A STUDY OF FARM TRACTOR RELIABILITY IN KANO STATE OF NIGERIA

BY

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MATRIC No. 2004/21161EA

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERSTATE.

FEBRUARY, 2010.

DECLARATION

I hereby declare that this project work is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information derived from communications, published and unpublished work were duly referenced in the text.

_____________________ _____________________

GALI SOLOMON DATE.

CERTIFICATION

This project entitled "A Study of Farm Tractor Reliability in Kano State of Nigeria" by Gali Solomon, meets the regulations governing the award of the degree of Bachelor of Engineering (B.ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project is dedicated to my ever supportive parents Mr & Mrs J.E Gali for all their love and support throughout my stay in the university.

ACKNOWLEDGEMENTS

I would love to express my profound gratitude to God Almighty for seeing me through this phase of my life dream and pursuit. Without him, life would have been a misery. To my project supervisor, DR B. A. ALABADAN., may God bless and reward you for your guidance all through this research work for the constructive criticism geared towards bringing out this work.

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I also wish to say a very big thanks to my lecturers in Agricultural & Bio-resource Engineering, especially to Engineer DAUDA SOLOMON. For being the guiding light all through my educational pursuits. To my friends and colleagues, MICHEAL, IDIM, ODION, CHIJOKE, SOLOMON, UMAR and to all those people (my memory failed to remember) that have contributed in one way or the other to my success, may your kind deeds be rewarded by the Almighty God, in Jesus name.

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ABSTRACT

The study of field reliability of tractor or machinery is executed. A field survey was conducted to assess the repair and maintenance facilities and reliability functions from the breakdown records of available tractors. The tractors evaluated are, FIAT, Massey Fergusson, Steyr and Ford. The workshop facilities for enhancing tractor reliability consist of technical staff and tools/equipment. The workshop staff consists of engineers, technicians and craftsmen/apprentices and in the ratio 1:2:6 respectively. The commonly owned tools are the basic hand tools. Comparison of the reliabilities of the various tractors revealed that the steering, traction and electrical systems are more prone to failure than the engine, cooling, transmission, fuel and hydraulic systems. The Massey Fergusson and FIAT tractors proved to be more reliable tractors in the state. Because their systems adapts more to the temperature and soil of that region.

CHAPTER ONE

1.0. INTRODUCTION

1.1. Background of the Study

The major goal to be achieved in any farm is the reliability, before repairs and other secondary features come into play. To attain this, the materials used or implement used must be considered. However farm tractor is a major element of farm mechanization in Nigeria. It's high efficiency and effectiveness has made it very favourable for many field operations. Timeliness in farm operations is an important factor for the success of agricultural operation Also the maintenance of the tractor has become very imperative due to the susceptibility and high management skill of the tractor to break down.

The failure of farm tractor especially during the busiest part of the season delay even at the time in which much work are not to be done which is as a result of some complications which causes losses and inefficient labour utilization and minimum optimization?

Failure can be defined or is been referred to as any condition which prevent operation of a machine or which causes or results in a level of performance below expectation. The

failure rate of a population of item for a period of time Ta to Tb is the number of items which fail per unit time in that period expressed as a fraction of the number of non-failed items at time Ta. Machine failure can be categorized into (Amjab and Chaudhary, 1988).

i) Early life failure

ii) Random failure

iii) Wear-out

Reliability is defined as probability that the equipment or system will complete a specific task under specified condition for stated period of time (Amjab and Chaudhary 1988). Hence reliability is a mathematical expression of the likelihood of satisfactory operations. In reliability, the reciprocal of failure rate is the mean time between failures [MBTF] (Wingate-Hill, 1981). Also Lewis in 1987 asserted that reliability consideration appears throughout the entire agenda or entire cycle of a system. He claimed that data collections on farm tractor failure are particularly invaluable because they are likely to provide the only estimate of reliability that incorporates the loading, environmental effects and imperfect maintenance found in practice.

As manual labour on the farm is being replaced with more and more capital in the form of farm machineries, the reliability of the tractor now assumes a greater importance and values to our economy. Neither the less looking into a deeper insight of the failures and their prevention is to be achieved by weighing its advantages to its disadvantages of the reliability characteristics of the system or parts that make up the tractor or as a whole.

1.2. Need for The Study

For the meaningful development to take place, provision of adequate tractors must be a prime characteristics or consideration, but the Nigerian economy has been suffering from setback which is no small way has been affecting the farm industry. As a result of this, any means by which improvement can be made or alternative achieved to reduce the cost of raising a farm will be a welcome development to the populace.

Looking at the importance of timeliness of operation in obtaining high yields, machinery breakdown especially at the busy period such as sowing and harvesting can lead to large losses of revenue quite apart from the cost of repairing the equipment, with these if estimates could be made of when equipment is likely to fail, this would assist in planning machinery purchases and reduce cost and spare part inventories.

However, increasing awareness of farm tractor as the best substitute for animal traction and hand implement on large scale farm has been the basis for the present work. The present work specially examines the field capacity performance of farm tractor in field cultivation of large scale farmer plot under previously cultivated land condition.

Several studies on farm machinery performance have been carried out elsewhere, Braide (1984) this includes the work of Barnes (1960). In which machine performance was divided into four categories namlely;

1. Functional
2. Mechanical
3. Capacitive
4. Economic

The capacity performance described how a machine completes a job within allowable constraints of time. The capacity performance of agricultural machine is measured in terms of field area covered per unit time. This capacity measure, termed effective field capacity can be evaluated with the following equation (ASAE 1979)

$$C = Swe/10 \qquad (1)$$

Where "c" is effective field capacity (ha/hr)

"S" is field speed (km/hr)

"w" is machine width (m)

"e" Field efficiency, decimal

In this equation, field efficiency is the ratio of effective field capacity to theory or theoretical field capacity and it includes the effect of time coast in the field and failure to utilize the full width of the machine. (Archer, 1963) have shown that turning idle travel and machine adjustment time tend to be proportional to operating time, while other delay like stopping to unload harvested crop and checking the full performance of the tractor tend to be proportional to area.

1.3. Problem Statement

The low investing of farmers to buy tractors and implements are some of the major problem that Nigeria agriculture is facing today. more power in place of tractor is essential in carrying out operations effectively at the right level and for changing the attitudes and uplifting of the social status and dignity of those who labour in agriculture. also the use of farm tractor on small scale farm is quite expensive and uneconomical. panin and Ellis (1992) reports that it cost more than twice as much to prepare a hectare of land using tractor as it does using draft animal power. That is why most people in the Northern part of Nigeria still prefer the use of animal draft power to tractors in their farm except that the fact that the use of tractor is much more effective and efficient.

1.4. Aims/ objectives

1) This research is aimed at determining the reliability of farm tractor in Kano state of Nigeria today and its failures in this region.
2) To collate data on maintenance, repair facilities and failures of farm tractors in Kano state.

1.5 Scope of the study

The scope of this research is the study of farm tractor reliability with particular reference to selected workshops. farms. ministries and manufacturing or distribution store of Kano State.

This would be achieved by administering structured questionnaire, personal visit to repair stations and farms, also interaction with information repositories. The reliability or strength of various tractors will be compared with its failure rate.

1.6 Significance of the study

The significance of the study includes the following:

1) It is important because it is a criterion for the award of Bachelor of Technology (B-Tech) in Agriculture and Bio-resource Engineering.

2) This work is reviewed to help readers have better understanding of the role of reliability of farm tractor in our farms today

3) It is important to the operators because it will enable them understand the various repairs and maintenance requirement that are necessary to make the farm tractor work efficiently.

4) This work will serve as a knowledge builder for future researchers of the repairs and also suggest ways of preventing the tractor from activities that will endanger it working-life.

1.7 Definition of terms

1) **Reliability:** is defined as the probability that the equipment or system will complete a specific task under specified condition for stated period of time.

2) **Failure:** can be defined or is been referred to as any condition which prevents the operation of a machine or which causes or results in a level of performance below expectation

3) **Maintenance:** is a set of compulsory operations specified in relevant documents which are carried out to keep the machine available throughout its service life.

4) **Repair:** is a set of operations intended to maintain and restore operability and to renew the overhaul period of a machine or is a set of operation for elimination of defeats and ensuring safe operation between overhaul periods.

5) **Tractor:** is a self propelled machine used to transmit power in pulling mobile machines, operating the mechanism of mobile or stationary machine by the use of belt and pulley or P T O.

6) **Innovation:** is anything like products, services or idea that is perceived be new.

CHAPTER TWO

2.0 LITERATURE REVIEW

Farm tractor is a collection of different parts for agricultural operation used in combination or collaboration with other implements or devices for applying power on the farms. These implement includes, ploughs, harrows and cultivators e.g. the disc plough, disc harrows, ground driven, rotary harrow, spike harrow, rigid time cultivator, spring time cultivator, rotary cultivator etc. which are used for the management of public and private projects and are of different types, sizes and shapes (Beppler and Hummeida, 1985).

2.1.0 Definition

Farm tractor can easily be defined as a self propelled machine that is used to transmit power in pulling mobile machine, operating the mechanism of mobile or stationary machine by the use of belt and pulley or P.T.O. thus tractor has been referred to as a "Central Power Station" in that it provides power for many activities both mobile and stationary and some of the functions of the power outlet from the tractor are as follows. (Hollenback,1977).

