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Evaluation and Prioritization of Strategies for Enhancing Gravel Roads Maintenance Practices in Tanzania

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ABSTRACT: Gravel roads maintenance (GRM) is essential for the national economy of developing countries like Tanzania, where over 75% of the road network remains unpaved. Hence, the objective of this paper is to explore management strategies and their effects on the performance of gravel roads maintenance projects in Tanzania using appropriate standard methods utilizing 385 questionnaires administered to professionals. The study revealed five key GRM strategies that are essential for the effective maintenance of gravel roads: These were off-prism strategy, risk management strategy, maintenance fund strategy, delivery and procurement strategy and construction materials strategy. Using the Pareto principle, the two most highly ranked strategies (off-prism and risk management strategy with mean value of 1.85 and 1.82 respectively) were identified as critical areas of focus. An implementation matrix has been proposed to provide clear maintenance guidance. The identified GRM strategies are recommended for implementation to enhance the efficiency of GRM projects in Tanzania, accounting for 53.5% of the variance. By focusing on the off-prism, risk management strategies and delivery and procurement strategy, significant improvements in road maintenance can be achieved, benefiting Tanzanian's road infrastructure and economy.

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The current practices in planning, designing, and contracting road maintenance projects in Tanzania do not adequately promote safe and reliable access to social services. These deficiencies could be rectified through the implementation of appropriate enhancement management strategies. Maintenance of gravel roads has predominantly been conducted on an empirical basis rather than through technically sound maintenance practices incorporating management-optimizing techniques. Effective improvement of gravel road maintenance projects often necessitates institutional reforms, human resource development, and changes to management practices prior to addressing technical issues. Mukasa (2013), observed that client and roads users' satisfaction with roads maintenance is moderately low due to suboptimal maintenance strategies. A decade later, the report of the Controller and Auditor General on the performance and forensic audit for the period ending 30th June 2023 highlighted three primary issues in the Tanzanian roads sector: time management, cost overruns, and quality of completed roads. Specifically, road development and maintenance works frequently exceed agreed timelines, resulting in delayed public benefits; costs often overrun for various reasons; and the quality of roads deteriorates faster than expected due to poor design, construction, or maintenance methods. These issues are exacerbated by factors such as changing conditions, values, and priorities. Addressing these challenges requires the integration of

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technical managerial strategies, including technological processes, materials, human capital, and the efficient delivery of procurement and financial resources. Mwaipungu *et al.* (2012), identified key improvement strategies such as securing sufficient roads maintenance funding, ensuring the availability of construction materials, enhancing the capacity and number of qualified staff, improving maintenance practices, and implementing decision-support systems. Ejohwomu *et al*. (2016), identified the causes of poor construction project practices, including inadequate financial projections by clients, excessive contract variations, lack of site condition knowledge, misrepresentation in contract documents, and poor contract administration. Olanrewaju and Abdul-Aziz (2015), concluded that maintenance should be considered during the design stage, and that implementing maintenance strategies such as maintenance plans, scheduling, control, and works is crucial. They emphasized the importance of clear maintenance policy, objectives, and strategies during the feasibility study and detailed preparation phases, advocating for collaboration between designers and maintenance experts. Mkilania (2016), identified several influences affecting best maintenance practices in the Tanzanian public sector, including maintenance policy and strategy, strategic maintenance planning, and operational maintenance planning. McCready (2007), emphasized that before developing strategies to address problems, it is essential to clearly explain the causal factors influencing and creating these problems. These factors, identified through numerous studies and research projects, include both internal factors (such as bias, delivery/procurement approach, project schedule changes, and poor estimation) and external factors (such as local concerns, inflation effects, market conditions, and unforeseen events). McCready further concluded that potential strategies focusing on mitigating the causes of poor project value are significant. Momoh and Itohan (2023), defined strategic management as the process by which managers develop and implement strategies that may result in a lasting competitive advantage in the long run while Ibrahim *et al*. (2023), added that management strategy is a comprehensive plan and course of action used by a firm or organization to gain advantage by efficiently allocating its resources in response to meeting the requirements of stakeholders. In this study, the stakeholders are the roads users, hence it is the series of actions to be taken by management so that the performance of gravel roads are maximized or better improved. Maintenance, defined as all technical and managerial functions required to keep a facility in a functional state (Decker, 1996), is essential for preserving the economic value of physical infrastructure (Zeni, 2021). Khalid *et al.* (2019), linked maintenance problems to the lack of integration between pre-contract and post-contract activities, highlighting that neglected maintenance strategies can diminish a facility's value. Adeyeye *et al.* (2013), noted that poor facility functioning often originates during the design, construction, and usage stages, with maintenance being critical at the usage stage. Current gravel roads maintenance practices in Tanzania have been piecemeal, uncoordinated, and lacking sustainable managerial skills, despite the growing concern that Africa's extensive unpaved roads network cannot be sustained with existing technologies and practices. Disseminating high-impact maintenance strategies is therefore essential for ensuring long-term roads infrastructure performance and quality. Effective maintenance management can be achieved through key performance indicators, routine monitoring, and supervision within maintenance plans, policies, and procedural strategies. Hence, the objective of this paper is to explore management strategies and their effects on the performance of gravel roads maintenance projects in Tanzania.

