Maintenance-State Assessment Model for Building Maintenance Forecasting

ABSTRACT

This study aims to provide maintenance-state assessment model for forecasting of building maintenance condition. The selected institutions for the study were state funded hospitals and schools (14 functional out of 23 general hospitals and 2 out of 3 tertiary schools). In this study, considering the shortcomings of the most widely accepted condition survey protocol (CSP) 1 matrix, that is suitable for small projects and defect based, the study developed a model that is suitable for large projects and maintenance management system based for assessment of building's condition. This model was developed analogous to CSP 1 matrix. Two types of ratings used are condition assessment and priority assessment. These two assessment criteria are then multiplied to determine the building maintenance rating score (BMRS).The study developed a 3x3 maintenance matrix model for evaluating building maintenance-state. It also found 25% of the buildings in "good condition" requiring only planned maintenance; 68.75% in "fair condition" requiring condition monitoring and 6.25% in "serious attention" condition.

Keywords: Building Maintenance Plan, Service Life, Modelling, Schools, Hospitals, Niger Delta.

1. INTRODUCTION

The growing number of aged buildings emphasis the importance of building maintenance and this has been recognized in recent years (Kwom et al 2019). Building maintenance plays an important role in guaranteeing the preservation of buildings (Au-Yong, Ali, and Ahmad, 2013). Building maintenance execution affects the performance of buildings (Kwom et al 2019; Kim, Han, and Hyun 2015). To guarantee that buildings are in good condition for optimal daily operations, a specific maintenance plan guaranteeing the preservation of the building is needed. Besides, a methodical maintenance plan is essential because the aging process affects repair costs for sustaining operational function (Kim, Lee, and Ahn 2019). Methodical maintenance plan ensures thewellbeing of buildings (Grussing and Liu 2013), especially in residential buildings. Aged buildings around the world account for a high proportion of all buildings (Park et al., 2019). Building inspections and correct and timely maintenance play a vital role in obtaining an optimum service life of a building (Kumar 2013).

Forecasting the maintenance condition of buildings or Service life forecast of building elements, components is rather tough and painstaking. It is not an exact science. Service life is dependent on various factors that makes itsforecast an interdisciplinary activity. Expert opinion is a very important part in ascertaining the life of building elements (Raess et al 2005). Mayer and Wornell (1999) suggested several techniques for service life prediction including inspection, failure pattern analysis, and service life factor modification analysis (Kirkham and Boussabaine 2005). The two principal service life prediction approaches are deterministic and probabilistic (Hovde 2002). There are three methods which have been developed utilizing these approaches namely:Deterministic Methods, Probabilistic Methods, and Engineering Methods

In Deterministicmethod, distribution of service life does not take degradation into account. Deterministic methods use a comparison between the condition of a component (adjusted by means of a modifying factor) and its reference service life to predict the time scale to the next maintenance intervention (Hovde 2000). Deterministic methods are easy to use, as they only require influence of different factors on the service life.The modifying factors influence the service life that brings it to a better estimated service life (Hovde, 2002). The outcome is an Estimated Service Life of Components (ESLC), a specific service life for the given situation and product (Hendriks et al 2004).The main difficulty in using this method is that there is no national or international standard in relation to reference service life of components (Bourke & Davies 1997). In this method service life is treated as a deterministic single figure but ideally, service life has a large scatter and should be modelled as a random quantity (Siemes&Edvardsen 1999). European Union suggested to adopt minimum design lives for building components from ISO 15686-1 (Boussabaine& Kirkham 2004).

For Probabilistic Method,the life of building components can vary considerably based on the quality of construction, usage, maintenance level, environment and numerous other factors. The degradation of building components is taken as a stochastic process and hence a probability distribution of the service life is predicted with an associated confidence interval. These distributions of forecasted service life are generally expressed as three parameters, the expected service life plus/minus one standard deviation of the mean(Boussabaine and Kirkham 2004). Thesemethods require inputs in the form of probabilities, which cannot be easily estimated and hence cannot be easily used by an ordinary asset practitioner.Stochastic models seek to address these problems through the use of probability theory, which can be used to accommodate the variations (Hovde and Moser, 2004; Kirkham and Boussabaine, 2005). While for Engineering Method, the methodology for dealing with uncertainty can be achieved by introducing probability density functions into individual factors with an associated confidence interval. The forecasted service life can be expressed as expected service life plus/minus one standard deviation. The inclusion of probabilistic methods significantly has been seen to increase the accuracy of the deterioration model output (Kirkham et al 2004).