- Trailer plough provides a pull from the rear of the tractor for drawbar machines.
- Bulldozer blade provides a push at the point of the tractor for equipment.
- Baler and Mowers connects the rotary drive to the power take off (P.T.O)
- To provide hydraulic power to 3 point-linkage or remote cylinder
- Thresher and pump provides power to a belt pulley
- Trolley provides a means of transportation

2.1.1 Tractor Classification

Tractors can be classified as follows;

a) According to the method of securing traction and self propulsion;

1) Wheel type,

- Tricycle which could be single or double front wheel.
- 4 wheel which could be single or double rear wheel drive.
- Standard or high clearance front wheel.

2) Tract Type.

b) Classification of Tractors According to Utility,

- General purpose or utility tractors.
- Row crop tractors.
- Orchard tractors.
- Lawn or Garden tractors.
- Industrial tractors.

c) Classification According to Value of Power or Power Rating ,

These types of classification we have category 0 to category 5 and its categories depends on the power to which it performs its operation or work. Examples of tractor that depends on value of power or power ratings are

- **Category 0:** Tractors with power between 0kw– 15kw used for horticulture.
- **Category 1:** Tractors with power between 15kw – 35kw used in our small farms
- **Category 2:** Tractors with power between 35kw – 70kw used as general purpose tractor
- **Category 3:** Tractors with power between 70kw – 110kw used in large farm operations.
- **Category 4:** Tractor with power more than 110kw. They are basically heavy duty tractors with mainly special features. These tractors are specifically used for heavy work such as road constructions, dam construction, over head bridge constructions etc.

2.1.2 Manufacturers/Makers of Tractor

There are various manufacturers or makes of tractors. These are some listed below;

1) John Deer
2) Foton
3) Fiat
4) Ford
5) Massey Fergusson (MF)
6) Steyr

2.1.3 Functions of Different Components of a Tractor

- **Fuel Gauge**: - This part indicates the level of fuel in the tank, when it reaches the red zone it means refill is required.
- **Main Switch**: - This allows electric current flow in the electric circuit when it's switched on.
- **Throttle Lever**: - This lever releases compression pressure from the combustion chamber of the engine and helps to start engine.
- **Battery Charging Indicator**: - This indicates the charge and discharge of battery.
- **Hour Meter**:- This meter indicates the engine hour or mile age and engine revolution per minute.
- **Water Temperature Gauge**: - Indicates the temperature oil pressure in the system.
- **Belt Pulley**: - Tractor is mostly provided with belt pulley. The function is to transmit power from tractor to other stationary machinery by a belt.
- **Hand Throttle Control Lever**: - It is used to select engine speed setting. Moving the lever down increases speed and up turns engine idle.

- **Differential Lock Pedal**: The differential lock mechanically locks the rear axles together so that both wheels pull together.
- **Service Brake Pedal**: This is mechanically operated, the two pedals can be used independently to aid turning in confined spaces or must be latched together to provide a master pedal for normal braking.
- **Clutch Pedal**: This helps travel two stages. The initial movement equals the extent of which is made apparent by a distinct increase in pedal pressure disengages the drive to the wheels. Added downward movement disconnects the drive to the hydraulic lift pump and power takes off shaft.
- **Parking Brake Lever**: This is use as a lock for the tractor rear wheels for parking and for stationary operation. To engage the brake, press the trot brake pedal down and pull the hand lever up. To release the parking brake, press the foot brake pedals down, then press the button on the end of the lever and push the lever down.
- **Operator's Seat**: Incorporates anchoring points for seat belt and also can be adjusted for height, for its distance from the steering wheel and for the seat suspension stiffness.
- **Starter Switch**: The switch has four positions. These positions, turning the key clockwise are

  Off

  Auxiliary: - this position permits electrical services to be switched on without the engine running.

  Auxiliary + heat – Energizes the flame plug coil for cold weather starting.

  Auxiliary + Heat + Start – Supplies power to the starter motor and maintains power supply to the flame plug coil.

2.1.4 Uses of Tractor

Some of the functions performed by these tractors or a tractor are

- To pull mobile or stationary machine through the drawbar or 3point linkage system
- To operate the mechanism of mobile and stationary machine through the P.T.O. e.g. Seed drill, threshers.
- Used to raise, hold, lower, control the working depth of mounted implement through the hydraulic system.
- Use for tillage operation (turning or pulverization of soil).
- Use to power other machines or machineries.
    - o The tractor hydraulic system can also be used for external service such as tipping trailer and operating drawn implement. The power required to perform operation listed above are called drawbar power, P.T.O. and hydraulic power respectively.

2.2.0 The Reliability of a farm tractor

Reliability is the property of an object to retain in time, within the predetermining limits, all the parameters ensuring the performance of the required functions in the preset services conditions. The failure of even one responsible component of a sophisticated system, more often than not disrupts the operation of the system as a whole. Insufficient reliability of industrial equipment results in huge expenditure on repairs, downtime, interrupted supply of power, water, fuel, gas, transportation facilities, and unfulfilled plans even in emergencies involving great economic losses, destruction of large installations and lost human lives.

The theory of reliability is a comprehensive science including such section as the mathematical theory of reliability, reliability by individual physical criteria of failures ("physics of failures"), analysis and prediction of reliability of reliability, measures of enhancing reliability monitoring (testing, statistical monitoring, management of inspection) and technical diagnosis, the restoration theory, reliability economic.(chukwu,2009)

The theory of reliability deals with the following generalized objects.

- **Articles:** a unit product manufactured by a given enterprise, production shop, e g a bearing, transmission belt, machine tool, motor vehicle.
- **Component:** the simplest element of an article for the purpose of a given treatise, which may include a plurality of parts in reliability problems
- **System:** The sum total of interacting components intended for independent performance of desired functions.

The main concepts of reliability are standardized. Reliability is characterized by the Following main states and events:

- **Operability:** is the state of an article capable of performing normally its required functions. Operability is unaffected by impairments not influencing directly the performance characteristics, such as peeling paint.
- **Fitness:** (understood as complete fitness) is the state of an article meeting both main and auxiliary requirements. A fit article is always operable
- **Malfunction:** is the state of an article failing to meet at least one requirement of the applicable technical documents and specifications. There are malfunctions not resulting in failures and malfunctions and their combinations resulting in failures.
- **Failure:** is an event arising from either complete or incomplete loss of operability. Failures are classified into:

1) Function Failure: when the element or object in question ceases to perform its functions (e g. broken teeth in gear).

2) Parameter Failure: when some parameters of an object very beyond the acceptable limit (e g. loss of precision by machine tools).

2.2.1 Properties of articles in the light of reliability problems.

Reliability of articles is defined by the failure free performance, durability, repairability and storage ability. Thus, reliability is characterized by the properties that makes themselves seen in operation, and enable one to assess how the articles meets the expectations of its manufacturers and users.(Chukwu, 2009)

- **Failure-free performance** (which is reliability in the narrow sense of the word) is the property of continuously maintaining operability over a predetermined services period or working time. This property is of particular importance for machine whose failure to perform involves the hazard to human lives, or else interrupted operation of large numbers of other machine, halted automated production, e t c.
- **Durability**: is the property of an article to retain its operability over prolonged periods up to its limiting state with proper maintenance repair routines. The limiting state of an article sets in when it either cannot be operated any further altogether, or can be operated with severely endangered efficiency or safety.
- **Storageability**: is the property of an object to maintain its indexes of failure-free performance, durability, and repair ability after storage and shipment. This property is of particular importance in the case of instrumentation. For instance, according to the United State source, during the World War II some 50% of radio and electronic hardware for military purposes and spare parts to it failed in the course of storage.(chukwu,2009)

2.2.2 Indexes of reliability

Indexes of reliability can be divided into indexes of failure free performance, durability, repairability and storage.(chukwu,2009)

- **Indexes of failure free performance:** The probability of free performance is the probability of no failure occurring within the predetermined operating time. Mean-time-to-failure [MTTF] and it is the mathematical expectation of the operating time before the failure of an unrestorable article, which can be measured in terms of either time or the amount of work performed by the article

  Mean-time-between failure: is the ratio of the operating time of a restorable article to the expectation of the number of failures during this time

- **Indexes of Durability:** Useful life (or simply life) is the operating time of an object between the commencing of its operation or the resuming of its operation after repairs and its limiting states. The life can be expressed in units of operating time (usually, work hours), distance (in kilometers) or output.

  Service life: is the calendar operating time to the ultimate state usually expressed in Years. Useful life is used as the criterion of durability for machine elements.

- **Repairability and storageability indexes:** Mean time of restoration of operability. Probability of restoration of operability within given time.

Storageability period (shelf life): average and gamma percent. Gamma percent indexes are those which are either shown or exceeded on the average by a predetermined number (gamma percent of articles of a given type)

Utilization ratio: is the ratio of the expectation to the time of operability over a certain period to the sum of expectations of the time of operability and all the downtime for the repairs and maintenance.

2.2.3 Laws of probability

1) **The Product rule**:

   If A and B are two events of interest and Pa and Pb the respective probability of the m occurring, then if A and B are independent, the probability A and B occur

   P (A and B occurrence) = Pa * Pb

2) **Additional rule**:

   If A, B, Pa, Pb are defined as above and A and B are mutually exclusive then P (A or B occurrence) =Pa + Pb.

   If A1, A2,……….An are mutually exclusive events, and they describe all possible outcome in a particular situation then P1+P2………Pn =1

   In particular, if there are only two possible outcomes in a particular situation call them success and failure, then p (success) =1-P (failure).

