# ASSESSMENT OF RELATIONSHIP BETWEEN PLANT AND EQUIPMENT MAINTENANCE STRATEGIES AND FACTORY PERFORMANCE OF THE KENYA SUGAR FIRMS

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## ABSTRACT

The study was carried out on the assessment of the relationship between plant and equipment maintenance strategies and the factory performance of the Kenya sugar firms. The focus was on South Nyanza, Mumias, Chemelil, Muhoroni, Nzoia and West Kenya Sugar Companies. *The study was prompted by the continued deficit in national sugar production occasioned by the inability of the industry to consistently produce sugar at the factory rated capacities. In addition no study has been carried out in this area in Kenya.* Factory time efficiency dropped from 79.58% in 2006 to 74.91% in 2008 in comparison to the international set standard of 92%. Technology adoption in the Kenya sugar industry is slow resulting in the operations of obsolete plant and equipment whose maintenance costs are very high and procurement of spares expensive and difficult to find. The specific objectives of the study were to*: identify the plant and equipment maintenance strategies adopted by the sugar firms; identify the factory performance indicators of the sugar firms; and assess the relationship between the plant and equipment maintenance strategies adopted and the factory performance of the sugar firms.* The researchers used survey research design. A sample of sixty respondents composed of ten respondents from Mumias, Chemelil, Muhoroni, Nzoia, South Nyanza and West Kenya Sugar Companies was used to provide information for analysis. A Likert–scale weighted average was used in the data analysis. The study established that robust plant and equipment maintenance strategies play a key role in the factory performance.

**Keywords:** Plant, capacity utilization, cost of maintenance, factory time efficiency, reduced overall recovery.

## INTRODUCTION

### Background to the Study

Over the years, maintenance has become important in the manufacturing industry and its role has grown into a much more prominent purpose in the plant operation. Most Managers see maintenance efficiency as a factor that can affect all business effectiveness including risk-safety, environmental integrity, energy efficiency, product quality and customer. Maintenance management is a relatively young academic discipline; which was developed as an academic discipline in the 1980s (Anderson, 1989). The old concept of Maintenance was: *"Maintenance is about preserving physical asset".* The new concept is that *"Maintenance is about preserving the functions of assets"* (Srivastava, 2004). The basic function of maintenance is to replace, repair, overhaul, rebuild, service, lubricate, inspect, test, adjust, align, calibrate or install a new system.

Maintenance strategies are methodologies which balance maintenance costs against the impact of plant failure. Srivastava (2004) notes that many maintenance strategies or methodologies have been developed mainly based on time for doing maintenance, frequency of maintenance, quality of maintenance, complexity and sophistication of plant/equipment and value of total assets. According to Qui and Lee (2007, issue 6) the objectives of maintenance management strategies is to increase the device reliability, reduce production downtime, increase the throughput, increase life expectancy of assets, improve safety and quality conditions and optimize the use of available funds, personnel, inventory (materials, spares), and facilities. Qui and Lee (2007, Issue 6) describes six types of maintenance strategies, namely: no maintenance, reactive maintenance, preventive maintenance, predictive maintenance, proactive maintenance and self- maintenance. Ellis (2003, April) observes that there are two types of maintenance costs; direct and indirect costs. Direct maintenance costs consist of wages and salaries, cost of materials, administration, training, spare parts, contracted work forces and modification. Indirect costs are breakdowns and unplanned plant shutdown losses, excessive set-up time, changeovers and adjustment losses, idling and minor stoppages, running at reduced speed, startup losses and quality defects. McGuin (2008, August) observes that *"Robust Maintenance Capacity can be the difference between ongoing profits and impending downfall".*

Moriarty (2009) has observed that the cost of poor leadership can be measured in dollars and cents. The maintenance leader has to be a good technician, economist and possess adequate skills in human management. Rehkopf (2006) observed that *"Great companies realize that employees are their most important resource".* Armstrong (2006) states that *"the Human Resource (HR) function is to enable the organization achieve its objectives by taking initiatives and providing guidance and support on all matters relating to its employees".*