MATERIALS AND METHODS

Sample Collection: Structured questionnaires with close-ended questions were used to collect data on strategies for enhancing gravel roads maintenance practices. The questionnaire was divided into two sections. Section one gathered demographic information about the respondents, while section two solicited their perceptions on ten strategies and gravel roads maintenance performance factors identified through literature review and a Delphi study. Respondents were asked to rate the effectiveness of these strategies in enhancing the value of gravel roads maintenance practices. The rating was conducted using a 5-point Likert scale, where 1 represented "Strongly Agree," 2 "Agree," 3 "Neutral," 4 "Disagree," and 5 "Strongly Disagree." This scale was adopted based on its successful application in a similar study by (Ishaq *et al*., 2021). Respondents provided their opinions on their level of agreement or disagreement with various strategic statements. To ensure a comprehensive analysis, 385 structured questionnaires were administered to professionals involved in roads construction and maintenance, which included Engineers, Quantity Surveyors, Architects, Environmental Engineers, and Civil Technicians. The sample size was estimated using the Yamane sampling techniques with the formula shown in equation 1 below:

$$Sample\ size\ (n) = \frac{N}{(1+Ne)^2} \qquad (1)$$

Where ‘’n’’ is the corrected sample size or minimum number of required respondents ‘’N’’ is the population size identified and ‘’e’’ is the margin of error which is the level of acceptance or precision. A pilot study was conducted to examine the groups identified in the research approach. Initially, 40 questionnaires were distributed to professionals in the roads sector operating under either Tanzania National Roads Agency TANROADS or Tanzania Rural and Urban

Roads Agency TARURA in the Dar es Salaam Region of Tanzania.

Table1: Reliability Statistic Test for the ten Strategies measurement items

Test Item	Number of Measurement Items	Cronbach's Alpha value
Strategies for enhancing gravel roads maintenance projects	10	0.881
Acceptable value		**≥ 0.70**

Table 2: Normality Test for ten strategies measurement items

	Kolmogorov-Smirnov			Shapiro-Wilk		
Strategy name	**Statistic**	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Management strategy	0.343	213	0.000	0.741	213	0.000
Document quality strategy	0.260	213	0.000	0.801	213	0.000
Construction materials strategy	0.287	213	0.000	0.787	213	0.000
Scope and schedule strategy	0.260	213	0.000	0.798	213	0.000
Risk strategy	0.239	213	0.000	0.810	213	0.000
Delivery and procurement strategy	0.246	213	0.000	0.804	213	0.000
Estimate quality strategy	0.295	213	0.000	0.777	213	0.000
Integrity strategy	0.261	213	0.000	0.804	213	0.000
Off-Prism strategy	0.228	213	0.000	0.817	213	0.000
Maintenance fund Disbursement strategy	0.241	213	0.000	0.807	213	0.000
Acceptable value			**<0.001**			**<0.001**

The purpose of the pilot study was to get comments on the initial version of the questionnaires before formulating the improved one which was used in the main survey. Out of 385 respondents issued with questionnaires, 213 properly filled and returned the questionnaires giving a response rate of 55.3%. The internal consistency of data was tested using Cronbach's Alpha value. The results of ten items tested presented in Table 1 show that the Cronbach's Alpha value is 0.881 which is greater or equal to the limit of 0.7 indicating that the scale used for the data is reliable (Hair *et al.*, 2014).

Further tests conducted are the normality tests in terms of Kolmogorov-Smirnov and Shapiro-Wilk tests and Pearson's Chi-Square tests for determining the correlation between variables. The results presented in Table 2 for normality tests show that the data are normally distributed.

Table 3 presents results for correlation tests between variables (Parametric) and results show that all variables were significant since the correlation is significant at the 0.01 level. As per Table 3 results summary, the off-prism and integrity strategy are the top ranked correlated variables with a Pearson correlation value of 0.571.

The rank of prioritized strategies was analyzed using the mean score values and standard deviations SD and results for the same is presented in Table 6. To identify and highlight critical strategies for enhancing gravel roads maintenance practices, the Pareto principle was employed. The Pareto principle, also known as the 80%-20% rule, posits that for many phenomena, eighty percent of the consequences arise from twenty percent of the causes. This approach aligns with the arguments of Buckley *et al.* (1976), who asserted that efforts to gather excessive amounts of information can be counterproductive.

The maintenance management strategies were subsequently linked to gravel roads performance factors to further analyze their correlations using SmartPLS software. The performance factors were derived from a documentary review and Delphi analysis, similar to what the study did in the identification of management strategies. Altogether, were rated by respondents in the administered questionnaires. These performance indicators were categorized into cost, quality, time, social and relational, and environmental aspects, as suggested by Luvara *et al.* (2020), who asserted that for a project to achieve effective performance, it must encompass both hard and soft project performance measures. Hard performance measures include cost, quality, and timelines, while soft performance measures encompass social, relational, and environmental aspects. The list of performance factors is as summarized in Table 4.

