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Evaluation of Performance and Safety Practices in the Oil and Gas Industry: A Case Study of Network Exploration and Production

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Abstract:
Safety practices and performance in Network Exploration & Production Nigeria Ltd was evaluated for a period of five years between 2019 – 2023 using the principles of statistical expectation and efficiency index. The number of prevented accidents and the corresponding values of lives and property saved were estimated annually for the same period of five years. The type of input resource, total number of input resources, total number of prevented accidents by class, the unit cost of each of the accident class, the cost of input resources, quantity of each type of input resources and the targeted period were identified. The study revealed that a total of 98 accidents were prevented in the period of the safety programme which translates to an average of 19.6 per year. The safety programme also saved lives and property worth N12.5 million for the five year period which is at an average of N2.5 million annually. The computation of efficiency indices due to the use of all the input resources when compared with the standard period and it was discovered that all the resources were well utilised. The significance and benefits of the work to the local community and other industries is that the principles of statistical expectation and efficiency index can be easily applied to analyse the performance of safety programme in the industries.

Keywords: *Safety, safety management system, safety policies, accident*

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I. Introduction

The campaign for safety is a long tradition (both at local and international levels) and the demand for safety and health improvement was originally prompted by poor conditions such as in lighting, ventilation and sanitation which arose as a result of rapid industrial revolution in eighteenth century [1]. However, it took centuries of experience to perfect discipline of safety which requires the knowledge of management, ergonomics, psychology, industrial aesthetics, engineering to mention a few [2]. Safety may be regarded as an attribute of only engineering set up, but, certainly entails more. The current trend in modern technological societies emphasis is safety conscious attitude on the part of employers of labour, individual employee, self-employed, designers, importers, exporters, suppliers and landlords to mention a few. Studies demonstrate that between 5 per cent and 15 per cent of accidents are caused by inherent job hazards and 85 per cent to 95 per cent are caused due to what employers do or fail to do [3]. Also, it was reported that there exists immense correlation between safety and productivity; and cost and suffering [4].

Several approaches have been employed to safety performance evaluation. These are statistical: expectation function, quality control; system analysis, engineering economic factor, price deflation, systems theory, risk assessment, system dynamics, etc. Also modeling efforts have been reported in literature. These include accident rate model safety programme efficiency index [5]; justification model and sampling model [6].

Despite all these efforts, absolute safety for humans and property is still an illusion; unsafe event persists, natural disasters ravage the earth; earthquakes, drought, tornadoes and floods still claim lives. Factory machines and oil exploration facilities are still claiming human lives or limbs. In the USA, about 6,500 American workers die each year because of accidents . Also, National Safety Council [7] reported that on an average day, 14 people are killed and more than 10,400 people are disabled at work. In the UK, 1.6 million injury accidents and 27 million non-injury accidents are being recorded annually [8]. In Nigeria, NISP [9}

reported that over 11,000 people die from on-the-job accidents each year and a worker is injured every 18 seconds in chemical industries in Nigeria.

In USA, the National Safety Council reveals that the death and disabling injuries cost is upward of $ 130 million annually [2]. However, NSC [7] revealed that the cost to the USA economy of the job – related injuries is estimated at more than $27 billion annually.

An accident is an unplanned, unexpected, and undesigned (not purposefully caused) event which occurs suddenly thereby causing injury or loss, a decrease in value of the resources, or an increase in liabilities. Virtually, every day and in every human endeavour, accidents have become a regular feature.

It occurs in human endeavours such as transport, homes and manufacturing organisations among several others. They most often occur as a result of unsafe conditions of work [10].

These undesirable events may lead to human injury, damage to property, and loss of production hours, disease, permanent disability or death, [4, 11]. The consequences of accidents, in some cases, are not borne only by those directly involved but extended to relatives, friends, employers and government [12]. Despite all established standards and legislations on safety, with sophisticated devices developed and researches carried out [13]; yet, a perfectly safe condition for human and property is still an illusion.

The desire for safety is on the increase in the manufacturing industry. Apart from the cost due to downtime, loss of wages and equipment, hospitalisation, the tragedy associated with personal injury, disability and fatality is enormous. As far as fatalities are concerned, industrial accidents take the third place after vehicle and homicide, [4, 12]. In Nigeria, the manufacturing sector has stagnated, and its contribution to GDP and employment remain small, due to "weak safeguards against occupational and other hazards" [13]. Although, this is one of the factors that is responsible for the stagnation, also abound are the problems of unstable electricity power supply, harsh government policy and lack of favourable enabling environment. In one of the reports of the Nigerian Institute of Safety Professionals (NISP) over 11,000 people die from on-the-job accidents each year and a worker is injured every 18 seconds in chemical industries in Nigeria.

Adebiyi [12] reported that there is higher incidence of fatal work-related injuries in developing world than in the developed ones.

