TRACTOR REPAIR AND MAINTENANCE MODEL FOR NIGERIA APPLICATIONS

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ABSTRACT

Many organizations in Kano State of Nigeria have more than half of their tractor fleet broken-down and making them not available for productive work throughout the year. The agricultural potentials of the state can only be optimally harnessed with adequate tractor power availability all year round. The basis for enhanced decision making is availability of timely, high-quality data. Most farmers in need of tractor rental services have no choice of the service vendor because of lack of adequate information on the service organizations' track record of performance. This leads to some frustrations in service delivery and sometimes legal litigation. A method of ranking tractor service organizations was developed in the form of tractor downtime index (TDTI) parameters which summarized the managerial capability of the vendors using operational time of the tractors. The TDTI programme developed using visual basic.net 2008 with Microsoft access 2007 as back end was used to generate 17 field/ downtime parameters that could be used as impetus for design modifications and management decision making tools. The programme can generate monthly and yearly reports for individual and any number of tractors operating in the organization. Verification showed that, the system has the ability to calculate all the required parameters as soon as the input data was entered within seconds. These could be aggregated and a ranking system of tractor service providers compiled for tractor end users to have preference instead of tractor vendors only deciding on where to work. The TDTI is an innovation, with positive value indicating good management and negative value otherwise, whereby the tractor manager is taken as pivotal in ensuring optimal utilization of the tractor investment. This work has advanced knowledge with seventeen parameters for proper monitoring of tractor fleet organizations as logistic performance index (LPI) is assessing global warehousing ranking of various countries with ten parameters.

Keywords: Customer preference, tractor ignition time segment, tractor downtime index, tractor rental service, visual basic.net

INTRODUCTION

Management Information Systems (MIS) solutions in agriculture have evolved from simple farm recordkeeping systems to large, comprehensive Farm Management Information Systems (FMIS) in response to the need for communication and data Ahmad[1,2],

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transfer between databases, and to meet the requirements of different stakeholders. Boehlje and Eidman (1984) defined FMIS as electronic tools for data collection and processing with the goal of providing information of potential value in making management decisions.

The use of tractor rental services by small-medium scale farmers will continue for the near future since these customers cannot afford owning or maintaining the huge infrastructure required for economic operations of the equipment. Agriculture has entered a new era in which the key to success is access to timely information and elaborate decision making (Fountans et. al., 2015). In complementing the traditional disciplines, innovative technologies have been embraced by agricultural engineers, e.g. computer software engineering, remote sensing, optical recognition, robotics, control engineering, ergonomics, informatics, ecological restoration, ICT, mechatronics, and data management (Rickson et al., 2013).

Farm Management Information Systems (FMIS) in agriculture have evolved from simple farm recordkeeping into sophisticated and complex systems to support production management. In machinery management aspects of agricultural equipment, huge data concerning operational time, repair and maintenance (R&M) among others are usually handled and analysed for proper decision making. Many farm management information systems (FMIS) softwares have been developed in academic institutions and commercialized with applications targeting recordkeeping and operations planning (Blackie, 1976; Thompson, 1976), logistic performance index (LPI) in warehousing and decision support tools (Plant, 1989). The LPI ranking for Malaysia was 32 out of 160 countries in 2016, as against number 25 in 2014 (Karim et al., 2018).

To improve FMIS functionality, a number of software architectures and designs have been introduced with increased level of sophistication, using, for instance, web-based applications or other emerging technologies in agricultural production. Farm management systems implemented with web-based services facilitate collaborative research over the Internet by connecting geographically dispersed teams (Schweik et al., 2005) such as farmers and crop advisors or customizing end-user data for analysis or presentation purposes (Chaudhary et al., 2004). Additionally, web services facilitate the use of standard language for data exchange between systems and services based on Extensible Markup Language (XML) and a service bus as message-oriented middleware for the connection of web services (Murakami et al., 2007).

The advent of precision agriculture (PA), information technologies and electronic communication along with the development of more accurate Global Positioning Systems (GPS) at reasonable costs have enabled farmers to acquire large amounts of data to be used effectively in site-specific crop management (Stafford, 2000; Tozer, 2009). This has created the need to design and develop dedicated FMIS to cope with this increased amount of data generated by applying PA in field production.

