performance of road transport systems due to flooding or water logging is the most detrimental factor for the society and it has been estimated at around €100k per hour for each main road affected (Pregnolato et al., 2017). Design considerations and technical aspects of road transport performance should therefore include adequacy and effectiveness of drainage systems.

Reliability value

Reliability value has to do with the transport infrastructure assets being available as and when needed. This suggests that reliability has to do with the functionality, time saving ability, and long-lasting nature of the network. Literature supported that the value of transport assets considers technical and engineering aspects such as functionality, designed life span of road (in years), adoption of sustainable material and renewable resource, and improved road network density (Friedrich and Timol, 2011; Liu *et al.*, 2015; Liyanage and Villalba-Romero, 2015). These factors were also supported in Schiff et al. (2013), who opined that users of transport infrastructure generally want assurance that the network and services will be available whenever they want to use them.

Furthermore, Zhu et al. (2017) suggested that the reliability value has to do with travel time savings, which can be measured by trip scheduling, traffic congestion, travel time uncertainty and pricing. However, Van Zyl et al. (2001) disagreed with Zhu et al.'s stance, stating that value of time is a sustainability element on its own which can be defined in terms of its cumulative monetary value, inclusive of safety, comfort and convenience costs during travel.

Economic value

Economic value has to do with the mortgage value or yield to an investor or concessionaire who gets accruable returns over a specified period of time (Opara, 2011). The economic value of a road asset also encompasses the economic costs of the health impacts associated with air pollution from vehicle emissions. According to Guo et al. (2010), the economic costs of air pollution from road transportation is substantial, costing millions in medical costs, sick leave and so on. Concurring with this view, Kapsky and Samoilovich (2009) expressed that the economic value of road relates to gains and savings obtainable due to the productive capacity of individuals sustained through the non-occurrence of accidents and thus absence of claims, disability pensions, *etcetera.*

Furthermore, the economic value of road networks also has to do with the accessibility value attached to it. The experience and satisfaction of individuals including users, developers and people served in an area where a road transport infrastructure network is planned are generally interested in the availability of interconnected networks to enable optimal reach of places to undertake daily activities.

Option value

Option value has to do with the number of alternative transportation choices available viz-a-viz walking, cycling, auto mobility, and so on (VanZerr and Seskin, 2011). Different modes of transport provide varying degrees of time savings, pollution emissions, travel costs, comfort and convenience. Therefore, the choice of mode of travel will depend on a particular individual's perception of value that they would obtain from the use of the specific mode. Citizens appreciate a more climate-friendly, healthier and more time-saving mode of transport and satisfaction can only be derived through available and functional choice of mobility. Available choices of transport also include walkability opportunities where citizens are able to use walking as an important and probably dominant mode of transport for movement in and around the city, for work and leisure (Shamsuddin et al., 2012). This improves quality of life and reduces air pollution in the environment.

Social value

Social value includes the benefits arising from the usage of the road for daily needs as well as the comfort, convenience, accessibility and travel possibilities accorded by the transport network (Opara, 2011). Walkability also attracts social value in the sense that residents of lower traffic volume streets would be more likely to interact and associate with their neighbours and thus create personal networks and groups in their local environment, than residents of higher traffic volume streets (VanZerr and Seskin, 2011). Social value also has to do with the benefits obtainable from road transport infrastructure as a result of the efficiency of the management organisation, for instance, the feeling of safety with regard to response to traffic accidents, maintenance needs, and so on (Dhingra, 2011).

Environmental value

The maintenance status or quality has far-reaching effects (reduction or improvement) on the quality of environment and the life of the users (Mukherjee, 2014; WRA, 2014; American Planning Association (APA), 2015), Hartmann and Ling, 2016; Pregnolato et al., 2017; Roadex Network, 2017). According to the APA (2015), maintained street-scale features such as public places as sidewalks, street trees and furniture (bus shelters, bike racks, benches), garden and so on:

- have significant value on their appearance and upkeep;
- promotes quality of life through increased physical activity, reduced frequency of accidents and/or severity of crashes or injury to pedestrians;
- influence social cohesion by fostering social interaction, building community trust and supporting social equity, creating a shared sense of identity (especially in local neighbourhoods);
- encourage compliance with traffic regulations (for instance, crossing aids and traffic signs); and
- generally improves health (including mental health).