Numerous definitions of safety exist in the literature. Definitions such as "the condition of being safe from undergoing or causing hurt, injury, or loss" may not be applicable in hazardous technologies since an absolutely safe technology does not exist. Therefore, a more appropriate definition of safety, applied in the study, would be "freedom from unacceptable risks",

Safety performance improvements in an organization can increase its resistance or robustness and lower the risk of accidents. On the other hand, poor safety performance can increase the organization's vulnerability and hence increase the risk of accidents. There is no common definition of safety performance. For instance safety performance may include; safety organization and management, safety equipment and measures, accident statistics, safety training and evaluation, accident investigations and safety training practice. Safety-related work is regarded as the efforts made to achieve safety. In the study, safety-related work does not include financial risks. Safety performance can be considered as a subset of the total performance of an organization In order to improve safety performance an organization must identify the different defensive barriers that protect the organization.

The primary purpose of safety evaluation is to determine the true basic cause of accident for the express purpose of taking remedial action to prevent a recurrence and to remedy the weakness in one or more of safety programme activities [6]. However, safety analysis is faced with problem of assessing the uncertain future and quantifying safety output. But, the quote from Peters and Waterman reported by Aggrawal, [6] that "What gets measured gets done. Putting a measure on something is tantamount to getting it done. It focuses management's attention on that area. Information is simply made available and people respond to it" thereby puts challenges to safety analyst.

The problem of appropriately quantifying human life is the major problem of costing accident and no generally accepted model has been developed for this.

There is need to provide useful mathematical tool to assist in taking judicious decisions concerning safety in our industries. This study investigates the performance of safety programme of an oil and gas firm for a period of eight years: from 2019 - 2023.

Specifically, the number of prevented accidents, the corresponding lives and property saved and the way resources were used to achieve such safety would be investigated.

The main objective is the investigation of the performance and evaluation of safety practice programme of an oil and gas firm for a period of eight years: from 2019 -2023.

II. Material and Methods

In order to achieve the stated objectives of the study, a study on safety performance evaluation was carried out using a production industry (Network Exploration & Production Nigeria Ltd) as a case study.

Questionnaire concerning safety culture and working environment were combined to one questionnaire, and a total of 120 questions was formed. The questionnaire was distributed to one work group. 20 questionnaires were distributed and 18 were answered, resulting in a reply frequency of 90% (18/20). The estimated time it took to fill in this questionnaire was about one hour. The questionnaire regarding safety activities was distributed to two employees involved in safety management.

In the process of developing the proposed model and the methodology discussions with a number of people, with relevant experiences in the field, were carried out.

The model, consists of the three areas or head categories *safety culture*, *working environment* and *safety activity*. Each one of these categories is evaluated through a questionnaire package. The methodology consists of a total of 150 questions divided into the following categories;

Safety culture: Consists of 50 questions that are to be answered by a representative selection of employees. As stated above, safety culture should represent the total values, attitudes and beliefs in an organization. Therefore, ideally all employees should answer these questions. However, often the only practicable solution is to choose a sample group that represents the organization.

Working Environment: Consists of 34 questions. The results should illustrate the quality of the working environment in an industrial setting. Therefore, these questions should be answered mainly by employees exposed to this environment. Similar to the safety culture category above, all the employees exposed to this environment should, ideally, answer these questions.

Safety Activities: Consists of 66 questions. These questions should be answered by personnel with adequate knowledge in this area, such as employees actively working with safety management issues in the organization. This includes people participating in safety committees, safety engineers, designers/constructors etc. These questions are not supposed to represent people's total values, attitudes and beliefs as in the case of the safety culture and the working environment areas. The questions are constructed to measure what activities are preformed and the quality of those activities (leading indicator) rather than their outcomes (lagging indicator). Therefore, results from two or three people should be enough to receive adequate information regarding safety activities. Additionally, a questionnaire designed for the top management was constructed which consists of 6 questions. These questions represent the top management's safety performance ambition and view on safety culture.

Safety programme performance can be examined by considering the losses and costs associated with accidents and safety programme. The efficiency of a safety programme is related to how much of these losses are reduced or eliminated. The inputs are the resources used to run such a programme. The principles of statistical expectation and efficiency function can be used to analyse the performance of safety programme. It is concerned with efficient and effective utilisation of budgeted resources to run a safety programme.

The Efficiency Index can be defined as:

$$\frac{Achievement\ Index\ in\ period\ z}{Resource\ Index\ in\ period\ z}$$

This model is one of the ways to estimate the amount of money gained/lost in operating a safety programme, how effectively the resources budgeted have been used to achieve the targeted safety level and to budget for the future. It also gives a scientific background upon which decision could be made. For this study the following were identified: (1) type of input resource (personnel, information, equipment etc), (2) total number of input resources, (3) the total number of prevented accident by class, (4) the unit cost of each of the accidents class, (5) the cost of input resources and (6) quantity of each type of input resources. It is also important to select a targeted period which is the standard period. The output of a safety programme in a manufacturing company is viewed from reduction in the following: number of accidents that occurred, accident frequency rate, man-hour lost, severity rate etc. If a safety programme is effective and efficient, there will be a reduction in the number of accidents obtained within the observed period. The quantity of the output which is the number of prevented accidents of particular class *i* observed in the period *x* will be high, while its associated monetary value can also determined.