While the act of modeling machinery management problems is a routine exercise in organizations with large fleet of tractors, precise solutions to the models are mainly done by managers of such equipment using tedious manual computation methods. These methods have inherent time consumption and prone to error due to human fatigue from a monotonous lengthy tasks (Oladokun et al., 2006).

Many performance indices have been developed in order to describe various phenomena and give guidelines for systems interpretation and possible usage. These include body mass index (BMI), discomfort index relating relative humidity and temperature of a particular region, index of qualitative variation (IQV) in statistics, sensory index on meat quality, wood quality index on quality, strength and machinability of wood (Nicholas, 1984; Bamber and Burley, 1983), manual and animal drawn planters adoption index (Ahmad and Ibrahim, 2015).
Many tractor rental/hiring schemes have failed in many countries such as Nigeria due to lack of modern coordinated management system linking the service providers and customers. Other problems relate to operators working in fields not assigned to and non remittance of charged fees. An organization (www.cotekit.com/tracking) using tracking system installed on tractors is currently monitoring fleet of tractors working in many states of Northern Nigeria. This tracking system provides the following:

- Real time internet tracking
- Manual download of reports (tractor mileage, alarm frequency, and geo-fence)
- Run trip report
- Ignition alert (recording start and stop time of the tractor engine-needed for TDTI parameters)
- History playback of tractor movements.

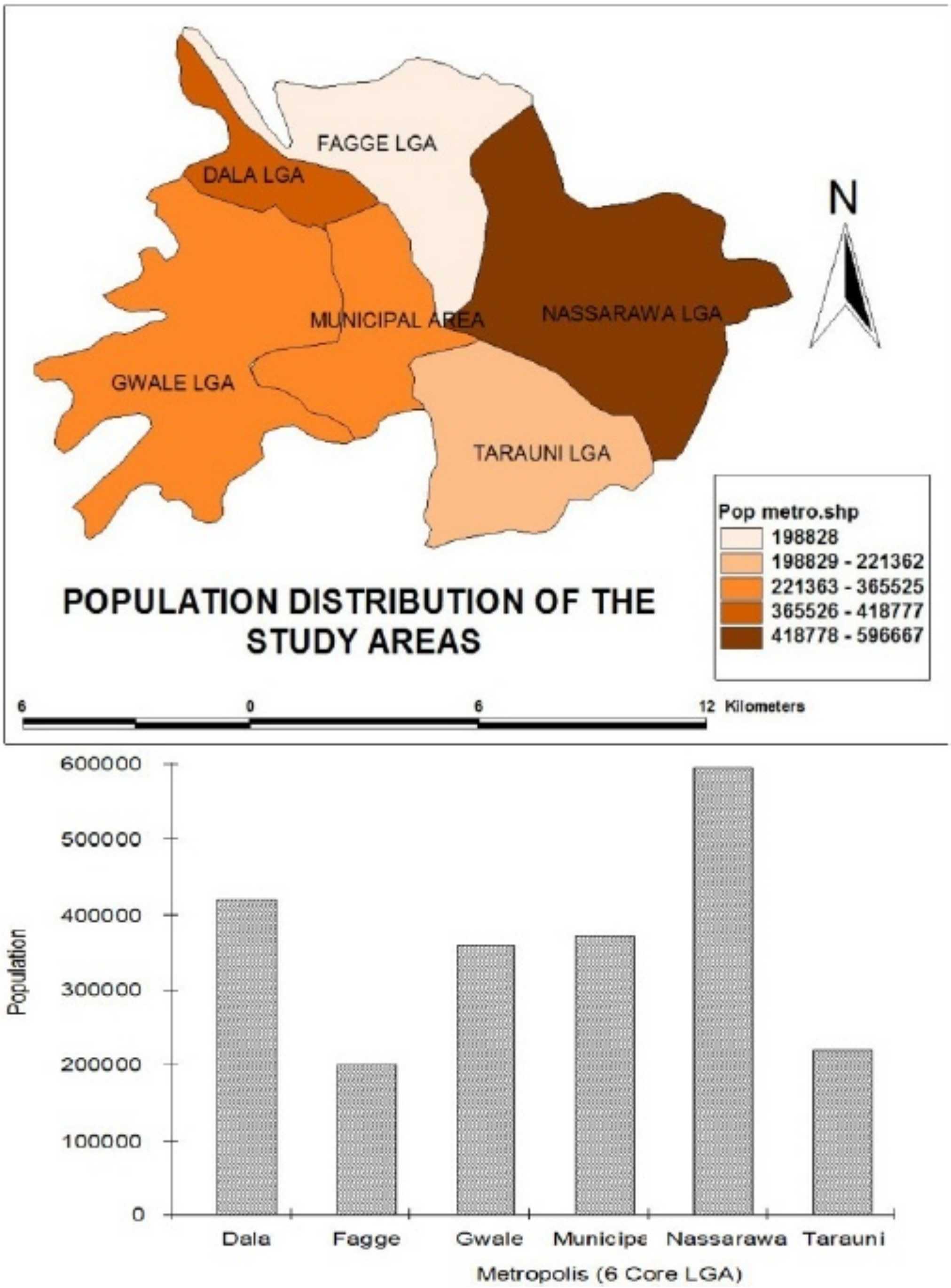
The coordination of tractor rental management processes has been dealt with elsewhere (Shin et al., 2014) whereby a web based Agricultural Machinery Rental Business (AMRB) Management System was developed. That was able to reduce processing time in analyzing and producing reports from 20 days per person to one day per person (Shin et al., 2014).
The above feats need to give the farmer an opportunity to compare and choose from different tractor service providers. Therefore, the objective of this study is to produce a means of categorizing tractor fleet organizations by determination of tractor downtime index and other operational performance parameters of tractor fleet organizations for farmers to select from available vendors and investors to finance for meeting national productivity targets.

