International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 8, October - 2012

Tractor Owners and Operators' Perception about Tractor Breakdown causes at Tamale, Ghana

Stephen Hill Mends Aikins[1] and Khairiya Haruna[2]
[1]*Department of Agricultural Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana*
[2]*Cummins Ghana Limited, Odorkor, Winneba Road, P.O. Box WJ 773, Weija, Accra, Ghana*

Abstract

Tractor breakdown is a major problem affecting crop production operations at Tamale, Ghana. A survey of 123 tractor owners and operators in Tamale was conducted to identify their personal profile, their perception about the causes of tractor breakdown, and the major constraints affecting tractor maintenance and repair. Data was collected through questionnaire administration. The mean age of all the respondents was 43 years. About 62% of the respondents had low level educational background. Approximately 21% of the tractor owners and operators had no formal education while 22% had 'Makaranta' level education. The remaining 19% of the respondents had primary level school education. The majority of the operators (93%) learnt how to operate the tractor from other tractor operators rather than through a formal tractor operator training school. Tractor owners and operators perceived the causes of tractor breakdown to be careless tractor operation, inadequate maintenance, aged tractors, poor roads to farms, use of fake spare parts for tractor maintenance and repair, and obstacles to tractor operation in the farms including stumps, roots, and buried stones. The major constraints affecting tractor maintenance and repair were found to be high cost of genuine spare parts, poor educational background of owners and operators, and lack of financial credit. The study draws attention to the need for the provision of professional training in tractor operation, financial credit and after-sales-service to tractor owners and operators.

Keywords: *Perception, Tractor breakdown, Tractor operator, Tractor owner, Tamale*

1. Introduction

More than half the number of tractors in Ghana is found in the Northern region of Ghana. However, over half the number of tractors in the region is unserviceable [1]. Tractors are important farming machines used in the production of crops at Tamale. The major crops grown in the area include maize (*Zea mays, L.*), rice (*Oryza sativa*), cowpea (*Vigna unguiculata* [L.] Walp), groundnut (Arachis hypogaea), bambara groundnuts (*Vigna subterrenea* (L) Verdc), yam (*Dioscorea rotundata*), cassava (*Manihot esculenta*), tomato (*Lycopersicon esculentum* L.), and pepper (*Capsicum frutescens*). Several factors constrain the production of crops at Tamale. Some of the constraints include heavy dependence on rainfall for crop production, incidence of crop pests and diseases, cutting of wooded land, bush burning, untimely weed control, poor soil productivity, inadequate tractor services, and tractor breakdown. Tractor breakdowns, which are field delays caused by sudden failure of a component, with consequential repair time likely to exceed half an hour [2; 3], are major problems affecting crop production at Tamale. However, there is inadequate information on the causes of tractor breakdown in the area.

From an economic viewpoint, tractor breakdown can be very costly due to loss of working time [4 cited by 5]. Repairs of broken down tractors are also expensive [6] because the breakdown consume resources, manpower, and spare parts, while production is lost [7 cited by 5]. Thus, this study will provide information necessary for making policy decisions on tractor breakdown. The objectives of the study were to identify the personal profile of tractor owners and operators; to assess tractor owners and operators' perception about causes of tractor breakdown; and to identify the main constraints affecting tractor maintenance and repairs at Tamale.

2. Materials and Methods

2.1 Study Area

The study was conducted in Tamale in the Northern Region of Ghana. Tamale is located in the Guinea savannah agro-ecological zone of Ghana at latitude

9°24'00"N and longitude 0°50'24"W. The area receives an average annual rainfall of about 1000 mm, which falls in a distinct wet season from April to mid-October followed by a distinct dry season from mid-October to April. Considerable variations exist between successive rainy seasons with respect to time of onset, duration, and amount of rainfall received.

2.2 Data Collection

A questionnaire was designed and administered to 123 tractor owners and operators at Tamale. Data was collected between July and December, 2009. The questionnaire was designed to obtain information on the personal profile of tractor owners and operators, the perception of tractor owners and operators about causes of agricultural tractor breakdown, and the major constraints affecting tractor maintenance and repair at Tamale.