In applying the model, data were collected from the Oil and gas exploration industry on the:

(i) Quantities of input for both before and during safety programme.

(ii) Classes of accident.

(iii) Industrial accident data for both before and during programme operations.

(iv) The unit cost of input resources.

III. Results And Discussion

The output data before the safety programme were analysed to determine the expected number of accidents in each class. These are found to be **2.0**, **3.0**, **4.3** and **34.9** for **fatal**, **major**, **minor** and **trivial wounds** respectively.

The outputs computation of the safety programme, which includes the number of accidents prevented, and is presented in Table 3. The monetary value of the accidents prevented was estimated and the results are presented in Table 4. For this study Year 2022 was chosen as The Standard Period or Targeted Period. The equivalent Money Gained or Lost and results are presented in Table 4. And for its corresponding money gained or lost and results are presented in Table 5.

Table 1 Pre-safety programme accidents records (2019 – 2023)

Year	Fatal	Major	Minor	Wound	Total
2019	2	2	5	41	50
2020	0	0	4	32	36
2021	1	2	2	30	35
2022	0	0	5	35	40
2023	0	1	3	28	32

Table 2 Safety programme accidents records (2019 – 2023)

Year	Fatal	Major	Minor	Wound	Total
2019	0	0	1	24	25
2020	0	1	0	21	22
2021	1	2	3	29	35
2022	0	0	1	27	28
2023	0	0	2	19	21

Table 3 Summary of accidents prevented during the safety programme

Year	Fatal	Major	Minor	Wound	Total
2019	2	3	3.3	10.9	19.2
2020	2	2	4.3	13.9	22.2
2021	1	1	1.3	5.9	9.2
2022	2	2	1.3	18.9	24.2
2023	2	3	2.3	15.9	23.2

Table 4 Summary of the safety programme performance

Year	Estimated number of prevented accidents					Values of lives and property saved (N)	Efficiency index	Money gained/lost (N)
	Fatal	Major	Minor	Wound	Total			
2019	2	3	3.3	10.9	19.2	2,958,400.00	1.291	470,215.31
2020	2	2	4.3	13.9	22.2	2,676550.00	1.157	255,968.76
2021	1	1	1.3	5.9	9.2	1278200.00	0.530	-798729.80
2022	2	2	1.3	18.9	24.2	2582050.00	1.00	-
2023	2	3	2.3	15.9	23.2	2971900.00	1.156	282709.35

Table 3.5 Summary of the resources safety programme performance

Year	Human resources Used		Information disseminated		Equipment used		Other resources used	
	Eff. Index	Money G/L	Eff. Index	Money G/L	Eff. Index	Money G/L	Eff. Index	Money G/L
2019	1.48	71602.29	0.71	-57734.98	1.37	454237.25	1.01	855.00
2020	1.24	39273.28	0.74	-44698.50	1.21	2,65798.13	0.92	-3510.00
2021	0.59	-63977.44	0.56	-47998.07	0.52	-661470.26	0.44	-25200.00
2022	1.00	-	1.00	-	1.00	-	1.00	-
2023	1.20	37335.83	0.78	-39581.01	1.19	278727.63	1.15	6040.00

