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Strategic Equipment Maintenance Management in A Medium Scale Quarry, Ogun State, Nigeria.

[1]S. O. Abdulraman and [2]B. M. Olaleye
[1]Earth Values Ventures Limited, 1, Taoheed Road, off Basin Road, Ilorin, Nigeria.
[2]Department of Mining Engineering, The Federal University of Technology, Akure, Nigeria

Abstract
Poor performance of granite aggregate quarries is a big challenge to the mineral industry in Nigeria. It threatens the future prosperity of the industry and granite aggregate supply to meet the ever increasing demand for infrastructural development projects. One major factor impacting on the reliability of quarries is the maintenance management system of the quarry equipment. This paper presents the present situation on equipment maintenance management system of Geoworld quarry in Ogun State, Nigeria. Maintenance management audit of the quarry was carried out through questionnaires with respect to five basic elements of maintenance management system (resource management, information management, preventive maintenance and equipment technology, planning and scheduling and maintenance support). 'SWOT Clock' Strategic Behaviour Model was adapted to suggest a rationalistic typology for the quarry management in considering the quarry's strategic direction on equipment maintenance based on the interaction between the quarry's capabilities and resources from the view point of strengths and weaknesses (SW) and between the opportunities and threats (OT) identified in the quarry's environment. Findings show that improvement strategies adopted will impart positively on the areas of deficiencies of the quarry by moving it from state of survival to growth.

Key words: strategic behavior, SWOT clock, maintenance management.

1.0 Introduction

Easy money is gone and quarry managers now worry about how to stay competitive in the new global economy that has emerged. It is time for quarries to concentrate on their core business, squeeze out the waste and differentiate themselves from their competitors in meaningful ways. It is becoming clear that there is no one best way of doing anything, whether it's selection of equipment or their maintenance management. The best way to operate depends critically on the characteristics and capabilities of the quarry and the competitive context in which it finds itself.

In order to benefit from the changing conditions, a quarry has to adopt a strategy for improvement that fits the specific needs of the quarry at that point in time in its life. Slow and steady improvement is appropriate in some situations; attempt at dramatic breakthroughs through process reengineering are appropriate in others. Moreover, different improvements require different resources, management styles, and support structures.

Quarries need to ask and then answer the question "what is our business?'. Addressing this question is the single, most important step in crafting a corporate business strategy. The quarry must clearly understand not only who are its customers and its competitors, but also what it sees as its competitive advantage. It must clearly identify its key business strategies. However, it is not just individual strategies in isolation, but the combination of the individual business strategies that, when combined, produces the quarry's overall competitive strategy.

A Quarry must decide which competencies and organizational context it must develop to help implement its strategy. Even after deciding on the competencies, culture, structure and incentives that are needed, the quarry still needs to harmonize them together in such

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a way that, on one hand they support and complement each other and on the other hand they collectively support and promote the chosen strategy.

One competency that must be developed by all quarries is the maintenance management function. Khan and Darrab (2010) reported that the purpose of maintenance is not only to upkeep the plant machinery and equipment preventing them from failures and breakdowns, increasing reliability, maintainability, and availability of the operating system for maximizing production, but also to improve quality and boost higher productivity through improving capacity, faster and more dependable throughput, reducing inventory, and lowering operating cost. A research in maintenance in Nigerian industries (Eti et al, 2004) shows that maintenance is not given a high priority, hence plants are often underutilized and run at high costs. Alsyouf (2006) showed in a case study that at least 14% of potential improvement in return on investment are directed to contribution of maintenance functions to lost profit, which is due to unplanned stoppages and bad quality caused by maintenance related problems. Blanchard (2004) demonstrated that a large percentage (e.g. 70% for some systems) of total life cycle cost for a given system is attributed to operating and maintenance activities. Maintenance management have been grouped into five key areas; resource management that deals with how adequate is maintenance staffing, their skill, remuneration and motivation; information management which determines kinds of maintenance records kept in the quarry, their applications for evaluating key performance indicators(KPIs) and their influence on management's decisions; preventive maintenance and equipment technology assess the level of mechanization in the quarry and adoption of appropriate preventive and predictive maintenance effort; planning and scheduling measures adequate planning and scheduling compliance before any major maintenance work is carried out; and maintenance support determine the level of spare parts inventory kept in the quarry and the relationship between the quarry management and the original equipment manufacturers or their agents.

