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Assessment of Level of Service for Roads under Performance Based Road Maintenance in Kenya

[1]Dominic Kundu, [2]Zachary Gariy, [3]Timothy Nyomboi

[1]Department of Civil Engineering, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya

[2]Department of Civil Engineering, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya

[3]Directorate of Special Projects, Kenya Urban Roads Authority, Nairobi, Kenya

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Abstract

Purpose: This paper seeks to assess Level of Service (LOS) of roads under performance-based road maintenance (PBRM) in Kenya. This was done through a comparison of actual ratings with performance targets defined by the agencies for each asset item within a sample unit. The comparison was used to determine if each asset item had been preserved at minimum acceptable Level of Service (LOS) with objective of establishing if there are any benefits accrued from adopting the PBRM method.

Methodology: Seven roads were identified in the study area and were divided into 14 sample units, each sample unit containing different asset items to be assessed. Data from the field was collected and recorded using field measurement tools for linear measurements. Dynamic Response Intelligent equipment (DRIMS) was used for measurement of International Roughness Index (IRI). Raw data was converted into performance information using guidelines from Quality Assurance in Highway Maintenance Programs and measurement of conformance conducted using Schedule Performance Index.

Findings: The performance obtained indicated that the goal objective for each road was not achieved with an overall performance deviating from the target performance by 25.05%. However, there was 10% compliance at the asset group level and 35% compliance at asset item level. Noncompliance at road section level, 10% compliance at asset group level and 35% compliance at asset item level signifies inadequacies in PBRM practice in Kenya. This informs need for improvement by road agencies and contractors for optimum benefits from PBRM. There is need for contractor capacity building and enhanced partnering environment between contractors and management engineering consultants to provide technical assistance for improved contractor compliance in PBRM practice.

Unique Contribution to Theory, Practice and Policy: The Concept of Performance based road maintenance (PBRM) is meant to solve problems arising from traditional contracting methods. As demonstrated in this study, effective application of PBRM principles results in cost savings in managing and maintaining roads, expenditure certainty, reduced inhouse workforce, greater road user satisfaction and improved conditions of contracted road assets. The requirement for contractors to provide a product of predefined quality is a definite means of ensuring that the road asset is performing over extended time. It is recommended that PBRM is adopted widely in road asset management to achieve an effective and efficient road network.

Keywords: *Level of Service, PBRM, Performance Indicators, Ratings, Payment Reductions*

INTRODUCTION

Road maintenance is the process of returning road assets to a level of service of acceptable performance. Investments through road maintenance contributes positively to economic development. By providing access to socio-economic benefits a road network is instrumental in poverty reduction. Challenges facing road asset maintenance have resulted in poor road conditions. Maintenance neglect leads to capital intensive works in rehabilitation of a road network to desirable service levels. Cost overruns from traditional unit rates contracts because of variations, interest on delayed payments, extension of time with costs are among common reasons for poor road conditions in many countries (Kenny, 2007, Robinson et. al., 2006).

Studies reveal that road implementing agencies face difficulties in controlling quality, time, and cost when using traditional methods of contracting. (Zietlow, 2005). In Kenya, road maintenance strategies span from 1970's to 1980's where roads were maintained through force account under the Rural Access Roads (RAR) and Minor Roads Program (MRP) with a resealing unit for paved roads under management of road officers at district level (KeRRA, 2015). Starting 1987, the force account method was discouraged with adoption of unit rates method. Deficiencies in unit rates method led to adoption of Performance-based Road maintenance in 2010s (MoTI, 2014).

Adoption of Performance based road maintenance in Kenya is aimed at improving Level of Service (LOS) of the road network, reduce road user and vehicle operating costs, improve road user satisfaction, and increase efficiency and effectiveness in road asset management.

Objective of the Study

This Study's objective was to assess the Level of Service (LOS) of roads under performance-based road maintenance in Kenya. The study also examined extent of contractor compliance in executing performance-based road maintenance works to realize benefits associated with performance based contracting method. It recommends partnering between local contractors and Engineering Consulting firms to enable successful implementation of performance-based road maintenance practice in Kenya.