An important design parameter which deals with minimization of repair time and which is often affected by the skills of the operator is machinery maintainability (Oni 1987). Many of the companies in Nigeria keeps logbook for their repair and maintenance. The failures of a farm tractor are engine, fuel, cooling, transmission, steering, hydraulics and traction (Adigun 1987). The reliability method to combine in both pre and post production operation was applied by Hollen Back (1977) prediction in terms of varying farm conditions under a particular machine are designed to work. The exponential model for analysis of reliability data was given by Wingate Hill and it was assumed that the failure rate of a machine is constant over the entire life of the equipment.

$R(t) = \exp -(\lambda t)$ (1)

Where exp = base of Naperian logarithm

λ = failure rate (per month)

t = time between successive failure (month)

However, some disadvantages were given on the use of exponential modal by Leitch (1988) they are

- It assumes that the equipment does not get older (i.e. the probability of failure in the interval from time.
- With only one parameter (e.g.) to vary the data is not always a good fit to the model "t" until (t + x) depends only on x, the length of the interval and not on "t" the age of the equipment. In addition Wingate Hill (1981) disclosed that reliability data may not be exponentially distributed, As such recommended the use of versatile three parameter Weibull failure model in conjunction with median ranking for greater accuracy. Amjab and Chaudhary (1988) used Weibull failure model to apply reliability theory to farm machinery such as tractors, combines etc. the Weibull cumulative density function (Cdf) or failure function was given as

$$F(t) = 1 - \exp - [(t - y)/\lambda]^{\beta} \quad (2)$$

Where exp = base of Naperian logarithm

λ = scale parameter (months)

β = shape parameter or Weibull slope (ratio)

y = location parameter or lower bound of life (months)

t = time taken between successive failure (month)

They disclosed that in the case of farm machinery. The first failure can be expected as soon as the machine is placed in service, so therefore the lower bound of the life or location parameter (y) is zero. This y = 0 and the Weibull cumulative density function becomes.

$$F(t) = 1 - \exp - [t/\lambda]^{\beta} \quad (3)$$

The reliability function R (t) was therefore given as

$$R(t) = 1 - F(t) \quad (4)$$

$R(t) = xp - [t/\lambda]^{\beta}$ (5)

Therefore the time between failures is

$t = \lambda\,[-Ln\,R\,(t)]^{1/\beta}$ (6)

For the estimation of α and β (Weibull parameters) Simple regression analysis was used. This method is based on the fact that the reliability function of Weibull distribution can be transformed into a linear function of Ln t by means of double logarithmic transformation. Taking the natural logarithm twice of both sides of equation (3) gives

$$Ln\,[Ln\,\frac{1}{1 - F(t)}] = \beta\,\{Ln\,t - Ln\,\alpha\} \quad (7)$$

$$Ln\,t = 1/\beta\,[Ln\,(Ln\,\frac{1}{1 - F(t)})] + Ln\,\alpha \quad (8)$$

This is the form $y = mx + c$

Where $M = 1/\beta$ (Slope of linear equation)

$C = Ln\,\alpha$ (Intercept of liner equation)

It was then claimed that Weilbull model provide considerable flexibility in describing failure distribution. That is upon setting $\beta = 1$, equation (3) becomes exponential distribution with a delay (which can be thought at as a guarantee period with in which no failure can occur or a minimum life)

Thus the assumption of a constant failure rate (exponential model) is also included as a special case in this Weibull failure model. Both Wingate Hill (1981) and Amjab and Chaudhary (1988) pointed out that reliability of a machine is a product of the individual components reliability, if the engine transmission, hydraulics and steering have reliabilities of 0.65, 0.75, 0.85, 0.95 respectively, then the reliability of the farm tractor will be 0.65 x 0.75 x 0.85 x 0.95 = 0.39. However, reliability study on farm tractor is supposed to be probability that the equipment or system will complete a special goal under specified condition for a length or period of time (i.e. reliability studies on farm tractor when it is been used) but with the above studies on reliability, experiment does not really satisfy this condition to the full, so therefore statistical analysis approach has to be applied on farm tractor reliability also through reliability study would be essential for the study of farm tractor which will help in making special level of quality for the farm tractor that can be reliable trusted and appropriate for the purpose.

2.3.0 Tractor Failure and Equipment Maintenance

Tractors and internal combustion engines in general are made up of different components, each of these components have specific functions to perform which contribute to the generation of power. As a result, these components or individual parts are bound to malfunction occasionally. If the malfunctionality of these components are not checked and normalized on time, they will fail individually and may further lead to the breakdown of the entire system of the internal combustion engine. In order to avoid complete failure of the tractor and other engines in the farm, it is very important to maintain them and their associated equipments at the appropriate times. Some of these components of internal combustion engine of the tractor are engine cylinder, piston, connecting rod, crankshaft, flywheel, cylinder head, inlet and exhaust, camshaft, crankcase and engine block.(Gbabo, 2009)

The Agricultural tractor is precision machinery which a large amount of money is invested on. It is capable of working long hours under adverse conditions if certain precautions are taken. These precautions are often referred to as "preventive maintenance". The effective use of farm tractor is largely dependent on the quality of maintenance and repair. With a high-level mechanization of agriculture it is impossible to keep machine available by routine repair alone. To ensure highly productive work and prevent premature wear and failure, a system of scheduled preventive maintenance and repair is established for the forming machinery. Maintenance and repair operations are carried out after a certain period of time, i e scheduled. Shift and periodic compulsory inspection of tractor condition, lubrication and elimination of defeats prevent failures; therefore the system is called preventive. (Chukwu, 2009)

This preventive maintenance includes servicing, adjusting, operating and repairing. It means caring for a tractor so that unnecessary wear is prevented. As a result, the time lost due to breakdown is held to a minimum. The useful life of the tractor is fully utilized

The key man in preventive maintenance is the tractor operator, he is familiar with the Tractor. He has studied the operator's manual; he understands how to correctly operate the controls and watches the oil pressure, temperature gauge and charge indicator. He sees the tractor is serviced regularly with the right fuel, oil, grease and coolant. He is alert for any sound or performance that might indicate faulty functioning of any part. (Chukwu, 2009)

2.3.1 Maintenance of a tractor

Maintenance is a set of compulsory operations specified in the relevant documents which are carried out to keep the machine available throughout its service life. Maintenance round includes operations to be performed at shipment, during run- in, operation, and storage. These are cleaning, washing, trouble shooting, tightening of bolted joints, lubrication, adjustments and replacement of high mortality parts. Periodic routine maintenance service may differ in the contents of its operation. Therefore, maintenance rounds are numbered in the increasing order, for instance, shift No. 1 maintenance, No. 2 maintenance, etc. Shift maintenance is carried out for all the tractors at the end of the shift. Seasonal maintenance is accomplished to prepare the tractor or machines for the next operation period. (chukwu, 2009)

2.3.2 Daily Preventive Maintenance

The most important part of preventive maintenance is the daily preventive is the daily maintenance carried out on the tractor each day. This includes the following checks.

- Engine oil level
- Battery electrolyte level
- Cooling system
- Air cleaner
- Gear differential transmission and/or hydraulic oil
- Tyre pressure
- Greasing points
- Bolts nuts and pins
- Fuel system
- Visual check of tractor in general
- During operation occasionally
    - Check oil pressure gauge or light
    - Check ammeter
    - Check temperature gauge
    - Observe fuel level
    - Listen for unusual sounds
    - Watch for leaks of fuel, oil or water.

2.3.3 How to maintain a tractor

Correctly maintaining a tractor will add years to its useful life. However, there are some basic differences in maintaining a tractor from other vehicles also, since there are many different types and brands of tractors, there is no comprehensive maintenance guide that universally applicable to all types of tractors, but the following steps would help.

- **Study your user or owner manual:** the manufacturer has specific instructions for basic care of your equipment and they have the expertise to give you the best advice on how to do it. If you don't have a manual get one, these are some item you should find out owner's manual:

  Maintenance schedule: This will tell you the internal for routine maintenance, including chassis lubrication engine, transmission and hydraulic oil change, filter change and other maintenance items.

  Specifications: This should be a table telling you the type of fluids for the transmission, hydraulic system, brake and engine coolant as well as their capacities, the inflation, bolt torques and other information may be found under specification or other section of the manual.

  Location of lubricant points (grease fittings), fluids check dipsticks or sight glasses and instructions on cleaning air and fuel filter.

  Basic operating instruction and other information specific to your tractor.

- **Obtain tools:** Tractor maintenance requires numerous wrenches and other tools in large sizes than for automobile maintenance so plan to buy or borrow the tools you need.

- **Protect the tractor from elements:** Because smaller farm or garden tractors do not have a cabin to protect the seat instrument panel and metal components it is good idea to store it in a shed or garage if you can't do this, keep rain out of the exhaust system and cover the seat and instrument

- **Check fluid regularly:** Tractor usage is measured in hours, not miles, so the amount of use may be deceptive and leaking components may cause failure of expensive parts. Refer to the owner manual to determine how each fluid is checked:

  Check the engine oil

  Check the transmission fluid

  Check the hydraulic oil

  Check the coolant in the radiator

  Check the battery electrolytes

- Keep the brake linkages lubricated, and make sure the brakes are adjusted equally. Many tractors have mechanical brakes, operated by a linkage and cam system instead of a master in the gear boxes. Often, the hydraulic system and the transaxle share fluid, and using the wrong fluid can cause serious damage.
- **Check the radiator screen.** Tractors are often operated in conditions where debris may accumulate on the radiator, so they usually have a front screen or grill to prevent plant matter, insects, or pollen from clogging the radiator
- **Check the filters regularly.** Most systems on tractors are equipped with filters to protect against dirt, water, or other contaminants that could cause failure of the components.
  - Check the fuel filter for accumulated water. Most diesel engines have a water separating filter, since diesel fuel attracts moisture.
  - Check the air filter often. Tractors are often operated in very dusty conditions, and in some cases, the filters must be cleaned daily or weekly. Clean the air

filter with a shop vacuum or with compressed air, never by washing it. Replace the air filter when it cannot be cleaned satisfactorily, or if the filter is damaged.