SmartPLS software was employed to examine the association between gravel roads maintenance management strategies and the associated performance metrics (Hair *et al.*, 2014) as portrayed in figure 2. The SmartPLS software assisted in analyzing information collected using the partial least squares structural equation modeling PLS-SEM technique. PLS-SEM is suitable for analyzing complex relationships that contain multiple constructs and indicators as well as strengths to non-normal distributions (Hair *et al.*, 2017).

Table 3: Correlations between strategy's variables

Strategy name	Correlation value name	Management strategy	Document quality strategy	Construction materials strategy	Scope and schedule strategy	Risk strategy	Delivery and procurement strategy	Estimate quality strategy	Integrity strategy	Off-Prism strategy	Maintenance fund Disbursement strategy
Management strategy	Pearson Correlation	1	0.542**	0.471**	0.443**	0.399**	0.479**	0.547**	0.301**	0.268**	0.351**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	N	213	213	213	213	213	213	213	213	213	213
Document quality strategy	Pearson Correlation	0.542**	1	0.445**	0.440**	0.397**	0.496**	0.369**	0.471**	0.327**	0.516**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	N	213	213	213	213	213	213	213	213	213	213
Construction materials strategy	Pearson Correlation	0.471**	0.445**	1	0.393**	0.547**	0.498**	0.434**	0.399**	0.294**	0.348**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000
	N	213	213	213	213	213	213	213	213	213	213
Scope and schedule strategy	Pearson Correlation	0.443**	0.440**	0.393**	1	0.429**	0.436**	0.274**	0.306**	0.353**	0.359**
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
	N	213	213	213	213	213	213	213	213	213	213
Risk strategy	Pearson Correlation	0.399**	0.397**	0.547**	0.429**	1	0.537**	0.434**	0.390**	0.414**	0.407**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
	N	213	213	213	213	213	213	213	213	213	213
Delivery and procurement strategy	Pearson Correlation	0.479**	0.496**	0.498**	0.436**	0.537**	1	0.516**	0.435**	0.406**	0.538**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
	N	213	213	213	213	213	213	213	213	213	213
Estimate quality strategy	Pearson Correlation	0.547**	0.369**	0.434**	.274**	0.434**	0.516**	1	0.519**	0.363**	0.387**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
	N	213	213	213	213	213	213	213	213	213	213
Integrity strategy	Pearson Correlation	0.301**	0.471**	0.399**	0.306**	0.390**	0.435**	0.519**	1	0.571**	0.446**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
	N	213	213	213	213	213	213	213	213	213	213
Off-Prism strategy	Pearson Correlation	0.268**	0.327**	0.294**	0.353**	0.414**	0.406**	0.363**	0.571**	1	0.433**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
	N	213	213	213	213	213	213	213	213	213	213
Maintenance fund Disbursement strategy	Pearson Correlation	0.351**	0.516**	0.348**	0.359**	0.407**	0.538**	0.387**	0.446**	0.433**	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	N	213	213	213	213	213	213	213	213	213	213

***. Correlation is significant at the 0.01 level (2-tailed)*

Table 4: Gravel roads maintenance projects performance measures

Performance Criteria	CODE	Indicator's name
Hard performance criteria (Cost, time and quality)	C1	No addition works and variations
	C2	Accurate budgets estimate as per roads condition survey reports
	C3	No maintenance scope creep
	C4	No maintenance scope changes
	C5	Adequate funds allocation considering actual maintenance needs
	T1	Minimum or no disputes for maintenance projects
	T2	Adequate timing of maintenance activities
	T3	Timely payments for works dully executed by clients
	Q1	No hike in construction materials due to inflation
	Q2	Proper project planning and control
	Q3	Good risk management
	Q4	Quality and conditions of construction materials
Soft performance criteria (Social, relational and environmental)	R1	Overall, personal relationships among members (employee-employee, Management employee relationships) are continually good
	R2	Overall achievement on adherence to health and safety measures on gravel roads projects well maintained
	R3	Overall satisfaction of road users and other stakeholders
	E1	Overall achievement of influence by local communities on environmental improvement for gravel roads maintenance projects sites
	E2	Overall achievement of training programs on environmental issues related to gravel roads management
	E3	Overall achievement of completed gravel roads maintenance projects' sites being environmentally protected
	E4	Overall achievement of compliance with implementing environmental management practices for gravel roads maintenance projects

Note: C = cost; T=Time; Q =quality; R =relational; E =environmental aspects

RESULTS AND DISCUSSION

Respondents Demography: The preliminary section of the questionnaires consisted of questions meant to gather information about the respondents'-profile and get insights on whether the data being collected is from respondents whose background provides relevant perception on the subject matter of the study. Table 5 illustrates the diverse array of organizations from which respondents were drawn, including the Tanzania National Roads Agency (TANROADS), Tanzania Rural and Urban Roads Agency (TARURA), Local Government Authorities (LGAs), Private Construction Companies (PCC). A summary of demographic profile results is presented in Table 5 whereby the majority of respondents (75.7%) had three or more years of experience in gravel roads maintenance, instilling confidence in the validity of the study findings. In terms of academic credentials, the majority of respondents (86.5%) held basic degrees, with 70.6% holding Bachelor's degrees (BSc), 15.9% holding Master's degrees (MSc), 11.7% holding diplomas, and 1.9% holding PhDs. Furthermore, the distribution of respondents' professional fields and organizational affiliations was fairly proportionate, with civil engineering being the predominant field (79.4%) and TARURA being the primary organizational affiliation (59.2%).

