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Dominating Factors of Road Failures: Perceptions of Key Stakeholders in the Small Island Developing State of Trinidad and Tobago

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Abstract: *Accelerated global population increase, socioeconomic and environmental changes have resulted in spiralling maintenance costs for pavements. Current understanding of pavement deterioration fails to address this longstanding issue, and Small Island Developing States (SIDS) are not immune to the recurring expense incurred from pavement degradation. Existing academic debates on design and construction inadequacies in pavement longevity do not address regular maintenance challenges. This research examines the reasons for frequent pavement failures and explains how they affect Trinidad and Tobago's future maintenance and economic development. A questionnaire was completed by 120 contractors, consultants, and state agency experts specialising in road construction and maintenance. The findings revealed from an assessment of the Relative Importance Index (RII) that utility cuts by the Water and Sewerage Authority were the most important (0.904), followed by maintenance culture (0.898), quality of work (workmanship) (0.888), poor drainage facilities, and overloaded vehicles (0.854). Climate change (temperature) was the lowest-ranked cause overall (0.568). The findings also show that economic growth and development are directly and indirectly affected, resulting in high vehicle running costs, longer travel times, and higher prices for fundamental products and services. Recommendations are made to aid engineers and policymakers in identifying critical causes and reducing the adverse consequences of frequent pavement failure.*

Keywords: *Maintenance, Pavement deterioration, Perceptions, Road failures, Trinidad and Tobago*

1. Introduction

Pavement Infrastructure is an important asset that is critical to the socio-economic development of developing countries. Over time, all pavement infrastructure will gradually deteriorate because they are all designed and constructed with an expected service life. Therefore, it will be in the best interest of road agencies to provide continuous assessment and maintenance of their road network, to keep them in a safe and functional condition. Failures to maintain pavement infrastructure, as described by Harral and Faiz (1988), can be considered equivalent to the act of disinvestment, as it suggests that the sacrifice made prior has been wasted. Pavement deterioration processes occur because of structural fatigue, and functional distresses. When these distresses become more prevalent, timely and adequate maintenance is required. However, if timely maintenance is neglected, improperly executed, or delayed, it results in further deterioration and consequently affects the travelling public's safety. Additionally, it also contributes to the riding quality, serviceability and the cost associated with future maintenance and rehabilitation (M&R) strategies (Zumrawi 2015).

Banda (2018) stressed that the deterioration of flexible pavements is increasing much quicker than the supporting maintenance budgets and institutional limits, thus, adversely affecting wealth generation and development. From a safety perspective, poor road conditions increase the severity of multiple-vehicle accidents on all roads (Lee et al., 2015). Research conducted by Pais et al. (2013) and Raheel et al. (2018) showed that traffic and axle loadings have increased and frequently surpassed existing roads' design limits. New pavements, if insufficiently maintained, will deteriorate quickly within the first half of their service life (Markow, 1990; Visintine et al., 2016).

Roads, and means of transport, make a crucial contribution to economic development and growth and bring important social benefits. Poorly maintained roads

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constrain mobility, significantly raise vehicle operating costs, increase accident rates and associated human and property costs, and aggravate isolation, poverty, poor health, and illiteracy in rural communities (Burningham and Stankevich, 2005). Failure to provide adequate road maintenance is the main reason for the lack of sustainable road transport networks in many countries (Gwilliam and Shalizi, 1996). Delaying or postponing road maintenance results in high direct and indirect costs. Neglected roads will progressively become more difficult to use, resulting in increased vehicle operating costs, more frequent repairs, increased fuel use, and the hesitancy of transport operators to use the roads. These effects impose a substantial burden on the economy: as passenger and freight services are truncated, there is a consequential loss of economic and social development opportunities (Burningham and Stankevich, 2005). The management and maintenance of a country's road network generate significant improvements in the general quality of transport provision, environmental, ecological, economic and technical sustainability aspects (Burrow et al., 2013).