- **Lubricate your tractor**. Tractors have many more moving parts that require greasing than do automobiles. If you see a part that moves, look for a grease fitting, and grease it. Use a grease cartridge pressure gun, clean the fitting, attach the hose, and pump grease until the associated seal begins to expand, or grease is seen oozing out of the attachment you are lubricating. Look for grease fittings on steering components, brake and clutch linkages, and three-point hitch pivot points.

  Older tractors require specific lubricants
- **Keep your tractor clean** This will help you to spot damaged components and leaks, and see if trash or debris is causing problem

2.4.0 Repairs of a tractor

Repair is a set of operation intended to maintain and restore operateability and to renew the overhaul periods of a machine or is a set of operation for eliminating defeats and ensuring safe operation between overhaul periods(overhaul means examination for the purpose of repairing, cleaning) etc. The machines are subject to periodic repairs after certain periods of time (or accumulated amount of work performed). Repair operations include disassembly, washing trouble – shooting, restoration of parts, assembly, adjustment, run-in and painting.

In the course of repair worn parts and assemblies are restored or replaced. Depending on the condition of the main units, wear of parts and labour input required to restore the operate ability and renew the overhaul periods. Repair is classified into routine and major repairs.

- **Routine repair**: This is intended to ensure or restore operate ability and consists in replacement or restoration of individual parts.

- **Major repair**: This is intended to restore operate ability and renew the overhaul period (close to the original one) with replacing or restoring any components including the basic ones. The overhaul period close to the original one is established in the relevant technical documents. The basic component is a major part of the tractor intended to carry other components.

2.4.1 Intervals of maintenance and repair for farm machinery

Equipment/Machine	Intervals hectares maintenance	Routine repair
Stubble cleaners	–	200
Cultivators	–	350
Seeders	–	200
Mowers	–	300
Silage combines	60	150
Grain combines	150	400

Source: Chukwu, 2009

2.5.0 Engine System and their maintenance.

The I C E of a tractor is provided with different system to govern each function of the major systems is the following;

1) Fuel system
2) Ignition and electrical system
3) Cooling system
4) Lubricating system
5) Transmission system

6) Hydraulic system

7) Valve system

2.5.1 Fuel system

The fuel system is the combination of mechanisms that ensures the delivery of fuel in the required proportion to the combustion chamber of the I C E engine of the tractor in order for it (fuel) to be converted to mechanical energy. Two systems are used in delivering fuel to the engine; they are petrol system, diesel system. And some of the components of fuel system are; fuel storage, Air supply system, Air fuel mixture regulatory device, fuel filters, fuel pump. (Gbabo, 2009)

2.5.2 Maintenance requirement of a Fuel system.

S/No	Problems	Causes	Remedy/ Repairs
1	Engine does not start	No fuel or improper fuel in the tank	Fill tank with fuel. Drain fuel case of improper fuel and replace with proper fuel.
		Water or dirt in fuel or dirty filter	Drain water from tank Replace or clean dirty filter
		Low cracking speed from low charge of battery.	Charge or replace battery
2	Engine start but does not run	Dirt or air restriction in fuel filter or air cleaner or	Check fuel system and bleed or clean or replace

	properly	clogged filter	filter and screens.
3	Engine detonates [gasoline]	wrong fuel	Use proper octane fuel.
4	Engine back fires	Clear mixture of fuel in carburetor.	Adjust carburetor.
5	Engine uses too much fuel	clogged or dirty air cleaner	Clean or replace air cleaner if too dirty.
		improper type of fuel	Drain fuel tank and fill with recommended one.
		Engine overload	Reduce load or use lower gear
		Incorrect carburetor adjustment	Adjust carburetor properly
6	Smoky exhaust	Improper type of fuel	Drain fuel tank and fill with recommended fuel.

Source: Gbabo, 2009

2.5.3 The Electrical and Ignition System.

The electrical and ignition system of a tractor uses the principle that when an electric current is forced to flow through air gap, a spark is created since air is a very poor conductor a considerably high voltage of 10- 15kV is necessary to make the current pass through even a very small amount of air. This spark can be created in two ways; battery and magneto systems. Some of the components of a battery system are; battery, coil, contact breaker, condenser, spark plugs, switch, distributor. (Gbabo, 2009)

2.5.4 Maintenance Requirement of an Electrical or Ignition system.

S/No	Problems	Causes	Remedy/ Repairs
1	Engine hard to start or does not start.	Low cracking speed	Charge or replace battery or service starter
		Improper timing	
		Defective coil or condenser	Check distributor Replace coil or condenser
		Pitted or burnt distributor point	Clean or replace points
		Cracked distributor cap or eroded rotor	Replace cap or rotor
		Loose distributor wire or installation of wire in wrong order	Push wire into sockets, install wires in correct firing order
2	Engine knocks	Improper distributor timing	Time distributor.
	Engine over heat	Incorrect engine timing.	Time distributor(spark ignition) Time injection pump(diesel engine)
2	Lack of power	Distributor point burnt	Replace point and condenser
	Noisy generator or alternator	Defective or badly worn belt	Replace belt
		Generator brushes not well seated	Seat brushes properly
		Worn or defective bearings	Replace bearing
		Loose pulley	Tighten pulley
		Misaligned Drive belt	Re-align belt
3	Mix-firing of engines	Improper spark plug heat	Replace spark plugs with

	range	hotter or colder range plug as
	Misplaced plug wiring	required.
	Worn out spark plug	Replace plug wire
	electrode	appropriately
	Defective spark plugs	Replace plugs
	Incorrect distributor timing	Replace plugs
	Insufficient voltage available	Retime distributor
	to spark plugs	appropriately
		Adjust point gap.

Source: Gbabo, 2009

2.5.5 Lubrication system

The lubrication system of a tractor performs function of supplying oil to moving parts of the engine in order to reduce or eliminate friction between the parts thereby reducing or eliminating problem of wear of such parts.

When the engine is in operation, many parts actuated to move which involves rubbing of surface over another, such as the sliding of the piston to and fro along the walls of the cylinders, the rotation of the crankshaft on its bearings etc. Friction causes heat and if not controlled can generate excessive heat which can melt rubbing surfaces together and causes the engine to seize. (Gbabo, 2009)

The lubricating oil works by forming a film between the moving parts, therefore the oil can be likened to a medium that sand witches the moving parts hence preventing them from rubbing against themselves, in addition to preventing wears, the lubricating oil also assist in cooling the engine as old oil is constantly replaced by new ones through the oil galleries as a result of the force supplied by oil pump. The following are type of lubrication system that can be commonly used; circulating splash system, force feed system, oil mist.

2.5.6 Types of oils:

Different types of oil are being manufactured by various manufacturers. These includes

1) Multi-grade oils
2) Detergent oils
3) Grease.

2.5.7 Maintenance Requirement of the lubrication system

S/No	Problems	Causes	Remedy/ Repairs
1	Engine uses too much oil	Crankcase oil too light	Use recommended oil with the correct viscosity
		Worn piston and rings	Replace rings
		Worn valve guides or stem oil seals.	Replace valve guide or seals
		Too high oil pressure	Adjust oil pressure
		External oil leakage	Correct oil leakage.
2	Engine over heats	Low engine oil	Add oil to the proper level

Source: Gbabo, 2009

2.5.8 The hydraulic and transmission system

The power generated by the I C E is expected to be used to provide an outlet for driving Stationary machine or forward and backward motion of the engine itself which in turn drives

Various field machines. In order to utilize the power for motion a mechanism called the "TRANSMISSION SYSTEM". Is used thus, the transmission system of a tractor is mechanism that obtain power or drive from the I C E and convert it to a linear motion. Manufacturers suggest checking the hydraulic fluid level every 10, 50 to 250 hours. It can be checked every time the regular oil level is checked because most systems have either a sight glass or a dip stick. Fill the systems as needed but never over-fill them

The ordinary four wheeled tractor has the engine, clutch, gear box, propeller shaft and drive axles all mounted in a rigid iron or steel frame. The two rear wheels are the traction member while the front wheels provide directional control. The oil level in the gear box, the rear axles and the hydraulic system must be checked daily. In some tractors common oil is used for transmission, gear box and the hydraulic system. Use only recommended oils for topping up the oil level, do not overfill oil reservoir.

2.5.9 Components of the hydraulic and transmission system.

The major components of the transmission system are

1) Clutch
2) Gearbox
3) Differential
4) Final drive

2.5.10 The cooling system

In the process of converting the chemical energy in fuel to mechanical energy, the fuel is burnt in the combustion chamber of the cylinder with a view to producing high pressure through the expanded burnt gases; in this process a tremendous quantity of heat is generated. In most cases temperature of up to 1600 degree is required inside the cylinder. If this is left unchecked by a cooling process, some of the engine parts can even melt. For the safety of the engine temperature has to be as low as 90 degree for efficient running of the engine. Usually only 25% of the heat generated in the combustion process is utilized for power generation out of the remaining 75%, about 35% of the heat is dissipated along with the exhaust gasses where the rest 40% is dissipated through cooling. Despite the fact that cooling of engine is necessary, overcooling can cause condensation of the fuel and water vapour leading to corrosion and oil dilution.(Gbabo, 2009)

2.5.11 Methods of cooling Engines.

Engines are cooled mostly by air or liquid or a combination of both. Thus, cooling methods are classified as follows:

1) Air- cooled system
2) Water- cooled system, under water cooling system we have two types which are: hopper or water jacket system, thermosyphonic system
3) Air and water cooled system.