Researchers are working very hard to prolong the life of structures but building defects are inevitable. Defects occur in various forms and to different extent in all types of building. Being able to forecast the maintenance need of a building would greatly aid the lifecycle attainment of that building

Yeoman (1988), Conducted research on forecasting building maintenance using the Weibull Process. Weibull Process is a statistical model that has been proven to predict the failures of repairable systems such as electronics and automobiles. Yeoman, assumed that buildings could be classified as repairable systems since they are repaired rather than thrown away the first time a component breaks down.Yeoman also used linear regression model which is seen as a possible and simple method of predicting maintenance. The Weibull Process and this linear regression model were used to test their applicability to predicting building maintenance. The tests found that neither the linear regression nor the Weibull Process model could accurately be used to predict the occurrence of maintenance on a set of buildings. Liu (2006) developed a forecasting model for maintenance and repair (M/R) costs for office buildings. The research developed a model to evaluate and forecast maintenance and repair cost of office buildings. The forecasting model considered the weight of the factors that influence M/R cost as well as the related adjusting factors of the cost. However, the model tends to proffer solution to maintenance cost forecast and not maintenance need forecast.Lee (2006) undertook a study on “forecasting the repair time of the building components in the apartment housing”. The study aimed at providing the repair time range over the building components. He found that the repair time over the building component could be calculated and equalized with the deterioration and performance degree.

Another method of forecasting building maintenance need has been through building inspection. This is one of the key components of building maintenance. The primary purpose of performing a building inspection is to evaluate the building's condition. Without inspection, it is difficult to determine a built asset's current condition. Traditionally, building surveyors have primarily relied on descriptive longhand surveys. Surveyors used to record every detail by hand while performing on-sight survey. These surveys are reasonable for small projects and defect based,but becomes difficult to manage for a large project due to its time-consuming nature. These condition assessment surveys yield variable results due to subjective perception of surveyor which is known as surveyor variability. This variability is caused by a variety of factors such as previous experience, attitude to risk and, heuristics – the use of “rules of thumb”, and biases – a leaning towards a particular opinion regardless of the available evidence. Surveys that employ ratings instead of descriptions are gaining wide acceptance in the building industry because they cater to the need for a quantitative approach (IfranChe-Ani et al 2011). Example of such is the condition survey protocol 1 matrix (CSP). The matrix requires concise explanations about the defects identified and score, thus saving on-site time during a building inspection. The full score is used to give the building an overall rating: good, fair or dilapidated. The overall findings reflect the reliability of the CSP1 matrix. It is on this background that this study seeks to develop a maintenance-state assessment matrix analogous to the CSP 1 matrix that will be suitable for large project and maintenance management system based.

2. MATERIALS AND METHODS

2.1 Study Area

The study area used for this research was Rivers State which is located in the Niger Delta region of Nigeria. The Niger Delta is the delta of the Niger River sitting directly on the Gulf of Guinea on the Atlantic Ocean. The Niger Delta region is located in the South-Central geopolitical zone of Nigeria that is made up of nine states; namely Rivers, Delta, Edo, Ondo, Akwa Ibom, Abia, Imo, and Cross River (Otoabasi, (2011).Most of the oil fields in Nigeria are mostly found in this region and is the heart of oil exploration in Nigeria. The region is known to be the oil producing region in the country as numerous oil wells are drilled in this region. River’s state is one of the nine Niger Delta state. It is bounded to the North by Imo state, to the East byAbia and Akwa Ibom, to the South by the Atlantic Ocean, and to the West by Bayelsa. The geographical coordinate of Rivers state lies between longitude 6^{o}22’58.88’’E and latitude 7^{o}35’6’’E and latitude 4^{o}21’N and 5^{o}43’12’’N. Port Harcourt is the capital of the state and it is considered to be the commercial center of the Nigeria oil industry. The colonial administration of Nigeria created the port to export coal from the collieries of Enugu to which it was linked by a railway called the Eastern Line, also built by the British(Udo, 1970).