Small Island Developing States (SIDS) are a collective group of countries that are mainly located in the Caribbean, Africa, Pacific, and the Indian Ocean regions (United Nations, 2022). They are relatively small in size and sparsely populated. Transportation networks in these states are critical assets that foster economic growth and development in key sectors such as tourism, agriculture, fisheries, and small-scale manufacturing activities. Dos Anjos Ribeiro Cordeiro et al. (2017) concluded that damage to any SIDS main transportation networks could potentially cripple their economic growth and hinder the effective transportation of goods and services around the islands.

Currently, there are 39 SIDS, in which the road network is often a large part of the country's infrastructure stock. Road sectors also often represent a substantial share of the government budget, especially for SIDS that do not rely heavily on international aid. While toll roads can partly finance road transport in many countries, SIDS faces significant challenges in attracting foreign direct investment and domestic private finance in road infrastructure. This means that road infrastructure maintenance, upgrading, and rehabilitation typically rely on public funds and international aid (Dos Anjos Ribeiro Cordeiro et al., 2017).

In an interview in April 2022, the Project Management Support Unit in the Ministry of Works and Transport (MOWT) in Trinidad and Tobago (T&T) indicated that the Programme for Upgrading Road Efficiency (PURE) agency under the MOWT, has spent TT$4.3 billion over the past decade on pavement maintenance and road rehabilitation projects to provide optimal service and ensure consistent road connectivity throughout the country. However, despite this effort, pavement deterioration seems to increase much faster than Trinidad and Tobago's corresponding maintenance budgets.

Previous research such as Shooshtarian et al. (2020), Pan and Pan (2020), and Zhao et al. (2016) revealed disparities in stakeholders' perceptions of construction-related activities. The number of stakeholders surveyed, according to these studies, limits the conclusions, generalisability, and application of perception research findings. Perceptions may be classified as subjective and variable across stakeholders due to elements such as fear, culture, education, society, connections, experiences, and knowledge (Zhao et al., 2016). These findings should be incorporated into the present stakeholder perception type research's conclusions and recommendations. This study focuses on identifying the causes of frequent pavement failure in Trinidad and Tobago (T&T) and how they impact economic growth, maintenance and rehabilitation strategies. The study's findings may help SIDs road agencies prioritise budget allocation, engage in focused research, and adopt initiatives to protect the nation's road network.

2. Road Infrastructure of Study Area

T&T is a Small Island Developing State in the Caribbean, with a land area of approximately 4,828 km2 and a population of 1.3 million. Due to the geographical location of the twin-island states, the country shares many common development challenges, such as economic isolation and limited resources, inclusive of the vulnerability to climate change and natural disasters. Despite the significant capital expenditure, a large portion of the road network is in poor condition, which indicates inefficiencies in the allocation and lack of road maintenance (Bollers et al., 2019).

For continuous stimulation of economic growth, the country heavily depends on its transportation and pavement network infrastructure by extension. Trinidad's entire road network is approximately 9,592km (5,960 miles) in length, including highways, main roads, and some secondary roads (MOWT, 2022). The country faces many challenges at the domestic level because the increasingly diversified economy requires an upgrade of the country's road infrastructure and internal connectivity to facilitate the growth of non-oil sectors such as agriculture and tourism (Oxford Business Group 2020).

In T&T, economic prospects are heavily underpinned by a single commodity, which is oil. The twin-island has produced more than three billion barrels of oil in the past century, making it the richest country in the Caribbean and the third-highest Gross Domestic Product (GDP) in the western hemisphere. Despite this, an increasing number of pavement infrastructures in the country are riddled with pavement defects, making some areas throughout the country impassable, which ultimately leads to vehicular damage (Seemungal, 2021). Moreover, since 2015 the energy sector has seen a fair share of problems with weak global energy prices and declining oil and gas production. As revenue associated with hydrocarbons has fallen in recent years, there has been a significant reduction in the

amount of government budgetary allocation to maintenance and road infrastructure development.