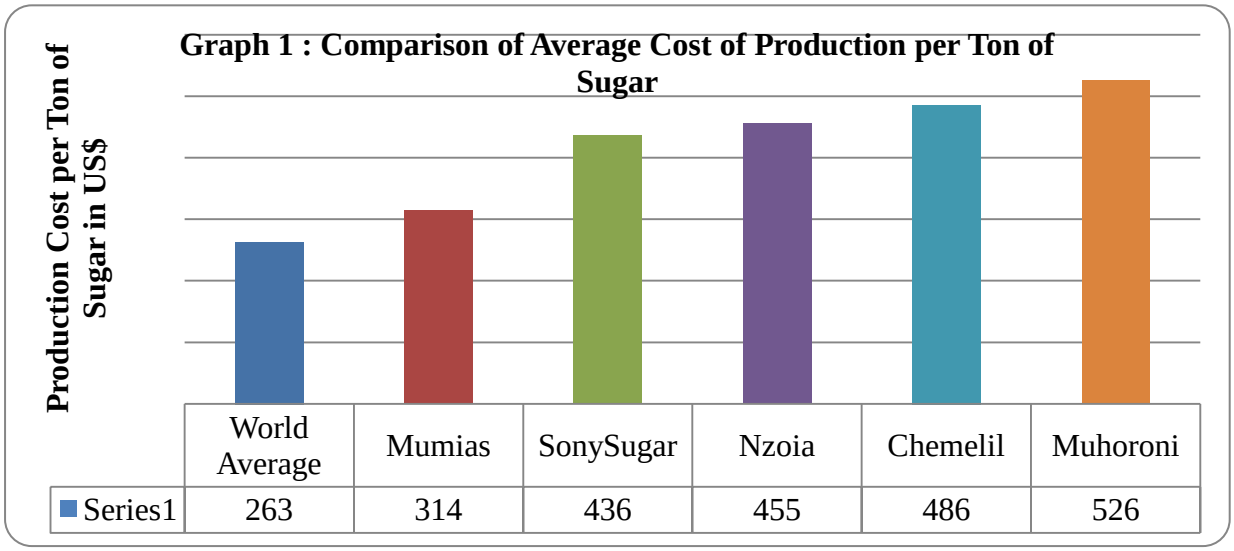
Singhal (2009) defines inventory as a list of movable terms required for manufacturing the product and to maintain plant facilities in working condition. Advantages of effective inventory control are better capacity utilization, better recovery, reduction in maintenance cost and reduction in inventory cost.

**Sugar Manufacturing Firms in Kenya**

From a global perspective, 78% of sugar in the world is extracted mainly from sugarcane, and the balance from sugar beet. Illovo Sugar Report (2007/8) indicates that the ten lowest cost sugarcane producing countries in 2005/06 were Brazil, Zimbabwe, Malawi, Swaziland, Guatemala, Sudan, Australia, Zambia, South Africa and India. Sugarcane growing was introduced in Kenya in the early 1900s. The industry dates back to 1922 when Miwani Sugar Company was established followed by construction of various sugar factories namely: Ramisi(1927), Muhoroni (1966), Chemelil (1968), Mumias (1973), Nzoia (1978), South Nyanza (1979), West Kenya (1981), Soin (2006) and Kibos (2007). Other sugar firms such as Sukari Industries at Ndhiwa, Trans Mara Sugar, Opapo, Butali and Tana basin multi-projects have either been recently constructed or approved. Miwani and Ramisi collapsed, though Ramisi has been revived under a new name of Kwale Sugar Company Limited.

The sugar industry is both strategic and political; it ensures food security, improves rural lives and provides sustainable livelihood for over 5 million Kenyans. The sugar firms are the "life-line" of surrounding towns such as Mumias, Awendo, among others. Most farmers in Western part of Kenya rely on sugarcane as the only major source of income. Population in sugar growing areas and potential sugar growing areas in Kenya stands at over ten million

Kenyans (Kenya Statistical abstract, 2004). LMC Worldwide Survey (2005) established that all public sugar companies in Kenya with the exception of Mumias Sugar Company produced sugar at a cost higher than 150% of the world average as depicted in the graph 1 below:




**Source:** LMC Worldwide Survey on Sugar Production Costs, 2005

The main players in the sugar sub-sector are the Government of Kenya (GOK), Kenya Sugar Board (KSB), the millers organized under the umbrella of Kenya Sugar Manufacturers Association (KESMA), the suppliers of cane organized under the Kenya Sugarcane Growers Association (KESGA) and customers.