2.2 Population of the Study

The population of the study was State-funded hospitals and schools located within Rivers State, Nigeria. The school or hospital buildings would have been in existence for over 20 years. The hospitals are located in each of the 23 Local Government Areas of the State. The hospitals had been in existence since the colonial master’s era and were inherited after independence in 1960. The hospitals were designed to bring health services delivery close to all especially those in the rural communities. The hospital immensely contributed to the reduction of maternal mortality, malaria control and aided immunization programmesand enhanced citizen participation etc. As at year 2016, an assessment visit revealed most of the general hospital were shut down and overgrown by weeds. The few that were still operating did so less than 20% of its capacity. Long years of neglect, wear and tear and elements of nature had affected the buildings. A rehabilitation intervention exercise was undertaken by the present administration. The same scenario also applies to the schools. The study administered questionnaires and responses retrieved and analyzed. It became obvious that empirical measure had to be put in places as to forestall future recurrence.

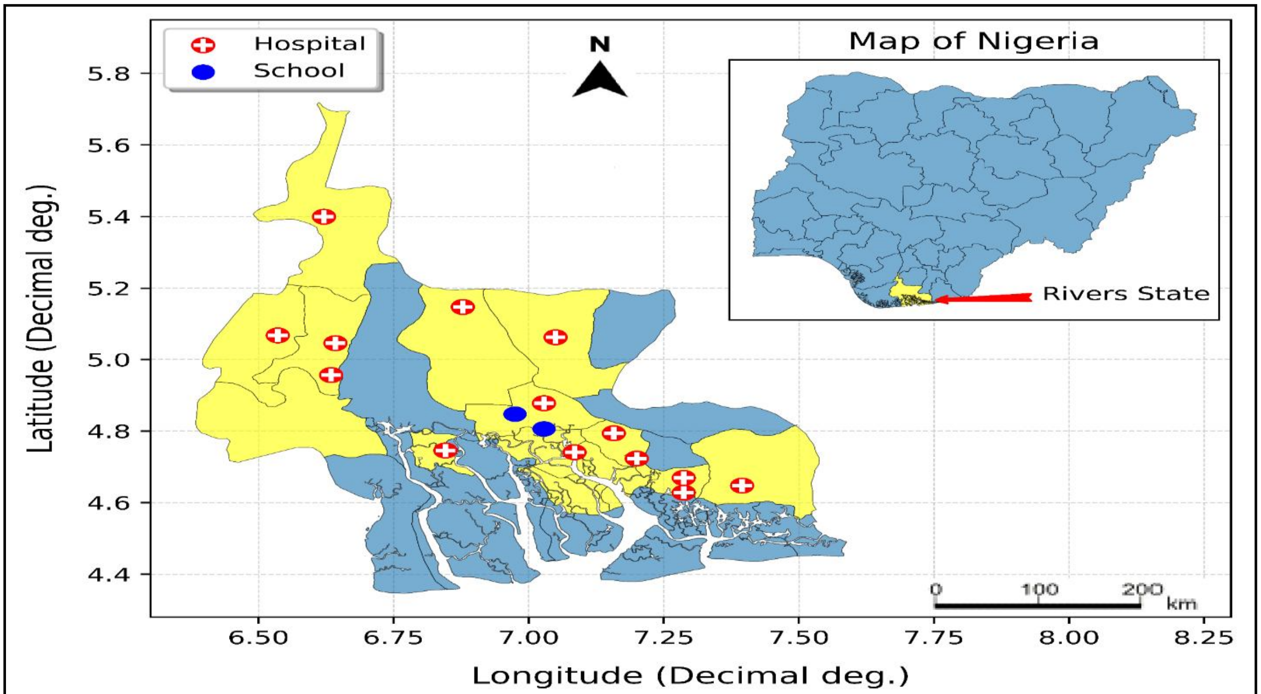

Figure 1: Study Area Map

Table 1: Schools and Hospital used in study

Name of Institution me of Institution	Type	Longitude	Latitude	LGA
Rivers State University, Port Harcourt	School	6.9746	4.8472	Port Harcourt
Zonal Hospital Okrika	Hospital	7.0848	4.7406	Okrika
General Hospital Ogu-Bolo	Hospital	7.1999	4.7231	Ogu-Bolo
General Hospital Eleme	Hospital	7.1575	4.7939	Eleme
Zonal Hospital IsiokpoIkwerre	Hospital	6.878	5.1478	Ikwere
Zonal Hospital BoriKhana	Hopsital	7.3949	4.6476	Khana
General Hospital OkomokoEtche	Hospital	7.0498	5.0632	Etche
Neuropsychatric Hospital RumuigboObioAkpor	Hospital	7.0283	4.8776	ObioAkpor
College of Health Science and Management ObioAkpor	School	7.0283	4.806	ObioAkpor
General Hospital Abua	Hospital	6.6344	4.9564	Abua
Rivers State Hospital Management Board Ahoada East	Hospital	6.6424	5.0468	Ahoada East
General Hospital Bodo City Gokana	Hospital	7.2869	4.6692	Gokana
General Hospital JoinKramaAhoada West	Hospital	6.5356	5.0685	Ahoada West