This study involves maintenance management audit of Geoworld quarry, this quarry is located in Obafemi- Owode local government area of Ogun State with GPS coordinates, N07° 07' 25", E003° 37' 46". Over the years, Geoworld quarry have continued to experience operating costs that are far in excess of what was estimated in their feasibility study report. The poor performances have been pinned to equipment maintenance management problems. Deficient maintenance practices have continued to affect productivity and profitability. This paper is therefore aimed at identifying the maintenance management challenges of Geoworld quarry with the view to provide strategic directions on equipment maintenance management for optimal productivity.

2.0 The Theory and Application of SWOT (Strenght, Weakness, Opportunity and Threat) Clock Strategic Behaviour Model

The SWOT Clock model proposes a strategic formula which relates Leading Strategy (LS) as dependent variable with Weighted Power Intensity (WPI) as independent variable. The clock behaviour reflects the effected change of the LS pointer over the time series scale factor. The CLOCK model offers a series of steps and principles in consolidating a strategy:

2.1 Principle no. 1 - The Generic Integrated Behaviour

There is a generic behaviour, reflecting the interaction between 'quarries and their environment,' that depict situation in which

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more opportunities can be seen than threats; more strength can be seen than weaknesses; and vice versa.

2.2 Principle no. 2 - Defining the Independent Variables to Calculate the Intensity of Power

The power intensity of the four variables (Opportunities, Threats, Strengths and Weaknesses) was evaluated by using a matrix that is based on the following components:

i. **Influencing Factor (IF):** The factor according to which the characteristics of a quarry and/or its environment are analyzed. The list includes factors that in the management and decision makers' view influence the quarry's level of power ('weaknesses', 'strengths') and environmental forces ('opportunities', 'threats'). In general, these factors reflect the perception of the quarry's stakeholders. This is also expressed in the studies by Bernroider (2002); and Lee and On Ko (2000). Establishment of the "IF" was done by the Delphi approach which reflects individual management perception. After establishment, the list of Influencing Factor is kept constant in the CLOCK strategy formula.

ii. **Relative Weight (RW) of the influencing factor:** The importance and influence of any factor that the quarry considers to be important in determining and consolidating its strategy. Deciding on the relative weight of the influencing factor is one of the greatest difficulties in applying the SWOT approach. Wheelen and Hunger (2011), suggest assigning a relative weight to the influencing factor in a subjective and arbitrary manner, on condition that the total sum of the relative weight of all the factors equals to 100%. In this way, it was possible to offset the influence of bias in the final result. The CLOCK model keeps the Relative Weight as a constant value in the strategy formula.

iii. **A quantitative, Objective Measuring Scale index:** A measurable index representing the factor's quantitative value. The index was determined according to the characteristic represented by the factor. For example, the resource management (%) was determined according to the level of maintenance resources i.e. labour, material and cost. Planning and Scheduling (%) reflects the level of efficiency in maintenance job scheduling, and market demand (%) reflects the level of patronage, and so on.

iv. **Relative Intensity (RI) positioning index:** Each IF was positioned according to three levels of an Interval Scale: level 3 reflects High position, level 2, Medium position, and level 1, Low position.

v. **Weighted Intensity (WI):** The weighted intensity represents the contribution of each factor to the total power intensity of each of the SWOT variables, calculated as the multiplication of the Relative Intensity (RI) and its Relative Weight (RW) determined according to the current positioning of the appropriate quantitative measuring index.

vi. **Weighted Power Intensity (WPI):** Reflects the total intensity of all the factors positioned in each of the SWOT variables, and is calculated as the total sum of the Weighted Intensity of those factors.