2.3 Data Analysis

The data obtained from the survey was summarized using descriptive statistics. The summarized data was presented in the form of tables and graphs. Tables were used to help focus on specific numbers in the results. Bar charts were used to compare respondent responses for the different categories in a question. Frequencies and percentages were used to describe the composition of sample. Chi-Square test was conducted to determine if tractor owners and operators differed about their perception of causes of tractor breakdown. The Chi-Square test statistic was conducted using the MINITAB Statistical Software Release 15 [8].

3. Results and Discussion

3.1 Profile of Tractor Owners and Operators

3.1.1 Sex and Age Group Distribution of Tractor Owners and Operators

The questionnaire was administered to 123 tractor owners and operators. The respondents included 122 male tractor owners and operators, and one female tractor owner. Out of the 123 respondents, 36 were tractor owners while 87 were tractor operators. The results show that tractor ownership and operation in Tamale is male dominated. Table 1 shows the age group distribution of tractor owners and operators. The mean age of all the respondents was 43 years with a standard deviation of 11.1 years. The tractor owners' mean age was 45 years with a standard deviation of 10.4 while the tractor operators' mean age was 42 years with a standard deviation of 11.2.

Table 1: Age group distribution of tractor owners and operators

Age Group	Frequency	Percentage (%)
20–29	16	13.01
30–39	28	22.76
40–49	46	37.40
50–59	24	19.51
60–69	9	7.32
Total	123	100

3.1.2 Educational Background of Tractor Owners and Operators

Education has an immense impact on the human society [9]. Education is the knowledge of putting one's potentials to maximum use. Education is one of the factors affecting the capability of the tractor operator. The literacy status of a tractor operator may influence understanding about the use of tractor and its associated implements because he can study the operation manual and understand all the instructions [10].The educational background of tractor owners and operators at Tamale is presented in Fig. 1. Generally, the educational background of the respondents was low. About 62% of tractor owners and operators had 'Makaranta' education, no formal education or had between one and six years of formal education. Twenty two percent (22%) of the respondents were 'Makaranta' graduates. 'Makaranta' is a word in Hausa which means 'Madrasa' in Arabic. The 'Makaranta' system of Islamic education involves only Arabic studies including arithmetic in Arabic excluding the study of English. About 21.1% of the tractor owners and operators had no formal education while 18.7% had between one and six years of formal education (primary school level education). About 16.3% of the respondents had Middle School level education; approximately 6.5% had Junior Secondary School level education, while about 7.3% had Senior Secondary School level education. Approximately 8.1% of the tractor owners and operators had Technical School level education and Polytechnic level education. This included about 3.2% of the tractor owners and operators with Technical School level education and 4.9% with Polytechnic level education.

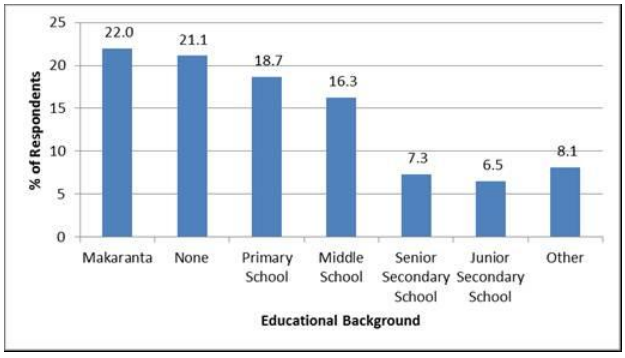

Fig. 1: Educational background of tractor owners and operators

3.1.3 Tractor Operators' Background Training and Experience

Table 2 displays the background training of the tractor operators. It can be seen that the majority of the operators (93.1%) learnt how to operate the tractor from other tractor operators rather than through a formal tractor operator training school. Only 6.9% of the operators had formal tractor operator training. While formal tractor operator training is structured, informal tractor operator training is not structured. This means that different tractor operators would train their subordinates based on their own limited experience producing 'gaps' in their (subordinate) training.

