Drawbacks to the Attainment of Sustainable Road Infrastructure in South Africa

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Abstract

In the quest to attain sustainable cities, sustainable infrastructures such as roads are vital to the everyday activity of dwellers within every community. However, roads within the rural areas are in most cases adjudged to be defective and unsustainable. This unhealthy situation tends to cripple activities within these rural areas in many ways. It is based on this view that this study assessed the causes of defective road infrastructures within rural communities in Limpopo province of South Africa. The study sought answers from rural dwellers and construction workers within the study area through a questionnaire survey. Data gathered were analysed using percentage, mean item score, and factor analysis. The reliability of the questionnaire was also tested using Cronbach alpha. Findings revealed that the principal causes of defective road infrastructure in rural areas are government/municipalities related, construction and maintenance related, and traffic and weather-related. It is believed that the findings of this study will help increase the delivery of sustainable road projects within the rural areas in a bid to provide a better standard of living for rural dwellers.

Keywords Defective roads, Sustainable infrastructure, Rural dwellers, South Africa

1. Introduction

Basic structures and facilities such as roads, buildings, water supply and power supply are necessary infrastructures required for the survival of dwellers of a community. Infrastructure development has overtime become a key issue for most developing countries particularly in Africa where a decay in the infrastructure of most countries is common (Jerome and Ariyo, 2004; El-Rufai, 2012). Although South Africa is not among the least developed countries in Africa (Aghimien *et al*., 2019), the country faces a similar issue of poor infrastructure. In terms of roads, Mamabolo (2016) concluded that South Africa has enough roads, but the major fallout is their unacceptable quality. There are roads in all nine provinces of the country, but their quality has been an issue since maintenance occurs after many years. Many potholes cause damages to vehicles and loss of valuable properties. Northern news (2015) earlier reported the temporary bridge between Vaalwater and Lephalale that was put in place after the road was destroyed during floods and the dangers of it being unable to withhold the load of all vehicles. In rural areas, the case is worse as the movement of products and people are done over long distances. Fungo *et al.* (2017) described road infrastructure as the backbone of many rural and urban transport systems. Rural transport provides assurance for the supply of agricultural inputs and facilitates the delivery of the farm outputs to the markets.

In rural areas, defective road infrastructure causes the farmers to seek better roads that can be used to distribute their goods, and these alternative routes could be longer thus leading to high transport cost. When no alternative routes exist, farmers are forced to travel on defective roads. The resultant effect of this includes damage to vehicles used, high maintenance costs, low profit, low earnings for workers, and a continuous rise of poverty among rural dwellers (Tunde and Adeniyi, 2012). Even though there has been a lot of research on road infrastructure, this matter is still a major concern in most developing countries around the world and South Africa is no exception. The rationale for this study, therefore, lies in the fact that new studies are helpful in discovering the depth of implications and the current issues that the country experiences. Based on this notion, the study assessed the principal causes of defective road

infrastructure in rural areas in South Africa with a specific focus on Limpopo province. The subsequent part of this paper includes the review of related literature, the research methodology adopted, the findings and conclusion drawn from the findings. Based on the conclusion, recommendations were made and the areas for further studies were suggested.

2. Review of Literature

"The municipal roads infrastructure grant, public-private partnerships and own municipality revenue streams allocated towards road infrastructure is a comprehensible fiscal strategy for the long-term sustainability for providing road infrastructure services in South Africa" (South African Local Government Association, 2011). Investing in road infrastructure is important for the country in making the roads safe to travel. Van Heerden *et al.* (2015) observed that the Department of Transport has a comprehensive plan for non–motorised transport. The department also strives to implement a rapid public transport network so that regular transport services can be available to the public in rural areas. Investing in roads creates more employment, and avenues to increase the knowledge of road construction, as well as training are being offered. Moeketsi (2017) stated that "road infrastructure in South Africa is a specific area of concern as the development of such infrastructure in the country has been neglected to a large extent in some provinces, thereby imposing significant limitations on growth and development in rural communities".

South Africa has a working road infrastructure network compared to other African countries, which provides a lot in terms of economic and social progress. However, poor quality roads are still evident, particularly within the rural settlements. This poor quality becomes more evident during heavy rainfall where materials used on construction roads gets eroded easily (Mamabolo, 2016). Jerome and Ariyo (2012) indicated that when it comes to quality standards, the roads that are constructed in Africa is far below. Van Heerden *et al*. (2015) note that majority of rural areas have no gravel and tar roads and rural dwellers drive in unsafe conditions.