MATERIALS AND METHODS

TRACTORS USED FOR THE STUDY

Ten Steyr Ursus tractors belonging to the Refuse Management and Sanitation Board (REMASAB) were monitored for between 250 and 350 hours while collecting and disposing solid municipal wastes (SMW) within Kano metropolitan area of Kano State of Nigeria. The Steyr tractor model 4514 DL, with power rating of 53.7kW and manufactured in Austria, with assembly plant in Bauchi, Nigeria were used in the determination of the TDTI parameters. SMW is generated at a rate of 3085 tonnes per day (Nabegu, 2010) in Kano due to high population and commercial activities in the area (Figure 1) and REMASAB tractors are always busy seven days in a week, as proper management of solid waste is critical to the health and well-being of urban residents (World Bank, 2003), thus requiring proper performance evaluation and monitoring (Agar et al., 2012). It has been reported that transport operation with tractors has the highest percentage (35%) among other operations (Seufert and Bernhard, 2001; Fröba, 1998). Any other farm operation could also be used to generate similar data as also proposed by Agar et al. (2007) in municipal solid waste (MSW) vehicles monitoring using geographical positioning system (GPS). The tractors were monitored everyday within the monitored period and start and stop times of the tractor engine recorded. Stoppages for repairs and maintenance (R&M) were designated and recorded as failure, since the tractor cannot be used again until all necessary R&M are completed.

Figure 1. Map/chart showing Kano Metropolitan area and population of 6 core LGAs (Source: Usman and Ahmed, 2013).



For the purpose of this study, the tractor is assumed only active for any meaningful job execution if the engine is on (Sharma and Jayaswal, 2012). Thus, the tractor fleet manager should always have economically feasible jobs ready to utilize the tractor whenever the engine is running to upset the ownership (fixed) and operating (variable) costs. Therefore the tractor downtime index (TDTI) and other parameters were determined based only on the start and stop time of the tractor engine.

VISUAL BASIC USER INTERFACE

The tractor information, operational time (time segments) and repair and maintenance (R&M) data for the generation of monthly and yearly prediction reports interface is depicted in Figures 2 and 3 respectively based on visual studio 2008. The interface for tractor Number 1 time segments is given in Figure 4.

Figure 2: Visual basic interface for monthly reporting on tractor operations and R&M computations.