Technology adoption in the Kenya sugar industry is slow resulting in the operations of obsolete plant and equipment whose maintenance costs are very high and procurement of spares expensive and difficult to find. Otieno, Kegode and Ochola (2003) and COMESA (2007, June) reports show that the problems affecting the millers are due to; inefficient factory operations, inefficient agronomic practices, State intervention and conditions under which the Chief Executive Officers are appointed. The performance of the Kenya sugar sub-sector has not been consistent. The production of sugar has fluctuated from year to year as shown in Table 1 below in a manner that implies deficient strategic focus on factors such as skills improvement, realistic company's Strategic Plans, maintenance policy, maintenance leadership, technology adoption , financial constraints, synchronizing cane availability and factory capacity and prudent management.

**Table 1: Sugar Production in Kenya; 2001-2008, MT**

| **Year** | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| **Production** | 377438 | 494249 | 448489 | 516803 | 488997 | 475670 | 520404 | 517667 |

**Source**: Kenya Sugar Board Year Book of Sugar Statistics, 2008.

**Maintenance in the Sugar Industry**

An important aspect of a successful crushing is to ensure minimal breakdowns during the grinding campaign. The main activities which go on in maintenance operation are replacement, repair, service and modification. Daily or running maintenance is maintenance that is carried out whilst the equipment is in operation. This consists of daily inspection of

machines, adjusting gland packing and other small jobs. Periodic maintenance is carried out when the condition of evaporators is not able to support the cane crushed by the milling plant. This window is used by maintenance personnel to carry out planned maintenance for identified areas of weaknesses and to check/rectify equipment within the stoppage period.
Annual maintenance is carried out during high rainfall months when accessing the cane fields by haulage tractors is difficult and tractors would likely destroy the cane fields. This is a period when a sugar factory is stopped for three weeks or more to carry out major overhauls and refurbishment of all critical machines, plants and equipment in the factory.

**Studies Carried Out In The Kenya Sugar Industry**

Studies carried out in the Kenya Sugar industry have been on issues such as production of cane varieties, cane husbandry, trade liberalization, factors affecting farmers and viability of sugar sub-sector. However, there is no evidence that a research has been done on the relationship of maintenance strategies and the factory performance in the Kenya sugar Industry; though poor factory performance is mentioned generally in some of the studies carried out (Kaumbutho, Awiti and Karuri, 1991; Otieno, Kegode and Ochola, 2003 and ActionAid International Kenya, 2005). It is evident that the previous studies carried out on Kenya sugar firms concentrated on factors not related to maintenance strategies and those on South African sugar firms researched on effects of predictive and proactive maintenance strategies on factory performance. No study has focused on the relationship of all four types of maintenance strategies, namely: breakdown, preventive, predictive and proactive maintenance strategies on factory performance of the sugar firms.

**Objective of the Study**

The general objective of the study was to assess the relationship between plant and equipment maintenance strategies and the factory performance in the Kenya sugar industry. The specific objectives of the study were to:

i. identify the plant and equipment maintenance strategies adopted by the firms in the sugar industry;
ii. identify the factory performance indicators of the sugar firms;
iii. assess the relationship between the plant and equipment maintenance strategies adopted and the factory performance of the sugar firms;
iv. other factors that influence factory performance.

**Statement of the Problem**

The study was prompted by the continued deficit in national sugar production occasioned by the inability of the sugar industry to consistently produce sugar at the factory rated capacities.