Performance Based Road Maintenance (PBRM)

In the late 1990s, road professionals introduced Performance-based Road maintenance (PBRM) contracting method with the objective of solving challenges arising from traditional contracting methods (Zietlow, 2005). PBRM is a contracting method where the contractor is given responsibility and flexibility to maintain road assets using innovative approaches to yield a product of predefined quality (Ozbek & de la Garza, 2007). Under PBRM the existing road is maintained based on performance indicators to achieve a acceptable level of service within specified time. The concept is defined by fixed payments if the level of service is met or payment reductions for noncompliance. The compliance and achievement of the specified performance target is dependent on prescribed response time. This contracting method allocates higher risk to the contractor compared to traditional contract arrangements, but it opens opportunities to increase contractor's margins due to possibility of improved efficiencies and effectiveness of design, process, technology, or management. Zietlow, (2015) demonstrates that PBRM approach reduces the cost of achieving the specified performance standards. It ensures the road asset condition is consistently performing over the extended period. A study by the World Bank in 2009 demonstrated that increased efficiency, savings of

30%- 50%, economic rate of return of 60% at a 12% cost of capital, reduced need for future capital investments by 30%. Payments are based on how well the contractor complies with Level of Service targets, not on quantity of works achieved.

The introduction of PBRM contracting in Kenya calls for a systematic performance monitoring approach to assist in evaluation for contractor compliance. Currently, unit rates method monitoring is aided by tracking change orders in every activity in the workplan and recording construction progress in detail (Shrestha, Shrestha & Kandie, 2014). This monitoring approach is premised on input of work items in each work category for payment of items based on quantities achieved at agreed rates with minimal considerations for delivery time, quality, and cost. The approach cannot be used for PBRM where compliance is determined by delivery of entire work section of predefined LOS.

Experiences in Performance Based Road Maintenance

Canada

In 1998, 1995 and 1996 the provinces of British Columbia, Alberta and Ontario respectively started implementing performance-based road maintenance. These provinces took a stepwise approach, starting with 3-5-year contracts then settled for 10-year contracts upon gaining experience. When the Province of British Columbia first introduced PBRM, they went from in-house road maintenance directly to PBRM (World Bank, 2004).

New Zealand

In 1998, New Zealand awarded the first 10-year performance-specified maintenance contract (PSMC). Two years later, Transit New Zealand introduced shorter 5-year hybrid contracts, which incorporated features of conventional method-based and performance-specified maintenance procurement. In addition to compliance to performance indicators, level of service, performance goals and response times the New Zealand PSMC requires the contractor to provide inspections and management of the road assets using cost effective methods (World Bank, 2014).

United States

In 1996, the Virginia Department of Transportation (VDOT) in the US awarded the first contract for asset management and maintenance based on performance levels with clearly defined outcomes. This contract was an innovative approach to provide a high and well-defined quality of service to the user at lower cost. VDOT estimated that this contract saved 16% over the 5.5-year contract period as the highway is maintained to its pre-existing condition. In December 2000, VDOT issued a report showing that actual conditions improved, resulting in further real savings (Lande, 1999).

Serbia

In 2004, Serbia transited from traditional unit rates contract to Performance based contracting. At that time, many routine maintenance works were still paid on a unit price basis. The contracts had 3-year terms, with a 2-year extension, if the contractor performed well and agreed to continue. Unfortunately, both pilot projects were discontinued after 3 years and 7 months due to lack of funds. The main challenge that the road agency and the contractors faced was lack of sufficiently qualified staff with the road administration, consultants, and contractors.

Nevertheless, the PBCs were considered successful, since they significantly improved road conditions, reduced routine maintenance cost by an average 49% (World Bank, 2009).