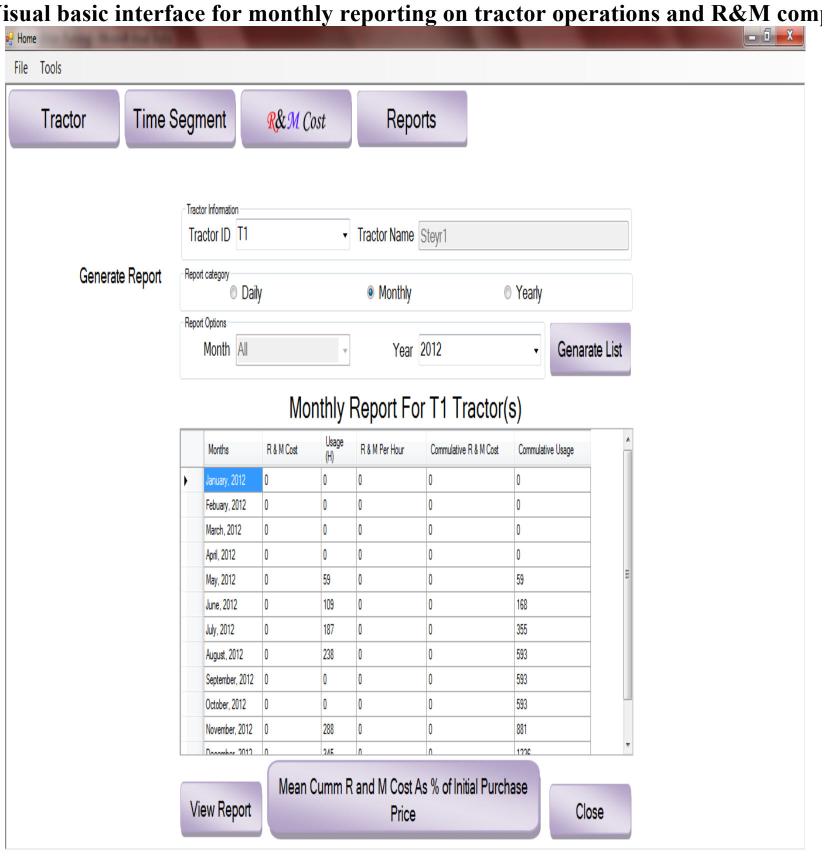
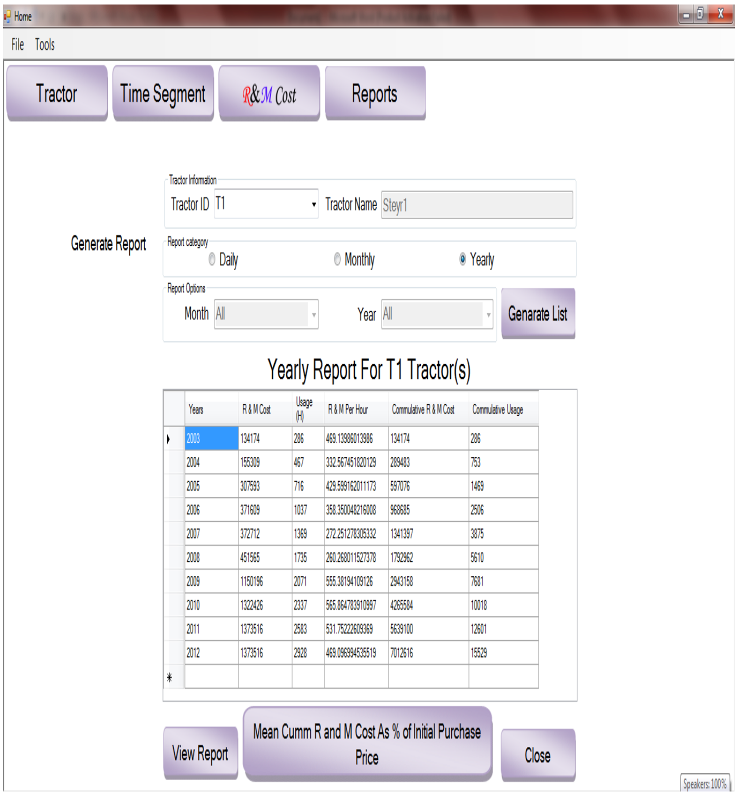


Figure 3. Visual basic interface for annual reporting on tractor operations and R&M computations.



RESULTS AND DISCUSSION

TRACTOR MONITORING DATA

The ten REMASAB tractors monitored hours and failure data are given in Table 1. All the tractors recorded a mean time before failure (MTBF) of more than 80 hours of operation.

Table 1: **REMASAB ten tractors life test (monitoring) results**

Tractor No.	Monitored period (hours)	No. of failures within period	Failure rate (λ)	MTBF
1.	279	3	0.011	91
2.	302	2	0.007	151
3.	321	3	0.009	107
4.	256	3	0.012	85
5.	329	2	0.006	164
6.	320	4	0.015	80
7.	322	2	0.006	161
8.	270	3	0.011	90
9.	318	2	0.063	159
10.	309	2	0.064	154

The tractor downtime index and other 16 parameters visual basic interface for tractor 1 (KN67A30) is given in Fig. 4. The parameter values are given in Table 2. The comparison values for nine parameters of the ten tractors are given in Table 3. The ignition alerts (start and stop time) records of tractors in any organization could also be used in the developed programme (Agar et al., 2007) to generate such parameters for customer preference.