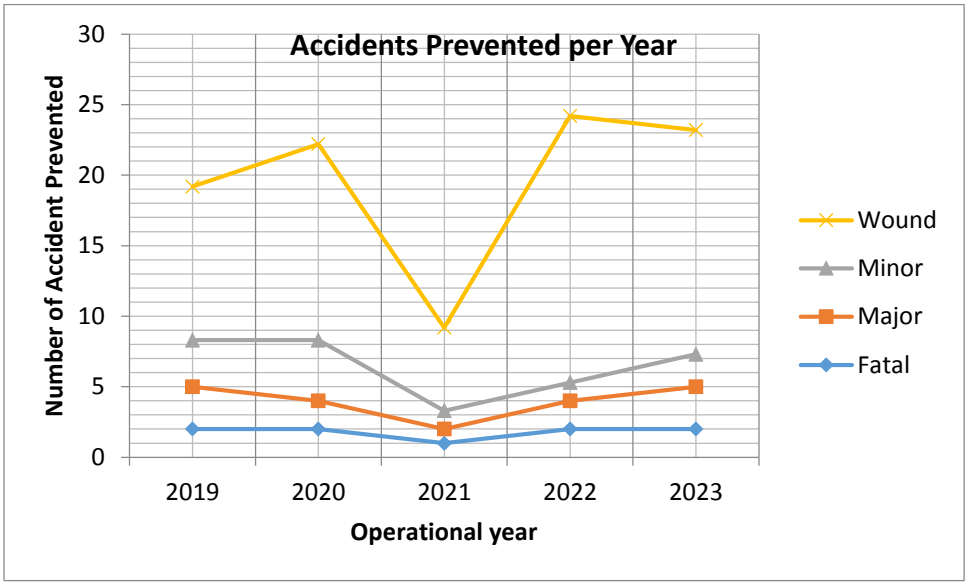

Fig. 1 Industrial Accidents Prevented per operating year

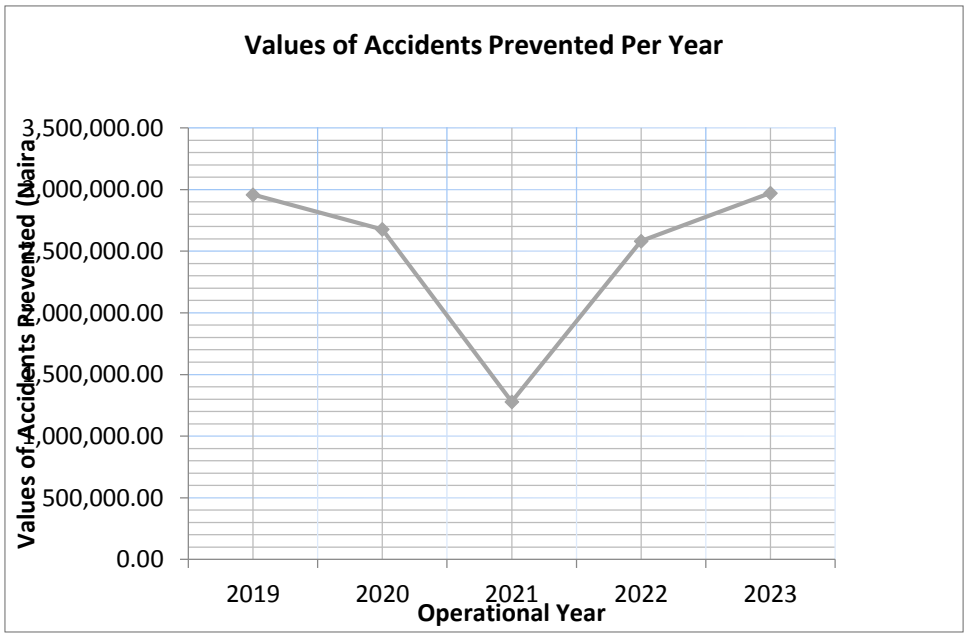

Fig. 2 Values of accidents prevented per operating year

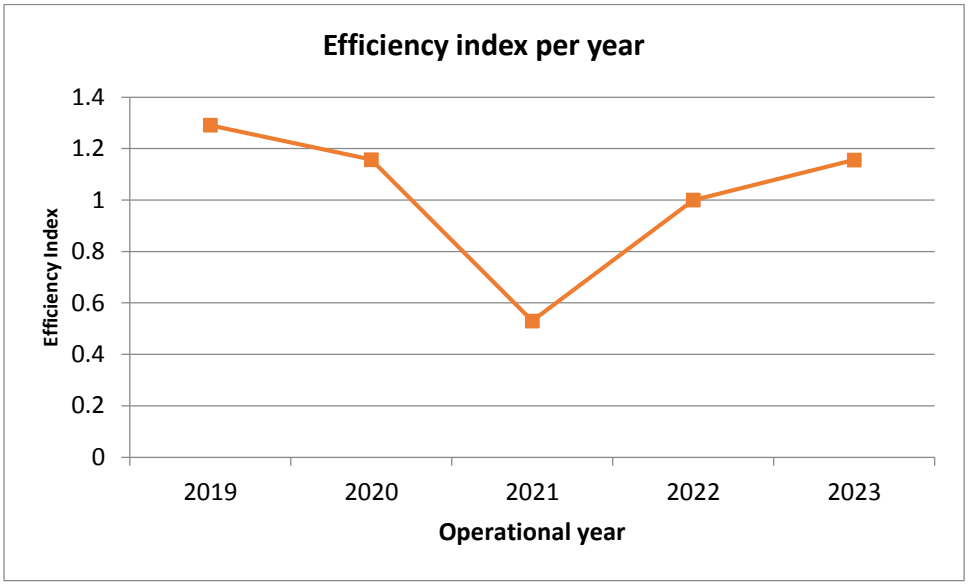

Fig. 3 Overall efficiency index per operational year

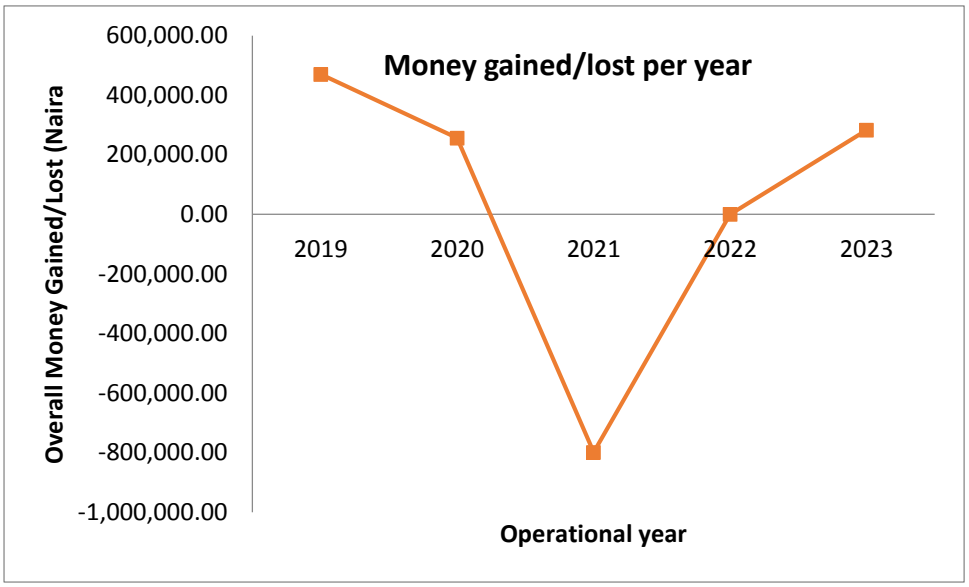

Fig. 4 Overall money gained/lost per operating year

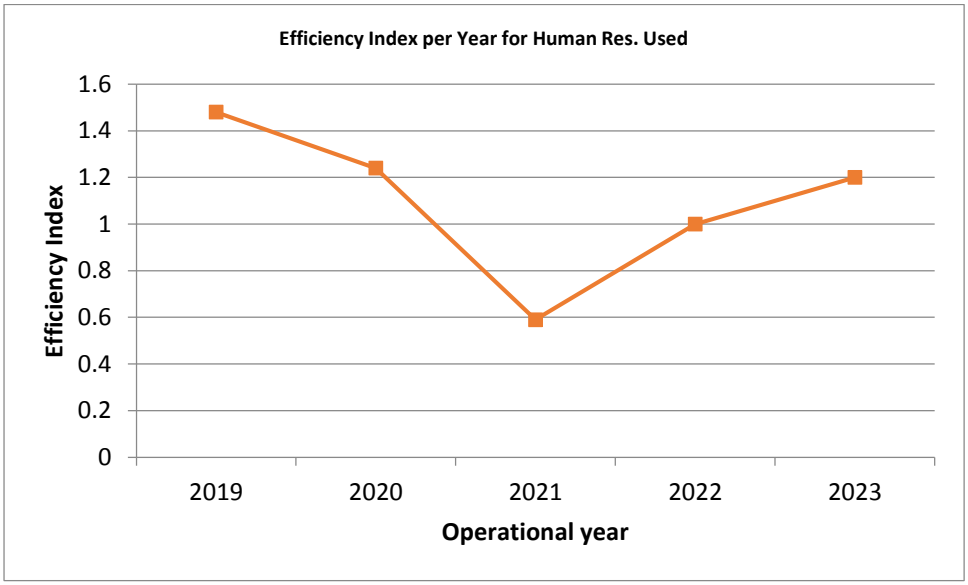

Fig. 5 Efficiency index per operating year for human resources used

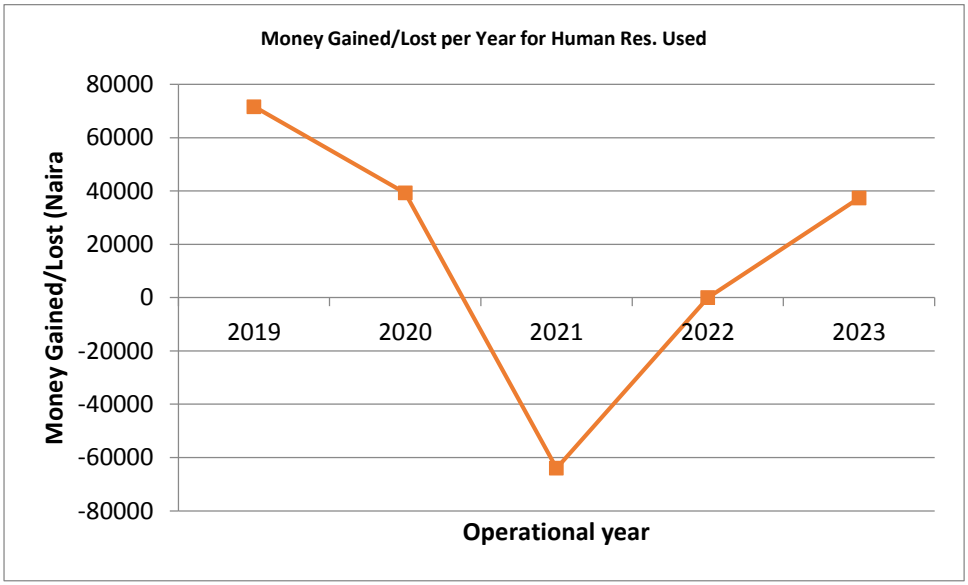

Fig. 6 Money gained/lost per operating year for human resources used

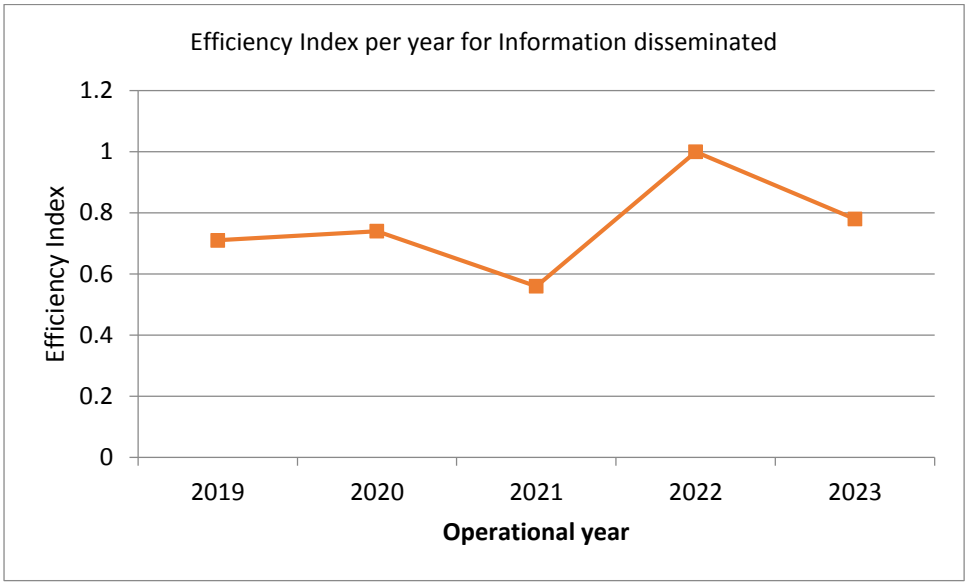

Fig. 7 Efficiency index per operating year for information dissemination

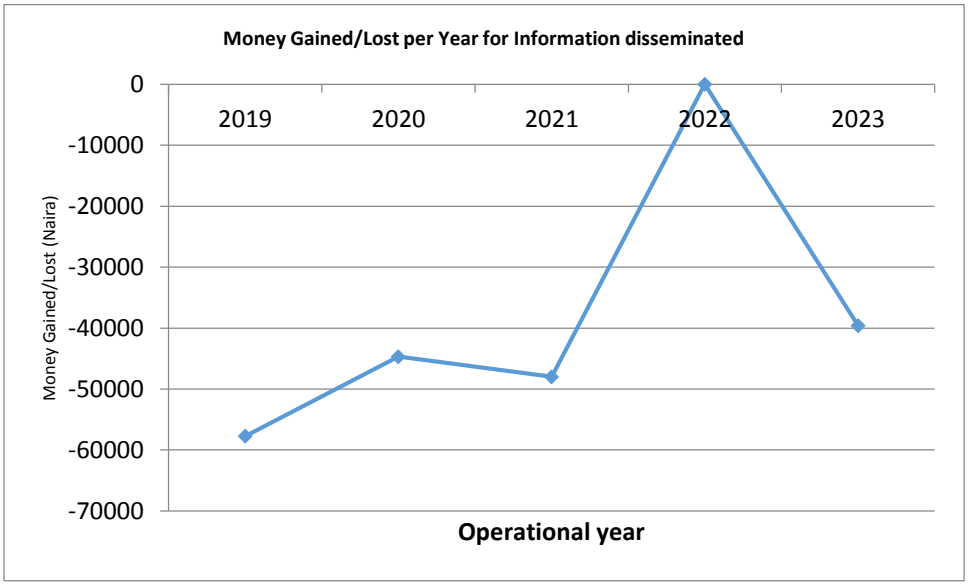

Fig. 8 Money gained/lost per operating year for information disseminated