2.3 Principle no. 3 - Developing a WPI matrix for the environment and the quarries

Two matrixes of identical structure exist, one for the quarry environment (external factor) and the other for the quarry's maintenance management (internal factor). Using these matrices, the power intensity was quantitatively calculated for the four SWOT variables.

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2.4 Principle no. 4 - Consolidating the 'Leading Strategy' (LS) direction

Four generic strategic directions exist, resulting from the simultaneous integration of the Weighted Power Intensity of the two external factors ('opportunities,' 'threats') with the two internal factors ('strengths,' 'weaknesses'), which were defined as follows:

i. **Growth (S+O):** a situation in which the WPI of 'opportunities' is larger than the WPI of 'threats' and that of 'strengths' is larger than that of 'weaknesses.' The Growth strategy can inform local production of items/wearable parts; commercialization of workshop i.e. turner shop; contract maintenance services to other quarries and so on.

ii. **Leverage (W+O):** a situation in which the WPI of 'opportunities' is larger than the WPI of 'threats' and that of 'weaknesses' is larger than that of 'strengths.' This situation calls for the Leverage strategy. This strategy could be applied in the directions of developing human resources (i.e. maintenance crew skill upgrade through training); investments in infrastructure and equipment (investment in maintenance facilities such as crane, hyab, mobile service vehicle, turning machine, etc.); developing business units; developing and encouraging innovativeness and creativity; and so on.

iii. **Response (S+T):** a situation in which the WPI of 'threats' is larger than the power intensity of 'opportunities' and that of 'strengths' is larger than that of 'weaknesses.' Therefore, the Response strategy employs 'strengths' to push away the 'threats'. This strategy could be applied and used by cooperation with another similar quarry for maintenance assistance; focusing and differentiating (plan production base on maintenance requirement, for example, a quarry can work five days per week and spend one and half days for maintenance of equipment depending on the criticality of maintenance problems); performance improvement; enhanced human resources motivation (adequate payment of overtime allowance to maintenance crew); and so on.

iv. **Survival (W+T):** a situation in which the WPI of 'threats' is larger than the power intensity of 'opportunities' and that of 'weaknesses' is larger than that of 'strengths'. The Survival strategy reflects the quarry's struggle to maintain its continued existence as a 'living body.' In this kind of strategy, action and application modes could include Design out i.e. Re-engineering the facility by disposing off the problematic equipment and acquiring a better facility that the quarry can afford at that time; vertical integration by the buyer (trade- off facilities by giving out weak equipment) to acquire better equipment from the manufacturer/ vendor; stood offs; and so on.

Thus, the CLOCK strategy formula can be defined as:

$$LS = f(WPI) = f(IF, RW, WI) \quad ...(1)$$

The positioning of the Weighted Power Intensity of each SWOT variable in the SWOT CLOCK Diamond Behaviour Model reflects the quarry's Leading Strategy (LS). Placing the values of the Weighted Power Intensity of each variable creates four triangles. Each triangle represents a combination of an external (environmental) variable with an internal variable of the quarry on the corresponding quadrate. Four possible strategies simultaneously at a certain moment in time are created, Growth, Response, Survival and Leverage. Intuitively, the Leading Strategy is

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determined by the largest triangle in size, out of all the possible strategy triangles.

2.5 Principle No. 5- 'The Strategic pointer'

The strategic pointer (henceforth, 'POINTER') points to the strategic direction that was determined by an analysis of the current position. The 'POINTER' is the weighted vector of the four SWOT forces, each having a direction and intensity. Vector diagram was drawn by using the WPI of 'strengths' drawn vertically allocated upwards. Then, the allocation of the WPI of 'opportunity' continued horizontally to the left. From this point, the WPI of 'weaknesses' continued to be allocated downwards, and finally, the WPI of 'threats' was allocated to the right. The 'POINTER' vector position was indicated accordingly (in red color) in any of the strategy quadrate (depending on the vector diagram). It is important to note here that, the pointer's positioning is momentary.