The seventeen parameter values could be aggregated region by region (based on significance as shown in the remark column of Table 2) and published by Agricultural Engineering Associations for policy formulations. This will help customers have preference over which vendors to subscribe to in the AMRB management system (Shin et al., 2014) or cotekit tracking company. The aggregation pattern may differ from region to region as done by industry managers in applying the Deming's 14 rules principle (www.stat.auckland.ac.nz/…mullins/quality/Deming.pdf).

Figure 4. Visual basic programme interface for tractor KN67A30.

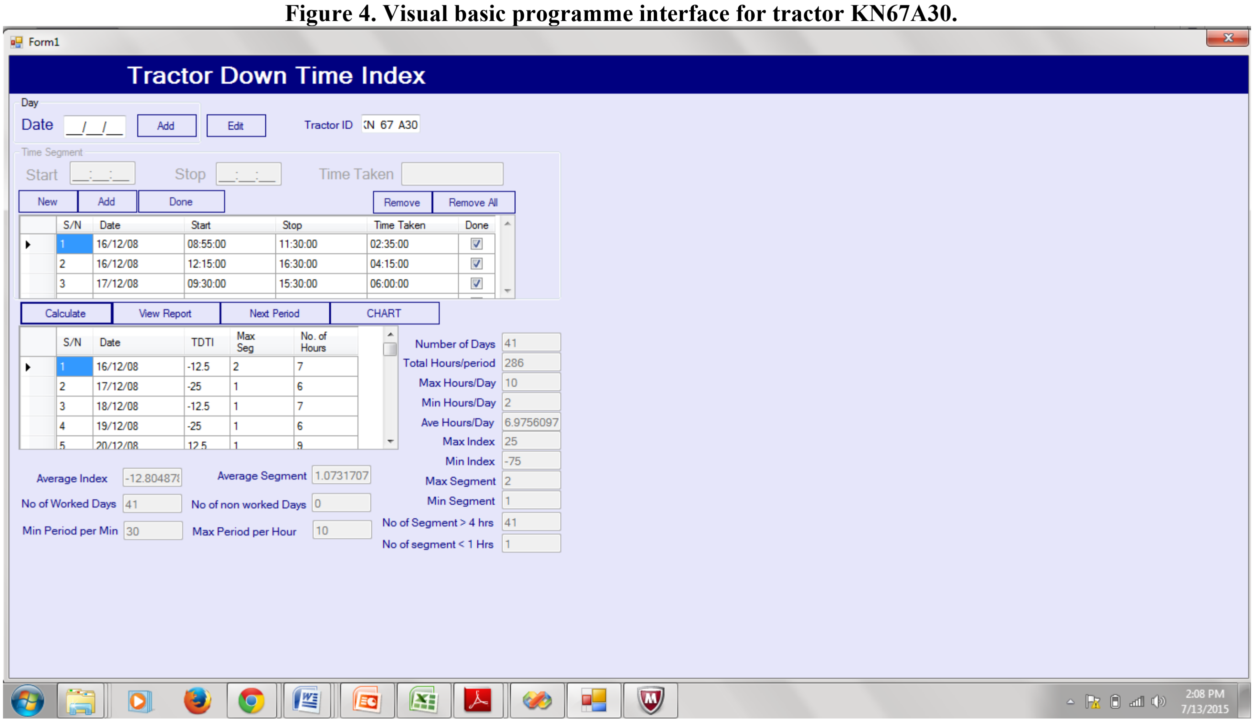


Table 2: Parameter values for tractor number 1 as determined from the Visual Basic programme in Fig. 4.