2.5.12 Components of cooling system

1) Radiator
2) Thermostat
3) Condenser

2.5.13 Maintenance Requirement of the cooling system

problems	Causes	Remedy/ Repairs
Engine overheats	Defective radiator cap	Replace cap
	Radiator core blocked with dirt and debris	Clean radiator core
	Defective thermostat	Replace thermostat
	Loss of coolant	Check for leakage and correct
	Loose fan belt	Adjust belt tension
	Cooling system has scale deposit build- up	Use cooling system cleaner
Engine uses too much fuel	Engine not operating at proper temperature	Check and correct thermostat.

Source: Gbabo, 2009

Remember that tractor and equipment maintenance can help to conserve energy and prevent needless repairs, but it is impossible to cover all the "tips', such as servicing of filters, belts, hoses, or hydraulic systems.

2.6.0 Tractor Power

Power first and foremost can be defined as the rate of doing work or work done power unit time, hence tractor power which is also known as engine power is the power developed by the combination of fuel in the engine which is comprises basically the drawbar power, P.T.O. power, hydraulic power etc and these engine power can be divided into two main types which are

(a) Indicated Power

(b) Effective Power (Smith, 1965)

2.6.1 Indicated Power

Indicated power is the power which is developed by combustion of gases in the cylinder of the running engine.

These indicated power has a formular of N_I = Laps.

Where N_I	=	Indicated Power (kW)
L	=	Length of Stroke (m)
A	=	Area of Piston (m^2)
P	=	Mean effective pressure in the cylinder (N/m^2)
S	=	Number of working stroke per second

And the "S" which is number of working stroke per second is

$$S = \frac{nc}{60T}$$

n = Speed of rotation (rpm)

c = number of cylinder

T = Engine Cycle factor

And these "T" which is the engine cycle factor could either be

T = 1 for 2 stroke engine

Or 2 for 4 stroke engine

Apart from these basic types we have some several other powers which are

- **Drawbar Power**: Which is the power available at the drawbar for pulling purpose

  Drawbar Power: P_{DP} = Drawbar Pull F (N) x speed of operation (v) km/h or m/s

  = Fv (kW) ≈ Fv/3.6kw

- **P.T.O. Power**: Which is the power available at the P.T.O. shaft and it is usually more than drawbar power with about 5%

P.T.O. Power = $\frac{2\pi NT\ (w)}{60}$

- **Hydraulic Power**: Which is the power required to hold lower and control the working depth of a mounted implement.

PHVD = $\frac{HQ}{60D}$

H = oil pressure in bars

Q = Volume of oil flow (L/m) it's a discharge

2.6.2 Classification of Farm Machinery

Farm machinery which is used in our farm can be classified broadly into three distinct categories . (Hunt, 1971) which are

1) Passive Implement or Machines
2) Active Implementor Machines
3) Self Propelled Implement

- **Active Implement:** These are power driven implement and they require power from the tractor through the P.T.O shaft e.g. boom sprayer, mowers, vibrative sub-soiler, Pneumatic planters, rotary plough etc.
- **Passive Implement:** These are implement that do not require power from the tractor to drive their working mechanism e.g. plough, harrow, rides, cultivator etc.

- **Self Propelled:** These are implements which have their own power unit e.g. Combine harvester. Taking about each of the examples of implement under the subdivided farm machinery we have. Mould board plough, Disc plough etc.

2.6.3 Field Efficiency of Farm Machinery (Tractor)

The cost of complexity of farm machinery increases year by year in order to justify the capital investment involves is essential that operator should be able to exploit to the full each machine capacity. Farm equipment acts as a device to ensure that other input gives the desire results, thus, it may be said that farm equipment and the techniques associated with it uses broadly constitute the field of agricultural mechanization. It encompasses the use of farm equipment including the power sources that are used to operate the various machines.

Farm machinery is a general term used to describe tractors, combines, implements, machines and any other devices (more sophisticated than hand tools) may be animal or mechanically powered at farm level. (Odigboh,1991). All member machines are designed to perform a given task at a specified time. If this designed objective is not met, it only means that the machine and power unit it not correct (Kepner et al 1978).

Efficient machinery management requires accurate performance data on the capability of individual machines in order to meet projected work schedule and to form balanced mechanization system by matching the performance of separate item of equipment (Whitney 1988).

Field efficiency has the reference to the time and width of utilization of machine comparison of the time a machine actually spends in the field doing exactly what is supposed to do, as compared to the total time the machine is in the field. The theoretical field capacity C_T, of an implement is the rate of work that will be achieved if the machine were performing this function at full rated forward speed for 100% of the time. It is calculated simply by

The effective field capacity C_E of an implement is the actual average rate of working usually expressed in hectare/hour or acres/hour it take care of the time wasted at the head line together with the time taken to repair the machine in case of any breakdown. The effective field capacity in hectare per hour is determined by multiplying the product of the speed in kilometer per hour and the rated width by the field efficiency expressed as a decimal fraction.

Field efficiency E_F of a machine is the ratio of the effective field capacity C_E, to the theoretical field capacity C_T and multiplied by 100 percent. The field efficiency of a machine is always less than 100 and is influenced by various factors involved in the effective field capacity. Smith (1965) presented typical ranges of field efficiency of some implements and is summarized below. (Source: Smith, 1965)

S/No	Implements	Field Efficiency
1	Plough	74 – 84%
2	Grain Drill	77 – 90%
3	Mower	60 – 78%
4	Combine	63 – 70%

These values above include all effects of time and width utilization and might be considered to represent the percentage of time that a machine spend actually doing what it is supposed to be doing. Also to increase field efficiency of a machine, we have to increase effective field and this can be done by

- Fully preparing the machine for the daily work
- Choose the best working system e.g. Plough system
- Reducing the time wasted for filling and refilling the machine and tools or implements, such as sowing machine, fertilizer distribution and sprayers.

- Reducing the time wasted for filling and refilling the machine and tools or implements, such as sowing machine, fertilizer distribution and sprayers.
- Fully utilizing the working width and capacity of the machines or implement eg. Attaching cultivator and drilling implement to the tractor and increasing the output.

The performance of an agricultural machine is assembled by the rate at which an operation is accomplished and by the quality of the output. Field machine performance or capacity is the rate at which it can cover a field while performing its intended function or useful work. It is usually measured by the rate of work in hectare per hour. The factors involved are the width of useful work and the instant or speed travelled with the allowance for lost time in turning and servicing the machine.(Kaul et al 1985) Efficiency of a machine shows how they are made to do the task that they are designed to perform. Certainly if you were an owner or manager of a farm enterprise, you would be deeply concerned with the different efficient operation or poor utilization of the capacities of the equipment would lead to greater operating expenses and reduces profits for the business (Mc Colly and Martins 1955).

Capacity of plouging machine depends on the working width, forward sped and field efficiency. Forward speed in a mould board plough can be up to 9km/h and is disc plough up to 10km – 12km/hr. assuming field efficiency of up to about 0.85 or 85%, disc plough with 3m work width can have capacity of 2 – 3ha/hr and for 5 – 7m working width 3 – 4ha/hr.

Seasonal capacity of mould board plough is approximately 150 – 200 hectare per season and for disc plough 250 – 500 hectare per season, so therefore good maintenance of farm machinery keeps the filled efficiency higher.

CHAPTER THREE

3.0 MATERIALS AND METHODS

This chapter is concerned with identification of all the sources through which information were collected, it also states the types of research design, research population, sampling techniques and sample size, data collection instruments, method of data collection, presentation and analysis

The data for the research shall be gathered through both the primary and secondary sources, as for the primary source, two sets of questionnaires would be administered on the repairer and the operators of farm tractors. The data collected will be presented by simple average and percentage would be used to analyses

For secondary source, data shall be collected from publisher materials, journals, logbooks, publications and past researches.

3.1 Research design

This covers the method adopted by the researcher in carrying out the study from selected case study. This study employs descriptive research on the study of farm tractor reliability on the successful repairers and farms in Kano State. Descriptive research seeks to define a subject; the subject may be workshops, farms, ministries, and manufacturing or distribution channels.

3.2 Research population

The research population for this study comprises of almost all selected farms and repair workshops, ministries and manufacturing or distribution centers in Kano state which is nightly estimated to be 26.

3.3 Sampling techniques and sample size

According to (Asika, 2001) population is made up of all considerable element, subjects, or observations relating to a particular phenomenon of interest to the researchers subject or elements are individual items that makes up the population. They may be observed or physically counted.

Therefore, the populations of this study comprises of the repairers and operators of the farm tractors in Kano State of Nigeria.

A sample is precisely a part of the population, the procedure for drawing samples from a population is known as "sampling" therefore, sampling for this research work are the sampling technique and sample size.

Sampling techniques: During this study, the tools to be used is "Random sampling"

Sampling size: In this study, a total number of 26 respondents shall be used for collecting the required data 17 respondents will be operators of the farm tractors while 9 respondents shall be repairer of farm tractors in Kano State of Nigeria.