3.0 Methodology

This study involves maintenance management audit of Geoworld quarry using questionnaires and interviews. The questionnaire survey was administered to quarry staff including operation and maintenance (O&M) managers, and maintenance technicians. Out of the 30 questionnaires administered in the studied quarry, approximately 80% were returned. This questionnaire addresses questions in five key maintenance areas; resource management, information management, preventive maintenance and equipment technology, planning and scheduling, and maintenance support. Furthermore, the current maintenance practices were explored through interview and their responses / submissions were rated subjectively as: below average; average; and above average with credit points 1, 2, and 3 respectively. The data collected were presented using MS Excel software. 'SWOT Clock' Strategic Behavior Model was adapted to suggest a rationalistic typology for managers and decision makers in considering the quarry's strategic direction on equipment maintenance. The model examined the interaction between the quarry's capabilities and resources from the view point of strengths and weaknesses (SW) and between the opportunities and threats (OT) identified in the quarry environment. The external analysis of the environmental forces focused on identifying opportunities and threats created by the business environment; and internal analysis that is analyzing the quarry's internal forces focused on positioning resources (tangible) and capacities (intangible) from the view point of its strengths and weaknesses, in an effort to adopt appropriate maintenance strategy.

4.0 RESULTS

This section presents the SWOT analysis and SWOT clock behavior model of present and future situations for the studied quarry.

4.1 SWOT Analysis of Present Situation in Geoworld Quarry

The SWOT analysis of the present situation in the studied quarry explains the effects of internal and external factors on the successful maintenance management of the quarry's equipment as shown in Tables 1 and 2. From the Tables, vector diagram and SWOT Clock were drawn as represented in Figures 1 and 2.

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Table 1: Matrix for the Intensity of Geoworld Quarry's Strengths and Weaknesses

Matrix of Geoworld Quarry's Power Intensity							
Internal Influencing Factor (Maintenance Management)	Relative Weight (100%)	Power Intensity of 'Strengths'			Power Intensity of 'Weaknesses'		
		1	2	3	1	2	3
Resource Management	15				1		
Information Management	10					2	
Preventive Maintenance	20					2	
Planning and Scheduling	15					2	
Maintenance Support	15	1					
Plant and Equipment Technology	25		2				
TOTAL	100	15	50	0	15	90	0
	Weighted Power Intensity	65			105		

Table 2: Matrix for the Intensity of Geoworld Quarry's Opportunities and Threats

Matrix of the Quarry Environment Power Intensity							
External Influencing factor(Environment)	Relative Weight (100%)	Power Intensity of 'Opportunities'			Power Intensity of 'Threats'		
		1	2	3	1	2	3
Market Demand	25					2	
Government Agency Regulatory Compliance	15					2	
Effect of weather	25					2	
External Maintenance Relationship	35		2				
TOTAL	100	0	70	0	0	130	0
	Weighted Power Intensity	70			130		

Table 3: Summary of the Weighted Power Intensity of the variables in the CLOCK model for Geoworld Quarry

Strength Intensity	Opportunity Intensity	Weakness Intensity	Threat Intensity
S	O	W	T
65	70	105	130