Table 5: Demographic profile results summary

Demographic profile	Frequency	Percent	Cumulative percent
Less than 3 years	52	23.9	23.9
3-5 years	49	23.0	46.9
5-10 years	47	22.1	69.0
10-20 years	47	22.1	91.1
More than 20 years	19	8.9	100
Total	**213**	**100**	
PhD	4	1.9	1.9
Master	34	16.0	17.8
Bachelor	150	70.4	88.3
FTC/ordinary diploma	25	11.7	100
Total	**213**	**100**	
Civil Engineer	169	79.3	79.3
Quantity Surveyor	15	7.0	86.3
Architect	3	1.4	87.7
Environmental Engineer	2	0.9	88.6
Civil Technician	24	11.3	100
Total	**213**	**100**	
Tanzania National Roads Agency	22	10.3	10.3
Tanzania Rural and Urban Roads Agency	126	59.2	69.5
Local Government Authority	15	7.0	76.5
Private Construction Company	50	23.5	100
Total	**213**	**100**	

The link observed between experience and education level highlights the relationship between theoretical knowledge and practical application. Similarly, the significance of professional qualifications and the relevance of organizations' roadworks underscore the credibility of the information gathered was from authoritative sources. Data collected therefore, is presumed to furnish a solid grounding in concepts and principles, as well as furnish invaluable understandings suitable for analysis of strategies for enhancing gravel roads maintenance practices

Critical Strategies for Enhancing Gravel Roads Maintenance Projects: Ten strategies for gravel roads maintenance practices were identified from the literature as influential for maintenance improvement. These strategies were presented to respondents to determine their criticality and significance. Using mean scores and standard deviation (SD) values for ranking, and applying the Pareto Principle (also known as the 80-20 rule), two strategies emerged as critical. The Off-Prism Strategy, with a mean score of 1.85, involves proactive engagement with external participants and assessment of environmental conditions affecting the cost performance of gravel roads. The risk strategy, with a mean score of 1.82, entails identifying risks, quantifying their impacts, and implementing actions to mitigate these impacts during the development of the maintenance scope. Table 6 summarizes the ranking results of all ten strategies, while Figure 1 illustrates the most critical strategies according to the Pareto Principle. Additionally, the correlation analysis revealed that the Off-Prism Strategy and the Integrity Strategy have the highest Pearson correlation value of 0.571, indicating a strong relationship between these variables - as closer to 1 than the other variables analyzed and presented in Table 3. The summary of a proposed implementation matrix is presented in Table 7 with five critical strategies and proposed respective actors.

Table 6: Prioritized strategies for improving gravel roads maintenance practices

Strategy variable name	N-Statistics	Mean	SD	Rank
Off-Prism strategy	213	1.85	0.750	1
Risk strategy	213	1.82	0.810	2
Maintenance fund disbursement strategy	213	1.81	0.768	3
Delivery and procurement strategy	213	1.81	0.791	4
Construction materials strategy	213	1.79	0.905	5
Integrity strategy	213	1.77	0.768	6
Document quality strategy	213	1.77	0.778	7
Scope and schedule strategy	213	1.76	0.769	8
Estimate quality strategy	213	1.69	0.768	9
Management strategy	213	1.63	0.800	10

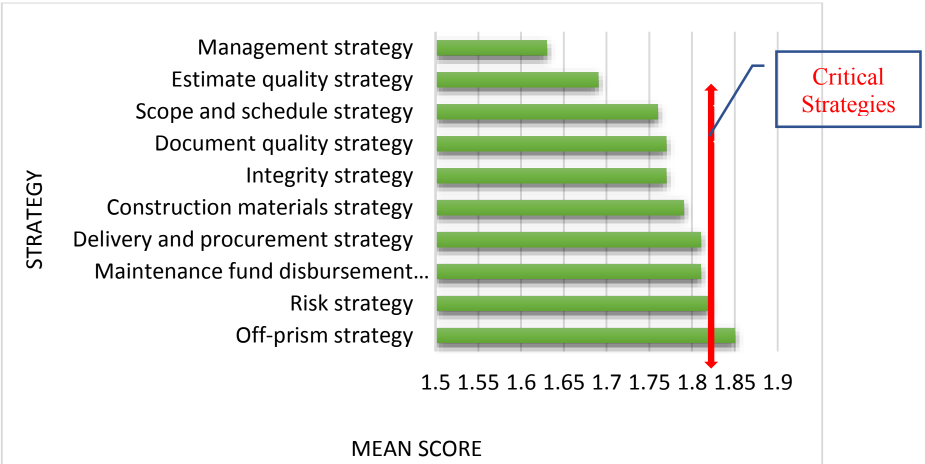

Fig. 1: Strategies for improving gravel roads maintenance projects

Table 7: Implementation matrix of critical strategies for enhancing maintenance performance