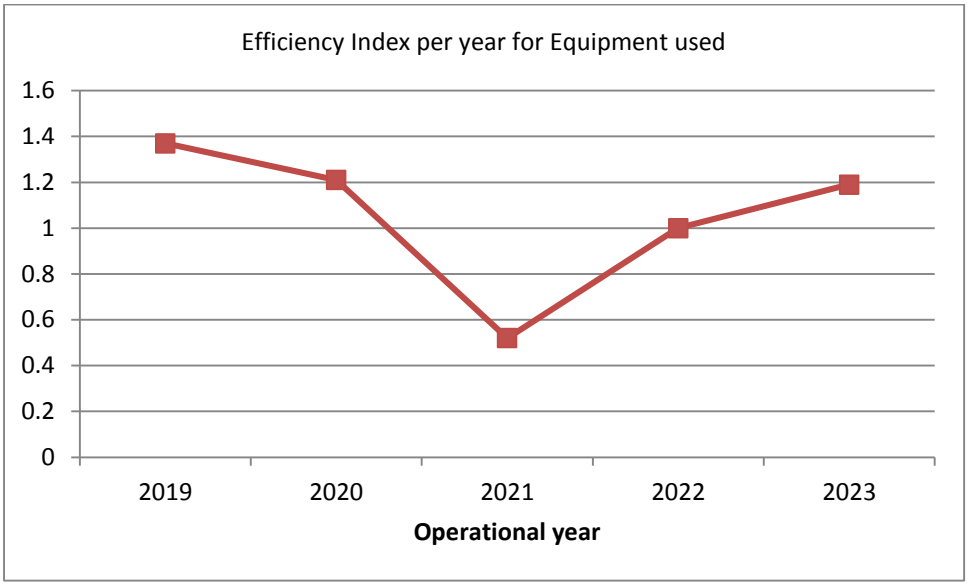

Fig. 9 Efficiency index per operating year for equipment used

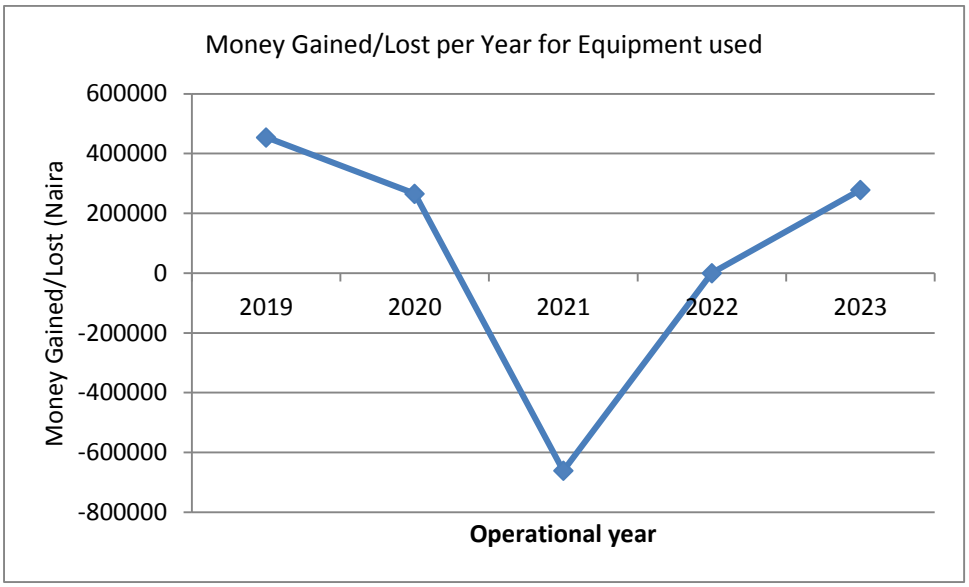

Fig. 10 Money gained/lost per operating year for equipment

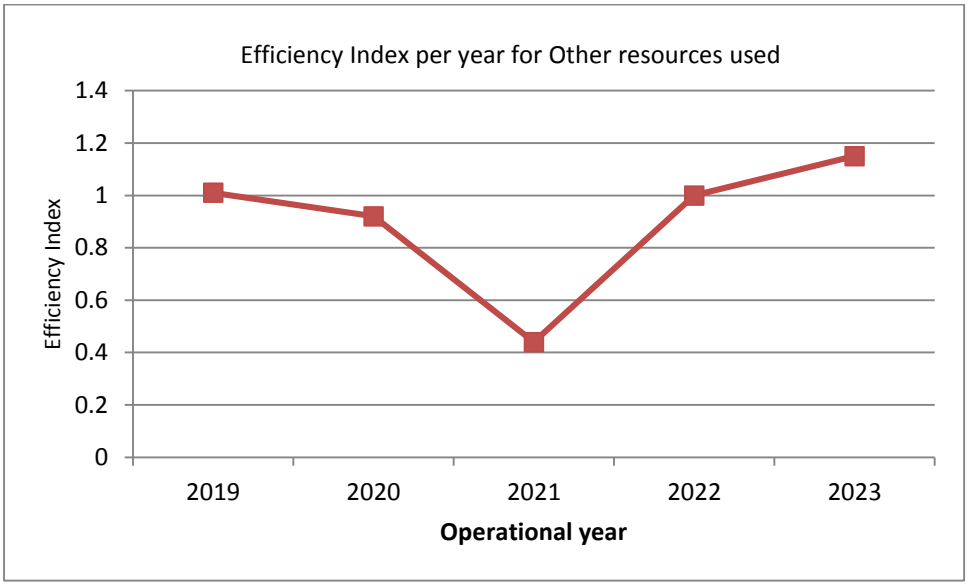

Fig. 11 Efficiency index per operating year for other resources used

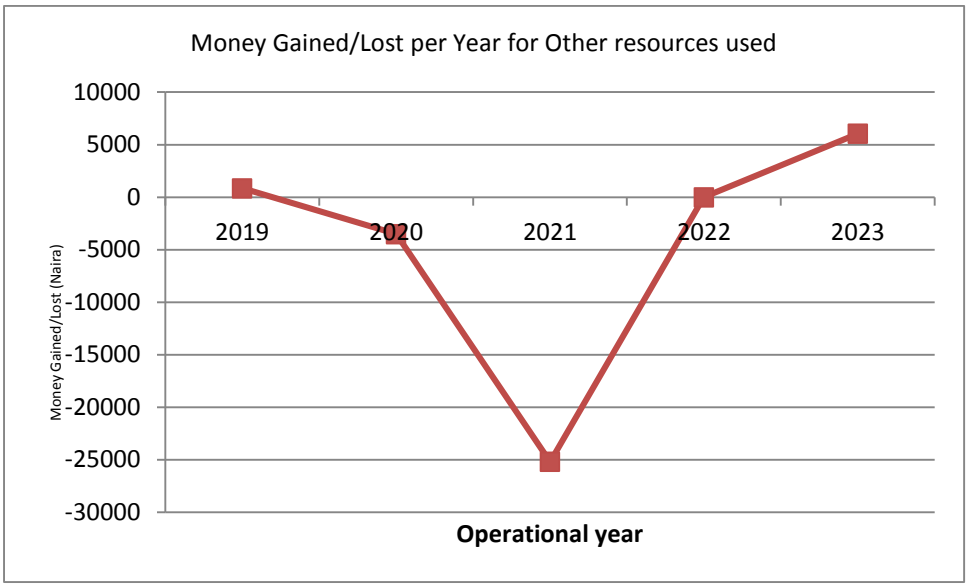

Fig. 12 Money gained/lost per operating year for other resources

IV. Discussion

The expected number of accidents in each class is: 2.0, 3.0, 4.3 and 34.9 for Fatal, Major, Minor and Wounds respectively. The computation of efficiency indices due to use of all the input resources show that all the resources are well utilised when compared with the Standard Period whose efficiency index is 1.000, except for year 2021, whose index was below 1.000. From Figure 3, the highest efficiency was attained in year 2023. Figure 1 