Consequently, this has created a view among many disgruntled citizens that most state agencies, such as the Municipal Corporations, Ministry of Works and Transport and Programme for Upgrading Road Efficiency (PURE), that are responsible for road construction, rehabilitation and maintenance, are disorganised and inefficient as it relates to the effective maintenance of roads in their respective networks and communities. Moreover, it has led to many reoccurring challenges, such as open protests by road users who openly express their dissatisfaction with the Ministry of Works and Transport as they complain about the poor road conditions of the secondary, residential and agricultural carriageways in their respective communities. These criticisms are prevalent notwithstanding provisions of $TT 2.5 billion for the roads and bridges sector, as part of the government's public investment programme, in the last four fiscal years. Funding for road construction and rehabilitation declined by 42 %, while funding for the 14 regional corporations for local government roads and bridges declined by 20 % from 2019 to fiscal 2021 (Seemungal 2021). These reductions in budgetary allocations for maintenance works will ultimately result in a number of selective roads not being properly maintained or receiving some form of deserved maintenance attention in a timely manner. Many of the roads under the purview of the local road agencies may further deteriorate into deplorable conditions over time.

3. Methodology

The objective of this study is to identify the causes of frequent pavement failure in Small Island Developing States with an emphasis on T&T. The perspectives of interest are those of the three main stakeholders of roadwork projects: state agencies, contractors and consultants.

3.1 Research Strategy

The study uses a deductive research design approach to incorporate simple mixed methods using an electronic survey with closed-ended and open-ended questions. Data collection was cross-sectional over a 3-month period. A population of 200 respondents was determined by those directly involved in the construction and maintenance of local roads. The population is comprised of relevant state agencies, such as the Ministry of Works and Transport, members of the Trinidad and Tobago Contractors' Association (TTCA), and members of the Construction Management Institute of Trinidad & Tobago (CoMITT).

3.2 Instrumentation

The survey instrument incorporated a five-point Likert-Type scale approach ranging from strongly disagree (1) to strongly agree (5), in which respondents were asked to provide feedback based on their experience. According to Nemoto and Beglar (2014), this approach allows respondents to freely choose options from multiple categories. The advantages of this method allowed the data to be gathered relatively quickly from many respondents. It also allowed the obtained data to be compared and combined with other qualitative data collection methods such as open-ended questions. The questionnaire is divided into four sections where:

Section 1 – Identifying the general profiles of the respondents by summarising their employment agency, position in their organisation, years of experience in the construction industry and the type of work executed by their organisation, such as new construction, maintenance and rehabilitation.

Section 2 – Listing their opinionated causes of frequent pavement failure and deterioration. A pilot test was conducted with 10 persons from 3 different agencies to review the 23 factors. These 23 factors were developed from a desktop study of published works from (Okigbo 2012, Tarawneh and Sarireh 2013; Pais et al. 2013; Zumrawi 2015; Adlinge and Gupta 2013; Burgess et al. 2010 and Tarawneh and Sarireh 2013). The pilot resulted in four additional factors that were included in the final survey.

Section 3 – Identifying the impacts of pavement failure on effective maintenance. This section entailed 11 closed-ended questions and six open-ended questions. The questions aimed to determine the impact poor pavement conditions have on maintenance works in T&T.

Section 4 – Identifying the impact of pavement deterioration on economic growth. This section consisted of 14 questions, which also involved open-ended and closed-ended questions. The aim of this section was geared toward ascertaining the effects pavement failure has on economic growth and wealth reaction in T&T.

3.3 Data Collection and Analysis

The electronically administered survey tool took place over a 3-month period achieving a response rate of 60% collectively which, according to Mugenda and Mugenda (1999), is considered adequate for data analysis and reporting. The quantitative data was analysed using the Relative Importance Index (RII) as shown in Equation 1. The RII is calculated for each of the indicators and ranked accordingly. The RII is derived to summarise the importance of each indicator. Each factor was ranked arithmetically within a range of 0-1, where a high RII value suggests a greater level of impact on each factor. Factors were then positioned in descending order based on this value to ascertain the most significant factor(s) affecting pavement maintenance failures in T&T.