Chad

In 2001 Chad started a 4-year performance-based road management and maintenance contract with help of the Word Bank. The contract was successful rendering the road in excellent condition. Unfortunately, due to higher vehicle speeds the accidents rates increased substantially. Nevertheless, road users appreciated that the road was always in good condition and not only after specific works where completed. Road users attested that they could use the road in the rainy season, which was impossible before (World Bank, 2004)

Benefits of Performance Based Road Maintenance

Cost Savings in Managing and Maintaining Road Assets: The USA Virginia Department of Transportation spent USD 22,400 per mile per year under PBRM against USD 29,500 per mile per year in traditional methods (FHWA 2005). In New Zealand, there has been a 30% decrease in professional costs and 17% decrease in physical works with traffic growth by 53% (FHWA 2005). Traditional methods provide for selection of contractors based on lowest evaluated bid, a criterion that does not favor a life cycle cost approach to projects (Carpenter et al., 2003). According to Reilly (2009) low-bid environment in traditional methods create uncertainties which causes cost and time overrun. However, in PBRM contractor selection is best on best value criteria. Since more risks and management responsibilities are carried by the contractor, road agencies ensure management capacity with the potential contractor, understanding of PBRM and ability to handle the associated risks. The selection process involves choosing a contractor with the capability to provide the required output. The best value contractor selection approach ensures a high-quality product at a low overall cost.

Expenditure certainty: PBRM payments are designed to a fixed price on a regular schedule. This allows the road agency to exercise full control of expenditures (Stankevich et. al., 2005). The risk of cost overruns from price variations to the expense of the overall cost of the project, design change, poor project coordination, and inadequate supervision as is the case with traditional methods is reduced.

Reduction of the in-house workforce: PBRM allows contractors to be responsible for supervision and quality assurance. The road agency changes its focus from supervision to policy, regulation and strategic management resulting in reduced staffing levels. A study by ENRA (2004) demonstrated that in Estonia where 63% of the national network is under PBC, the workforce of the national and sub-national road agencies declined, from 2,046 in 1999 to 692 employees in 2003.

Greater road user satisfaction: Road become more satisfied with the condition of the roads maintained under PBRM as road agencies notice declined complaints from road users. In Chad for instance, road users expressed appreciation for their roads being in good conditions over extended period. Especially important is that road users in Chad can use the road in the rainy season, which was impossible before (Zietlow 2004).

Multi-year financing: The practice of PBRM requires consistent funding to sustain the contractor's cashflow. Since the contracts are spread over extended period, long-term payment obligations are legally binding on the financier. The experience from PBRM contracts in Argentina demonstrates how the Treasury was deterred from failing to provide funding for road maintenance (Liautaud 2004).

Improved conditions of contracted road assets: At end of PBRM contract period road assets are generally returned in improved condition. The Department of Transportation in Texas State, USA, has reported that after the first year of the performance-based contracts, [road] facilities were rated at an average of 91%, an 18-point increase over their pre-contract condition (FHWA 2005). Argentina has reduced the share of roads in poor condition from 25 percent to less than 5 percent by the end of 1999 due to the PBC approach (Liautaud 2004). According to Bushey and Kwak, (2000), to make economic sense contractors in traditional methods are inclined to provide inadequate quality works because of the low tender sum submitted to become the lowest evaluated bidder.

A Study by Stankevich, et. al., (2005) show that introduction of PBRM to replace traditional contracting methods faces bottlenecks like resistance from agency staff to change role from micromanager to strategic manager to allow the contractor the freedom of innovation and creativity in execution of works, inexcusable need to downsize staffing at the roads agency since significantly less effort is needed to administer and supervise PBRM works compared to traditional contracts and the inherent inadequacy in skills and expertise to develop and manage effective PBRM programs. Such skills are necessary in identification and clear definition of appropriate performance specifications and in Design of an incentive payment mechanism that encourages the contractor to consistently meet or exceed the specified minimum performance indicators. This requires good knowledge by the agency staff of how to establish the actual and desired condition of road assets, to specify achievable and realistic performance indicators for each asset item and to establish reasonable response times. The long-term funding requirement for multi-year PBRM contracts is a major problem for countries with annual budgeting process. This makes it virtually impossible to have total assurance about funding for each year in a multi-year contract. However, this can be overcome by political will to comply with the financial obligations assumed by the government when such contracts are signed.