Okigbo (2012) conducted a study on the causes of highway failures in a similar developing country and observed that inaccurate concrete curing, settlement and restraint at the road joints lead to cracks and subsequent failures on the road. It was observed that majority of roads in the country are planned and designed by personnel who are not familiar with the site and this leads to wrong decisions being made and the roads being designed and constructed poorly. A similar observation was made by Adlinge and Gupta (2012) where it was noted that poor subbase leads to settlement and uneven road surface. Okigbo (2012) noted the issue of heavy traffic affecting road structures in Nigeria. It was noted that as the traffic increases road deformation becomes increasingly evident since it accommodates more cars than it was constructed for. In India, Adlinge and Gupta (2012) also noted that the increase in traffic is bound to affect the road pavement leading to what was described as "alligator cracking". A similar observation was made in Sri Lanka (Harischandra, 2004).

Poor maintenance culture has been a common issue for most developing countries. Evidence abound in the body of literature about the poor maintenance of construction works in these countries (Abdul Lateef, 2010; Abigo *et al*., 2012; Edmond *et al*., 2010). Road projects suffer this same fate as poor maintenance culture adversely affects most roads and subsequently leads to their deterioration. Afolayan and Abidoye (2017) and Oluwatobi (2010) have earlier noted that proper designing and construction of road is necessary as roads contribute immensely to the economy of any nation. Furthermore, after construction, these roads must be maintained to that ensure safety, strength and durability are achieved (2010). There must be appropriate maintenance regardless of the design and construction issue to achieve sustainability. However, in rural areas, maintenance is a major problem in roads and in cases where maintenance is done, it is not planned (Okigbo, 2012). Adlinge and Gupta (2012) and Harischandra (2004) made similar observations in their study. In South Africa, Mamabolo (2016) stated that lack of enough funds from municipalities causes poor maintenance of municipal roads. The Road infrastructure policy for South Africa also stated that the poor standard of many provincial and local roads is further compounded by limited funds as well as a reduced focus on maintenance and limited skills in the public sector. It was further stated that many municipalities and provinces lack the skill, capacity and funding to efficiently manage local road networks.

Poor road facilities, using materials with low quality, poor workmanship, inadequate management, low knowledge base, no local standard of practice, inadequate sanctions for road failures were also noted as key causes of road deterioration in Nigeria (Okigbo, 2012). Similar Harischandra (2004) noted issues such as the age of the road, road geometry, weather condition, road facilities such as drainage, construction quality, and maintenance policy as the key culprit of road failures in Sri Lanka. Adlinge and Gupta (2012) pointed out issues surrounding temperature variation, poor shoulders, poor clayey subgrade, poor drainage conditions, and overheating of bitumen as some key causes of road failure in India. Other studies have noted predominant issues such as inadequate preliminary geological investigation, poor design of roads, bad supervision and workmanship, lack of routine and periodic maintenance, bad

drainage, improper use and overloading of roads, inadequate sanction for highway failure (Momoh *et al.*, 2008; Oluwatobi, 2010; Osadebe *et al.*, 2013; Osuolale *et al.*, 2012).

3. Research Method

In assessing the major causes of defective road infrastructure in rural areas, a quantitative survey approach was adopted to gather empirical data (Ikuabe et al., 2022). The study sort answers from rural dwellers and construction workers in the Limpopo province of South Africa using questionnaire. The questionnaire was adopted as the instrument for data collection due to its ease of usage and ability to cover a wide range of respondents (Tan, 2011). A total of 72 questionnaires were conveniently distributed with 65 retrieved and 60 found fit for data analysis. The remaining 5 questionnaires were discarded as a result of inaccurate completion and missing vital information. Some of the questionnaire was self-administered while others were done through the help of field agents who read the questions to some of the rural dwellers who were unable to fully understand the questions asked. The data collection spanned a period of one month. The questionnaire used was designed in sections; the first section gathered information on the respondent's background. The second section sort answers regarding the major causes of defective road infrastructure in rural areas in South Africa. Respondents were provided with a list of causes identified from literature to rate based on their level of significance. A Likert scale of 1 to 5 was employed, with 5 being very high, 4 being high, 3 being average, 2 being low and 1 being very low. Data analyses were done using percentage for data on the background information of the respondents. The reliability of the questions in this second section was tested using Cronbach's alpha test which gave an alpha value of 0.898, thus implying high reliability of the questionnaire used as the alpha value is closer to 1. Exploratory Factor Analysis (EFA) was conducted to reduce the causes of defective road infrastructure assessed into a smaller number of underlying grouped factors (Aghimien *et al.*, 2021). EFA was adopted based on the assertion that there is a possibility for some causes to have similar underlying meaning, and as such grouping such causes together will help give better perspective of issues that need to be addressed (Chan and Aghimien, 2022; Ikuabe *et al.*, 2022)