Table 2: Tractor operator training

Mode of Tractor Operator Training	Frequency	%
From another Tractor Operator	81	93.1
Government Sponsored (Ministry of Food and Agriculture)	6	6.9
Total	87	100

Fig. 3 illustrates the years of experience of the 87 tractor operators. Tractor operators with one to ten years of operating experience constituted 36.8% of the respondents. This was followed by those with 11 to 20 years of experience (27.6%); and 21 to 30 years of experience (17.2%). Tractor operators with 31 to 40 years of operating experience represented 13.8% of the respondents while those with 41 to 50 years' experience made up 4.6 % of the respondents. The average operator had 17.7 years of experience with a standard deviation of 12.1.

Fig. 2: Tractor Operators Years' of Experience

3.2 Profile of Tractors at Tamale

3.2.1 Tractor Makes at Tamale

In Fig 3, the make of tractors used by tractor owners and operators surveyed are depicted. Massey Ferguson, Farmtrac and Ford consisted of 73.2% of the make of tractors at Tamale. The most dominant tractor make used by the owners and operators was Massey Ferguson (49.6%). Farmtrac constituted 13.8% while Ford represented 9.8% of the make of tractors in the study area. John Deere, Shanghai and Fiat formed 16.3% of the make of tractors while other make of tractors included Swaraj (3.25%), Mahindra (1.63%), Vari (1.63%), Brazil (1.63%), New Holland (0.85%), and Universal (0.85%).

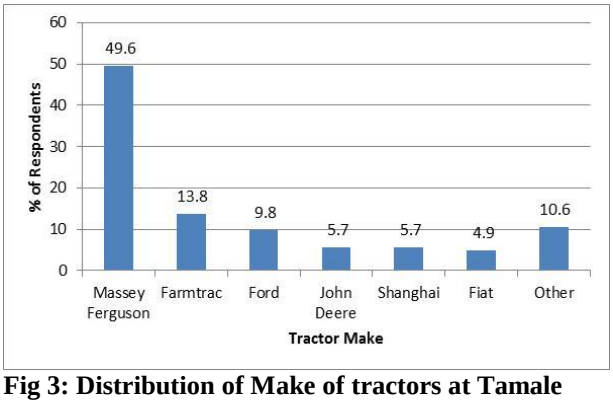

Fig 3: Distribution of Make of tractors at Tamale

3.2.2 Tractor operations at Tamale

Table 3 shows the results of tractor operations obtained from the survey. It can be seen that most tractors at Tamale were used for ploughing, harrowing, transporting, and planting. Approximately 38.2% of the respondents reported that they use their tractors for ploughing, harrowing and transportation of food stuff, water, and or refuse. About 17.1% of the tractor owners and operators used their tractor for ploughing, harrowing, planting and transportation while another 17.1% of the tractor owners and operators used their

tractors for ploughing and harrowing only. About 11.4% of the respondents indicated that they used their tractors for ploughing and transporting while another 11.4% pointed out that they used their tractors only for ploughing. The other 4.9% of the tractor owners and operators said that they used their tractors for transporting (3.3%); ploughing, harrowing and planting (0.8%); and ploughing, harrowing and shelling (0.8%).

Table 3: Tractor operations at Tamale

Operation	Frequency	%
Ploughing, Harrowing and Transporting	47	38.2
Ploughing, Harrowing, Planting and Transporting	21	17.1
Ploughing and Harrowing	21	17.1
Ploughing and Transporting	14	11.4
Ploughing	14	11.4
Other	6	4.9
Total	123	100.0

Table 4 depicts the results of the annual usage of tractors in the study area. It is clear that 87% of the tractors were used between three and six months in a year. Approximately 5% of the tractors were used less than three months in a year while about 4% of the tractors were used between six and nine months annually. The remaining 4% of the tractors were used between nine and twelve months in a year.

Table 4: Annual tractor usage

Tractor use in a years	Frequency	%
Below 3 Months	6	5
3 to 6 Months	107	87
6 to 9 Months	5	4
9 to 12 Months	5	4
Total	123	100

3.2.3 Nature of Tractor Purchase, and Tractor Engine Capacity

Table 5 shows the nature of tractor purchase obtained from the survey. About 58.5% of the tractor owners and operators reported that their tractors were purchased as brand new while 41.5% of the respondents indicated that theirs were purchased as "second hand."