General Hospital Asari-Toru	Hospital	6.8458	4.7456	Asari-Toru
General Hospital Gokana	Hospital	7.2869	4.628	Gokana
General Hospital OgbaEgbemaNdoni	Hospital	6.6211	5.3998	Ogba/Egbema/Ndoni

2.3 Method of Data Analysis

This model is developed analogous to Condition Survey Protocol (CSP) 1 Matrix as an assessment method for evaluating building condition. CSP1 Matrix was specifically developed for first-line, visual building inspection work. It comprises three protocols: Protocol 1 is defined as visual inspection, Protocol 2 as Non-Destructive Testing (NDT) and Protocol 3 as sample- taking and/or Destructive Testing (DT).

The goals behind the CSP1 Matrix are:

1) To enable the surveyors to collect data within shortest possible time by avoiding descriptive, longhand write- ups during fieldwork;
2) To record the existing defects of the building, the main source of data, by assessing the condition and assigning priority to each defect recorded;
3) To obtain an overall rating of the building's condition.
4) To use the numerical rating acquired from the survey work to perform statistical analysis.

This system gathers two sets of data, namely, the condition of the building and the seriousness of a building's defects, which can be analyzed to provide a rating of the building's overall condition.

The data required for the CSP1 Matrix are the condition and the priority assessments as shown in table 1 and 2 each numerical score is accompanied by a scale value and description. This will help surveyor rate buildings defects and determine the exact condition implied by the scale value.

Table 2: Condition assessment protocol 1 (Hamzahet al 2010)

Condition	Scale value	Description
1	Good	Minor servicing
2	Fair	Minor repair
3	Poor	Minor repair/replacement
4	Very poor	Malfunction
5	Dilapidated	Damage/replacement of missing part

Table 3: Priority assessment (Hamzahet al 2010)

Priority	Scale value	Description
1	Normal	Functional; cosmetic defect only
2	Routine	Minor defect, but could become serious if left unattended
3	Urgent	Serious defect, doesn't function at an acceptable standard
4	Emergency	Element/structure doesn't function at all; OR Presents risks

		that could lead to fatality and/or injury

Each recorded defect is assigned a condition and priority rating. Each rating is then multiplied to determine the total score of a defect. The total score is then matched with the matrix. The scores range from 1 to 20. A colour (green, yellow or red) is then applied to indicate the score in each of the 3 parameters: Plan Maintenance (1 to 4), Condition Monitoring (5 to 12) and Serious Attention (13 to 20), as shown in Table 3.

Table 4: The Matrix (Hamzahet al.,2010)

Scale		*Priority assessment*			
		E4	*U3*	*R2*	*N1*
Condition Assessment	*5*	*20*	*15*	*10*	*5*
	4	*16*	*12*	*8*	*4*
	3	*12*	*9*	*6*	*3*
	2	*8*	*6*	*4*	*2*
	1	*4*	*3*	*2*	*1*

This method of analysis makes it easy to identify the level of seriousness of each defect recorded during the building inspection.It is important to keep in mind that red coded defects should be dealt with first, this will influence the overall building rating and highlight the individual defects that are posing extreme danger to building. This will also help the surveyor to identify the risk of individual defects and provide clients with well-informed defect summaries.

Table 5: The descriptive value according to score (Hamzahet al., 2010)

No	Matrix	Score
1	Planned Maintenance	1 to 4
2	Condition Monitoring	5 to 12
3	Serious Attention	13 to 20

After scoring every defect, the overall building condition is calculated by adding up the score of each defect and dividing it with the total number of defects. The building is then rated Good, Fair or dilapidated, according to the score (out of 20).

Table6: Overall building rating (Hamzahet al., 2010)

No	Building Rating	Score
1	Good	1 to 4
2	Fair	5 to 12
3	Dilapidated	13 to 20

CSP 1 Matrix suites for small projects, individual or non-organization and is building defect based. Taking this as a departure point this present method of building assessment goes further to suit for large projects, organization and maintenance management based.