4. Findings and Discussion

Background information of respondents
The result on the background information of the respondents revealed that 52% of population was male while the remaining 48% were female. Forty-five per cent (45%) of these respondents are rural dwellers that operate local businesses such as farming and selling of farm products, petty shop owners, motorist and the likes. The remaining 55% are into construction works within these rural areas. For their academic qualification, result revealed that 5% of the respondents had a below matric qualification, 18% had matric, 13% had National Certificate, 37% had a National Diploma, 20% had a bachelor's degree, and 7% had a master's degree. Following these results, it can be said that the respondents for the study have considerable understanding of happenings within the rural environment as they reside in these areas.

4.2   Drawbacks of sustainable road infrastructure
In determining the causes of defective road infrastructure in rural areas in South Africa, 12 major causes were identified from the review of the literature and presented to the respondents to rate according to their level of significance. Since there is the likelihood of some of the identified causes having similar underlying effects, EFA was deemed necessary to reduce these causes into a smaller number of coherent subscales. To conduct EFA, the suitability of the sample size was considered. Although there have been several disparities about the ideal size of a sample for EFA to be conducted, Preacher and MacCallum (2002) suggested that if the communalities are high, and the expected number of factors is small, the sample size is inconsequential. Zhao (2008) went further to suggest a communalities figure above 0.6 as being suitable irrespective of the sample size being adopted. The result from the communalities analysis revealed that 11 out of the 12 assessed variables have communalities figure above 0.6 as seen in Table 1.

Table 37. Communalities of the causes of defective roads

Causes	Initial	Extraction
Lack of funds from municipalities	1.000	0.597
Negligence by municipality	1.000	0.713

Using materials with poor quality for road construction	1.000	0.606
Lack of capacity in public sector	1.000	0.665
Poorly formulated policies by the departments	1.000	0.627
Inadequate sanctions for road failure	1.000	0.668
Poor road management skill	1.000	0.740
Poor maintenance culture	1.000	0.781
Poor drainage construction leading to over-flooding of road	1.000	0.735
Heavy traffic	1.000	0.600
Poor laboratory and in-situ tests on soil	1.000	0.699
Erosion from the adverse weather	1.000	0.640

Extraction Method: Principal Component Analysis

The result in Table 2 shows the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity which were also used to ascertain the suitability of the data for EFA. The result of the KMO test gave a value of 0.778 and a significant level of 0.000 for Bartlett's test. Tabachnick and Fidell (2007) have earlier noted that the KMO index ranges from 0 to 1, with 0.6 being the minimum value for a good EFA. Also, Pallant (2005) submitted that Bartlett's test of sphericity shows whether the correlation matrix is an identity matrix, and this should be significant at p-value < 0.05. The result of the KMO and Bartletts test derived, coupled with the communalities of above 0.6 derived and the 0.898 value obtained from the Cronbach alpha reliability test conducted, proves that the use of EFA for the data gathered is appropriate.

Table 2. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.778
Bartlett's Test of Sphericity	Approx. Chi-Square	357.204
	df	66
	Sig.	0.000

Having met the necessary requirement for EFA to be conducted, EFA was done using principal component analysis (PCA) with varimax rotation. EFA extracted 3 components with eigenvalues greater than 1 with 0.50 set as the cut-off point for the factor loading. The final statistics of the PCA and the components extracted accounted for approximately 67.3% of the total cumulative variance. This result is above the 50% limit stated by Stern (2010). The 3 extracted components and the variables loading on them are shown in Table 3.