Performance Measures

These are parameters that specify standards by which maintenance works will be evaluated. The main goal when defining these standards is to ensure safety and comfort of road users and for each asset type to be preserved at minimum acceptable performance levels throughout the life of the asset.

i) *Performance indicators:* standards by which contractor's maintenance works will be evaluated. Some of the highway elements considered when defining performance indicators are asset type, roadway system and traffic volume (Frost & Lithgow 1996).
ii) *Performance goals:* minimum acceptable levels to be achieved for each performance indicator.
iii) *Response Time:* time allowed to the contractor to complete the action towards maintaining road usability.
iv) *Payment Reduction:* This is a subtraction of funds from the contractor's claim due non-compliance with LOS requirements.

v) *Relative Weighting:* established relative importance among asset items and asset groups (Stivers et al., 1997).

Level of Service Assessment

Different frameworks are used in monitoring performance-based road maintenance works. The Virginia Department of Transportation (VDOT) in the United States of America published a report on assessment of efficiency and effectiveness of performance-based highway maintenance contract between VDOT and VMS, Inc. (VDOT 2000). The report presented results from performance and cost-efficiency evaluation of contractor's works in managing VDOT's interstate assets. Performance monitoring was guided by LOS for asset items, timeliness of response, and cost efficiency (Pinero, C. J., 2003).

ISO 9001:2015 guidelines are effective in monitoring Performance based road maintenance works as provided under Clause 9.1 of the Standard on Monitoring, Measurement, Analysis and Evaluation. It demonstrates a process approach with guidelines on data collection and interpretation. The Standard shows data analysis from a variety of inputs in the quality management process (QMS). The ISO standard reveals that data related to performance must be evaluated to determine need for improvement, emphasizing its importance in performance by identifying nonconformities and taking corrective actions to eliminate causes of such nonconformities.

Stivers et. al., (1997) researched on quality management concepts, monitoring, and evaluation of existing maintenance quality programs, and subsequently developed a maintenance Quality Assurance (QA) program providing guidance in developing, implementing, and routinely monitoring performance-based road maintenance works. The QA program comprises;

a) *Key Maintenance Activities* – defining maintenance elements to evaluate program quality.

b) *Customer Expectations*-Collecting Road user expectations concerning the LOS at which an agency should maintain the road system.

c) *LOS Criteria* - Defining conditions to be met to consider the existing LOS to be acceptable.

d) *Weighting Factors* - Establishing relative importance between maintenance elements and between each maintenance item under each maintenance element.

e) *Maintenance Priorities* - Establishing the order in which maintenance activities will be executed considering the available budget.

f) *Baselining Existing LOS* - Assessing existing maintenance condition of the agency's road network.

g) *Workload Inventory* - Estimating workloads for maintenance activities using detailed information with respect to type, location, and dimensions of key maintenance items.

i) *Zero-based Budget* - Determining costs required to produce a specific LOS established from customer expectation.

j) *Formal LOS Inspections, Analysis and Reporting* - Evaluating periodic LOS based on random inspections of portions of an agency's highway system.

The approach taken to assess efficiency and effectiveness of PBRM contracts may vary from one implementing country to another. Experiences from Serbia and Chad (World Bank, 2009), United States (Lande, 1999), Canada and New Zealand (World Bank, 2014) demonstrates advanced PBRM practice. PBRM practice in Kenya is deficient in many ways. The country adopted guidelines developed by Japan International Cooperation Agency (JICA) Kenya. The guidelines are explicit on performance indicators, performance targets and application of payment reductions for noncompliance (JICA, 2016). However, the guidelines are lacking in assessment of critical performance indicators. For Instance, whereas the International Roughness Index (IRI) is a reliable parameter for monitoring road unevenness and costs to road users, it is not included as one of the specifications to be assessed by road authorities in Kenya. Concerning relative weightings of asset items and asset groups, it is not possible to establish relative importance among asset items in their contribution to usability, safety, and durability of the road. Without a known assessment approach, visual inspection is used to determine the level of service of asset items. The absence of a methodological approach to assessment for level of service and compliance with expected performance targets before payment is a major contribution to poor road asset maintenance practice and resultant poor road conditions. This has contributed to a failure in determination of payment reductions. This study has established a framework for assessment of contractor compliance to ensure effectiveness in the practice of performance-based road maintenance. It shows that adoption of this framework will assist road authorities to realize the benefits associated with performance-based road maintenance contracting method.