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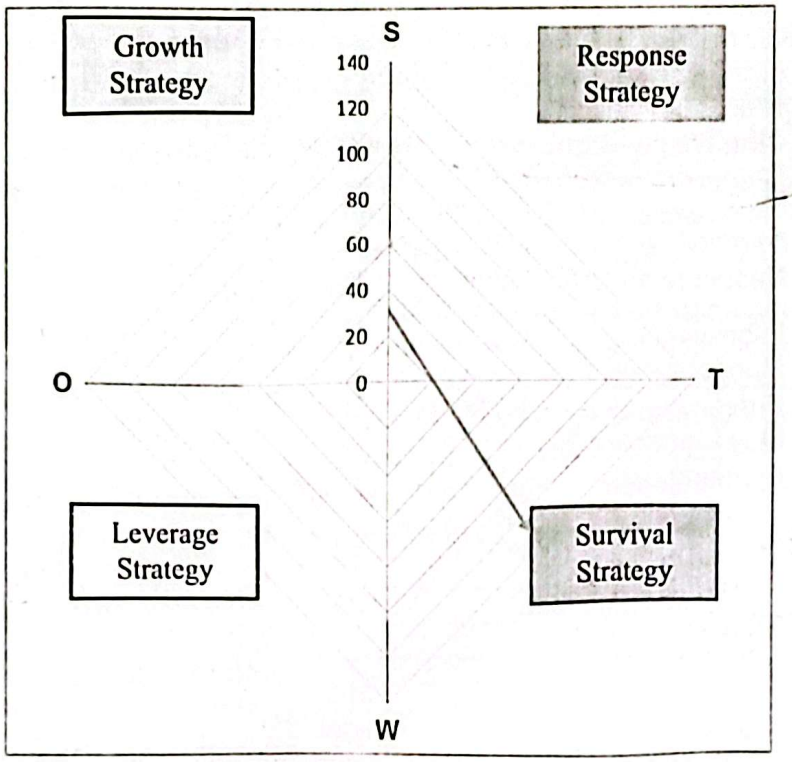


Figure 1: SWOT Clock Diamond Behaviour model for Geoworld Quarry

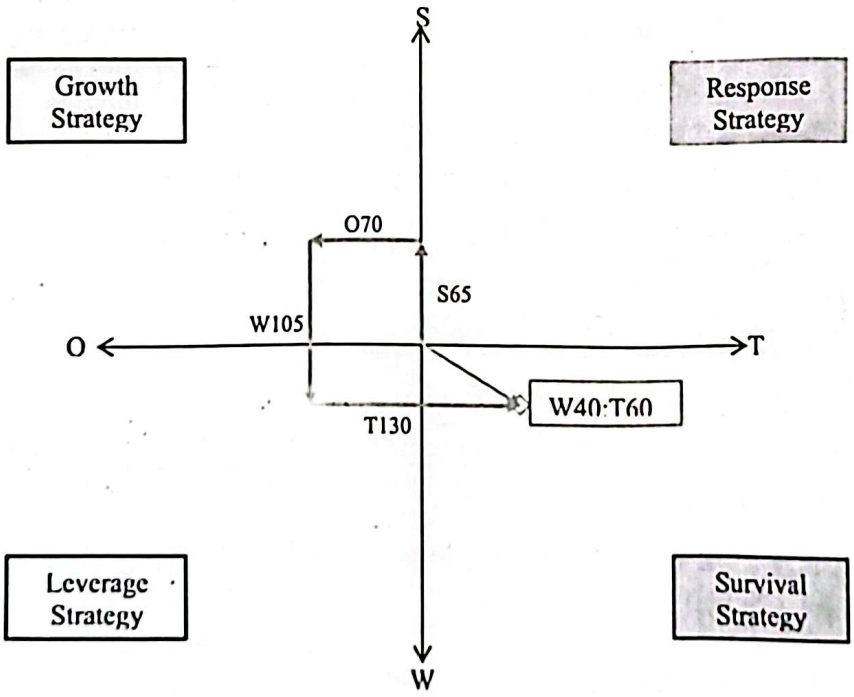


Figure 2: POINTER Strategic Position for Geoworld Quarry

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4.2 SWOT Analysis of Future

Situation in Geoworld Quarry

The SWOT analysis of the future situation in the quarry shows an improvement design strategies for future operations in the quarry. This improvement design explains the effects of internal and external factors on the successful maintenance management of the quarry's equipment.