3.4 Instrument for data collection.

The instrument used in collecting the data will be questionnaire.

Questionnaire: This shall be used for the collection of data or in formations. This is designed using instructions, multiple choices and opened ended questions to make respondents responds easily to any questions, views and opinions were also used. The questionnaire was designed to collect data on such as: technical staff strength, available tools and equipment of repair and maintenance workshop, time between successive failures of each of the systems of the tractor. The tractor system considered were engine, fuel, traction, cooling, transmission, hydraulic, steering and electrical.

3.5 Method of data collection.

The data for this research will be collected from both primary and secondary sources.

1) **Primary source:** These are primary data, which are collected by the researcher from original sources and are used for the purpose of this research work. They are obtained through the following.

   1) Questionnaire

   2) Personal interview

   3) Observations.

3.6 Method of data presentation and analysis

Data collections for this research work were mainly questionnaire and for sample analysis, a total of twenty six organizations responded to the questionnaire, the respondent all spread all over Kano State, about forty tractors were surveyed and they were all still serviceable. They cover a period of operations ranging from thirty to one hundred and twenty months. They were used for tillage, haulage, stationary barn yard operations. The data obtained from time measurement was compiled and used to quantify reliability. This data were grouped into were presented average, class mark, class interval and percentage, analysed by equation using median rank equation and regression analysis equation in conjunction with Weibull model . The time between successive failures data for each system of the tractor make was analysed to obtain the Weibull parameters and the time between successive failures at a set reliability of each system. It tells how well an observed set of data were analyzed. For quick and easy understanding of data analysis.

Since all the data collected are normal, they can be used in generating qualitative data simply counting the number of each categories contained in the scale to form frequency and summarize in item of the percentage in each category.

3.6.1 Procedure for Weibull analysis using Weibull graph:

Steps:

1) Write down the K failure ages Ti of component in increasing order to magnitude at each Ti
2) Calculate the corresponding estimate of the distribution function using Bernard formula.
3) Plot the data on a Weibull graph and draw the best straight line through the data point.
4) Construct the perpendicular to the plotted line which goes through the estimation point
5) Estimate the value of the shape parameter which is where the perpendicular cuts the shape parameter estimate line.
6) If the graph does not indicate time (t) scale by default, you need to choose your scales.
7) To draw put your compass at estimate point then cut the straight line at A and B, bisect A, B then draw the perpendicular line. The line cut shape and scale parameter at some perpendicular values.

3.6.2 List of Establishments that responded to the questionnaire.

Government owned Organizations

1) Ministry of Agriculture and Natural Resource Kano.
2) National Youth Service Corporations Headquarter Kano
3) National Horticulture Research Institute Kano
4) National Truck Manufacturer Limited Kano
5) River Basin Development Project Kano.

Commercial/ Privately owned Organizations

1) Hairi Farms ltd, Adamawa Road
2) Khyber Agro Industries ltd, Dambatta road Kano
3) Vultaren Farms, Zoo Road Kano
4) Zantata Foods, Tiga Dam Kano
5) Anadariya Farms, Jos road Kano.
6) Aufuk Farms 15 Km western bye-pass Gwarzo road, Kano
7) Ringim Farms, 119 NNDC quarters Sharada Kano
8) A U I farms, Badawa extension Kano
9) Koki farms, Hadejia road Kano

Repair Workshops

1) Hisab Gen. Enterprises, Badawa Kano
2) National Truck Manufacturers.ltd
3) Ministry of Agriculture and National Resource, Kano
4) Anadariya farms, Jos road Kano
5) Zairo green U S A, Obasanjo way Kano
6) Green finger limited, Sabo Garri Kano
7) Howeidy Engineering workshop, 5Km Rano/Rurum road Rano LGA Kano.
8) Golden Acres limited, Kano
9) Talas Auto – plant Engineering Works, Kano

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

This chapter contains data gathering from respondents, these respondents are selected operators of repair workshops and farms within Kano metropolis and then responses have been presented in qualitative form using tables of average and percentage.

The chosen sample sizes of each group are 17 and 9 respectively.

A total of twenty six establishments corresponded to the questionnaire and these establishments comprises of government, privately owned and repair workshops, as listed in table 3.6.2. The results of the survey on the facilities of repair and maintenance are presented on the tables as shown below. The data collected was analysed to obtain the failures between each systems of different tractor makes and the average relative percentage of the workshop technical staff and tools/equipment.

4.1.0 Frequency table of time between failures of systems of Massey Ferguson tractors

4.1.1 Engine systems

S/No	Class interval	Class mark	Frequency
1	40– 44	42	5
2	45 – 49	47	3
3	50 – 54	52	2

Source: field survey 2009

Class mark = addition of the two class intervals divided by two

In the above table, it was found out that the frequency of failure was very high between the 40^{th} – 44^{th} months of the engine system of the Massey Fergusson Tractor make.

4.1.2 Hydraulic systems

S/No	Class interval	Class mark	Frequency
1	20 – 24	22	7
2	25 – 29	27	5
3	30 – 34	32	6
4	35 – 39	37	2

Source: field survey 2009

The class marks of each class intervals between each months was achieved by adding the class interval and dividing by two to get the each result as shown in the table above, also it was noticed that the frequency between the 20th – 24th month was the highest.

4.1.3 Steering systems

S/No	Class interval	Class mark	Frequency
1	9 – 13	11	11
2	14 – 18	16	9
3	19 – 23	21	6
4	24 – 28	26	7
5	29 – 33	31	4

Source: field survey 2009

The class marks of each class intervals between each months was achieved by adding the class interval and dividing by two to get each result as shown in the table above, also it was noticed that the frequency between the 9th – 13th months was the highest.

4.1.4 Transmission systems

S/No	Class interval	Class mark	Frequency
1	15 – 19	17	7
2	20 – 24	22	5
3	25 – 29	27	5
4	30 – 34	32	3
5	35 – 39	37	2
6	40 – 44	42	1
7	45 – 49	47	1

Source: field survey 2009

The class marks of each class interval between each months was achieved by adding the class intervals and dividing by two to get the results as shown in the table above, it was noticed that the frequency between the 15^{th} – 19^{th} months was the highest.

4.1.5 Fuel systems

S/No	Class interval	Class mark	Frequency
1	39 – 43	41	5
2	44 – 48	46	3
3	49 – 53	51	2

Source: Field survey 2009

From the table above it was noticed that the frequency of failure between the 39^{th} – 43^{th} months was determined to be the highest.

4.1.6 Cooling systems

S/No	Class interval	Class mark	Frequency
1	25 – 29	27	8
2	30 – 34	32	6
3	35 – 39	37	1

Source: Field survey 2009

From the table above the frequency of failure was at it least between the $35^{th} – 39^{th}$ months.

4.1.7 Electrical systems

S/No	Class interval	Class mark	Frequency
1	11– 15	13	16
2	16– 20	18	10
3	21– 25	23	7
4	26 – 30	28	4

Source: Field survey 2009

From the above table the electrical system experiences the highest intervals of failures. And it was noticed between the $11^{th} – 15^{th}$ months.

4.2.0 Frequency table of time between failures of system of Fiat tractors

4.2.1 Engine systems

S/No	Class interval	Class mark	Frequency
1	30– 34	32	18
2	35– 39	37	13
3	40 – 44	42	3

Source: Field survey 2009

The engine system of the Fiat tractors experiences its highest failures between the $30^{th} - 34^{th}$ months.

4.2.2 Hydraulic systems

S/No	Class interval	Class mark	Frequency
1	19– 23	21	23
2	24– 28	26	18
3	29– 33	31	8
4	34 – 38	36	3

Source: Field survey 2009

From the above table the Hydraulic system of the Fiat tractors experiences its highest failures between the $19^{th} - 23^{th}$ months.

4.2.3 Steering systems

S/No	Class interval	Class mark	Frequency
1	13–17	15	21
2	18–22	20	18
3	23–27	25	15
4	28–32	30	7

Source: Field survey 2009

From the table above it was noticed that that the frequency of the steering system of the Fiat tractor was at its highest between the $13^{th} - 17^{th}$ months.

4.2.4 Transmission systems

S/No	Class interval	Class mark	Frequency
1	16–20	18	20
2	21–25	23	18
3	26–30	28	14
4	31–35	33	2

Source: Field survey 2009

From the table above, the transmission system of the Fiat tractor experienced its lowest amount of failures between the $31^{th} – 35^{th}$ months.

4.2.5 Fuel systems

S/No	Class interval	Class mark	Frequency
1	35 – 39	37	11
2	40 – 44	42	9
3	45 – 49	47	6
4	50 – 54	52	2

Source: Field survey 2009

From the above table it was noticed that the frequency of failure between the $35^{th} – 39^{th}$ months was determined to be the highest.

4.2.6 Cooling systems

S/No	Class interval	Class mark	Frequency
1	19 – 23	21	23
2	24 – 28	26	14

3	29 – 33	31	11
4	34 – 38	36	3

Source: Field survey 2009

From the table above, the cooling system of the Fiat tractors experienced it lowest amount of failures between the 34^{th} – 38^{th} months.

4.2.7 Traction systems

S/No	Class interval	Class mark	Frequency
1	11 – 15	13	25
2	16 – 20	18	18
3	21 – 25	23	16
4	26 – 30	28	10

Source: Field survey 2009

From the table above, the traction system of the Fiat tractors experienced it highest amount of failures between the 11^{th} – 15^{th} months, which was about 25 times.