Strategy	Actor	Role
Off-Prism Strategy	Responsible Ministries, Roads Authority Implementing Agencies and Government Regulating Authorities	-Use of proactive engagement with external participants and assessment of environmental conditions affecting the cost performance of gravel roads -Employ qualified technical personnel in gravel roads maintenance practices -Conduct regular training to all technical personnel involved in maintenance
Risk Strategy	Responsible Ministries, Roads Authority Implementing Agencies and Government Regulating Authorities	-Identifying risks, quantifying their impact, take actions to mitigate the impact as maintenance scope is developed -Employ risk management consultants in planning, design and supervision of roads maintenance projects.

Effects of Management Strategies on the Performance of GRM Projects: Efficient management strategies and practices in the construction industry have been widely studied to create and sustain a competitive advantage. These studies focus on developing frameworks that ensure consistent performance of construction projects. Gravel roads maintenance projects, which account for over 75% of the roads networks in many developing countries, have not received comparable attention despite their importance. Padalkar *et al.* (2016), noted that construction project management has traditionally relied on a deterministic perspective, emphasizing control and predictability. However, for gravel roads maintenance projects, it is crucial to balance short-term efficiency with long-term innovation due to limited resources. Meng (2012), highlighted that breakdowns in relationships among project actors can lead to poor performance. Therefore, this study explores critical management strategies to enhance gravel roads maintenance project performance. This paper also delved into examining the total effect of management strategies (MST) on the maintenance performance of gravel roads. The SmartPLS software was used to analyze complex relationships between various management strategies and performance factors. The data analysis aimed to determine the coefficient of determination (R^2) and the total effects of MST on overall maintenance performance (OMP). The analysis revealed a strong relationship between MST and OMP of gravel roads, with an R^2 value of 53.5%, significantly exceeding the acceptable threshold of 20% set by (Hair *et al.*, 2014). This indicates that MSTs substantially explain the variance in OMP. Among the ten management strategies assessed, the delivery and procurement strategy (ST6) emerged as the most influential, with a path coefficient of 0.766. This strategy involves applying appropriate delivery methods to better manage maintenance costs, indicating its significant impact on OMP. The results also showed that the MST-OMP relationship is statistically significant, as detailed in Table 8, which summarizes the P-values of all dependent and independent variables. Quality criteria such as R^2, f^2, reliability, and validity were used to finalize the total effects, summarized in Table 9. The findings indicate that MST has the highest effect on quality performance (0.635), followed by cost performance (0.610). Similarly, the OMP subscales of performance factors showed that quality and cost were the top factors, with total effects of 0.866 and 0.833, respectively. These results suggest that effective management strategies significantly enhance the performance of gravel roads maintenance projects, providing a competitive advantage. The dominant logic concept underscores the importance of delivery and procurement strategies in managing maintenance costs and improving overall gravel roads projects' performance. By employing tools like SmartPLS therefore, the complex relationships between management strategies and performance factors can be effectively analyzed, providing valuable insights for improving project outcomes in Tanzania and other developing countries.

Table 8: Significances path coefficients values of MIST to OMP factors

Path Name	Original sample (O)	Sample Mean (M)	Standard Deviation(STDEV)	T Statistics (IO/STDEVI)	P-Values
MST->OMP	0.733	0.743	0.030	24.038	0.000
OMP->C	0.833	0.835	0.023	35.624	0.000
OMP->E	0.530	0.519	0.093	5.698	0.000
OMP->Q	0.866	0.869	0.020	42.600	0.000
OMP->R	0.590	0.579	0.086	6.841	0.000
OMP->T	0.776	0.779	0.037	21.032	0.000

Note: MST=management strategy, OMP =overall maintenance performance, C=cost, Q=quality, T=time, R=relational, E=environment

Table 9: Total effects of MST on overall maintenance performance of gravel roads

Variable Name	Cost	Environment	Quality	Relational	Time
MST	0.610	0.388	0.635	0.432	0.569
OMP	0.833	0.530	0.866	0.590	0.776