2.4Development of Building Maintenance Rating Matrix

The building maintenance rating evaluation was done with a building maintenance rating matrix developed by the researcher for evaluating the maintenance state of hospital and school buildings in Rivers State, Nigeria. The building maintenance matrix developed was analogous to the Condition Survey Protocol (CSP) 1 matrix, which provides rating criteria that can be used to access building defects (Raag*et al*., 2019). The building maintenance rating matrix used two parameters in rating the maintenance state of the building. The two parameters used for evaluation were the facility present condition and the maintenance management system practice adopted by the maintenance unit. The maintenance management system practice was a composite factor that was made up of four maintenance management factors namely:

i) Does the school or hospital have a maintenance plan?
ii) Does the school or hospital have a database where maintenance activities are recorded?
iii) Is there good quality assurance system in place
iv) Human resource management (Adequate maintenance staffing)

Information about each of the factors used in evaluating the building maintenance state was obtained using a checklist. The researcher physically evaluated each building by noting if the above factors used in evaluating the maintenance management system practice were available and functioning. Buildings that have a factor available and functioning was given a higher maintenance rating score. The rating score used for the factors that make up the maintenance practice is presented in Table 7. To obtain the maintenance practice score, the average score was obtained for the four maintenance factors.

For the facility present condition, ten key elements were used in evaluating the facility present condition. Elements used in evaluating the facility present conditions includes: if the building appeared in good shape, if the water system works, if the waste system works etc. A rating score of 1 to 3 was given to each condition based on the present condition of that particular element. The average score for the ten elements was then obtained to get the score of the building present condition. The building maintenance rating matrix used in evaluating the maintenance state of the building is presented in Figure 2. Once the score for the facility present condition and maintenance practice is known, the evaluation for the maintenance state of the building can easily be obtained using Figure 2.

Table 7: Rating Score for factors that make up the maintenance practice

Checklist Parameters Evaluated	Score
If a particular factor exists and it is functioning	3
If a particular factor exists and it is not function	2
If a particular factor does not exist	1

	Maintenance Practice

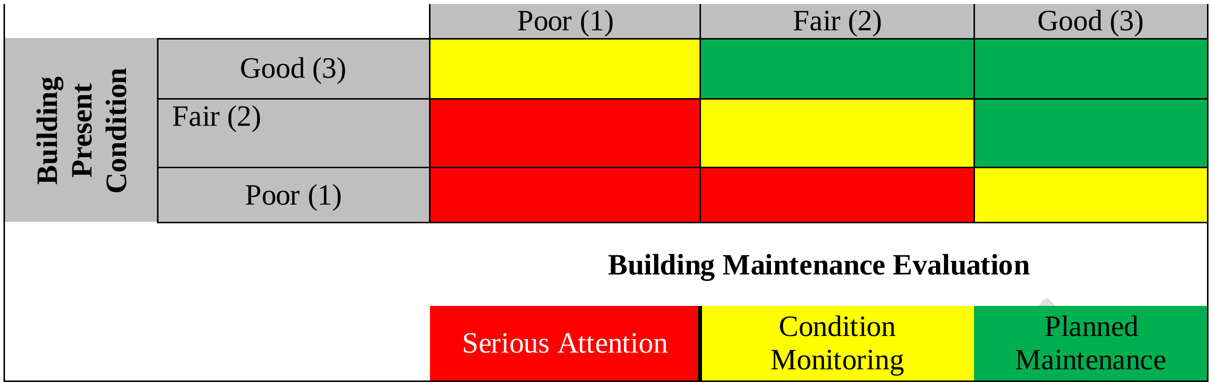

Figure 2: Building Maintenance Rating Matrix

2.5Case Study

Building Maintenance-State
Taking River state University as a case study

<u>Present Facility Condition</u>
The facility present condition for Rivers State University is presented in Table 8. The ten elements and the rating score used to evaluate Rivers State University can be seen in Table 8. Result from Table 8 showed that the state of the building was in a good state. The average score of the ten-element used was obtained and the result showed that the facility present condition score for Rivers State university building was 3.

Table 8: Facility Present Condition

Facility Present Condition Factors	Rating	Score
Building appears in good shape	Good	3
Water systems works	Good	3
Waste system works	Good	3
Electrical system works	Good	3
Workplace free of inoperable equipment	Good	3
Irreparable equipment's are removed from the buildings and not disposed on facility grounds	Good	3
Workplace grounds and environments is clean and free of litter	Good	3
Toilet blocks are clean, and plumbing is in order	Good	3
Required renovation on the outside and inside of the building have been performed recently and appear sound when inspected.	Good	3
Handicapped persons ramp available.	Good	3
	Average Score	3

<u>Maintenance Management Practice</u>
As stated earlier, the maintenance practice which is a composite factor was made up of four maintenance factors. Rating based on the availability and functionality was done for Rivers State university building and the result is presented in Table 9.