METHODOLOGY

Data used in this study was collected from roads under performance-based road maintenance contracting by Kenya Rural Roads Authority and Kenya National Highways Authority. The roads were categorized with respect to traffic volumes classified as high category signifying roads with traffic volume greater than 50,000 Vehicles Per Day and Standard category for roads with traffic volume less than 50,000 Vehicles Per Day as shown in table 1.

Table 1: Standard Service Level Category

Road Type	**Paved Roads**	
Annual Average Daily Traffic Volume	High	Standard
	More than 50,000 VPD	Less than 50,000 VPD
Service Category	High	Standard

Source: Jica, 2016

Pinero, C. J., (2003) states that population in evaluation of PBRM is defined by small segments of a road of specific length known as sample units. For this study, 7 roads were identified in the study area and were divided into 14 sample units, each sample unit containing different asset items to be evaluated. Data from the field was collected and recorded on paper forms. This was carried out using field measurement tools for linear measurements and related conversions to determine LOS of pavement. Dynamic Response Intelligent equipment (DRIMS) was used to measure International Roughness Index (IRI). Road agency records were reviewed to corroborate data from field inspections. Table 2 shows the roads for this study.

Table 2: Roads in the Study Area

S/No	Name of Road	Service Category
1.	Kisii – Isibania (A)	High
2.	Angurai – Malaba B	Standard
3.	Busia – Malaba C	High
4.	Junc B5 - Ngobit - Lamuria	Standard
5.	Kijauri - Nyansiongo	Standard
6.	Muhoroni - Londiani	High
7.	Kisii - Kilgoris	High

Source: Field Data, Author

Raw data was converted into performance information using Stivers approach highlighted in table 3.

Table 3: Matrix for Methodology

Asset grp	Asset Item	Req. to be Inspected	Inspected	passed	Weight	Total Score	Actual Score	Actual Rating	Target	Score req	Actual Rating	Req. Rating	Confidence level
1	2	3	4	5	6	7	8	9	10	11	12	13	14

Source: Modified from Pinero, C. J., (2003)

Data collected from the field was presented in columns 4 and 5, as the number of asset items inspected and the number of items that met conditional criteria specified in the contract respectively. Relative weightings were applied to each asset item within each asset group to establish relative importance among asset items. Each weight (column 6) was multiplied by the number of items required to be inspected (column 3), also with the number of passing samples (column 5), generating a total possible score (column 7) and an actual score (column 8) for each asset item.

Asset group scores were obtained by adding all asset item scores on each asset group. Therefore, the totals for total score (column 7) and Actual Score (column 8) were obtained for each asset group. The actual and required LOS ratings were obtained by dividing the actual or required asset group score by the total possible asset group score. Table 4 shows a complete matrix of results.

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Table 4: Calculation of Ratings

Road Name (1)	Asset Item (2)	Req. to be Inspected. (3)	Inspected (4)	Passed (5)	Weight (6)	Total Score (7)	Actual Score (8)	Actual Rating (9)	Target (10)	Score Req. (11)	Actual Rating (12)	Req. Rating (13)	Confidence Level (14)
Kisii - Isibania	**Section I**												
	Pavement Roughness	72	72	72	0.9	64.8	64.8	100%	100%	64.8			95%
	Vertical Signs	4	3	3	0.1	0.4	0.3	75%	95%	0.38			71.25
	Total				1.00	65.2	65.1			65.18	**99.85%**	**99.97%**	**83.13%**
	Section II												
	Pavement Roughness	28	28	28	0.7	19.6	19.6	100%	100%	19.6			95%
	Pavement edge break	5	5	4	0.1	0.5	0.4	80%	98%	0.49			95%
	Vertical signs	6	6	4	0.2	1.2	0.8	66.7%	95%	1.14			95%
	Total				1.00	21.3	20.8			21.23	**97.65%**	**99.67%**	**95%**

Source: Author

This procedure was repeated for each road. Actual ratings computed were then compared with the performance targets defined by the agency for each asset item within each asset group.