In future, it is expected that the management of Geoworld quarry would increase their understandings of the nature of failures associated with their equipment. As such there will be no variations in the relative weight (RW) of the internal influencing factors (IF), rather we envisage their power intensities (PI) to respond to management strategic improvements due to years of practice/ operations. However, changes in Government policies regarding mineral industry and economic situation of the country will certainly cause variations in the external influencing factors (IF) and their relative weight (RW). For the purpose of this evaluation, we assume drop in market demand for quarry products and a strict enforcement of environmental regulation. These changes will affect the relative weight of market demand from 25 to 15 and relative weight of regulatory compliance from 15 to 25, as shown in Tables 4 and 5.

The corresponding strategic decision directions are represented by the SWOT clock and vector diagram shown in Figures 3 and 4.

Table 4: Matrix for calculating the Intensity of Geoworld Quarry's Future Strengths and Weaknesses

Matrix of Geoworld Quarry's Power Intensity							
Internal Influencing Factor (Maintenance Management)	Relative Weight (100%)	Power Intensity of 'Strengths'			Power Intensity of 'Weaknesses'		
		1	2	3	1	2	3
Resource Management	15	1					
Information Management	10	1					
Preventive Maintenance	20	1					
Planning and Scheduling	15	1					
Maintenance Support	15		2				
Plant and Equipment Technology	25				1		
TOTAL	100	60	30	-	25	-	-
	Weighted Power Intensity	90			25		

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Table 5: Matrix for the Intensity of Geoworld Quarry's Future Opportunities and Threats

Matrix Of The Quarry Environment Power Intensity							
External Influencing factor(Environment)	Relative Weight (100%)	Power Intensity of 'Opportunities'			Power Intensity of 'Threats'		
		1	2	3	1	2	3
Market Demand	15	1					
Government Agency Regulatory Compliance	25	1					
Effect of weather	25					2	
External Maintenance Relationship	35		2				
TOTAL	100	40	70	-	-	50	-
	Weighted Power Intensity	110			50		

Table 6: Summary of the Future Weighted Power Intensity of the variables in the CLOCK model for Geoworld Quarry

Strength Intensity	Opportunity Intensity	Weakness Intensity	Threat Intensity
S	O	W	T
90	110	25	50

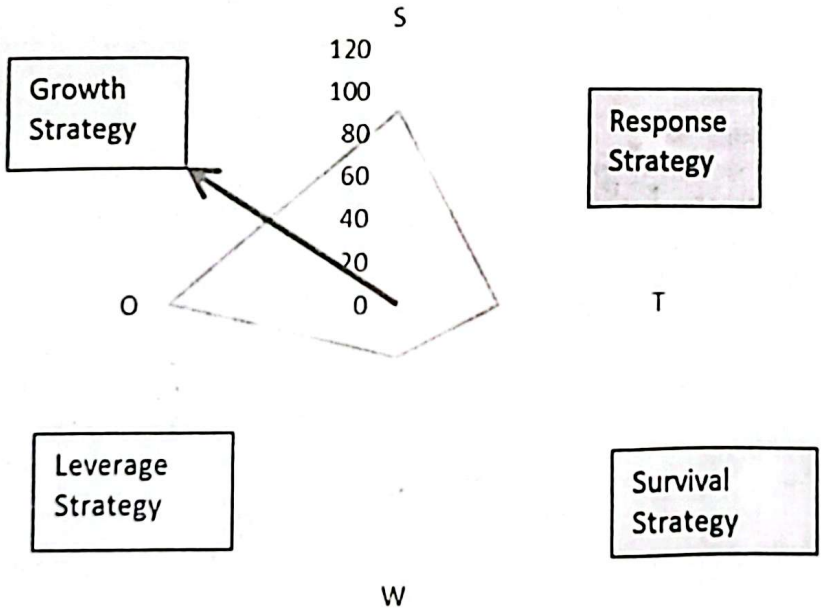


Figure 3: SWOT Clock Diamond Behaviour model for Geoworld Quarry

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its direction position later on. This movement is similar to the pointer's move in an analogical clock; hence the name "The SWOT CLOCK".