Table 9: Maintenance Practice Rating

Maintenance Management Practice	Rating	Score
Maintenance Plan	Good	3
Quality Assurance System	Good	3
Human Resource management	Poor	1
Maintenance System	Good	3
	Average Score	2.5

Combining the facility present condition score and the maintenance practice score for the case study, the maintenance state for River state University can be computed. After the maintenance state score has been obtained, the building maintenance rating matrix can be used to evaluate the maintenance state of the building. Table 9 shows the maintenance state rating for the case study.

Maintenance state rating = facility present condition score x maintenance management practice score

Maintenance state rating = 3 x 2.50

Maintenance state rating = 7.50

Table 10: Risk Rating for the case study

Name of Institution	Facility Condition	Maintenance Practice	BMRS	Evaluation
Rivers State University, Port Harcourt	3	2.5	7.5	Planned Maintenance

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Building Maintenance-State Evaluation

The result of the building maintenance state evaluation for all the buildings is presented in Table 11. The result from Table 11 showed that the Building Maintenance Risk Score (BRMS) ranged from 2 to 8.25. General hospital Abua had the least building maintenance risk score while General hospital Ogu-Bolo had the highest BMRS. The building maintenance rating matrix presented in Figure 3 showed that just four buildings were in good condition and required just planned maintenance, which accounted for 25% of the total buildings used for this study. Out of the four building, two of the building were hospitalsand two schools. The building maintenance matrix showed that eleven buildings were in fair condition and required condition monitoring, which accounted for 68.75% of the total building considered for this study. All eleven building that required condition monitoring were hospital buildings. Figure 3 showed that just one building required serious attention, which accounted for 6.25% of the total building considered for this study. The only building that required serious attention was a hospital building.

Table 11: Maintenance state of hospitals and schools' building

Name of Institution	Facility Condition	Maintenance Practice	BMRS	Evaluation
Rivers State University, Port Harcourt	3	2.5	7.5	Planned Maintenance
Zonal Hospital Okrika	2	2	4	Condition Monitoring

General Hospital Ogu-Bolo	3	2.75	8.25	Planned Maintenance
General Hospital Eleme	3	1.75	5.25	Condition Monitoring
Zonal Hospital IsiokpoIkwerre	2	2.25	4.5	Condition Monitoring
Zonal Hospital BoriKhana	3	1	3	Condition Monitoring
General Hospital OkomokoEtche	2	1.5	3	Condition Monitoring
Neuropsychatric Hospital RumuigboObioAkpor	3	1.5	4.5	Condition Monitoring
College of Health Science and Management ObioAkpor	3	2.5	7.5	Planned Maintenance
General Hospital Abua	2	1	2	Serious Attention
Rivers State Hospital Management Board Ahoada East	2	2	4	Condition Monitoring
General Hospital Bodo City Gokana	2	3	6	Condition Monitoring
General Hospital JoinKramaAhoada West	2	3	6	Condition Monitoring
General Hospital Asari-Toru	3	1.5	4.5	Condition Monitoring
General Hospital Gokana	3	3	9	Planned Maintenance
General Hospital OgbaEgbemaNdoni	2	2.25	4.5	Condition Monitoring

Where BMRS = Building Maintenance Rating Score

		Maintenance Practice		
		Poor (1)	Fair (2)	Good (3)
Building Present Condition	Good (3)			2 School
	Fair (2)		11 Hospitals	2 Hospital
	Poor (1)	1 Hospital		
		Building Maintenance Evaluation		
		Serious Attention	Condition Monitoring	Planned Maintenance

Figure 3: Building Maintenance Rating Matrix

3.1.2 Modeling the Building Maintenance Rating Score against the maintenance factors

In other to understand the relationship between the building maintenance rating score and the maintenance factor, a multiple linear regression model was developed. The goodness of fit of the multiple linear regression model is shown in Table 12. Result from Table 12 showed that the coefficient of determination (R^2) was 0.975, which indicate that 97.5% of the variation in the building maintenance rating score (BMRS) can be explained by the maintenance factors. The adjusted R^2 for the model was