RESULTS AND DISCUSSION

The schedule performance index (SPI) was used to measure conformance of actual progress (earned value) to the planned progress (planned value):

$SPI = \frac{EV}{PV}$. …….. Equation 1

Where EV = Earned Value (actual rating)

PV = Planned Value (Required rating)

SPI = 1.0 implies an achievement of the objective performance,

SPI > 1.0 implies surpassing of the goal objective.

SPI < 1.0 implies a fall below the goal objective.

Roads Performance Indices

First, the performance indices for each section of the road were obtained as indicated by SPI 1 and then each road performance index obtained as indicated by SPI 2 in Table 5 below.

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Table 5: Roads Performance Indices

Name	Section	Expected (%)	Actual (%)	Variance (%)	SPI 1	SPI 2
Kisii-Isibania	Section I	99.97	99.85	0.12	0.9988	0.9893
	Section II	99.67	97.65	2.02	0.9797	
Angurai-Malaba	Section I	100.00	83.00	17.00	0.8300	0.7183
	Section II	95.60	58.00	37.60	0.6067	
Busia-Malaba	Section I	99.92	40.00	59.92	0.4003	0.7002
	Section II	100.00	100.00	0.00	1.0000	
JNB5-Lamuria	Section I	99.70	5.60	94.10	0.0562	0.0343
	Section II	99.90	1.25	98.65	0.0125	
Kijauri-Nyansongo	Section I	99.90	90.20	9.70	0.9029	0.9168
	Section II	99.79	92.88	6.91	0.9308	
Muhoroni-Londiani	Section I	98.89	98.38	0.51	0.9948	0.9862
	Section II	95.00	92.86	2.14	0.9775	
Kisii-Kilgoris	Section I	95.52	86.09	9.43	0.9013	0.9085
	Section II	99.48	91.09	8.39	0.9157	