S/NO.	PARAMETER DESCRIPTION	PARAMETER VALUE	REMARK
1.	No. of days in period (days)	41	Operational charges used with hours of worked to determine revenue
2	No. of days worked (days)	41	
3.	No. of non-work days (days)	0	
4.	Total hours worked (hours)	286	
5.	Max. hours worked/day (hours)	10	
6.	Min. hours worked/day (hours)	2	
7.	Ave. hours/day (hours)	6.98	
8.	Max. TDT Index (%)	25	Indicating level of tractor utilization for productive work
9.	Min. TDT Index (%)	-75	
10.	Ave. TDT Index (%)	-12.8	
11.	Max. No. of Work segments/day	2	Fuel tank, Planting and fertilizing hoppers may be redesigned to avoid stoppages. Frequent stop and go operation causes engine problems due to water contamination in lubricating oil.
12.	Min. No. of Work segments/day	1	
13.	Ave. No. of Work segments/day	1.073	
14.	No. of segments > 4 hours	41	Indication of operator overuse against labour law.
15.	No. of segments < 1 hour	1	Indication of fragmented land tenure system causing idle running between work fields.
16.	Max. time/segment (hours)	10	Overuse of operator
17.	Min. time/segment (minutes)	30	Improper operational arrangement.

Table 3: Comparison of nine parameters value for ten tractors

Field operation/ TDTI parameter	Tractor No.									
	1	2	3	4	5	6	7	8	9	10
Days in period	43	43	44	43	43	44	42	43	43	43
Total hrs monitored	286	284	320	259	325	326	325	269	319	301
Max hrs/day	10	13	10	10	10	15	10	12	12	10
Min. hrs/day	0	0	0	0	0	0	0	0	0	0
Ave. hrs/day	6.7	6.6	7.3	6.0	7.6	7.4	7.7	6.3	7.4	7
Max. index (%)	25	62	25	25	25	88	25	50	50	25
Min index (%)	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100
Ave. index	-16.8	-17.4	-9.1	-24.7	-5.5	-7.4	-3.3	-21.8	-7.3	-12.5
Max. No. of segments	2	2	2	2	2	3	1	2	3	2

An aggregate of these parameters can be used to compare different tractor operators or different tractor fleet organizations. Operators or organizations with highest values could be given awards for increased performance and for others to emulate. The tractor organizations can benefit from this performance ranking in attracting funds for expanding tractor business to address food security and eradicate hunger.

A TDTI of less than zero percent is showing that the tractor unit was used (or engine on) for less than eight hours per day. Farmers can deduce that either the tractor organization is not handling R&M issues appropriately or they do not have enough jobs to use the tractor. In both cases the organization may overcharge farmers in order to off set overhead costs and also not be able to finish jobs on time. Tractor vendors with positive TDTI may charge farmers lower rates since they can spread operating costs over long hours of annual use (Ertugrul et al., 2013). Karim et al., (2018) considered ten parameters to assess the failure factors of warehouse productivity in the Malaysian logistics service sector. They found labour productivity, warehouse utilisation and inventory space utilization as the main factors for lower ranking despite higher trade activity in the year. The highest utilization of tractor power is in transport operation (Seufert and Bernhard, 2001; Fröba, 1998) also used in sea and air ports for hauling goods.

The TDTI and LPI researches among others may enable decision makers to recognise problematic factors when planning their sectoral productivity improvement strategies, which may contribute to fulfilling various governments' targets and empowering their national economies.

The results in Table 2 has clearly shown the achievement of the study objective by indicating possible areas of tractor downtime and means of solving them. It is therefore suggested that tractor fleet managers be conversant with remarks given for each parameter in Table 2.

CONCLUSIONS

The agricultural tractor rental service is vital for the continued survival of small-medium farmers as they cannot afford owning and operating tractors on a cost benefit basis. These groups need to be given the chance of choosing which tractor company to contract their work based on vendors tract records. An appraisal method of tractor performance level between various tractor operators and tractor fleet organizations was presented in this article using the tractor engine start and stop times only. Determination of the tractor downtime index and other parameters was programmed using visual basic.net in visual studio 2008 environment. The programme executes all the parameters in less than one minute once the input data is keyed compared to hours of tedious calculations using manual methods. It also prevents human errors usually encountered in lengthy monotonous tasks. Monitoring of tractors for this study is limited by lack of adequate staff to handle large number of tractors in more than one organization.

RECOMMENDATION

In order for the farmer to have an authentic basis of comparing the tractor rental organizations, the Council for the Regulation of Engineering in Nigeria (COREN) in conjunction with the Nigerian Institution of Agricultural Engineers (NIAE-www.niae.net) should make it mandatory for all tractors to be registered on a dedicated website and daily operational records be uploaded for those interested to use.

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