The environmental significance attached to road transport infrastructure maintenance and management is therefore a crucial element of value.

The developed transport infrastructure value-in-use conceptual framework depicts relationships between users' experience and satisfaction obtained from the use of roads transport infrastructure and services and the value they attribute and/or obtain from it. The conceptualised model is important because it provides evidence on ways to increase satisfaction of users (consumers) and subsequently demand for particular road transportation infrastructure and its services. Customer satisfaction is important since it influences the choices that they make and since users are one of the main drivers for road infrastructure delivery, attention to their perceived value is vital (Faed, 2014). Although quality is difficult to measure in absolute terms, it is clear that it involves a variety of variables including state or improvement of the physical road infrastructure as well as the services it provides (Mamabolo, 2016). Therefore, increased quality, sustainability and value will in turn leverage customer satisfaction and demand, which is good for all parties involved.

Contribution of the conceptualised model to theory and practice

Since value emerges from users' usage and experience, customer experiences are crucial for the extent to which a service and state/condition of road transportation infrastructure contributes to the value creation of the customer. However, the use of a model that focuses on a particular aspect only, such as physical or economic attribute will not drive sustainability. Sustainability includes aspects related to environmental, social, economic, physical conditions and so on. Choosing few outcomes therefore means that more weight will be placed on some aspects or certain factors at the detriment of others. Thus, incorporating all aspects of value which individuals may ascribe to the use of road transportation infrastructure offers a full understanding of value attributable to the use of such projects.

In addition, road safety management can devise adequate measures, interventions and systems to provide roads that experience fewer accidents, which will in turn increase road user's perception of safety for a particular mode of transport and invariably result in increased demand, which is good for economic sustainability of the subject project.

The framework provides a new way of viewing the importance and influence of users' satisfaction in road infrastructure sustainable development. Since users are the main drivers of road infrastructure development, consideration of the value they perceive from the usage of the projects is a paramount consideration in road infrastructure sustainability. Road agencies and concessionaires responsible for management and maintenance should therefore pay more attention to road user experience and devise ways to improve the quality of service delivery (for instance, traffic management) and road conditions prevent deterioration of infrastructure and pollution. In this way, road agencies can contribute to the value creation for the users/consumers.

CONCLUSION

The study examined the concept of value-in-use with regard to road transport developments, as evinced in existing literature. The study found that the physical condition of roads and the level of service obtained from road management relates to the experience of users to the extent that they attach value to their experience. Road value should be set on road users' experience. Furthermore, the current study established that the factors identified to influence users' experience invariably influence the value attached to the assets (value-in-use).

The study highlights the significance of users' satisfaction and attention to their experience in the evaluation of roads, especially in terms of sustainability encompassing social, economic, and environmental aspects. Road transport planning will be benefited if more attention is given to the value obtainable from the use of road transport networks, by users. In addition, strategies to sustain the quality and condition of roads should be given consideration during planning in order to attain maximum value from the road transport infrastructure investments. Recommendations to improve services and reduce customer complaints (increase customer satisfaction) based on their perceived value-in-use, are posited. Since road infrastructure is a universal phenomenon and the conceptualised model is based on literature on both international and South African context, the applicability of the model is generic. It can be used by road agencies and management stakeholders to ensure that the quality of services and physical infrastructure are improved in order to create value and overall sustainability.

The limitations of the study lies in the fact that it considered only asset-condition related factors as influencers of road value. Other models can incorporate other factors which influence user's experience and satisfaction such as number of networks, coverage and connectivity of travel modes, and so on. Further studies can also be dedicated to evaluating, statistically, the influence of the identified user-experience asset-condition factors on road transport infrastructure value.

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