Source: Author

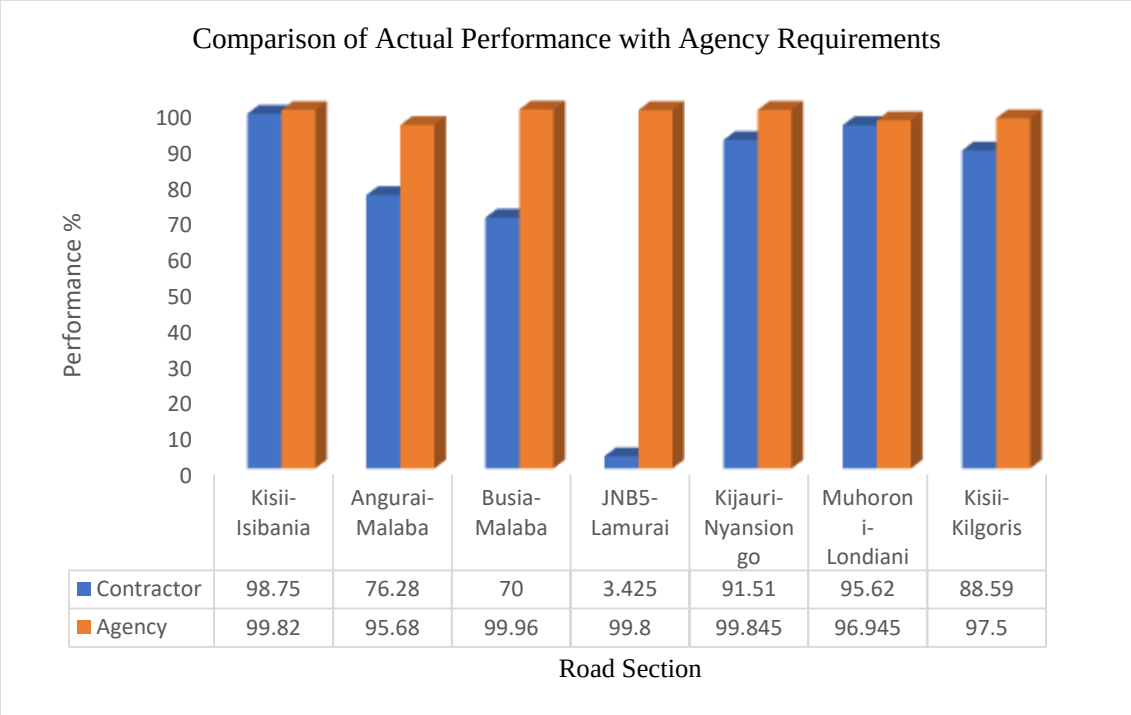

Figure 1: Comparison of Actual Performance and Agency Requirements

Based on the outcome for the performance indices, only section II of Busia-Malaba Road achieved the goal objective performance (SPI = 1.00) implying 100% goal target performance achieved while section II of JNBS-Lamuria Road achieved the lowest goal target of performance (SPI = 0.0125) with only 1.25% of the target goal achieved.

Overall, Kisii-Isibania Road achieved 98.93% of the target achievement (SPI = 0.9893), Agurai-Malaba Road achieved 71.83% of the target achievement (SPI = 0.7183), Busia-Malaba Road achieved 70.02% of the target achievement (SPI = 0.7002), JNBS-Lamuria Road achieved 3.43% of the target achievement (SPI = 0.0343), Kijauri-Nyansongo Road achieved 91.68% of the target achievement (SPI = 0.9168), Muhoroni-Londiani Road achieved 98.62%

of the target achievement (SPI = 0.9862) and Kisii-Kilgoris Road achieved 90.85% of the target achievement (SPI = 0.9085).

Sample Performance Index

Sample data from 7 roads with each road having section I and II was gathered for the expected value and the achieved value (actual value). Then an overall performance of the progress was obtained, (SPI = 0.7495) with standard deviation of ± 0.3475 and standard of error of 0.0929 as shown in Table 6 below.

Table 6: SPI Coefficient

	Coefficient	Sd. Error	Sig.	95% Confidence Interval	
				Lower level	Upper level
1	0.7495265	0.0928709	0.004	0.5674995	0.9315535

**significant at .001

Source: Author

An SPI of 0.7495 imply an overall performance of 74.95% which falls below the expected by 25.05% with a margin of error (MoE) of 0.182. Hence, the true performance index lies between 0.5675 and 0.9316.

CONCLUSSIONS AND RECOMMENDATION

Conclusion

The performance obtained indicated that the goal objective for each road was not achieved with an overall performance deviating from the target or expected performance by 25.05%. The findings from this assessment prove that the PBRM practice has not been fully developed. The analytical comparisons of actual ratings against specified targets from road agencies shows that most contractors did not meet the performance targets. A score of 0% at road section level, 10% compliance at asset group level and 35% at asset item level signifies poor performance. There is a need for capacity building for contractors involved in performance-based road maintenance by promoting a partnering environment between contractors and consulting management firms. The evaluation and determination of suitability for contractors should be based on “best value” instead of lowest evaluated bidder practice that is common with traditional unit rates contracting methods. Road agencies and contractors are advised to seek technical assistance from learning institutions or countries that so far have gained experience in PBRM contracting.

Recommendation

The assessment of Level of Service of roads under PBRM has demonstrated that Kenyan contractors are not ready to execute PBRM works given the shifting of risks to the contractor The study recommends that roads agencies should switch from contractor micro-management and close supervision to strategic management and regulation to promote contractor stability for effective execution of performance-based road maintenance contracts.

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