$$RII = \sum W / (A \times N) \quad (1)$$

Where,

W = weighting as assigned on Likert's scale by each respondent in a range from 1 to 5, where 1 = no impacts, 2 = negligible impact, 3 = marginal impact, 4 = moderate

impact and 5 = major impact.
A = Highest weighting (here it is 5)
N =Total number in the sample / respondents

Qualitative content analysis is the classical method of analysing responses to open-ended questions since it can be employed both to gather information and to motivate respondents (Zull, 2016). According to Chambers and Chiang (2012), qualitative content analysis is a methodology that requires researchers who use it to make a strong case for the trustworthiness of the data. Every finding should be as trustworthy as possible, and the study must be evaluated concerning the procedures used to generate the findings. For this study, a categorisation scheme was developed for each open-ended question. Each question was tallied based on the assigned category, and each responded response was reviewed, evaluated, and summarised.

4. Analysis and Findings

4.1 Descriptive Characteristics of the Respondents

A total of 120 questionnaires were collected, of which 52% were professionals from state agencies, 31% were professionals from contractor firms, and the remaining 17% were from road and pavement consultant firms. Figure 1 shows the distributions of the respondents' positions in their respective organisations. Many of the respondents were positioned at the medium level of management, with the majority representing engineers, which account for 34%, project managers representing 26%, directors representing 17%, and construction managers representing 9%. Other junior positions accounted for 14%, collectively.

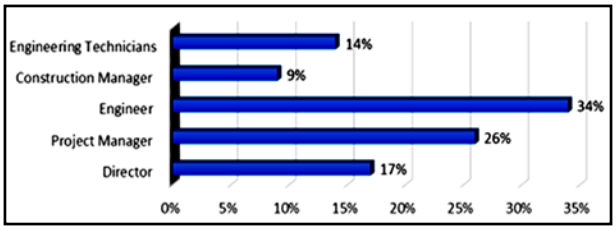

Figure 1. Respondents Current Position in Respective Organisations

As it relates to years of work experience in the related area of study, 10% of the respondents had entry-level to intermediate (<5 years) experience, as shown in Figure 2. Respondents with mid-level experiences (5-15 years) summed up to 51%, while the senior level experienced persons (>15 years) were 39%. The distribution of these experiences allowed for a balanced and holistic approach to the data collection.

Figure 3 highlights the type of work undertaken by the respondents identified in Figure 1. Persons involved in the new construction works of roads accounted for 87% of total study respondents. It is noted that respondents may be involved in more than one work-related activity. Although maintenance activities are part of the life cycle of road infrastructure, the result showed that it had the least amount (47%) of respondents' involvement in maintenance works or related projects. The remaining road infrastructure design and rehabilitation activities scored 49% and 64%, respectively.

