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Mechanization and Agricultural Productivity Functions in Umuahia North LGA, Abia, Nigeria

Bello R. S.[1, *], Onyeanula P.[1], Saidu M.J.[2], Bello M. B.[3]

[1]Department of Agricultural & Bio-Environmental Engineering Technology, Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria
[2]Department of Agriculture & Bio-Environmental Engineering, College of Agriculture, Jalingo, Nigeria
[3]Department of Agricultural Economics and Management, Federal College of Agriculture, Ishiagu, Nigeria

Email address:

segemi2002@gmail.com (Bello R. S.), paulrhema2@gmail.com (Onyeanula P.), msjauro2020@gmail.com (Saidu M. J.), mojirayobello@yahoo.com (Bello M. B.)

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Abstract: Index of mechanization and other productivity functions were used as indicators in assessing the impact of mechanization on agricultural production in Umuahia North LGA of Abia state, Nigeria. Analysis of research findings revealed that farmers in the area are predominantly small scale farmers with the major power source being human being. The level of agricultural mechanization was determined by a relationship between the various sources of farm power and the level of human involvement in each operation while the mechanization index was determined for the two identified sources of farm power; human and mechanical. Low level of mechanical power input, underutilization of available mechanical power and reliability on human power in most of these areas contributed to low production efficiency, low level of mechanization (37.12%) and high MI average of 96.59%.

Keywords: Mechanization Index, Utilization, Production, Mechanical, Power

1. Introduction

Generally, agricultural mechanization involves the selection, operation, utilization, and maintenance of mechanical devices and systems in agricultural operations their management in crop production in agriculture for the utmost benefits of man (Almasi *et al*., 2005, Fadavi *et al*., 2010). Mechanization of agriculture is recognized as one of the greatest engineering achievements of the 20th century. The introduction of agricultural technology, including mechanization, is a complex process. Assessment tool and prediction models depend very much on country's specific economic characteristics, level of development, and the agriculture sector. This implies that the assessment tools and prediction models cannot be prescribed in a simple set of guidelines. Mechanization does not involve only machining of agricultural operations; rather it involves every effective factor in energy utilization, economic management and sustainability of farming systems.

2. Challenges of Mechanization in Nigeria

The agrarian structure of Nigerian agriculture has failed to make adequate contributions to the nation's economic development (Mrema and Odigboh, 1993). This failure of agricultural industry especially in farm settlement schemes can be attributed to the absence of appropriate level of mechanization. Anozodo (1985) observed that the application of human, animal and mechanical equipment in agriculture with reference to technical, socio-economic and cultural constraints of farm can be acknowledged in the continuing official promotion of primitive hand tool technology characterized by low productivity. FAO (1981) affirmed that Nigeria as a nation from the first decade of the country's independence in 1960 had experienced failure in improving the farm mechanization through various agricultural policies that have been implemented.

Comparing human power, animal power and engine power ratio with the world outlook on agricultural production in Latin America, Africa and Nigeria, Latin America has 59%, 89%, 90%, Africa has 89%, 10%, 1% and Nigeria 90%, 8%, 2% respectively (Odigboh, 1991, Oni, 2003). From the foregoing, it is clear that the extent of mechanization in Nigeria is still very low; 86% human power, 4% draught animal power and 10% mechanical (engine) power (Oni, 2003). Human power remain all the time high in Nigeria while engine power remain significantly lower than the Latin America. The current level and practice of agriculture is characterized by low level of acquisition, distribution and utilization of farm machinery and associated implements for farm operations.

The agro-ecological variations ranging from humid in the tropics and subtropics of the southern coastal regions to arid in the northern regions towards the Sahara Desert are known have overriding influence on the mechanization patterns found in the various agricultural zones. The climates, low precipitation and high temperatures increased the difficulty to achieve a sustainable soil/cropping system that preserves the soil (FAO, 1995b). This implies that, different tillage systems, using different means of mechanization and implements, are used in the various agro-ecological zones of Nigeria.

Until lately (about year 2009), Nigeria has not been able to define the economic role of sustainable agricultural mechanization that can transform the experimental phase presently existing in the farm settlement schemes and pilot projects to a sound commercial production mechanism. The nation can achieve this goal through accelerated food production by increasing both labour and land productivity as well as expanding areas of cultivated land-one of the objectives of agricultural transformation agenda (ATA). The expectation of these innovations was to provide for the farmers certain production conditions that will be technically feasible and socio-culturally compatible with production technology that will be well sustained.