**CONCEPTUAL FRAMEWORK**

Maintenance remains one of the very few areas through which significant increase in company profits can be achieved. McGuin (2008, August) observes that *"Robust Maintenance Capacity can be the difference between ongoing profits and impending downfall".* The independent variable is the factory maintenance strategy while the dependent variable is the factory performance which is the primary interest variable. The intervening variable is the Organization's Policies. The researchers sought to establish the relationship

between the independent and dependent variables which guided the study as summarized in the conceptual framework model, figure 2 below.

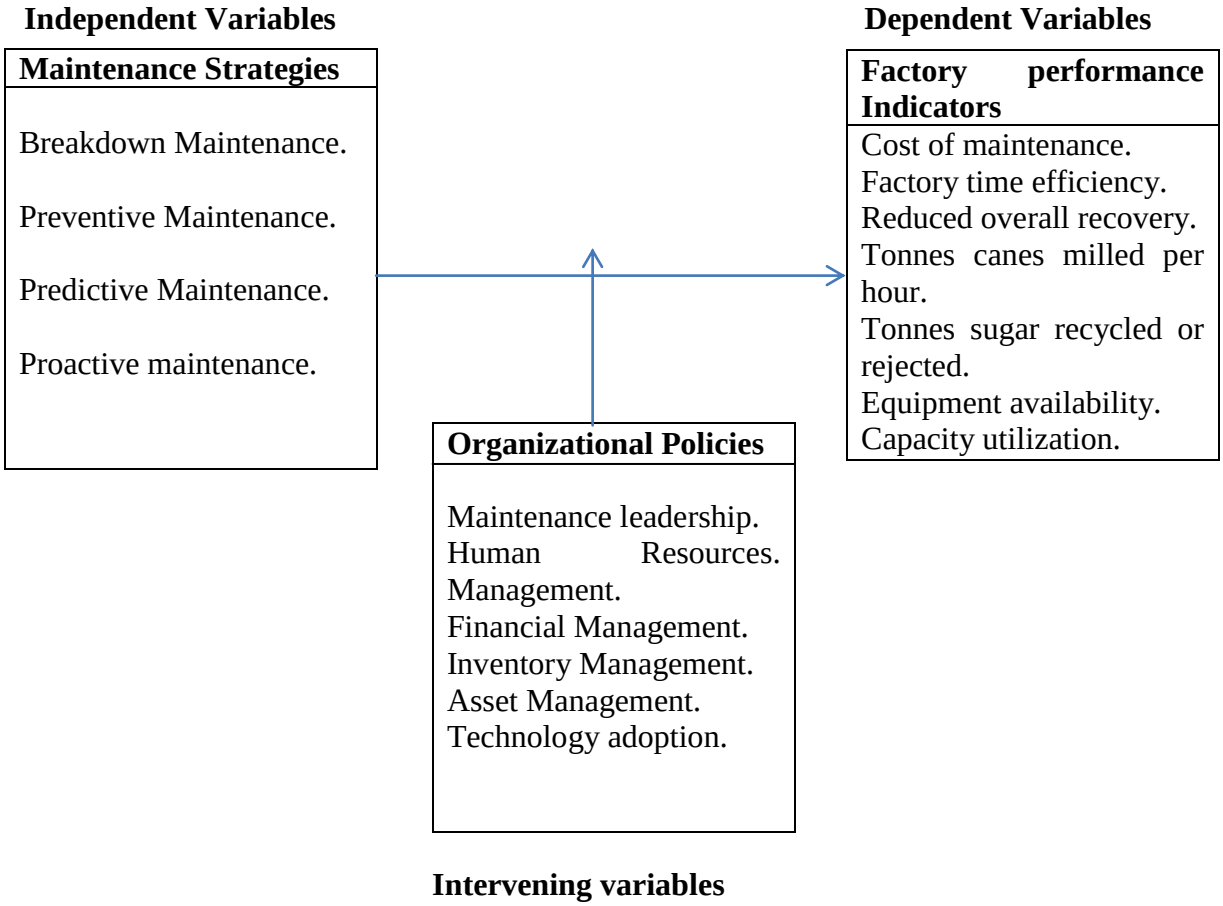



**Figure 2:** Conceptual Framework Model; **Source:** (Researchers).

## RESEARCH METHODOLOGY

A survey research design of Mumias, Chemelil, Muhoroni, Nzoia, SonySugar and West Kenya Sugar companies was carried out. The firms are situated in Western part of Kenya. The target population consisted of 236 managers and Supervisors involved in maintenance activities in manufacturing department as tabulated in the **Table 3** below.