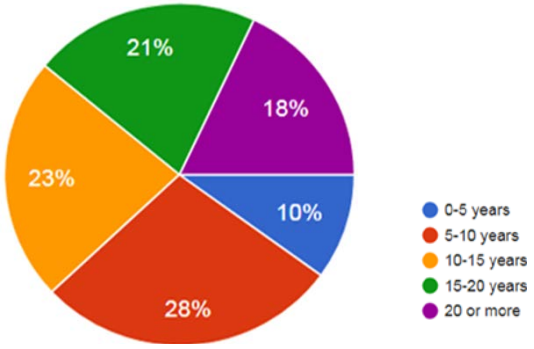

Figure 2. Respondents Experience

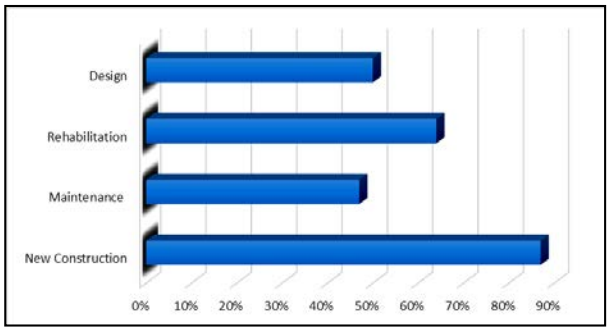

Figure 3. Type of Works Undertaken by Respondents

The statistical results suggest that the study population is sufficiently capable of identifying and addressing the factors of road failure based on the perception of persons involved in the design, construction and maintenance of roads. There is sufficient data that allowed a mixture of respondents from both the public and private sectors in the construction industry. Moreover, most of the respondents were positioned at the top and mid-levels of management within their respective organisations with sufficient experience and knowledge in the construction, maintenance, rehabilitation, and designs of pavement structures in T&T. Thus, the findings from this section give credence to the quality and validity of the research.

4.2 Perception of the Major Causes of Frequent Failures of Paved Roads

Table 1 provides the Relative Importance Index (RII) of the 27 factors and their respective ranks regarding the major causes of frequent failures of maintained roads in T&T. The five most critical factors are identified from the perspectives of respondents from state agencies, contractors and consultants. These are:

Table 1. Relative Importance Index (RII) and their rank

Cause of Pavement Failures	State Agencies		Contractor		Consultant		Combined Results	
	RII	**Rank**	RII	Rank	RII	Rank	RII	Rank
Utility cuts by W.A.S.A.	0.908	3	0.922	1	0.859	2	0.904	1
Maintenance Culture	0.919	1	0.884	2	0.859	2	0.898	2
Quality of Work (Workmanship)	0.912	2	0.865	3	0.859	2	0.888	3
Poor Drainage Facilities	0.865	5	0.865	3	0.847	3	0.862	4
Overloaded Vehicles	0.877	4	0.807	6	0.871	1	0.854	5
Quality of Design	0.808	9	0.826	5	0.800	6	0.812	6
Uncontrolled domestic water flowing into the road structure	0.812	8	0.774	8	0.835	4	0.804	7
Moisture (water)	0.839	6	0.755	10	0.729	10	0.794	8
Use of Poor-Quality Material	0.819	7	0.742	11	0.765	8	0.786	9
Political influence or involvement	0.750	12	0.839	4	0.788	7	0.784	10
Poor Supervision by Contractor	0.781	10	0.716	12	0.812	5	0.766	11
Lack of monitory and quality control	0.738	14	0.781	7	0.765	8	0.756	12
Inadequate Sanctions for Highway Facilities	0.762	11	0.774	8	0.682	13	0.752	13
Poor Supervision by client	0.742	13	0.671	16	0.788	7	0.728	14
No local Standard of Practice	0.712	17	0.761	9	0.706	11	0.726	15
Inferior asphalt mix design	0.712	17	0.716	14	0.741	9	0.718	16
Soil Type (Clay)	0.742	13	0.658	18	0.671	14	0.704	17
Prolonged flooding	0.704	18	0.677	15	0.741	9	0.702	18
Lack of efficient/competent contractor	0.723	15	0.652	19	0.671	14	0.692	19
No Laboratory and in situ test on existing subgrade	0.669	19	0.716	12	0.694	12	0.688	20
Large Traffic Volume	0.719	16	0.632	21	0.670	14	0.684	21
Lack of expert technical personnel by client, contractor, or consultant	0.665	20	0.658	18	0.659	15	0.662	22
No Local Professional Bodies in Highway Design, Construction and Maintenance	0.646	22	0.658	18	0.659	15	0.652	23
Oxidisation of bitumen over time	0.650	21	0.639	20	0.588	16	0.636	24
Slow administrative process by client	0.592	23	0.710	13	0.588	16	0.628	25
Delay on payments of contractor	0.554	25	0.677	17	0.553	17	0.592	26
Climatic Changes (Temperature)	0.573	24	0.568	22	0.553	17	0.568	27

1) Utility cuts by the Water and Sewerage Authority (W.A.S.A) (0.904),
2) Maintenance culture (0.898),
3) Quality of work (workmanship) (0.888),
4) Poor drainage facilities (0.862) and
5) Overloaded vehicles (0.854).