The formulation of an assessment tool requires prediction models and comprehensive knowledge of many aspects of agriculture in its widest sense (Olaoye and Rotimi, 2010). Therefore the main objective of this research work is to evaluate the index of agricultural mechanization and its implications to farm productivity in major farming communities of Umuahia North Local government Area of Abia state, Nigeria. This paper provides a platform for better understanding of assessment tools and models for prediction of different levels of mechanization in an area to address the major issues involved and for strategy formulation.

3. Research Methodology

3.1. Study Area and Geographical Description

The study was conducted in Umuahia North Local Government Area of Abia state, located within latitude 5° 20' and 30 N, of equator and longitude 7° 40', and 7° 50' E of the Greenwich meridian. It is located in the South – East agro-ecological zone of Nigeria. Umuahia North LGA is characterized with wet climate zone with a heavy rainfall of (2500-3000) mm per annum, temperature range of 29°-38°C and high relative humility of 89%. It is a topographic land with a maximum height of 150 meters above sea level.

The study areas comprises of the following communities; Okaiuga, Afugiri, Umuda, Ossah, Amuzukwu, Ugba, Afara, Ajata Isieke, Ibeku, and Ikwuano, eleven (11) communities. The major crops grown in the area include cassava, yam and vegetables. The animals reared include goat, sheep, fishery, poultry and piggery. Non-agricultural activities in the areas are petty trading, salons, barbing, vulcanizers and civil service.

3.2. Data Collection and Sampling Method

Data were collected through primary and secondary sources. The primary data was collected by site visit and field interaction with the farmers based on local condition (participatory rural appraisal) (PRA) and through administration of structured questionnaire (Busha and Harter, 1980; Gittinger, 1982; Gomez and Gomez, 1984). The questionnaire covered the general background information of the selected farm settlement, land preparation /tillage operation aspects and the identified type of machineries involved, planting/transplanting aspect, weeding/fertilizer application aspects, harvesting operation aspects, processing and storage aspects, farm transportation and handling aspects, and tractor operators/repair and maintenance. Secondary data were principally collected from agro-service centers responsible for agricultural development project and agencies. Various indices of measurement of agricultural mechanization and productivity were defined for the purpose of the investigation. Other secondary data was based on results of published works in journals, seminar papers, conference paper etc.

Random sampling technique was used within the study centers for the selection of production and processing operations (Busha and Harter, 1980; Gittinger, 1982; Gomez and Gomez, 1984). Random selection of thirty (7) farmers; five (5) from each community, which makes a total of sixty (70) respondents was carried out.

3.3. Method of Data Analysis

The collated data was analyzed using descriptive statistics and budgetary techniques to investigate the involvement and effect of agricultural mechanization on agricultural production in 11 communities in Umuahia North LGA. The results were analyzed using percentages. Descriptive statistics such as percentages and frequencies is used to describe the socio-economic characteristics of the respondents, identify the different levels of technology and identify the constraints to agricultural mechanization. The level of agricultural mechanization was established using established relationship between the various source of farm power and the level of human involvement.

3.4. Determination of Mechanization Index

Mechanization index, (MI), represents the percentage of total work done by the tractors in the area, total of human work and that of the machinery, expressed in percentage calculated using Equation 2 above. This index presents the measure of the assessment and grading of the different levels of mechanization practiced in a particular area. Relative to different power sources predominant in an area or region, mechanization index is seen as a deviation of the actual amount of motorized farm work from the normal values at regional level. Agricultural mechanization index, (MI) based on the use of human and mechanical energy inputs, represents the percentage total works of tractor, human and that of the machinery and is calculated using the following relations (Aragón-Ramírez et al., 2007; Bello, 2012);

$$MI_E = \frac{E_M}{E_H + E_M} \text{x } 100\% \quad (1)$$

Where

E_M = Energy from mechanical operation (kWhr/ha)

E_H = Energy from human operation (kWhr/ha)

By implication, E_H parameter is determined based on the exact response of the average farmers in the surveyed areas on the estimated resting period in minute per hour of work on each manual operation.