Table 3. Rotated Component Matrix

Drawbacks	Component		
	1	2	3
Lack of capacity in the public sector	0.801		
Lack of funds from municipalities	0.779		
Inadequate sanctions for road failure	0.758		
Poor road management skill	0.736		
Poorly formulated policies by the departments	0.702		
Negligence by municipality	0.636		
Poor maintenance culture		0.844	
Poor drainage construction leading to over-flooding		0.816	
Using materials with poor quality for road construction		0.667	
Poor laboratory and in-situ tests on soil			0.817
Heavy traffic			0.774
Erosion from the adverse weather			0.698

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

4.3   Extracted Factors

A.   Government and Municipalities related causes

The first principal component has the highest factor loading of 6 variables and it accounts for 45.3% of the total variance explained. This percentage is higher than the percentage for the remaining two extracted factors combined. This means that variables loading on this component are a major culprit of defective road infrastructure in rural areas. These causes are; lack of capacity in public sector, lack of funds from municipalities, inadequate sanctions for road failure, poor road management skill, poorly formulated policies by the departments, and negligence by municipality. Based on the latent properties of these variables, this component was named the "Government and Municipalities related causes".

B.   Construction and Maintenance related causes

The second principal component has 3 variables loading on it and accounts for 13.3% of the total variance explained. These variables are poor maintenance culture, poor drainage construction leading to over-flooding of road, and using materials with poor quality for road construction. These factors were subsequently named "Construction and Maintenance related causes".

C.   Traffic and Weather-related causes

The last principal component has 3 variables loading on it and accounts for 8.7% of the total variance explained. These variables on this component are poor laboratory and in-situ tests on soil, heavy traffic, and erosion from the adverse weather and it is subsequently named "Traffic and Weather-related causes".

5. Discussion

The findings revealed that government and municipalities related issue is one of the major drawbacks to the attainment of sustainable road infrastructures. There is no gainsaying that the government plays a significant role in the delivery of public infrastructure. The activities of the government, therefore, plays a significant role in the development or decay of public infrastructures. Mamabolo (2016) has earlier noted that shortage of funds from municipalities causes poor maintenance of municipal roads which subsequently leads to defective roads within the country. Similarly, defective roads are the resultant effect of municipalities and provinces lack of required skills and capacity to efficiently manage local road networks. Findings of this study further affirm the submission of Okigbo (2012) that inadequate sanctions for road failures is among the principal culprit of defective roads in developing countries. This is because when roads are poorly constructed, the construction participants involved in the delivery are not properly sanctioned, hence no subsequent acts of poor construction are repeated.

Similarly, it was revealed that construction and maintenance issues also contribute immensely the non-attainment of sustainable road infrastructure in rural areas in the country. This finding is in line with the submissions of Adlinge and Gupta (2012), Harischandra (2004), and Okigbo (2012) who discovered that poor maintenance issue affects road infrastructure in India, Sri Lanka and Nigeria respectively. Similarly, the findings also confirm the submissions of Okigbo (2012) and Afolayan and Abidoye (2017) that poor drainage and the use of poor materials for construction can affect the road adversely. Thus, care must be taken during designing and construction and adequate consideration must be given to its maintenance (Afolayan and Abidoye, 2017).

The last principal culprit of defective road infrastructure within the rural community of the country is traffic and weather-related issues. The harmful effect of increased traffic on constructed roads have been reiterated in past studies. The findings of this study are in line with previous submissions which shows that when traffic increases beyond the capacity a road was initially designed for, deformation of such roads occurs and cracks as well as uneven road surface becomes evident on such roads (Adlinge and Gupta, 2012; Okigbo, 2012). This point to the need for experts in the designing and constructing of road networks. Afolayan and Abidoye (2017) have earlier noted that most road projects fail because of lack of adequate planning before construction. If better road projects that can withstand its traffic are to be achieved within the country, adequate pre-planning and planning must be done with the calculation of the current and future traffic to be handled by such road done correctly. Similarly, proper designing of road facilities must be properly done to avoid destruction of road surfaces during adverse weather conditions.

6. Conclusion

This study assessed the major causes of defective road infrastructure in rural areas, with answers sought rural dwellers and construction workers in the Limpopo province of South Africa. Based on the findings, the study concludes that the major causes of defective roads in rural areas are government/municipalities related, construction and maintenance related, and traffic and weather-related. Therefore, if road projects are to improve and serve their intended purposes, the government and municipalities representatives must be willing to champion this course through proper funding of road project, creating capacity in public sector, and ensuring that adequate sanctions for road failure are in place. Similarly, due consideration must be given to road design and construction and their subsequent maintenance.

It is believed that the findings of this study will help increase the delivery of sustainable road projects within the rural areas in a bid to provide a better standard of living for rural dwellers. However, while the findings of this study are essential to the delivery of better road infrastructure within rural settlements, care must be taken in generalizing its findings as the study was limited to a single province in the country. Further studies can, therefore, be conducted in other rural areas in other provinces to compare results and have a wider view of the subject

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