Conversely, the lowest-ranked factor was climatic changes (temperature), with a RII = 0.568.

Scholars such as, Adlinge and Gupta (2013) and Praveen and Ankit (2010) have arrived at similar findings concerning the most critical factors of road failure. They highlighted that sudden increase in traffic loading, temperature variation, poor construction, inadequate materials selection process and poor drainage were the most prevalent failure mechanisms, corresponding with three of the presented study's critical factors.

Figure 4 provides an overview and illustrates the ranking of state agencies contractors, consultants and combined, highlighting that these factors have the highest impact on the causes of frequent pavement failures of maintained roads in T&T. Although not top-ranked, Wilde (2002) indicated that utility cuts into the pavement introduce discontinuities and increase the roughness of the pavement structure, which has the potential to cause both structural and functional degradation of the pavement, which leads to premature pavement failure. Additionally, the correlation between poor maintenance culture and the cause of pavement failure, as similarly indicated in the present study and work by Okigbo (2012), highlight that those in authority do not release funds for road maintenance at the appropriate time, which consequently allow roads to deteriorate to the extent that they become impassable or more expensive to rehabilitate. It should be noted that the possible biases in responses vary because of the categories and duties of respondents (including state agency, contractor, consultant) of the study. This is evident in Figure 4 as it highlights that the contractors were the only agency that indicated political influence or involvement as causes affecting the maintenance processes of roadways.

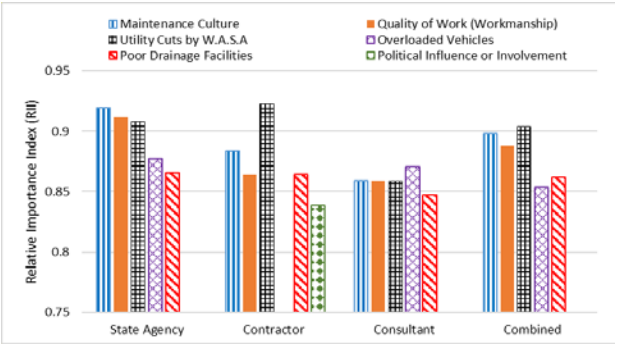

Figure 4. Major Causes of Frequent Failures of Maintained Roads in T&T

Moreover, the Water and Sewage Authority (WASA) utility cuts are the highest ranking contributing issue for road contractors, which they claim that it occurs after the construction stage of the road pavement structure. Their perspective is based on their responsibilities to provide a user-friendly, visually beautiful, and functional road product at the end of construction. The effort and quality with which they created the road is not the same as the devotion with which WASA patched the cuts, resulting in the early beginning of collapse.

The quality of workmanship is linked to the improper training of construction workers. The abovementioned results suggest that workmen in the local pavement construction industry may not be well trained. This view is supported by Okigbo (2012), who concluded that this lack of training amongst the artisans and craftsmen could lead to the inappropriate application of pavement construction materials or inadequate soil compaction. Another major cause of pavement failures is overloaded vehicles, which research (Abadin and Hayano, 2022; Pais et al., 2013; Sadegh and Fathali, 2007) has shown to cause fatigue cracking and rutting, eventually requiring pavement rehabilitation. The actions of overloaded vehicles will continue to wear down the pavement surface and, thus, gradually reduce the high-speed skid resistance. It is suggested that the increase in overloaded vehicles on a pavement that is already experiencing pavement deterioration would cost billions due to maintenance and rehabilitation and vehicle operating cost.

4.3 Impact of Effective and Timely Maintenance of Road in Trinidad

As indicated by the data in Table 2, poor maintenance of the roads in T&T inevitably causes unnecessarily traffic delays; however, this seldom discourages road users, thus not assisting with the appeasing heavy traffic. As in the case of Yitages (2017), this study highlights that the lack and mismanagement of maintenance increase the cost of rehabilitation and repairs, which progressively leads to pavement failures. Extensive rehabilitation and even re-construction could save TT$ millions if timely maintenance was carried out earlier. The data indicates that the advantages of timely and adequate road maintenance sustain the quality of the road infrastructure while simultaneously providing a level of safety to the road users.