3.5. Measurement of Labour Productivity (Machine and Human)

The productivity of machine and human labour could be determined based on the principle of production schedule which represent the maximum amount of output that can be produced from any specific set of inputs given the existing technology. The productivity of labour, machine and total productivity were expressed mathematically by Ortiz-Canavate and Salvador, (1980) as presented in the following equations:

$$A_M = \frac{1}{E_M} \quad (2)$$

$$A_H = \frac{1}{E_H} \quad (3)$$

$$\Rightarrow A_T = \frac{1}{E_M} + \frac{1}{E_H} \quad (4)$$

Where:

A_M = Productivity of machines, defined as the work carried out as a function of the machinery employed

A_H = Productivity of labour, defined as the work carried out as a function of labour employed

A_T = Total productivity and all other terms as defined previously.

The level of labour productivity for each farm settlement was determined as an inverse of the work outlay of the explicit factors involved in production function (capital or machine and labour).

3.6. Profitability of Crop Production

This could was determined using the difference between the total revenue and the total cost of investment obtained from the expression given by Jhingan, (1997) and Olaoye and Rotimi, (2010).

$$GM = TR - TC. \quad (5)$$

Where:

GM = Gross margin/gross profit value;

TR = Total revenue, expressed as (TR = P x Y);

P = Price;

Y = Yield tons/ha or kg/ha;

TC = Total cost, expressed as (TC = FC+VC);

FC = Fixed cost and

VC = Cost of the variable inputs

Note: Values of all farm labour should be based on the variable inputs (i.e. the prevailing agricultural wages per day) and outputs (i.e. the prevailing market prices) based on the conditions as at the time of the analysis.

4. Results and Discussion

4.1. Results

From the analysis of the returned questionnaires, the outcome showed that of the 70 questionnaires administered, 60 were returned and these were used for the purpose of analysis. The majority of the respondents were male (60%) implying that agricultural production is gender specific in the area.

Table 1. *Respondent gender.*

Sex	Frequency	Percentage
Male	36	60
Female	24	40
Total	60	100

Source: Field survey, 2012

Majority of the farmers in the study area are individual farm owners rather than farm scheme settlers and do not have formal education, a possible reason for the predominantly higher human power involvement in agricultural production.

4.2. Power Utilization Outlay

The work outlay (LM: machines, LH: Human labour) were determined for various communities and Tables 2 and 3 presents various work outlays for the power sources investigated.

Table 2. *Outlays for the mechanical power source.*

Operations	Okaiuga	Afugiri	Umuda	Ossah	Amuzukwu	Ugba	Afara	Ajata Isieke	Ibeku	Ikwuano
	Work output									
Ploughing	7	10	9	6	8	5	3	11	5	10
Harrowing	7	10	9	6	8	5	3	11	5	10
Ridging	2	5	6	3	4	3	3	9	3	9
Planting	-	-	-	-	-	-	-	-		-
Herbicides	-	-	-	-	-	-	-	-	-	-
Fertilizer		-	-	-	-	-	-	-	-	
Harvesting	7	10	9	6	8	5	3	11	5	10

Mechanical operations were restricted only to tillage operations such as ploughing, harrowing and ridging. Other operations like planting, weeding, fertilizer/herbicide application and harvesting are manually done. This is because of the subsistent level of agricultural production practiced in the area.

Table 3. *Outlays for human power source.*

Operations	Okaiuga	Afugiri	Umuda	Ossah	Amuzukwu	Ugba	Afara	Ajata Isieke	Ibeku	Ikwuano
	Work output									
Clearing	42	45	43	53	55	58	58	54	56	49
Manual tillage	43	53	55	58	58		43	53	58	58
Weeding	-	-	58	54	49	56	54	49	-	-
Planting	-	-	-	-	-	-	53	55	-	-
Herbicides application	54	49	56	49	-	43	53	55	58	-
Fertilizer application	49	-	43	58	58	54	49	-	49	56
Harvesting	58	58	54	-	58	54	-	-	55	58

4.3. Level and Index of Agricultural Mechanization

The results of levels and index of mechanization for each community was determined using mathematical equations as presented in Table 4. This table shows that as index of mechanization increase, energy input per land area in hectare by human work is greater than the energy input of machine. This is because great work capacity and more time of utilization of the human work are needed for the same area.