0.9629, which was close to the R^2. The adjusted R^2 indicated that there was no redundant independent variable in the multiple linear regression which provide evidence that all the independent variable (maintenance factors) used in developing the model contributed in explaining the BMRS. The mean squared error and adjusted mean squared error were 0.1493 and 0.3864 respectively. The result from the ANOVA for the model presented in Table 13 was statistically significant $F(5,10)=78.83$, p-value=<0.0001. The result from the ANOVA provided further evidence in stating that the maintenance factors contributed in explaining the BMRS. The model parameter is presented in Table 14 and the result from Table 14 showed that the model coefficient for facility condition, maintenance plan, quality assurance team, human resource management, and maintenance information management were 2.199, 0.6168, 0.5495, 0.6117, and 0.7476 respectively. The model coefficient gave indication that as the facility condition, maintenance plan, quality assurance team, human resource management, and maintenance information management increase so does the building maintenance rating score also increase. The result of the standardized model parameter is presented in Table 15. The computation of the standardized regression parameter is shown in Appendix A. The result from Table 15 showed that facility present condition had the highest standardized coefficient value of 0.566. The result indicates that change in the facility present condition by 1 standard deviation will result to a change in the BMRS by 0.566 standard deviation. The standardize coefficient enables one to knowwhich regression independent variables in a multiple regression have the greatest effect on the dependent variable. From result from Table 15, it was seen that facility present condition had the greatest influence of a building in having a good maintenance rating score than other maintenance factors. This implies that if the facility present condition is in excellent condition, then the building maintenance rating score will be high. The result from the regression model suggest that the facility present condition should be criteria that should be evaluated in other to know if maintenance should be done on the building. The result from Table 15 showed that management information was the next maintenance factor that influenced the BMRS. The result from the model suggest that provide information and management done in the past and the next schedule maintenance should be properly recorded. Therefore, building should have a database where information about the management of the building will be stored. Lack of knowledge about the past maintenance carried out and which part of the building requires to be maintained next which leaves no room for proper planning. Human Resource Management, Maintenance Plan and Quality Assurance Team were the next three important criteria that would influence BMRS.

Table 12: Goodness of fit of multiple linear regression model

Observations	16.0000
Sum of weights	16.0000
DF	10.0000
R^2	0.9753
Adjusted R^2	0.9629
MSE	0.1493
RMSE	0.3864
DW	2.0217

Table 13: Analysis of Variance for Model

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	5	58.8660	11.7732	78.8383	< 0.0001

Error	10	1.4933	0.1493
Corrected Total	15	60.3594	

Computed against model Y=Mean(Y)

Table 14: Model Parameter of Multiple linear Regression

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	-5.5776	0.7051	-7.9107	< 0.0001	-7.1486	-4.0066
Facility Condition	2.1999	0.2226	9.8851	< 0.0001	1.7041	2.6958
Maintenance Plan	0.6168	0.1764	3.4969	0.0058	0.2238	1.0098
Quality Assurance Team	0.5495	0.1244	4.4163	0.0013	0.2723	0.8268
Human Resource Management	0.6117	0.1341	4.5629	0.0010	0.3130	0.9105
Maintenance Information Management	0.7476	0.1778	4.2037	0.0018	0.3513	1.1439

Table 15: Standardized Model Parameter

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Facility Condition	0.5663	0.0573	9.8851	< 0.0001	0.4387	0.6940
Maintenance Plan	0.2722	0.0778	3.4969	0.0058	0.0987	0.4456
Quality Assurance Team	0.2688	0.0609	4.4163	0.0013	0.1332	0.4044
Human Resource Management	0.2920	0.0640	4.5629	0.0010	0.1494	0.4346
Maintenance Information Management	0.3394	0.0807	4.2037	0.0018	0.1595	0.5192