Table 5: Nature of tractor purchase

Tractor Purchase	Frequency	Percentage (%)
New	72	58.5
Second Hand	51	41.5
Total	123	100

Fig. 4 presents the results of the tractor engine capacity found from the administration of the questionnaires. Out of the 123 respondents, 56.9% did not know their tractor engine capacity (in kW or hp). About 17.9% indicated their tractor engine capacity to be about 37 kW while 23.5% reported their tractor engine capacity to be 52 kW (8.9%), 22 kW (8.1%) and 15kW (6.5%). The other 1.6% of the respondents indicated their tractor engine capacity to be 5 kW.

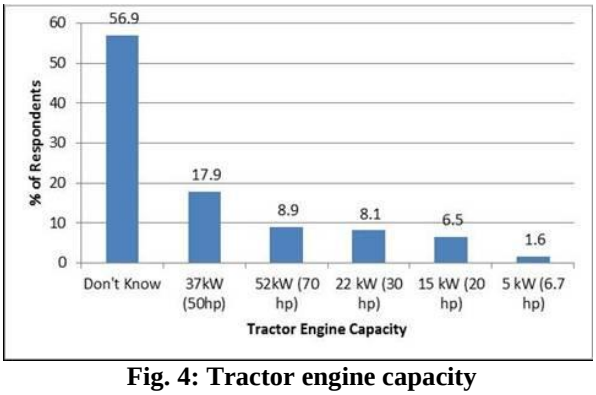

Fig. 4: Tractor engine capacity

3.2.4 Tractor Speedometer, Hour meter and Hydraulic System Condition

A speedometer is a device used to measure the travelling speed of a vehicle, usually for the purpose of maintaining a sensible pace. The speedometer usually shares housing with an hour meter, which is a mechanism used to record total hours worked. When asked about the working condition of their tractor speedometer, 59.3% of the tractor owners and operators indicated that their tractor speedometer was not in working order while 40.7% said that their tractor speedometer was in working order (Table 6).

Table 6: Tractor speedometer, hour meter and hydraulic system condition

Working Condition	Tractor Speedometer		Tractor Hour Meter		Hydraulic System	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
In order	50	40.7	46	37.4	119	96.8
Not in order	73	59.3	77	62.6	4	3.2
Total	123	100	123	100	123	100

Tractor owners and operators were also asked about the working condition of their tractor hour meter. As shown in Table 6, 62.6% of the respondents indicated that their tractor hour meter was not in working order

while 37.4 reported that that their tractor hour meter was in working order. An hour meter operates whenever the tractor engine is running and shows the total hours of operation. It is important to record the hour meter reading and watch this meter to tell when services are required [11].

Apart from the working condition of their tractor speedometer and hour meter, survey participants were asked about the condition of their tractor hydraulic system. About 96.8% reported that their tractor hydraulic system was in working order (Table 6). Only 3.3% of the respondents did not have their tractor hydraulic system in working order and therefore used their tractors only for the transportation of various items over short distances.

3.3 Tractor Breakdown

Table 7 presents the tractor owners and operators' responses about tractor breakdown. As can be seen, 95.1% (117) of the respondents reported that their tractor broke down at least once during the farming season while 4.9% indicated that theirs did not breakdown during the farming season. The latter respondents happened to have brand new tractors.

Table 7: Tractor Breakdown during the Farming Season

Tractor Breakdown	Tractor Breakdown		When tractor breaks down	When tractor breaks down	
	Frequency	%		Frequency	%
Tractor breaks down	117	95.1	When ploughing	112	95.7
Tractor does not break down	6	4.9	Travel	5	4.3
Total	123	100	Total	117	100

Table 7 also summarizes tractor owners and operators responses about when their tractor broke down during the farming season. About 95.7% of the respondents stated that their tractor broke down when ploughing while 4.3% disclosed that their tractors broke down while travelling to and from the farm. It can be inferred that most of the tractor breakdown occurred during ploughing due to the stressful nature of the ploughing operation.