**Table 3:** Managers and Supervisors involved in maintenance in each Sugar Firm

| Company | SonySugar | Mumias | Chemelil | Muhoroni | Nzoia | West Kenya |
|---|---|---|---|---|---|---|
| **Managers** | 20 | 16 | 18 | 28 | 26 | 17 |
| **Supervisors** | 28 | 18 | 18 | 19 | 16 | 12 |
| **Totals** | **48** | **34** | **36** | **47** | **42** | **29** |

**Source:** Researchers

A sample size of sixty respondents composed of ten respondents from each of the six sugar firms provided information for the analysis of the study. The ten respondents consisted of seven managers and three supervisors from each sugar firm. The seven managers were composed of two electrical engineers, one instrument engineer and four mechanical engineers while the three supervisors were one from each of the three previously mentioned disciplines.

Fifty one questionnaires were received representing a total response rate of 85%. The instrument for data collection was a close ended questionnaire. The raw data collected were analyzed using a Likert–scale weighted average and conclusions drawn.

**Data Analysis and Interpretation**

The first objective of the study was to identify the plant and equipment maintenance strategies adopted by the sugar firms as summarized in **Table 4a** below**.**

**Table 4a:** Frequency of Maintenance Tasks carried out on Plant and Equipment.

| **Maintenance Tasks** | **Most Frequ -ently 5** | **Very Frequ -ently 4** | **Frequ -ently 3** | **Moderate ly Frequentl y 2** | **Less Frequ -ently 1** | $\sum f_i$ | $\sum w_i f_i$ | $\frac{\sum w_i f_i}{\sum f_i}$ |
|---|---|---|---|---|---|---|---|---|
| Monitoring equipment. | 26 | 12 | 7 | 3 | 3 | 51 | 208 | 4.08 |
| Restoring equipment to operations. | 9 | 12 | 12 | 8 | 10 | 51 | 155 | 3.04 |
| Involvement in selection of original equipment manufacturers (OEM). | 7 | 10 | 16 | 6 | 12 | 51 | 147 | 2.88 |
| Enlarging the scope of predictive techniques. | 6 | 15 | 17 | 9 | 4 | 51 | 163 | 3.20 |
| Managing scheduled maintenance activities. | 18 | 14 | 15 | 4 | 0 | 51 | 199 | 3.90 |
| Designing better production processes. | 5 | 5 | 24 | 8 | 9 | 51 | 142 | 2.78 |
| Maintaining equipment in operation. | 13 | 14 | 13 | 7 | 4 | 51 | 178 | 3.49 |
| Replacing the broken down equipment. | 7 | 7 | 16 | 7 | 14 | 51 | 139 | 2.73 |
| Improving the production processes. | 2 | 11 | 22 | 12 | 4 | 51 | 148 | 2.90 |
| Deferring planned maintenance | 6 | 9 | 4 | 8 | 24 | 51 | 118 | 2.31 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| activities to attend to emergency cases. | | | | | | | | |
| Monitoring equipment failure trends with a view to taking corrective action before failure occurs. | 16 | 20 | 7 | 3 | 5 | 51 | 192 | 3.76 |
| equipment overhauls at intervals. | 9 | 19 | 10 | 3 | 10 | 51 | 167 | 3.27 |

**Source:** Researchers

From the result, it was observed that the very frequently carried out maintenance task and its weighted Likert score was monitoring equipment (4.08), while the less frequently carried out maintenance task was the deferring of planned maintenance activities to attend to emergency cases with a weighted Likert score of 2.31. Monitoring production equipment status and equipment failure trends represent the predictive maintenance. Preventive maintenance strategy is represented by managing scheduled maintenance activities, maintaining equipment in operation and carrying out equipment overhauls at intervals. Involvement in selection of original equipment manufacturers (OEM), designing better production processes and improving the production processes are all consistent with an approach to a proactive maintenance strategy. Restoring equipment to operations, replacing the broken down equipment and deferring planned maintenance activities to attend to emergency cases represent the traditional, reactive/breakdown maintenance strategy. The above maintenance tasks representing each of the four maintenance strategies are summarized in **Table 4b** below.