4.2.8 Electrical systems

S/No	Class interval	Class mark	Frequency
1	11 – 15	13	28
2	16 – 20	18	24
3	21 – 25	23	13
4	26 – 30	28	7

Source: Field survey 2009

From the above, it was noticed that the frequency of failures between the 11^{th} – 15^{th} months was the highest experiencing a failure of about 28 times.

4.3.0 Frequency table of time between failures of system of Steyr tractors.

4.3.1 Engine systems

S/No	Class interval	Class mark	Frequency
1	20 – 24	22	10
2	25 – 29	27	8
3	30 – 34	32	2

Source: Field survey 2009

From the above table, it was noticed that the frequency of failures between the 20^{th} – 24^{th} months was the highest experiencing a failure of about 10 times.

4.3.2 Hydraulic systems

S/No	Class interval	Class mark	Frequency
1	16 – 20	18	10
2	21 – 25	23	7
3	26 – 30	28	3

Source: Field survey 2009

In the table above, the frequency of failures of the hydraulic system of Steyr Tractor. It was noticed that the highest amount of failure fall between the 16^{th} – 20^{th} months with result amounting to about 10 times.

4.3.3 Steering systems

S/No	Class interval	Class mark	Frequency
1	9 – 13	11	19
2	14 – 18	16	14

3	19 – 23	21	3

Source: Field survey 2009

From the record of the table above, it was noticed that between the 9^{th} – 13^{th} months the steering system of the Steyr Tractor experiences the most failure.

4.3.4 Transmission systems

S/No	Class interval	Class mark	Frequency
1	11 – 15	13	17
2	16 – 20	18	9
3	21 – 25	23	4

Source: Field survey 2009

From the record of the table above, it was noticed that between the 21^{th} – 25^{th} months the transmission system of the steyr tractor experiences the least failures.

4.3.5 Fuel systems

S/No	Class interval	Class mark	Frequency
1	31 – 35	33	10
2	36 – 40	38	8
3	41 – 45	43	2

Source: Field survey 2009

From the record above, it shows that during 31^{th} – 35^{th} months, the fuel system of the Steyr Tractor experiences its highest amount of failures of about 10 times.

4.3.6 Cooling systems

S/No	Class interval	Class mark	Frequency
1	10 – 14	12	9
2	15 – 19	17	8
3	20 – 24	22	3

Source: Field survey 2009

From the table above, the cooling systems of the Steyr Tractor experiences it highest amount of failures between the $10^{th} – 14^{th}$ months having a frequency of about 9.

4.3.7 Traction systems

S/No	Class interval	Class mark	Frequency
1	10 – 14	12	17
2	15 – 19	17	9
3	20 – 24	22	4

Source: Field survey 2009

From the table shown above, the result illustrated about the traction system of the Steyr Tractor indicates that the system experiences its highest amount of failure during the $10^{th} – 14^{th}$ months of about 17 times.

4.3.8 Electrical systems

S/No	Class interval	Class mark	Frequency
1	10 – 14	12	17
2	15 – 19	17	11
3	20 – 24	22	2

Source: Field survey 2009

From the table shown above, the result illustrated about the electrical system of the Steyr Tractor indicates that the system experiences its highest amount of failures during the $10^{th} - 14^{th}$ months about 17 times.

4.4.0 Frequency table of time between failures of systems of Ford tractor makes

4.4.1 Engine systems

S/No	Class interval	Class mark	Frequency
1	14 – 16	15	19
2	17 – 19	18	8
3	20 – 22	21	3

Source: Field survey 2009

From the above table shown, it was noticed that the frequency of failure of the between the $14^{th} - 16^{th}$ months was determined to be the highest.

4.4.2 Hydraulic systems

S/No	Class interval	Class mark	Frequency
1	15 – 19	17	11
2	20 – 24	22	7
3	25 – 29	27	2

Source: Field survey 2009

From the table shown above, the result illustrated about the Hydraulic system of the Ford Tractor indicates that the system experiences its highest amount of failures during the $15^{th} - 19^{th}$ months about 11 times.

4.4.3 Steering systems

S/No	Class interval	Class mark	Frequency
1	9 – 13	11	15
2	14 – 18	16	13
3	19 – 23	21	3

Source: Field survey 2009

From the table shown above, the result illustrated about the Steering system of the Ford Tractor indicates that the system experiences its highest amount of failures during the 9^{th} – 13^{th} months about 15 times.

4.4.4 Transmission systems

S/No	Class interval	Class mark	Frequency
1	11 – 15	13	17
2	16– 20	18	10
3	21 – 25	23	3

Source: Field survey 2009

From the table shown above, the result illustrated about the Transmission system of the Ford Tractor indicates that the system experiences its highest amount of failures during the 11^{th} – 15^{th} months about 17 times.

4.4.5 Fuel systems

S/No	Class interval	Class mark	Frequency
1	16 – 20	18	10
2	22 – 25	23	8

3	26 – 30	28	2

Source: Field survey 2009

From the table shown above, the result illustrated about the Fuel system of the Ford Tractor indicates that the system experiences its highest amount of failures during the 16th – 20th months about 10 times.

4.4.6 Cooling systems

S/No	Class interval	Class mark	Frequency
1	15 – 19	17	9
2	20 – 24	22	8
3	25 – 29	27	3

Source: Field survey 2009

From the table shown above, the result illustrated about the cooling system of the Ford Tractor indicates that the system experiences its highest amount of failures during the 15th – 19th months about 9 times.

4.4.7 Traction systems

S/No	Class interval	Class mark	Frequency
1	10 – 14	12	16
2	15 – 19	17	9
3	20 – 24	22	5

Source: Field survey 2009

From the table shown above, the result illustrated about the Traction system of the Ford Tractor indicates that the system experiences its highest amount of failures during the 10th – 14th months about 16 times.

4.4.8 Electrical systems

S/No	Class interval	Class mark	Frequency
1	10 – 14	12	17
2	15 – 19	17	11
3	20 – 24	22	2

Source: Field survey 2009

From the table shown above, the result illustrated about the electrical system of the Ford Tractor indicates that the system experiences its highest amount of failures during the 10^{th} – 14^{th} months about 17 times.

4.5.0 Overall Frequency table of time between failures of systems.

4.5.1 Engine systems

S/No	Class interval	Class mark	Frequency
1	10 – 14	12	10
2	15 – 19	17	17
3	20 – 24	22	13
4	25 – 29	27	8
5	30 – 34	32	20
6	35 – 39	37	13
7	40 – 44	42	10
8	45 – 49	47	3
9	50 – 54	52	2

Source: Field survey 2009

From the table shown above, the result illustrated about the engine system of the overall Tractor makes indicates that the system experiences its highest amount of failures during the $30^{th} - 34^{th}$ months about 20 times.

4.5.2 Hydraulic systems

S/No	Class interval	Class mark	Frequency
1	15 – 19	17	30
2	20 – 24	22	41
3	25 – 29	27	25
4	30 – 34	32	14
5	35 – 39	37	2

Source: Field survey 2009

From the table shown above, the result illustrated about the Hydraulic system of the overall Tractor makes indicates that the system experiences its highest amount of failures during the $20^{th} - 24^{th}$ months about 41 times.

4.5.3 Steering systems

S/No	Class interval	Class mark	Frequency
1	9 – 13	11	50
2	14 – 18	16	57
3	19 – 23	21	28
4	24 – 28	26	20
5	29 – 33	31	10

Source: Field survey 2009

From the table shown above, the result illustrated about the steering system of the overall Tractor indicates that the system experiences its highest amount of failures during the 14^{th} – 18^{th} months about 57 times.

4.5.4 Traction systems

S/No	Class interval	Class mark	Frequency
1	10 – 14	12	51
2	15 – 19	17	40
3	20 – 24	22	23
4	25 – 29	27	15

Source: Field survey 2009

From the table shown above, the result illustrated about the Traction system of the overall Tractor indicates that the system experiences its highest amount of failures during the 10^{th} – 14^{th} months about 51 times.

4.5.5 Transmission systems

S/No	Class interval	Class mark	Frequency
1	11 – 15	13	36
2	16 – 20	18	47
3	21 – 25	23	27
4	26 – 30	28	21
5	31 – 35	32	4
6	36 – 40	38	1
7	41 – 45	43	2

Source: Field survey 2009

From the table shown above, the result illustrated about the transmission system of the overall Tractor indicates that the system experiences its highest amount of failures during the 16th – 20th months about 47 times.

4.5.6 Fuel systems

S/No	Class interval	Class mark	Frequency
1	16 – 20	18	10
2	21 – 25	23	8
3	26 – 30	28	2
4	31 – 35	33	8
5	36 – 40	38	15
6	41 – 45	43	13
7	46 – 50	48	8
8	51 – 55	53	4

Source: Field survey 2009

From the table shown above, the result illustrated about the Fuel system of the overall Tractor makes indicates that the system experiences its highest amount of failures during the 36th – 40th months about 15 times.

4.5.7 Cooling systems

S/No	Class interval	Class mark	Frequency
1	16 – 20	18	10
2	21 – 25	23	8
3	26 – 30	28	2

4	31 – 35	33	8
5	36 – 40	38	15
6	41 – 45	43	13
7	46 – 50	48	8
8	51 – 55	53	4

Source: Field survey 2009

From the table shown above, the result illustrated about the cooling system of the overall Tractor makes indicates that the system experiences its highest amount of failures during the 36^{th} – 40^{th} months about 15 times.

