Measurement of agricultural mechanization index and analysis of agricultural productivity of farm settlements in Southwest Nigeria

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Abstract: The levels of agricultural mechanization on some farms in two states in Southwest of Nigeria were measured and the productivity of each of the surveyed farms was analyzed. Factors that lead to profitability of farm activities and whole farms were deduced. Structured questionnaire was used to establish the socio – economic characteristics, educational level, and technical knowhow of the farmers. The inventory of the farm machinery was also established at each of the farm settlements visited. Agricultural mechanization index was used to evaluate the level of agricultural mechanization while the level of productivity for each farm settlement was determined as an inverse of the work output of the explicit factors involved in production function (capital or machine and labour). Profitability of activities was measured in terms of gross margin and of whole farms. This was measured subjectively as net benefits of physical productivity (crop yield) and the returns from the resources used during production activities. The results of the farm mechanization index revealed that the average level of mechanization in Ogun and Osun States was 31.3% and 28.6%, respectively and the average level of mechanization in the two States was 30.6% while the total productivity ranges between 0.0115 ha/kWh and 0.0951 ha/kWh. The average physical productivity (crop yield) on maize ranges between 1.2 to 1.7 tons/ha and that of cassava was about 11.5 tons/ha in the two states. The sustainability analysis of the schemes indicated that inconsistency in agricultural mechanization policy, lack of favorable conditions for full integration of agricultural mechanization, lack of essential infrastructure and financial credits among other variables explained the observed low spectrum in the scale of production.

Keywords: agricultural mechanization, mechanization index, agricultural productivity, farm settlement, farm machinery, settlement, sustainability

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1 Introduction

Tools, implements, and powered machinery are essential and major inputs to agriculture. The term mechanization is generally used as an overall description of the application of these inputs (Clarke, 2000). The level, appropriate choice and subsequent proper use of mechanized inputs into agriculture has a direct and significant effect on achievable levels of land productivity, labour productivity, the profitability of farming, the sustainability, the environment and, on the quality of life of people engaged in agriculture.

Starkey (1998) defined farm mechanization as the development and introduction of mechanized assistance of all forms and at any level of sophistication in agricultural production to improve efficiency of human time and labour. The present state of mechanization in Nigeria agriculture is still far from increasing the rate of farming earnings and productivity. This is because mechanization plan has not been formulated following a well designed, reliable and thorough analysis (Nwoko, 1990). Tropical agricultural mechanization involves the use of tools, implements and machines to improve the efficiency of human time and labour. The most appropriate machinery and power source for any

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operation depends on the work to be done, cultural settings, affordability, availability and technical efficiency of the options. These indications were clearly evident that agricultural mechanization is not an end in itself, but a means of development that must be sustained. Therefore a socially beneficial agricultural production is determined based on a wide range of social, economic and ecological factors. These factors determine whether a technology is practicable, beneficial, or sustainable in an area.

Tooy and Murase (2007) researched extensively on the behavioral interest identification for farm mechanization. The objectives were to identify and explain the predictor and the most important variables of perceptional and behavioral characteristics of young people to the interest in farming jobs and farm machines in a region. Path analysis and neuro-fuzzy models were developed to take advantage of both techniques to explain the causal reasoning, nonlinear representation, and the human-likeness reasoning of the imprecise behavioral and perceptional data. Aragón-Ramírez et al. (2007) used a single hidden layer artificial neural network (ANN) model to estimate simultaneously two mechanization indicators: Mechanization Index (MI) and Machinery Energy Ratio (MER) to characterize a group of farms in a target farming region in Mexico.

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 an appropriate level of agricultural mechanization. Anozodo et al., (1986) observed that the application of human, animal and mechanical equipments 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 production efficiency. 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 were implemented.

Ou et al. (2002) reported that agricultural mechanization as system engineering requires not only advances in machine development and applications but also the close cooperation of many sections. In recognition of this fact, certain environmental, agricultural, social and economic conditions must be ascertained to favour investments in mechanization technologies and their sustainable use. Timeliness of tillage and planting, weeding and/or harvesting are critical factors where affordable labour is insufficient to permit timely operation. Other key factors that influence successful mechanization include Socio-economic factors, supporting infrastructure, land and other agro-ecological conditions, technical skills and service (Olaoye, 2007).

Ozmerzi (1998) affirmed that the agricultural mechanization level of a country in terms of kW/ha, ha/tractor, number of tractors/1,000 ha, equipment weight/tractor, and mechanical power/total power. The current level and practice of agriculture in Nigeria is characterized by low level of distribution and utilization of farm machinery and associated implements for farm operations. Odigboh (1991) reported that the strategy for a shift from the traditional concept of primitive tools and technology to achieving sufficiency in food could be undertaken through the development of farm settlement schemes in rural communities. The expectation of these innovations was to provide for the farmers with certain production conditions that will be technically feasible and socio-culturally compatible with production technology that will be well sustained.