Out of the 117 tractor owners and operators who said that their tractor broke down at least once during the farming season, 86.3% reported that their tractor broke down between one and five times during the farming season (Fig. 5). About 25.6% of the respondents indicated that their tractor broke down once during the farming season; 26.5% revealed that their tractor broke down two times during the farming season; 13.7% pointed out that their tractor broke down three times during the farming season; 15.4% stated that their tractor broke down four times during the farming season while 5.1% reported that their tractor broke down five times during the farming season. The rest of the respondents (13.7%) said that their tractor broke down more than ten times during the farming season. From an economic viewpoint, tractor breakdown can be very costly as a result of loss of working time [4 cited by 5].

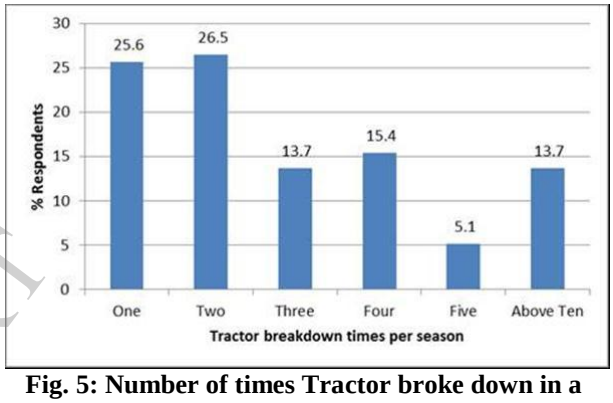

Fig. 5: Number of times Tractor broke down in a season

When asked about parts of the tractor that frequently break down, 37.4% of the tractor owners and operators indicated the hydraulic system (typically the hydraulic pump); 35.8% of the respondents stated the engine (main bearings, crankshaft bearings, piston, piston rings, liners, and crankshaft); 13.8% pointed out the tyre while 4.1% stated the belts. The remaining 8.1% indicated the transmission system (4.1%); electrical system (2.4%) and steering 2.4% (Fig. 6). A tractor operator can raise or lower heavy implements or control implement depth with a minimum of physical effort when the tractor has a hydraulic system [12]. Tractor engine problems due to poor servicing are very costly and time consuming especially, compared to the cost and time required for proper maintenance [13; 14].

3.4 Perception about causes of Tractor Breakdown at Tamale

The causes of tractor breakdown identified from the survey include careless tractor operation, inadequate maintenance, aged tractors, poor roads to farms and use of fake spare parts, and the presence of field obstacles (including stumps, roots, and buried stones). Table 9

presents the distribution of the causes of tractor breakdown as perceived by the tractor owners and operators. As shown in Table 9, 27.6% of the respondents identified careless tractor operation and inadequate maintenance as the cause of tractor breakdown. About 58.5% of the respondents attributed tractor breakdown causes to be: inadequate maintenance (13.8%); aged tractors (11.4%); poor roads to and from the farms (11.4%); careless tractor operation (8.1%); use of fake spare parts for tractor maintenance and repairs (13.8%). The remaining 13.8% of the respondents perceived field obstacles to be the cause of tractor breakdown.

Table 9: Perception about causes of tractor breakdown

Perception about cause of tractor breakdown	Frequency	%
Careless Tractor Operation & Inadequate Maintenance	34	27.6
Inadequate Maintenance	17	13.8
Aged Tractors	14	11.4
Poor Roads	14	11.4
Careless Tractor Operation	10	8.1
Fake Spare Parts	17	13.8
Obstacles	17	13.8
Total	123	100.0

Fig. 7 illustrates the field obstacles identified by the respondents to be responsible for tractor breakdown. They include stumps, roots and buried stones (56.1%); stumps and buried stones (27.6%); stumps and roots (13.0%), stumps alone (2.4%) and roots alone (0.8%). Chi-squared analysis did not show that tractor owners' perception about tractor breakdown differed significantly from those of the tractor operators (Chi-Sq = 7.897, DF = 6, P-Value = 0.246).