3.2 DISCUSSION

The findings of this research anticipated the expected quality of service delivery from the selected public schools and hospitals by showing the present maintenance-state of the buildings. The quality of the maintenance-state of a facility has been found to be indicative of the quality of service delivery expected. The findings showed a Building Maintenance Rating Score (BMRS) ranging from 2 to 8.25. General hospital Abua had the least building maintenance risk score, indicative of a very bad facility present condition. This means that the quality of service delivery expected from General hospital Abua would not meet required standard. Adeboyeje (2000) and Emetaron (2004) corroborates the above findings. They found that good facilities are the physical and spatial enablers of wellness, teaching and learning which will increase the production of result.WhileAsiyai (2012) revealed that conducive school environment could enhance student's school attendance, involvement in academic activities and academic performance positively. The findings also highlights the importance and possibility for performance of routine maintenance audit, maintenance data generation and usage in the selected public schools and hospital. This finding is supported by (Lavy and Bilbo, 2008) who in their work "Facilities maintenance management practice in large public schools, Texas" found that100.0 per cent of the schools studied perform routine facility condition audit, generated dataand used the generated data for short-term facility planning, routine operation and maintenance planning, 83.3 per cent of the schools use it for long-term facility planning, 72.2 per cent of the schools use it to plan their preventive maintenance, and 66.7 per cent of the schools use it to establish benchmark. Hence, they are able to make better decision on the maintenance of their facility.Durosaro (1998) found that institutes that planned and maintained their facilities had higher wellness rating, student's retention and they are more effective than the others.The findings further showed that out of the 2 schools and 14 hospitals under evaluation, 2 schools and 13 hospitals were in good working condition. This finding corroborates with the ongoing renovation and resuscitation exercise embarked upon by the present administration of the Rivers State government of Nigeria on the general hospitals.

CONCLUSION

The study developed a 3x3 maintenance matrix model for building maintenance-state evaluation. The model also evaluated building maintenance-state of 14 public hospital (general hospitals) and 2 public schools (tertiary institutions). The study result showed that 25% of the buildings were in "good condition" and required only planned maintenance, 68.75% in "fair condition" requiring condition monitoring and 6.25% in "serious attention" condition. "Planned maintenance" is a scheduled service visit carried out by a competent and suitable agent, to ensure that an item of an asset is operating correctly and to therefore avoid any unscheduled breakdown and downtime (Wood, 2003). As a general rule, the more planned maintenance you perform, the longer your assets will remain operating at peak without failures. "Condition monitoring**"** is a predictive maintenance management process of monitoring a parameter of condition in an asset, in order to identify a significant change which is indicative of a developing fault (Wikipedia). While "Serious Attention" is notice taken of an asset that is demanding careful consideration. The findings provide an opportunity for stakeholders to review their current practice and identify improvement actions for Building Maintenance Management in Rivers State public schools and hospitals. There are opportunities to extend the applicability of the methodology to other small engineering works besides buildings.

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Appendix A

Standardization Computation and Data for Model Development

The standardized model coefficient which is also known as the beta weights are the estimates resulting from a regression analysis where the underlying data have been standardized so that the variances of dependent and independent variables are equal to 1. Therefore, standardized coefficients are unitless and refer to how many standard deviations a dependent variable will change, per standard deviation increase in the predictor variable.

Standardization of the coefficient is usually done to answer the question of which of the independent variables have a greater effect on the dependent variable in a multiple regression analysis where the variables are measured in different units of measurement.

The formula for computing the standardize coefficient is given as Equation (A.1).

$$\beta = a_1\left(\frac{S_x}{S_y}\right) \quad \text{(A.1)}$$

Where β = standardized coefficient, a_1 = model parameters, S_x =standard deviation of the independent variable, and S_y = standard deviation of the dependent variable.

Example

To obtain the standardized coefficient of the facility present condition = 0.5663

Appendix 1: Data Used for developing the Regression Model

Index	Facility Condition (x1)	Maintenance Plan (x2)	Quality Assurance Team (x3)	Human Resource Management (x4)	Maintenance Information Management (x5)	BMRS (y)
1	3	3	3	1	3	7.5
2	2	3	1	1	3	4
3	3	3	3	3	2	8.25
4	3	2	3	1	1	5.25
5	2	3	3	1	2	4.5

6	3	1	1	1	1	3
7	2	1	1	1	3	3
8	3	1	3	1	1	4.5
9	3	3	1	3	3	7.5
10	2	1	1	1	1	2
11	2	3	1	1	3	4
12	2	3	3	3	3	6
13	2	3	3	3	3	6
14	3	2	2	1	1	4.5
15	3	3	3	3	3	9
16	2	3	3	1	2	4.5
Std. Dev.	0.516	0.885	0.981	0.957	0.911	2.006

The model parameter (a_1) for facility presented condition after development of the multiple linear regression was 2.1999 which is shown in Table 8. The standard deviation for the facility present condition = 0.516 and the standard deviation for building maintenance rating score (BMRS) = 2.006. Using the standardized model coefficient formula given in Equation 1 to obtain the beta weight shown below.

$$\beta = 2.1999 \times \left(\frac{0.516}{2.006}\right) = 0.5658$$