Up till now, 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 to a sound commercial position. Nigeria needs to embark on sustainable mechanization because currently there is national awareness on the immense potential of agriculture in boosting the economy of the country. 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. The main objective of this research work is to evaluate the level of agricultural mechanization application and farm productivity of some selected farm settlements in Nigeria.

2 Materials and methods

All the existing state owned farm settlement schemes in Ogun State which includes Ajegunle, Ado-odo, Ibi-ade, Ikenne, Ilewo-Orile, Coker, Ago-Iwoye, and Sawonjo, and those in Ondo State includes Onisere, Okiti-pupa, Ile-Oluji, Imariwo, and Ifon-Isobe were surveyed (Figure 1). Ogun State lies at latitude 6°10'0″N, and longitude 4°42'0″E while Ondo State lies at latitude 5°45'0″N and longitudes 4°20'0″E. Ondo's land area is about 15,500 square kilometers. Ondo State is neighboured by the states of Edo and Delta on the east, by Ogun and Osunon the west, by Ekiti and Kogi on the north, and by the Bight of Benin and the Atlantic Ocean to the south. Both states have annual rainfall of 1,150 mm. The average temperature ranges from 30 to 31℃. There are two growing seasons due to bimodal pattern of rainfall distribution. The first growing season is from late March to late July while the second season begins in late August and ends in December. There are two types of dominant vegetation: thick tropical rainforest and tropical secondary forest.