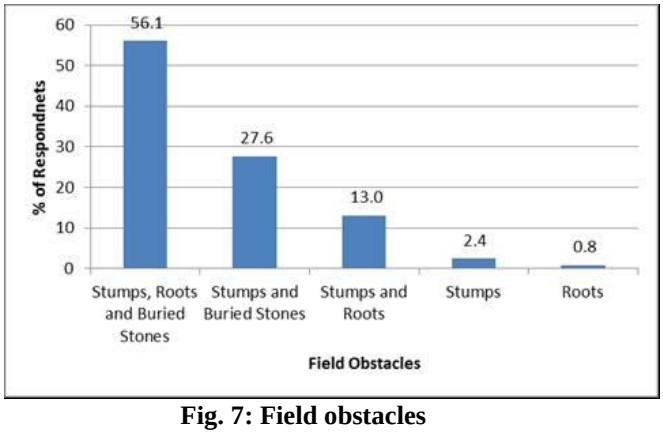

Fig. 7: Field obstacles

3.5 Use of Tractor Operators' Manual and Tractor Maintenance and Repairs

Tractor and tractor implement operator's manuals are the "oracle" on proper tractor operation and maintenance. Reading the operator's manual is important because it tells the owner or operator how to set the machine and what parts to check before one takes it to the field [15]. Tractor owners and operators were asked if they have access to their operator's manual. About 57.7% of the respondents said that they do have access to it while the remaining 42.3% indicated that they do not have access to their manual (Table 10). Furthermore, 78% of the respondents indicated that they do not follow the tractor manufacturer's instruction in the maintenance of their tractors while 22% reported that they follow the tractor manufacturer's instruction in the maintenance of their tractors.

Table 10: Tractor operators' manual and manufacturer's instruction

Access to Tractor Operator's Manual	Frequency	(%)	Manufacturer's Instructions	Frequency	(%)
Yes	71	57.7	Follow	27	22
No	52	42.3	Does not follow	96	78
Total	123	100	Total	123	100

Tractor owners and operators were asked to report on how they repair their tractor once it was broken down. Approximately 90.8% reported that they depended on tractor mechanics (way-side mechanics), 8.3% pointed out that they depended on their own experience while the remaining 0.9% said that they depended on their friends (Table 11).

Table 11: Tractor repair

Tractor Manufacturers Recommendation	Frequency	%
Depend on Tractor Mechanics	99	90.8
Own Experience	9	8.3
Depend on Friends	1	0.9
Total	109	100.0

3.6 Adulterated Fuel and Engine Oil

Survey participants were asked to indicate if they had unknowingly purchased adulterated fuel and engine oil. The distributions of tractor owners and operators responses to the question are presented in Table 12.

About 37.4% of the respondents reported having unknowingly purchased adulterated fuel while 62.6% said they had not made such purchase. Twenty three percent of the survey participants also reported that they had unknowingly purchased adulterated engine oil while 77% pointed out that they had not unknowingly purchased adulterated engine oil.

Table 12: Adulterated fuel and engine oil

Adulterated Fuel	Frequency	(%)	Adulterated Engine Oil	Frequency	(%)
Purchased Adulterated Fuel	46	37.4	Purchased Adulterated Engine Oil	28	23
Not Purchased Adulterated Fuel	77	62.6	Not Purchased Adulterated Engine Oil	95	77
Total	123	100	Total	123	100

Table 13 portrays responses of tractor owners and operators regarding the effect of adulterated fuel on tractor performance. Respondents provided a variety of responses. Overall, the respondents indicated poor engine starting, engine does not pull, black smoke from exhaust and fuel filters getting damaged. About 26.1% stated poor starting of engine in addition to the engine not pulling; 19.6% stated engine does not pull and 13% indicated poor engine starting, engine does not pull, and black smoke from exhaust. About 36.8% of the respondents provided various responses ranging from: poor starting (8.7%); poor starting, engine does not pull, black smoke from exhaust and fuel filters getting damaged (8.7%); engine does not pull, black smoke from exhaust and fuel filters get damaged (6.5%); engine does not pull and black smoke from exhaust (4.3%); poor starting, engine does not pull, and fuel filters get damaged (4.3%); and engine does not pull and fuel filters get damaged (4.3%). The remaining 4.3% said the tractor makes unusual noise when started.