The analysis reveals that gravel roads management strategies are positively perceived and significantly enhance performance by providing clear direction for management activities based on their importance as portrayed by the structural model in Figure 2. Effective performance in maintenance outcomes requires roads authorities to consistently and regularly address management strategies to optimize the limited resources allocated for gravel roads maintenance in Tanzania and similar developing countries. This aligns with McWilliams *et al.* (2019), who argue that management strategies facilitate performance evaluation and outline objectives to meet both current and future needs, thereby maximizing performance. Figure 2 illustrates that the relationship between management strategies (MST) and overall maintenance performance (OMP) has a coefficient of determination of 53.5% ($R^2 = 0.535$). This exceeds the acceptable threshold of $R^2 \geq 0.2$ established by (Hair *et al.*, 2016). Table 9 confirms the quality of the relationship between gravel roads management strategies and performance factors, as per (Hair *et al.*, 2016). All quality criteria are met, except for the Average Variance Extracted (AVE) for MST, which is 0.483, slightly below the acceptable threshold of $\geq$0.50. Despite this, the decision was made to retain the result to avoid compromising other performance factors. Table 11 outlines the preferred order of gravel roads management strategies, with ST1, ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9 and ST10 representing management, document quality, construction materials, scope and schedule, risk, delivery and procurement, estimate quality, integrity, off-prism and maintenance fund disbursement strategies respectively. The findings suggest that implementing these strategies should consider the suggested priority order to avoid potential dilemmas. Notably, the management strategy path ST6-MST-OMP-Quality-Q4 ranks highest, while ST9-MST-OMP-Environment-E2 ranks lowest. The ST6-MST-OMP-Quality-Q4 path is considered most effective in enhancing gravel roads maintenance performance. This supports Fedushko *et al.* (2021), who argue that introducing a long-term strategic approach can improve project performance and efficiency by addressing all feasible means and circumstances.

Table 10: Reliability and validity tests results summary for MST and OMP

MST and OMP factors	Item code	Rho-A	Cronbach's alpha	Composite reliability	AVE
Cost	C	0.757	0.754	0.833	0.500
Management strategy	MST	0.891	0.881	0.903	0.483
Environment	E	0.982	0.978	0.984	0.938
Overall maintenance performance	OMP	1.000	-	-	-
Quality	Q	0.762	0.759	0.847	0.582
Relational	T	0.946	0.941	0.962	0.894
Time	C	0.795	0.791	0.878	0.707
Acceptable value		**≥ 0.70**	**≥ 0.70**	**≥ 0.70**	**≥ 0.50**

Table 11: Ranking of the top five management strategies relative to performance effects.

Management Strategy to performance path name	Path coefficient values (ST-MST)	Path coefficient values (OMP-T,C,Q,R,E)	P-Values	Rank
ST6-MST-OMP-Q	0.766	0.866	0.000	1
ST2-MST-OMP-C	0.737	0.833	0.000	2
ST1-MST-OMP-T	0.731	0.776	0.000	3
ST5-MST-OMP-R	0.709	0.590	0.000	4
ST7-MST-OMP-E	0.704	0.530	0.000	5

The discriminant validity of the constructs was examined using the Fornell-Larcker criterion and the Heterotrait-Monotrait Ratio (HTMT), with results presented in Tables 12 and 13. The HTMT values range between 0 and 1, with 46.7% of the constructs having values close to 1. This indicates a fairly proportionate and moderate level of similarity among the constructs. The Fornell-Larcker ratio results provide insight into the constructs' convergent validity (Fornell and Larcker, 1981), showing how well the management strategies relate to each other. As depicted in Table 12, the diagonal values are greater than the off-diagonal values in the same row, thus satisfying the discriminant criteria for the management strategies and gravel roads maintenance performance metrics.

Table 12: The Fornel-Larker Criterion results summary

Construct	C	MST	E	OMP	Q	R	T
C	0.707						
MST	0.599	0.695					
E	0.202	0.265	0.969				
OMP	0.833	0.733	0.530				
Q	0.755	0.671	0.179	0.866	0.763		
R	0.275	0.317	0.968	0.590	0.233	0.945	
T	0.618	0.573	0.107	0.776	0.726	0.164	0.841

Table 13: The Heterotrait-Monotrait Ratio results summary

Construct	C	MST	E	Q	R
MST	0.700				
E	0.215	0.260			
Q	0.984	0.810	0.203		
R	0.299	0.321	1.000	0.272	
T	0.775	0.681	0.119	0.933	0.186

The results on the total effects of management strategy (MST) on the performance of gravel roads maintenance projects, summarized in Table 8, demonstrate that all MST effects on performance are statistically significant (P-values = 0.000), meeting the criterion of $P < 0.001$. In addition to the statistical significance of MST on overall maintenance performance (OMP), the importance-performance analysis results are compelling. The performance value of the latent variables is 25.38% for MST and 28.043% for OMP, with the highest performance observed for the manifesto variable at 39.98% for sub-indicator Q4 (quality and conditions of construction materials). This indicates that MST has satisfactory effect on OMP. The importance-performance map (MST-OMP) constructs, displayed in Figure 3, further supports these findings. Consequently, it is concluded that implementing the highlighted management strategies positively characterizes the effects on the overall maintenance performance (OMP) of gravel roads maintenance projects. This affirms therefore, the notion of continual performance improvement in roads infrastructure maintenance and development projects.