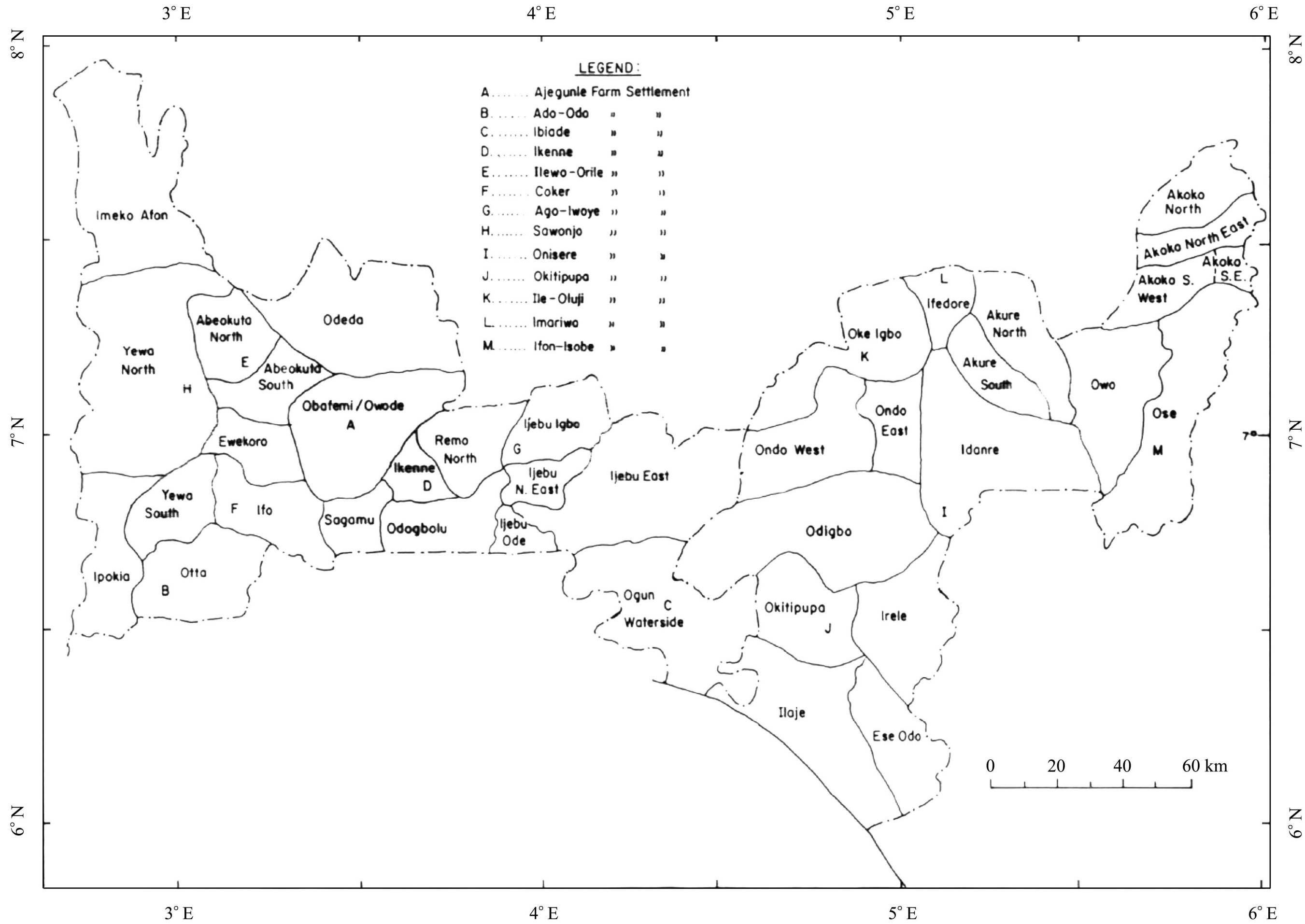

Figure 1 Map of the surveyed areas: Ogun State and Ondo State

2.1 Instruments used for investigations and measurements

Primary data were collected through administration of questionnaire. The questionnaire was structured following Gittinger (1982). The questionnaire covered the general background information of the selected farm settlements, technical aspects involved in setting up the existing farm settlements, institutional – organizational management techniques, land preparation/tillage operation aspects, the identified types of machinery involved, planting/transplanting aspects, weeding/ fertilizer application aspects, harvesting operation aspects, processing and storage aspects, farm transportation and handling aspects, and tractor operators/repair and maintenance. The last section of the questionnaire is on the livestock production. The questionnaire also delved down into information on the socio-economic characteristics of the farmers such as age, level of education, hired/family labour contributions, availability of farm resources (land, labour, capital, and modern management). Questionnaires were administered at the farmers' farms and their residences. Information on socio – economic characteristics, educational level, and technical knowhow of the farmers were garnered. The inventory of the farm machinery was also established. Interactive sessions with the farmers in groups at all the farm settlements were first conducted before individual interviews. Secondary data were principally collected from agro-service centres responsible for each settlement in states of Ogun and Ondo Agricultural Development Project. Various indices of measurement of agricultural mechanization and productivity were defined for the purpose of the investigation.

3 Measurement of agricultural mechanization index

3.1 Degree of agricultural mechanization

According to Nowacki (1974), the assessment of the grading of the level of mechanization was: hand tools (M_1) = 1, animal drawn (M_2) =2, Tractorized (M_3) = 3.

For the purpose of this research study, the index of mechanization is limited to the prominent available power sources in the Western zone, Nigeria (M_1 and M_3). The degrees of mechanization at the two available power sources were defined as follows:

Degree of Mechanization M_1 is the average energy input of work provided exclusively by human power (labour) per hectare: it is indicated as described by Nowacki (1974);

$$L_H = 0.1.\ N_H.\ T_H / A \qquad (1)$$

where, L_H = average energy input or work provided per hectare by human labour kWh/ha; N_H = average number of labour employed; T_H = average rated working time devoted to manual operation; 0.1= Theoretical average power of an average man working optimally; A = Area of land cultivated (ha).

A was determined for each farm settlement by multiplying areas of cultivated land in hectare allocated to each participating farmer by the total number of farmers, and T_H was determined as a function of rate of energy consumption and resting period for different manual operations (planting, weeding, fertilizer application, and harvesting).

According to Caruthers and Rodriguez (1992), resting period t_R was defined as follows:

$$t_R = 60(1-250/P) \qquad (2)$$

where: t_R = required resting time for 8 hrs effective working hrs per day in minute per hour of work; P = rate of power consumption in watts for various farming activities.

Degree of Mechanization M_3 represents the first degree of mechanization, motorized machinery coexisting with a high participation of operators (Nowacki, 1974). It is indicated as;

$$L_M = 0.2.\ N_M - T_M/A \qquad (3)$$

where: L_M = Average energy input or work per hectare by motorized machines; 0.2 = Corrector co-efficient of the tractor-powered machine; N_M = Rated working power of the tractor (kW); T_M = Rated working time of the motorized energy source, hr/ha; A = Area worked in hectare by motorized machines.

$$\text{Effective field capacity } C = \frac{SWE_f \ ha/hr}{10}$$

$$\text{(Kepner et al. 1978)} \qquad (4)$$

$$T_M = 1/C \qquad (5)$$

where: C = Effective field capacity, ha/hr; W = Width of cut of implements, m; E_F = Field efficiency, %; S = Operating speed, m/s.

$$D_{BP} = S.D/3.6 \text{ (kW)} \qquad (6)$$

where: S = Operating speed, m/s; D = Draft, representing total force parallel to the direction of travel required to propel the implement KN/m.

$$Nm = D_{BP}/0.74 \text{ (kW)} \qquad (7)$$

where: 0.74 is the average value of the tractive and transmission coefficient on firm soils ranging from 0.73 to 0.75 for 80% loading as characterized by the textural soil type of the surveyed areas.