Table 13: Effect of adulterated fuel on tractor performance

Effect of Adulterated Fuel	Frequency	%
Poor Starting and engine does not pull	12	26.1
Engine does not pull	9	19.6
Poor Starting, engine does not pull, and black smoke from exhaust	6	13.0
Poor Starting	4	8.7
Poor Starting, engine does not pull, black smoke from exhaust and fuel filters get damaged	4	8.7
Engine does not pull, black smoke from exhaust and fuel filters get damaged	3	6.5
Engine does not pull and black smoke from exhaust	2	4.3
Poor Starting, engine does not pull, and fuel filters get damaged	2	4.3
Engine does not pull and fuel filters get damaged	2	4.3
Other	2	4.3
Total	46	100

3.7 Tractor Mechanics and Well Equipped Repair Workshops

Table 14 shows the responses provided by the participating respondents on availability and proficiency of tractor mechanics at Tamale. Of the 123 tractor owners and operators, 96.7% said that tractor mechanics are readily available at Tamale (Table 14). Similarly, 96.7% of the respondents reported that the tractor mechanics are proficient. Only 3.3% of the respondents stated that the tractor mechanics are not proficient.

Table 14: Table: Availability of tractor mechanics

Availability of Tractor Mechanics	Frequency	(%)	Proficiency of Mechanics in Tractor Repairs	Frequency	(%)
Yes	119	96.7	Proficient	119	96.7
No	4	3.3	Not Proficient	4	3.3
Total	123	100	Total	123	100

Over 72.4% of the respondents perceived Tamale as having well-equipped tractor repair Workshops while 27.6 believed that Tamale did not have well-equipped tractor repair Workshops (Table 15). Table 15 also shows that only 18.7% of the tractor owners and

operators sought help outside Tamale for the repairs of their broken down tractors.

Table 15: Well-equipped tractor repair Workshop

Well Equipped Tractor Repair Workshop	Frequency	(%)	Seek help for Repairs Outside Tamale	Frequency	(%)
Yes	89	72.4	Seek Help	23	18.7
No	34	27.6	Does not Seek Help	100	81.3
Total	123	100	Total	123	100

3.9 Tractor Housing

Participating tractor owners and operators were asked to report on the type of housing they used for their tractors. About 54.5% of the respondents stated that they kept their tractors in the open while 27.6% disclosed that they kept their tractors in a shed. The remaining 17.9% revealed that they kept their tractor in a garage (Table 16). There are no conclusive data to prove the economic value of sheltering farm machines. Nevertheless, providing shelter is often associated with better care and maintenance of machines that can result in longer life, improved appearance, and better resale value. If shelter is provided, the cost of providing that shelter can be calculated. If no shelter is provided, there is probably an economic penalty associated with reduced machine life and/or resale value [16].

Table 16: Tractor housing

Tractor Housing	Frequency	%
Open	67	54.5
Shed	34	27.6
Garage	22	17.9
Total	123	100.0

3.10 Genuine and Fake Spare Parts

Table 17 shows the responses to the availability and affordability of genuine tractor spare parts at Tamale. Over 81.3% of the 123 respondents said that genuine spare parts were readily available while 18.7% stated that genuine spare parts were not readily available. However, 97.6% of the respondents reported that genuine spare parts were not affordable while only 2.4% thought that genuine spare parts were affordable (Table 17). Tractor owners and operators were asked whether they sometimes resorted to using fake ("imitation") spare parts for the repair of their tractor. Of the 123 respondents in the survey, 88.6% said they did while only 11.4% indicated that they did not use fake spare parts for the repair of their tractors.

Table 17: Genuine and Fake Spare Parts

	Genuine Spare Parts Available		Genuine Spare Parts Affordable		Use Fake Spare Parts	
	Frequency	(%)	Frequency	(%)	Frequency	(%)
Yes	100	81.3	3	2.4	109	88.6
No	23	18.7	120	97.6	14	11.4
Total	123	100	123	100	123	100

3.11 Access to Credit

Table 18 shows the respondents' responses to the question as to whether they had access to credit from banking institutions for the repair of their tractors. Over 77.2% of the tractor owners and operators reported that they did not have access to credit from banking institutions for the repair of their tractors while 22.8% stated that they did have access to credit from banking institutions for the repair of your tractor.