The respondents were of the view that the quality achieved on maintained paved roads is not sufficient. They also lamented that the maintenance culture in T&T is considered reactive as opposed to being proactive. The best approach is one that addresses maintenance as soon as failures are identified to prevent further deterioration.

Moreover, the lack of adequate budgetary allocations leads to delays in effective and routine maintenance works. This finding corroborates the conclusions of Donev and Hoffmann (2020), who suggested that the objective of maintenance and repair works is to minimise agency and user costs or to minimise risk/environmental impacts by selecting the most appropriate treatments subject to budget constraints. Furthermore, the work highlights the correlation between the lack of technical training for road maintenance personnel, leading to poor management policy and the consequences of developing poor road conditions.

4.4 Pavement Deterioration on Economic Growth

Robbins and Tran (2015) suggested that smooth roads cost transportation agencies less over the life of the pavement and result in decreased highway user operating costs, delayed costs, decreased fuel consumption and decreased maintenance costs. As highlighted in Table 3, in T&T, there is a strong belief that effective and efficient road maintenance strategies lower vehicle operating costs (VOC). The VOC is considered to impact economic growth since poorly maintained roads directly would exhibit costly repairs to motorists' vehicles over time. Given the current economic climate of the Caribbean, 41% of the respondents believe that providing adequate funding for road maintenance works can improve the country's economic health.

Table 2. Responses Regarding the Impacts of Timely Maintenance

Statement	Strongly Disagreed (1)	Disagreed (2)	Neutral (3)	Agreed (4)	Strongly Agreed (5)
	%	%	%	%	%
Poor maintenance can unnecessarily cause traffic delays.	0	0	2	59	39
Lack of maintenance increases the cost of rehabilitation and repair.	1	0	0	38	61
Poorly maintained roads seldom discourage users or curb the volume of traffic.	8	33	14	38	7
Timely and adequate road maintenance sustains the quality and safety of the road.	0	0	0	55	45
The lack of technical training for road maintenance personnel's results in poor road conditions.	2	9	16	57	16
Lack of maintenance provides low service levels to its users.	0	2	11	56	31
Maintenance works are only executed when major failure occurs.	1	3	7	47	42
Mismanagement of maintenance works lead to the progression of pavement failures.	1	1	8	59	31
Lack of government's budgetary allocations for long-term commitment leads to delays in effective maintenance	1	9	17	36	37
The lack of sophisticated equipment and resources are limitations to effective maintenance.	10	32	23	25	10
Roads are considered sustainable when it is maintained in a satisfactory condition over time.	1	3	10	57	29

Table 3. Responses Regarding the Impact of Pavement Deterioration on Economic Growth

Statement	Strongly Disagreed (1)	Disagreed (2)	Neutral (3)	Agreed (4)	Strongly Agreed (5)
	%	%	%	%	%
Effective road maintenance can be considered the life blood of the economy and serve as a catalyst that fuel economic growth	2	5	20	50	23
Poor road maintenance can be considered hindrance to foreign investments	0	7	25	53	15
Delayed maintenance has the potential to impose a heavy burden on the economy	0	4	9	52	35
Deterioration of pavements is a clear indication of the decline of economic growth of a country	0	26	26	37	11
As roads deteriorate, the costs of essential goods and services begin to increase	1	5	16	56	22
Effective and efficient road maintenance lowers vehicle operating cost to the users	0	0	1	43	56
There is a causal relationship between well maintained pavement infrastructure and economic growth	1	4	31	48	16
The boost in the economy can only be achieved when adequate funding is provided for road maintenance works	2	26	31	30	11

Another area is the lack of data to make viable assessments and develop interventions that are unique to the country when thinking of transportation-economic growth policies. The poor or ineffective existing pavement management system (PMS) has uncovered major deficiencies locally. One of which is that the public road agency lacks an effective monitoring system. This deficiency has made it difficult to execute an adequate data collection policy that can be used to generate the necessary feedback on the road networks. The step forward to mitigate these issues is implementing a framework suited for analysing the economic effects of pavement maintenance. Such a framework can allow relevant stakeholders to analyse and implement maintenance projects properly.