4.5.8 Electrical systems

S/No	Class interval	Class mark	Frequency
1	10 – 14	12	72
2	15 – 19	17	57
3	20 – 24	22	26
4	25 – 29	27	14

Source: Field survey 2009

From the table shown above, the result illustrated about the electrical system of the overall Tractor makes indicates that the system experiences its highest amount of failures during the 10^{th} – 14^{th} months about 72 times.

4.6.0 Weibull parameters and t_{50} of tractor makes

Tractor systems		Massey Fergusson			Fiat			Steyr		
S/No		A	B	t_{50}	α	B	t_{50}	α	B	t_{50}
1	Engine	48.35	9.78	46.57	37.26	8.18	35.62	27.16	6.12	25.58
2	Hydraulic	30.59	5.15	28.49	27.50	4.88	25.51	23.41	4.93	21.73
3	Steering	21.61	2.70	18.86	22.93	3.88	20.86	15.82	3.56	13.94
4	Transmission	30.21	3.00	26.74	25.04	4.74	23.17	17.68	3.64	15.98
5	Fuel	47.35	9.56	45.57	44.65	7.86	42.61	38.22	7.75	36.45
6	Cooling	32.01	7.24	30.43	27.74	4.74	25.67	16.78	3.58	15.14
7	Traction	-	-	-	21.03	3.31	18.83	16.65	3.42	14.96
8	Electrical	20.17	3.18	17.97	20.08	3.42	18.04	16.24	3.70	14.71
	Whole Tractor	29.35	2.82	25.78	27.56	2.96	24.36	21.61	3.36	19.38

Source: Field survey 2009

4.6.1 Continuations of the Weibull parameters and t_{50} of tractor makes

Tractor systems		Ford			Overall		
S/No		A	B	t_{50}	α	B	t_{50}
1	Engine	17.57	6.08	16.54	31.75	2.88	27.96
2	Hydraulic	21.83	4.71	20.19	25.87	4.36	23.78
3	Steering	15.98	3.62	14.30	19.79	2.91	17.45
4	Transmission	17.47	3.78	15.86	23.36	2.98	20.66
5	Fuel	22.27	5.01	21.16	39.31	3.39	35.28
6	Cooling	2264	4.97	21.03	24.99	3.51	22.51
7	Traction	14.04	3.42	15.30	19.12	3.14	17.01

8 Electrical	16.24	3.70	14.71	18.41	3.19	16.41
Whole Tractor	18.66	4.94	17.33	26.13	3.31	23.39

Source: Field survey 2009

The time record collated from both breakdown and repair logbooks were analysed to obtain the Weibull scale parameter and shape parameter. Since reliability can assume values between 0 and 1(0% and 100%), the time between failures at which a system will have a reliability value of 50% or 0.5 was calculate using the Weibull parameters in the Weibull model. Thus, the time between failures at 50% reliability its general functions.

$$t = \alpha \,[\, - \mathrm{Ln}\ R(t)]^{1/\beta} \quad \text{...(1)}$$

Becomes

$$t_{50} = \alpha \,[\, - \mathrm{Ln}\ R(0.5)]^{1/\beta} \quad \text{...(2)}$$

The significance of the time between failure 50% reliability (t_{50}) is the time between failure at which a system has a 50 – 50 chance of failure. The various Weibull parameter and time between failures at 50% reliability are shown in table 4.6.0 above. It can be deduced that the engine of Massey Fergusson tractor is the most reliable with a 50% reliability of 46.57 months. The least reliable is the ford tractor with a 50% reliability time between failures of months. Generally, on all the tractor systems pulled together, fuel system showed the least tendency to failure because it has the highest t_{50} value of 35.28 months compared to other systems. It is closely followed by the engine with t_{50} value of 27.96 months. The steering, electrical and traction systems are the least reliable systems with average t_{50} value of 16.96 months. Taking the tractor as a whole, Massey Fergusson and Fiat tractors are relatively more reliable than the Steyr and Ford tractors. It can be deduced from the figure that Massey Fergusson tractor is the most reliable tractor; it is then followed by Fiat tractor, then the Steyr tractor while the least reliable is the Ford tractor.

4.7.0 Technical staff Distribution

S/No	Staff category	Qualification	Total	Average per Establishment	Percentage
1	Engineer	B. Eng/ HND	15	1.2	10.9
2	Technician/ Technologist	OND/ C & G	35	2.7	25.4
3	Craftsmen	Trade Test	50	3.8	36.2
4	Apprentices	Pry/sec. sch. Certificate	38	2.9	27.5
		Total	138	10.6	100

Source: Field survey 2009

The table above indicates that the bulk of the workshop technical staffs are the craftsmen and the technicians consisting of 36.2% and 25.4% respectively. They form a total of 61.6% of the workforce and the main skilled workers that are physically engaged in the repair work in the workshops. Their figure is closely followed by 27.5% for the apprentices. The engineers form 10.9% and the least percentage of the workforce. Although, craftsmen form the highest percentage of the technical staff, their competence and proficiency are still questionable because not all of them have procured the final stage certificate of the recognized national trade test. The apprentices who are still under training form the second highest percentage of the workforce.

4.8.0 Workshop Tools Available

S/No	Tools	Total	Average per Establishment	Percentage
1	Set of spanners	114	8.8	21.1
2	Set of screwdrivers	46	3.5	8.5
3	Hammer	35	2.9	6.5
4	Torque/ Wrench	22	1.7	4.1
5	Chisel/ Punches	56	4.3	10.4
6	Pliers	45	3.5	8.3
7	Cranes	21	1.6	3.9
8	Hydraulic Press	7	0.5	1.3
9	Tap & Die(set)	11	0.8	2.0
10	Ring Compressor	35	2.7	6.5
11	Grinder	13	1.0	2.4
12	Drills	18	1.4	3.3
13	Hydraulic jack	38	2.9	7.0
14	Files	64	4.9	11.8
15	Pulley Extractor	16	1.2	3.0
	Total	541	41.7	100.0

Source: Field survey 2009

Table 4.8.0, shows the relative percentages of the workshop tools/equipment. It reveals that the largest percentages of the tools are the spanners, hand files, chisel and pliers which are the basic hand tools. However, the special tools are the hydraulic press, tap and die, torque wrench, pulley extractor etc which facilitates precision and accuracy of the work are lacking. The few ones are mostly available in the government establishments. Hence, most of the skilled workers in the private workshops lack the knowledge of usage of these special tools. It was also gathered that the cost of purchasing the special tools has contributed to their non-availability. This situation could no doubt have affected the reliability of the tractors. Despite the fact that there are comparatively enough skilled workers in the repair workshops, they lack the requisite special tools and genuine spare parts to enhance the repair and maintenance of the tractors. All the workshops visited complained of lack of genuine spare parts for repair and maintenance of the farm tractors. According to them, they are sometime forced to buy fairly used spare parts which tend to further affect the reliability of farm tractors.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

From the study of farm tractor reliability using proper method in analyzing our data and collecting data on the available staff and tools with their various average and percentage, the following conclusions were drawn;

1) It was revealed that the workshop staff consists of engineers, technicians and craftsmen/apprentices and in the ratio 1: 2: 6 respectively.
2) The commonly owned tools are the basic hand tools.
3) That some of the problems of repair and maintenance of tractor in the state are unavailability of genuine spare parts, few or lack of special repair and maintenance tools and improper record keeping habit.
4) Comparison of the reliability of the tractors showed that traction, steering and electrical systems have higher tendency of failure than the cooling, transmission, engine, fuel and hydraulic systems.
5) That Massey Fergusson and Fiat tractors were found to the comparatively more reliable tractors in the state.

5.2 Recommendations

From the above study on the study of farm tractor reliability, some of these recommendations should be adhere to for future purposes, for a proper repairs and maintenance of the tractors.

1) Genuine spare parts should be provided so as to make the tractor last longer after repairs are conducted

2) Proper records should be kept on the repair and maintenance logbook for tackling problems related for future purposes.
3) More tools should be provided apart from the basic hand tools for easy handling of different problems and purposes.
4) More Engineers and technologists should be employed or provided to the solution of any problem or should be provided in any organization.
5) The reliability of the tractor traction, electrical and steering system should be improved on, so as to reduce the problems which are associated with them.
6) The overall systems of the Steyr and Ford tractors should be improved on for the better usage of these farm tractors in the busiest periods.

APPENDICES

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

DEPARTMENT OF AGRICULTURAL AND BIO-RESOURCES ENGINEERING

A STUDY OF FARM TRACTOR RELIABILITY IN KANO STATE OF NIGERIA

Note: this data collection exercise is to enhance the study of farm tractors reliability in this state and not to implicate or prosecute anyone in any form of it kind.

SECTION A: Background Information.

1. Questionnaire Number? ....

2. Date and time? ………………………………………………………………………

3. Name of Organization/Repair workshop/Farm? ....

4. Location/Address of Question 3 above? ....

SECTION B: Personal data

5. Number of Technical staffs? ....

6. What are the strengths of the staffs? ....

   A. B-Eng/ HND B. OND/ C & G C. Trade test D. Pry/Sec. Sch. cert E. Adult Education.

7. What is the type of ownership? ....

A. Government B. Private C. Commercial

8. Population of staffs (overall)......................and per departments.........................

9. What are the available tools in the facility? ....

10. Are all the tractors in operational condition? ....

A. Yes B. No

11. If (No) give data? ....

12. How many equipment are for repair? ....

13. Give makes/manufacturer of available tractors? ....

14. Number of available tractors? ....

15. What are the time intervals between successive failures for each system of the tractors? ....

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