Table 18: Access to credit

Access to credit	Frequency	(%)
Yes	28	22.8
No	95	77.2
Total	123	100

4. Conclusion

Based on the results obtained, the following conclusion is drawn: Tractor ownership and operation in Tamale is male dominated. The mean age of tractor owner and operators was 43 years. Generally, the educational background of the respondents was low. The average operator had 17.7 years of experience. The majority of the operators (93%) learnt how to operate the tractor from other tractor operators rather than through a formal tractor operator training school. The most dominant tractor make used by the owners and operators was Massey Ferguson. About 95.1% of the respondents reported that their tractor broke down at least once during the farming season. Tractor owners and operators perceived the causes of tractor breakdown to be careless tractor operation, inadequate maintenance, aged tractors, poor roads to farms, use of fake spare parts for tractor maintenance and repairs, and presence of obstacles including stumps, roots, and buried stones in the farms. The study draws attention to the need for the provision of professional training in tractor operation, financial credit and after-sales-service to tractor owners and operators.

Acknowledgment

The authors are sincerely grateful to Mr. Iscandar Yakubu, Tamale, Ghana for kindly helping with the questionnaire administration.

References

[1] PAB Development Consultants Ltd and COWconsult (1995). Ghana Land and Water Management Project: A Study of Mechanised farming in Ghana, Ministry of Food and Agriculture, Accra.

[2] Hunt, D. (1983). *Farm Power and Machinery Management* , 8th Edition, 66-69. Ames, Iowa: Iowa State University Press.

[3] Witney, B. (1996). Choosing and Using Farm Machines, Land Technology Ltd., Edinburgh.

[4] Jacobs, C. O., W. R. Harrell, and G. C. Shinn. (1983). *Agricultural Power and Machinery*. New York: McGraw-Hill, Inc.

[5] Paman, U., Uchida, S., Inaba, S. and Kojima, T. (2007). A Survey on Causes of Tractor Breakdowns in Riau Province, Indonesia: A Case Study of Small Tractor Operations, Applied Engineering in Agriculture, 23(1): 43–48.

[6] Hunt, D. (1971). Equipment reliability: Indiana and Illinois data. *Transactions of the ASAE* 14(5): 742-746.

[7] Dodson, B. (1994). Determining the optimum schedule for preventive maintenance. *Quality Engineering* 6(4): 667-679.

[8] MINITAB Inc. (2007). MINITAB Statistical Software Release 15 for Windows. Minitab Inc. State College, Pennsylvania.

[9] Goel, M. (2007). The Importance of Education. Available online: http://searchwarp.com/swa230219.htm

[10] Bhutta, M.S., Tanveer, T. and Awan, H.M. (1997). Technical Skill of Tractor Operator: A Case Study in Multan, Pakistan. *Agricultural Mechanisation in Asia, Africa and Latin America*, 28 (1): 18–22.

[11] Hathaway, L. and Buckingham, F. (1980). *Fundamentals of Machine Operation: Preventive Maintenance*, Deere & Company, Illinois.

[12] Goering, C.E. and Hansen, A.C. (2004). *Engine and Tractor Power*, 4th Edition, American Society of Agricultural Engineers, St. Joseph, Michigan.

[13] Ehmke, V. (1986). Help your tractor live longer, *Soybean Digest*, April: 22, 23.

[14] Wertz, K., Grisso, R. and Von Bargen, K. (1990). A Survey of Agricultural Tractor Service Intervals – Part I, *Applied Engineering in Agriculture*, 6 (5): 537–541.

[15] Wehrspann , J. (2003). 10 biggest causes of machinery breakdowns (and how to prevent them), Available online: http://farmindustrynews.com/mag/farming_biggest_causes_machinery/

[16] Srivastava, A.K., Goering, C.E., Rohrbach, R.P. and Buckmaster, D.R. (2006) *Engineering Principles of Agricultural Machines*, (2nd edn), American Society of Agricultural and Biological Engineers, Michigan.