The strategic direction highlights the strategic question of How? That is, How to grow? How to respond? How to lever? and How to survive?. In the quarry, the pointer point in the SURVIVAL quadrate leaving the quarry's management with the strategic question of How to Survive:

It becomes pertinent that the managers of Geoworld quarry management will have to focus more of their effort on improving their strengths to push away their threats, most importantly in the area of preventive maintenance, maintenance planning and scheduling and information management. Though, consequently the strengths would become weaker but more opportunities will evolve than the threats and the pointer will move to LEVERAGE. At the leverage status, the management will have to apply opportunities to strengthen weaknesses. The quarry will combine opportunities and stretch new strengths affecting the pointer to move to Growth Leading Strategy quadrate.

5.1 SWOT Analysis of Future Situation in Geoworld Quarry (Improvement Design for Survival Strategies for Future Operations)

In designing an improvement for the survival strategies occasioned by internal capabilities and environmental factors affecting the equipment maintenance management systems of Geoworld quarry, we considered and assumed the possibility of variations in the nation's economy and Government policy as they affect the nation's mineral industry. Change in nation's economy like it is happening now as a result of dwindling global oil price, which has limited the available resources for Nigerian government to fund engineering construction projects. Furthermore, strict environmental regulatory enforcement will mandate the quarries to comply with Government agency's laid down standard on environmental issues. As such, there will be low patronage of quarry products with less pressure on production; and operations will be carried out in clean environment. Tables 4 – 6 and Figures 3 and 4 present the possible outcomes from the scenarios. Geoworld quarry's situation will consequently change to GROWTH.

6.0 Conclusion and Recommendations

This paper has adapted 'SWOT CLOCK Diamond Behavior Model to identify the strategic direction of the studied quarry on equipment maintenance management system and from the investigation carried out, the following conclusions were drawn:

i. equipment maintenance is not given utmost attention and this informed the inappropriate and/ or lack of maintenance management system in the studied quarry as depicted by the result of maintenance management audit;
ii. maintenance department is not adequately staffed; and
iii. change in nation's economy and strict compliance with environmental standards can affect the strategic behavior of quarries' decision makers regarding equipment maintenance management.

It is therefore recommended that, management's view about equipment maintenance as a 'cost centre' should change. Management should establish appropriate maintenance management system coupled with competent maintenance technician to guarantee high availability of equipment.

References

Alsyouf, I. (2006), Measuring Maintenance Performance using a Balanced Score Card Approach, Journal of Quality in Maintenance Engineering, Vol. 12, pp. 133-149.

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References

Alsyouf, I. (2006), Measuring Maintenance Performance using a Balanced Score Card Approach, Journal of Quality in Maintenance Engineering, Vol. 12, pp. 133-149.

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Bernroider, E., (2002), "Factors in SWOT Analysis Applied to Micro, Small- to-Medium and large Soft Enterprise: An Austrian Study", European Management Journal Elsevier, Vol. 20, No. 5, pp. 562-573.

Blanchard, B.S. (2004): Logistics Engineering and Management, 6th ed., Prentice Hall Pearson, p. 546.

Eti, M. C., Ogaji, S. O. T. and Probert, S. D. (2004): "Implementing total productive maintenance in Nigerian manufacturing industries", Applied Energy, Vol. 79, pp. 385-401.

Khan, M.R.R. and Darrab, I.A. (2010): Development of Analytical Relation Between Maintenance, Quality and Productivity, Journal of Quality in Maintenance Engineering, pp. 341-353.

Lee, S.F. and On Ko, A. S., (2000), Building Balanced Scorecard with SWOT Analysis, and Implementing Sun Tzu's 'The Art of Business Management Strategies' on QFD Methodology", Managerial Auditing Journal 15/ 1/ 2, MCB University Press, pp. 68-76.

Nathan, T. (2012), The "SWOT CLOCK" Strategic Behaviour, (www.swotclock.com), p15.

Wheelen, T.L. and Hunger J.D. (2011), Strategic Management & Business Policy (7th Ed.) Prentice Hall.

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