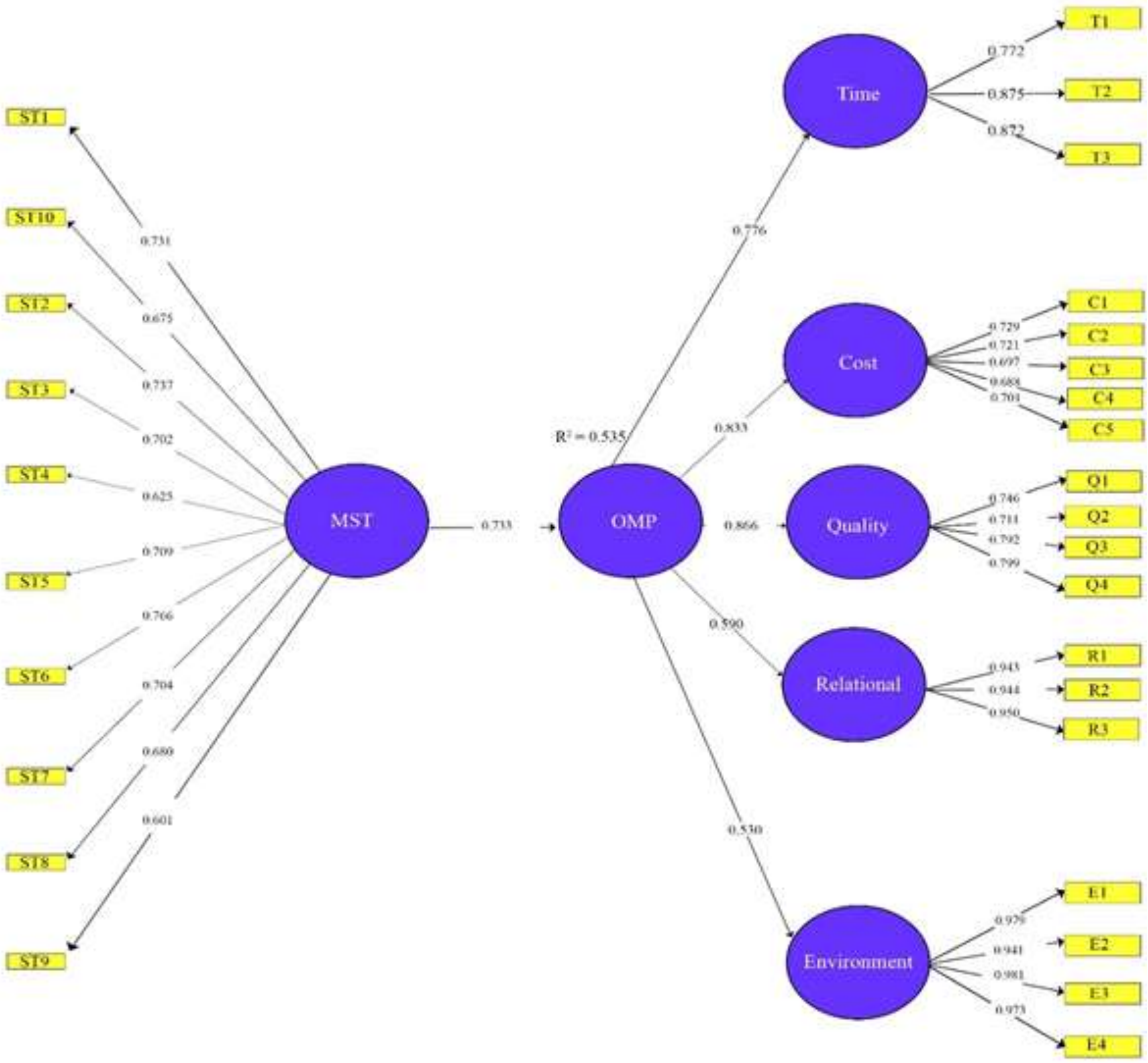

Fig 2: Graphical Structural Model Representation of Management Strategies Effects on OMP

Conclusion: This study aimed to assess and prioritize strategies for enhancing gravel road maintenance practices, focusing on performance improvement parameters. Based on the study findings, it is concluded that two strategies; the off-prism strategy with a mean value of 1.85 and the risk strategy with a mean value of 1.82 are critical due to their significant influence on improving gravel roads maintenance practices. Furthermore, the analysis revealed a strong correlation between the off-prism strategy and the integrity strategy, with a Pearson correlation value of 0.571. This suggests that the Integrity Strategy can be effectively implemented alongside the Off-Prism Strategy to achieve enhanced maintenance outcomes. To better boost the performance, this research recommends instituting mechanisms in managing maintenance costs effectively via implementing delivery and procurement strategy due to its vitality in maintenance performance outcomes. The study recommends that road sector implementing agencies and other construction stakeholders prioritize the application of these influential strategies when managing gravel roads maintenance projects. By doing so, they can optimize overall maintenance practices and achieve better performance.

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REFERENCES

Adeyeye, K; Piroozfar, P; Rosenkind, M; Winstanley, G; Pegg, I. (2013). The Impact of Design Decisions on Post Occupancy Processes in School Buildings. *Facilities*, 31(5), 255–278. https://doi.org/10.1108/02632771311307142

Buckley, JW; Buckley, MH; Chiang, H (1976). Research Methodology and Business Decisions, *National Association of Accountants*, New York (pp. 1-89).