**Table 4b:**Frequency of Carrying out Maintenance Tasks in Reference to Maintenance Strategies.

| **Maintenance Strategy** | **Maintenance Tasks** | **Weighted Likert Score** | **Aggregated Means** |
|---|---|---|---|
| Predictive | Monitoring production equipment status | 4.08 | |
| | Monitoring of equipment failure trend with a view to taking corrective action before failure occurs | 3.76 | |
| | Enlarging the scope of predictive techniques | 3.20 | 3.68 |
| Preventive | Managing scheduled maintenance activities | 3.90 | |
| | Maintaining equipment in operation | 3.49 | |
| | Carrying out equipment overhauls at intervals | 3.27 | 3.55 |
| Proactive | Involvement in selection of original equipment manufacturers (OEM) | 2.88 | |
| | Designing better production processes | 2.78 | |

| | | | |
|---|---|---|---|
| | Improving the production processes | 2.90 | 2.85 |
| Breakdown | Restoring equipment to operations | 3.04 | |
| | Replacing the broken down equipment | 2.73 | |
| | Differing planned maintenance activities to attend to emergency cases | 2.31 | 2.69 |

**Source:** Researchers

The second objective of the study was to identify the factory performance indicators of the sugar firms. The results of the survey are summarized in **Table 5** below.

**Table 5:** Frequency of Monitoring Factory Performance Indicators.

| **Factory Performance Indicators** | **Most Frequ-ently 5** | **Very Frequ-ently 4** | **Frequ-ently 3** | **Moderately Frequently 2** | **Less Frequ-ently 1** | $\sum f_i$ | $\sum w_i f_i$ | $\frac{\sum w_i f_i}{\sum f_i}$ |
|---|---|---|---|---|---|---|---|---|
| Cost of maintenance | 13 | 15 | 12 | 5 | 6 | 51 | 177 | 3.47 |
| Factory time efficiency | 29 | 11 | 7 | 4 | 0 | 51 | 218 | 4.27 |
| Reduced overall recovery | 19 | 14 | 11 | 2 | 5 | 51 | 193 | 3.78 |
| Tonnes cane milled per hour | 28 | 9 | 8 | 1 | 5 | 51 | 207 | 4.06 |
| Tonnes sugar recycled or rejected | 10 | 8 | 8 | 8 | 17 | 51 | 139 | 2.73 |
| Individual equipment availability | 21 | 11 | 9 | 3 | 7 | 51 | 189 | 3.71 |
| Factory capacity utilization | 19 | 10 | 10 | 6 | 6 | 51 | 183 | 3.59 |

**Source:** Researchers

The survey revealed that the most monitored factory performance indicator and its weighted Likert score was factory time efficiency (4.27), while the least monitored was tonnes sugar recycled or rejected (2.73).

The third objective of the study was to assess the relationship between the plant and equipment maintenance strategies and the factory performance of the sugar firms. The

respondents were asked to rate how effectively their maintenance tasks helped in the achievement of low maintenance cost. The results are summarized in **Table 6** below.