shows that year 2020 has the highest number of accident prevented. From Table 4, it is shown that the amount of money spent on the programme (N 1,819,835.05) is less than the output of the safety programme (N 2,582,050:00) for the Standard Period. Also the highest money saved was recorded in 2023 (N2,971,900.00), while the least money saved was recorded in 2021 (N1,278,200.00).

The overall efficiency indices for the 5-year period (2019-2023) showed that the safety programme was effective, even though, the total annual efficiency index was not always increasing and it is particularly low in 2021 (0.530). For each of the input resources employed in operating the safety programme, varying amount of money is saved for each year, and the highest money saved is obtained from the use of equipment (N688,924.72) within the period of operating the safety programme, while the highest money lost is from information (N83,121.30).

The safety programme as indicated in Table 4 shows that a total of 24.2 accidents were prevented in the Best Period (Standard Period) of the programme (2022), and the highest money saved due to the overall use of

all resources (inputs) is N470,215.31 in year 2019 and the highest money saved due to the use of single input resource is N 454,237.25 in year 2019 for equipment. The total value of accidents prevented for the safety programme period under consideration (2019-2023) is N12,467,100.00 and the total amount of money gained due to the use of the safety programme is N 6,646,173.98 (nearly half of the money invested in the programme). The total number of accidents prevented for the same period, under consideration, is 98 which translate to an average of 19.6 per year. The implications of the results of the model are that, the model is sensitive to quantity of resources and how the resources are utilised.

V. Conclusion

This study used the principles of statistical expectation and efficiency index to analyse the performance of safety programme in an oil and gas exploration industry based in Ibeno LGA, Akwa Ibom State of Nigeria. The number of prevented accidents and the corresponding values of lives and properties saved were estimated and results obtained indicate that the programme is efficient, though there is still a need for more improvement, particularly in the use of resources. The firm, through its workers can improve on the performance of the safety programme, by effectively utilizing the input resources provided for them, so as to increase the efficiency of the model.

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