Table 4. *Table of level and index of mechanization.*

Community	Ta (ha)	T_{tp} (kW/ha)	T_{hp} (kW/ha)	ΣMa (kWhr/ha)	ΣHa (kWhr/ha)	$ΣE_T$ (kWhr/ha)	LOM (%)	MI
Okaiuga	120	88.25	1.8	5295	108	5403.0	55.31	0.9800
Afugiri	98	88.25	1.8	5295	108	5403.0	45.02	0.9800
Umuda	150	94.2	1.8	5652	108	5760.0	47.10	0.9813
Ossah	186	88.25	1.9	5295	114.0	5409	23.73	0.9789
Amuzukwu	148	88.25	2.0	5295	120.0	5415.0	29.82	0.9789
Ugba	134	88.25	1.7	5295	102.0	5397.0	32.93	0.9811
Afara	167	88.25	1.6	5295	96.0	5391.0	26.43	0.9822
Ajata Isieke	147	75.00	1.8	4500	108	5403.0	38.27	0.8329
Ibeku	110	88.25	1.7	5295	102.0	5397.0	40.12	0.9811
Ikwuano	136	88.25	1.6	5295	96.0	5391.0	32.45	0.9822
Total average	**139.6**	**87.52**	**1.77**	**5251.2**	**106.2**	**5436.9**	**37.118**	**0.9659**

Where Ta= Total area of land cultivated (ha)
T_{tp}= Total actual tractor power (kW/ha)
T_{hp}= Total human power (kW/ha)
$ΣE_M$= Ave sum of mechanical operation (kWhr/ha)
$ΣE_H$= Ave sum of human operation (kWhr/ha)
$ΣE_T$= Sum of all human + mechanical operation (kWhr/ha)
LOM= Level of mechanization (%)
MI= Index of mechanization

The study revealed that low production efficiency, drudgery and low patronage of mechanical power such as tractor and implements, contributed to low levels of mechanization within the locations with the highest level of 55.13% recorded for *Okaiuga* and least of 26.43% recorded for *Afara. In all the locations, the index of mechanization is all time high with Ikwuano having the highest index of 0.9822 while* Ajata Isieke *recorded the least MI of* 0.8329. The reason for this value in the rea was as a result of low utilization of mechanical power of 4500 (kWhr/ha).

4.4. Productivity Levels

Table 5 shows the inverse relationships of the work outlay as an explicit factor of production functions in the areas under survey. From the table, the average productivity level of mechanical power involvement is significantly low

(0.0002) compare to human labour productivity (0.0077). This implies more human efforts were employed in production than machines. Which also confirms the low level of mechanization.

Table 5. *Productivity levels each farm settlement.*

Community	ΣA_m (Ha/kWhr)	ΣA_H (Ha/kWh)	ΣA_T (ha/ kWhr)
Okaiuga	0.00019	0.0093	0.00949
Afugiri	0.00019	0.0093	0.00949
Umuda	0.00018	0.0093	0.00948
Ossah	0.00019	0.0050	0.00519
Amuzukwu	0.00019	0.0083	0.00849
Ugba	0.00019	0.0010	0.00119
Afara	0.00019	0.0104	0.01059
Ajata Isieke	0.00022	0.0093	0.00952
Ibeku	0.00019	0.0010	0.00119
Ikwuano	0.00019	0.0140	0.01419
Total ave	0.0002	0.0077	0.0079

4.5. Gross Margin Analysis

The gross margin analysis established for the assessment of the average physical productivity (crop yields) and the returns on resources employed in agricultural production on major available crops in each of the area reflects a non-declining yield over time while the destruction of natural capital is avoided in each of the farm settlement studied.

The prevalence of small size of farm holdings of (2 - 4) ha of the farmer has encouraged the intensity of continuous cultivation on the same piece of land which does not permit good cultural management practices like crop rotation/shifting cultivation. Therefore, intensity of cultivation on the same plot had resulted in loss of soil fertility together with absence of soil and moisture conservation. The uniformity of the pattern and size of farm cultivated in each community shows that for the same rate of agronomic inputs, the total cost of production inputs, including the cost of performing field operations was found to be N64, 580 per hectare for the selectively mechanized system, (N 199 = $1).

5. Conclusion

The study revealed that low production efficiency, high drudgery, underutilization of mechanical power; all these contributed to low level of mechanization with the highest level of 55.5% for Okaiuga and least level of 26.23% for Afara and an average MI in the LGA was 96.59%.

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