**Table 6:** Effectiveness of Plant and Equipment Maintenance on the Factory Performance Indicators:

| **Factory Performance Indicators** | **Most Effecti-vely 5** | **Very Effecti-vely 4** | **Effect i-vely 3** | **Moderate ly Effectivel y 2** | **Less Effect i-vely 1** | $\sum f_i$ | $\sum w_i f_i$ | $\frac{\sum w_i f_i}{\sum f_i}$ |
|---|---|---|---|---|---|---|---|---|
| Cost of maintenance | 19 | 18 | 12 | 1 | 1 | 51 | 206 | 4.04 |
| Factory time efficiency | 22 | 19 | 6 | 2 | 2 | 51 | 210 | 4.12 |
| Reduced overall recovery | 14 | 16 | 10 | 5 | 6 | 51 | 180 | 3.53 |
| Tonnes cane milled per hour | 19 | 19 | 10 | 2 | 1 | 51 | 206 | 4.04 |
| Tonnes sugar recycled or rejected | 7 | 14 | 13 | 6 | 11 | 51 | 153 | 3.00 |
| Individual equipment availability | 21 | 17 | 9 | 1 | 3 | 51 | 205 | 4.02 |
| Factory capacity utilization | 15 | 18 | 14 | 3 | 1 | 51 | 196 | 3.84 |

**Source:** Researchers

The maintenance tasks were found to have meaningful effects on the achievement of factory performance indicators. Influence of plant and equipment maintenance on the factory performance indicators was recognized by the respondents who acknowledged that five out of the seven factory performance indicators were very frequently affected by the maintenance tasks and were all given a Likert score of above 3.80 (see Table 6 above).

The fourth objective of the study was to identify other factors that influence factory performance. Organizational policies are the intervening variables between the independent and the dependent variables. The respondents were asked to state the influence of maintenance leadership, financial management, manpower policy, inventory management,

asset management and technology adoption on factory performance. The results are summarized in **Table 7** below.

**Table 7:** Frequency of Influence of Organizational Policies on Factory Performance

| **Organizational Policies** | **Most Effect i-vely Influe -ntial 5** | **Very Effecti- vely Influe- ntial 4** | **Effect i-vely Influe -ntial 3** | **Moderate ly Effectivel y Influentia l 2** | **Less Effect i-vely Influe -ntial 1** | **$\sum f_i$** | **$\sum w_i f_i$** | **$\frac{\sum w_i f_i}{\sum f_i}$** |
|---|---|---|---|---|---|---|---|---|
| Maintenance Leadership | 23 | 15 | 8 | 1 | 4 | 51 | 205 | 4.02 |
| Financial Management | 21 | 18 | 5 | 2 | 5 | 51 | 201 | 3.94 |
| Manpower | 22 | 13 | 9 | 4 | 3 | 51 | 200 | 3.92 |
| Inventory Management | 19 | 14 | 12 | 2 | 4 | 51 | 195 | 3.82 |
| Asset Maintenance | 19 | 11 | 14 | 5 | 2 | 51 | 193 | 3.78 |
| Technology Adoption | 19 | 14 | 10 | 3 | 5 | 51 | 192 | 3.76 |

**Source:** Researchers

The findings showed that Maintenance leadership had profound effects on factory performance with a weighted Likert score of 4.02 while technology adoption had the least effects with a weighted Likert score of 3.76. The score difference between the most effectively influential organizational policy and the least effectively influential policy was 0.26 showing the importance of organizational policies in maintenance.

## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

Management Policies in the company greatly influence the way maintenance of plant and equipment is carried out and its effects on factory performance. The study established that robust plant and equipment maintenance strategies play a key role in the factory performance. Maintenance leadership was the most influential intervening variable to the way plant and equipment maintenance is managed. Key factory performance indicators were found to be factory time efficiency (4.27), tonnes cane milled per hour (4.06), reduced overall recovery (3.78) and individual equipment availability (3.71). The least monitored was tonnes sugar recycled or rejected (2.73). Infrequent monitoring of cost of maintenance (3.47) and factory capacity utilization (3.59) may lead to uneconomical operation and hence high cost of

production. The cost of maintenance of plant or equipment may reveal whether it is prudent to continue operating a plant or purchase a new and better technology oriented plant. Maintenance is synonymous with high level of availability, reliability and operable assets which are linked directly to production capacity, productivity and business profit.

**Recommendations**

The Management of the sugar companies in Kenya should invest optimally in the maintenance resources, namely: human resource, maintenance materials, technology adoption and maintenance methodology to enhance the quality of maintenance and hence, improve and sustain the factory performance.

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