The evidence-based framework will eliminate the existing ad hoc approach, which is currently being used in most instances. Other benefits of such a framework will be:

1) Improved development of a comprehensive strategic plan for road maintenance,
2) A more rigorous approach to analysing the correlation between pavement maintenance strategies and economic defects or benefits,
3) Initiating the development and improvement of policies, local codes, and regulations related to pavement maintenance, and
4) Access to historical data can inform decisions based on lessons learnt from successful or unsuccessful initiatives.

5. Conclusions

The literature revealed that well-maintained roads reduce the impacts associated with motorist safety, improve users' benefits and foreign investments' attractiveness, and boost economic wealth. The adverse effect of poorly maintained rood also holds true. The study investigated the causes of frequent failure of maintained roads in T&T. The results from the study suggest that the major causes of frequent failure of maintained roads are due to maintenance culture, quality of work (workmanship), utility cuts, overloaded vehicles, and poor drainage facilities in the country.

The study's approach investigated the perspectives of three important stakeholders on the prevailing reasons of road failures. The study's findings clearly show that there are significant disparities in key stakeholders' perspectives on what constitutes road failure in T&T. For example, the state agency and consultants argue that political influence is a factor, while the contractor places a high value on it. The involvement of each stakeholder clearly influences and unavoidably influences the ranking of these failure producing elements.

The research also sought to determine the impacts of pavement deterioration on economic growth and timely maintenance of roads in T&T. The results suggest that pavement deterioration can significantly impact economic growth both directly and indirectly, given that a functioning road transportation infrastructure serves as a catalyst that fuels economic growth. Furthermore, it was revealed that sufficient funding for maintenance works must be made available in a timely manner since the lack of budgetary allocations leads to delays in effective maintenance, which, consequently, can increase the cost of rehabilitation and repair.

Based on existing literature, case studies, and the current study's findings, the following points are recommended to stakeholders to diagnose the causes of frequent failures of maintained roads in T&T. These are:

1) Regularly assess the performance of the road networks to take timely corrective actions regarding the road condition. Random and sporadic maintenance interventions should be changed to specific and results-oriented condition responsiveness. Proper investigations into the causes of pavement failure will help bring an existing pavement to its original condition before the pavement deteriorates further.
2) Invest in Road Maintenance Management System (RMMS) or Pavement Management System (PMS) with adequate training for staff to manage the nation's road network effectively. This system systematically allows for proper planning,

scheduling, and budgeting of maintenance works with little to no political involvement.

3) Dedicate a special unit that should be solely responsible for developing maintenance schedules and budgets for the nation's road network.
4) The utility companies and road agencies should work together to ensure that road damages are properly repaired to reduce the effect of further pavement deterioration. Consideration for the construction of utility corridors along the roadways for future projects can significantly reduce the deterioration of the pavement structure.
5) Provision for automatic weight control devices at strategic locations to monitor overloaded vehicles. This should include the involvement of police and traffic wardens who should regularly patrol not only highways but also secondary and tertiary roads. All heavy vehicles operating on the nation's roads without the necessary permit should be charged in accordance with the law.
6) Road agencies and contractors have to take responsibility for the quality of work and workmanship and the failures that occur post maintenance work that can reduce the causes of frequent failure of maintained roads in Trinidad. Quality assurance methodologies for the post maintenance period need to be developed in order to determine whether the desired target is achieved or not.
7) Evaluate and adopt innovative maintenance strategies and maintenance treatment selection techniques to develop effective maintenance programmes for the nation's roads.

Further work is required to establish whether the findings of this research are consistent with other small island developing states in the Caribbean. The new studies can evaluate the alternative funding options for maintenance works, as well as innovative and sustainable alternative strategies and treatment selection techniques to develop effective maintenance programmes.

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