Decker R (1996). Applications of Maintenance Optimization Models: *A Review and Analysis*. Reliability Engineering and System Safety, 51(3): 229-240.

Ejohwomu, AO; Oshodi, OS; Onifade, MK (2016). Identifying the Critical Causes of Conflicts in Construction Projects in Nigeria. *Nig. J. Technol.* 35(2), 290-296.

Fedushko, S; Peracek, T; Syerov, Y; Trach, O (2021). Development of Methods for the Strategic Management of Web Projects. *J. Sustainability*, 13(2), 742.

Fornel, C; Larker, DF (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *J. Market. Res.* 18(1), 39-50)

Ibrahim, R; Kyando, N; Kiwonde, F (2023). Analysis of Strategic Planning Practices and School Performance: Evidence from Public Secondary Schools in Tanzania. *Asian Research Journal of Arts & Social Sciences*, 21(4), 1-12

Ishaq, ZH; Muhammad, S; Abubakar, M; Lawal, S; Isah, I (2021). Impact of Risk Factors on Construction Projects' Quality in Nigeria. Procs West African Built Environment Research (WABER) Conference, 9-11 August 2021, Accra, Ghana, 685-699

Jacob D. Mukasa (2013). Management of Road Maintenance Projects in Local Government Authorities, Case of Southern Highlands Regions (Mbeya, Iringa, Rukwa and Katavi; A paper presented to Annual Roads convention for TARA between 28-29 November 2013 Karimjee Hall, Dar Es Salaam (pp. 23.36).

Hair, JF; Hult, GTM; Ringle, CM; Sarstedt, M (2017). A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). SAGE Publication (pp. 1-374).

Hair, JF; Hult, GTM; Ringle, CM; Sarstedt, M (2016). A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). Thousand Oaks, CA: SAGE Publication (pp. 1-262).

Hair, JF; Thomas MH; Christain, MR; Joseph, F; Marko S (2014). A Primer on Partial Least Squares Structural Equation Modeling. Copyright by SAGE Publication (pp.1-112).

Luvara, VGM (2020). Development of Social Capital Model for Organization Performance of Building Contractors in Tanzania. Unpublished Ph.D Thesis, Ardhi University (pp. 22-23).

Kavishe, N; Chileshe, N (2020). Critical Success Factors in Public-Private Partnerships (PPP)s on Affordable Housing Schemes Delivery in Tanzania: A qualitative Study. *J. Facil. Manag.* 17(2), 188-207. Doi:10.1108/jfm-05-2018-0033

Khalid, EI; Abdullah, S; Hanafi, MH; Said, SY; Hasim, MS (2019). The Consideration Maintenance at Design Stage in Public Projects Such as Buildings: *The current scenario in Malaysia*. Facilities, 37(13–14), 942–960. https://doi.org/10.1108/F-04-2018-0055

McCready, RD (2007). Guidance for Cost Estimation and Management for Highway. (pp 29-31).

Padalkar, M; Gopinath, S (2016). Six Decades of Project Management Research: Thematic Trends and Future Opportunities. *Inter. J. Project. Manage.* 34 (7): 1,305-1,321.

Projects During Planning, Programming, and Preconstruction, Highway Research Program, Washington DC.

McWilliams, A; Siegel, DS (2019). Creating and Capturing Value: Strategic Corporate Social Responsibility, Resource-Based Theory and Sustainable Competitive Advantage. *J. Manage.* 37(5), 1480-1495.

Meng, X (2012). The Effect of Relationship Management on Project Performance in Construction. *Inter. J. Project. Manage.* 11(4), 259-274

Mkilania, JN (2016). Factors Affecting Best Maintenance Practice in Tanzania Public Sector. *Inter. J. Mech. Engineer. Technol.* 7 (3): 139–149).

Momoh, JI; Itohan, I (2023). The Effect of Strategic

Management Practices on Organizational Competitiveness. *Epra. Inter. J. Res. Develop.* 8(5), 12-15.

Mwaipungu, RR; Allopi, D (2012). The Use of Gravel Loss Prediction Models for Effective Management of Gravel Roads. In: 31st Annual Southern African Transport Conference. CSIR, Pretoria, 9-12 July 2012. Pretoria: SATC (pp. 23-58).

Olanrewaju, AL; Abdul-Aziz, AR (2015b). Building Maintenance Processes and Practices: The Case of a Fast Developing Country. Building Maintenance Processes and Practices: The Case of a Fast Developing Country, 1–331. https://doi.org/10.1007/978-981-287-263-0

United Republic of Tanzania URT (2023). Annual General Report of the Controller and Auditor General on the Financial Statements of Tanzania Rural and Urban Roads Agency for the Financial Year 2022/2023. National Audit Office pp. 46-109.

Zeni, KS; Kikwasi, GJ (2021). Factors Affecting Maintenance Cost of Public Buildings: Case Study of Tanzania Buildings Agency and National Housing Corporation. *Inter. J. Build. Pathol. Adapt.* 41 (5): 926-941 https://doi.org/10.1108/IJBPA-08-2021-0107