3.2 Determination of index of mechanization

Mechanization index (MI), represents the percentage of work of the tractors in the total of human work and that of the machinery. It was calculated using Eqation (8) (Nowacki, 1974);

$$W_{ME} = L_M / L_T \cdot 100\% \tag{8}$$

where: W_{ME} = Mechanization index, %; L_M = Average sum of all mechanical operation work of the machine, kWh/ha; L_T = Sum of all average work outlays by human and tractor powered machines, kWh/ha.

$$L_T = L_M + L_H \tag{9}$$

Parameters for T_H and L_H were 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.

3.3 Measurement of the productivity of machine and human labour

Productivity may be conceived of as a measure of the technical or engineering efficiency of production which is characterized by a shift of the production function and a consequent change to the output / input relation. 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 input of labour and capital are the explicit independent variables in the production function measured in terms of a man-hour and in a machine-hour, which are related by Equation (10) (Jhingan, 1997).

$$Q = F(K, L) \tag{10}$$

where: Q = the output; F = functional relationship; K = the amount of capital; L = the amount of labour.

The productivity of labour, machine, and total productivity were obtained from Ortiz-Canavate and Salvador (1980) as presented in Equation (11) to (13)

$$A_M = 1/L_M \tag{11}$$

$$A_H = 1/L_H \tag{12}$$

$$A_T = 1/L_H + 1/L_M \tag{13}$$

where: A_M = Productivity of machines, defined as the work carried out in function of the machinery employed; A_H = Productivity of labour, defined as the work carried out in function of labour employed; A_T = Total productivity and all other terms as defined previously.

3.4 Gross margin analysis for the production of major arable crops (Maize & Cassava) in the surveyed areas

The profitability was determined using gross margin analysis. The gross margin is obtained from the expression given in Equation (14) by Jhingan(1997).

$$(G_M) = T_R - T_C \tag{14}$$

where: G_M = Gross Margin/gross profit value; T_R = Total revenue ($P \times Y$), P = Price, Y = Yield tons/ha or kg/ha, T_C = Total Cost (F_C+V_C), F_C = Fixed Cost, V_C = Cost of the variable inputs.

Values of all farm labour were based on the prevailing agricultural wages per day and the prevailing market prices were used for variable inputs and outputs. These were estimated on the probable rates of returns based on the conditions as at the time of the study.

4 Results and discussion

4.1 Socio-economic characteristics and demographic data of the farm settlers

The majority of the farmers in the schemes are above 40 years of age. About 63% of the farmers are illiterate (Table 1). This influences their level of awareness of adopting new innovations, which can create motivation to change, and enhance productivity. Negligence and radical departure from the planned scheduled of operation in the policy of farm settlement schemes in the aspect of provision of available mechanization inputs for production and other services which are supposed to be generally handled cooperatively to secure greater efficiency are now basically the responsibility of individual settlers.

Table 1 Relative distribution of educational level in the research study areas: Ogun and Ondo States farm settlement schemes

Name of farm settlement	Total number of settlers	Educational level			
		NIL	Primary school	Secondary school	Tertiary level
Ogun State					
Ajegunle	60	39	11	8	2
Ado-Odo	130	83	34	10	3
Ibi-ade	59	35	13	9	2
Ikenne	38	22	11	4	1
Ilewo-orile	44	31	8	3	2
Coker	153	98	36	15	4
Ago-Iwoye	126	79	33	12	2
Sawonjo	72	47	16	8	1

Name of farm settlement	Total number of settlers	Educational level			
		NIL	Primary school	Secondary school	Tertiary level
Ondo State					
Onisere	95	53	34	6	2
Okiti-pupa	80	50	19	8	3
Ile-Oluji	48	32	10	4	2
Imariwo	32	21	6	4	1
Ifon-Isobe	29	19	7	2	1
Ground Total	966	609	238	93	26
Overall Percentage/%		63	24.60	9.60	2.80

4.2 Index of agricultural mechanization

The practice of selective mechanization was prominent in all the farm settlements. Mechanical operations were restricted only to tillage operations such as ploughing, harrowing and ridging. Other operations like planting, weeding, fertilizer application and harvesting are manually done. This is because of the deficient standardization and non-availability of mechanization inputs to serve the whole scale of production. This is an indication that the schemes age long practice has not witness visible application of modern technique. The study revealed that low production efficiency, drudgery, under utilization of mechanical power, and uses of old tractors with its attendant constant break down during operation, contributed to low level of mechanization with the highest level of 40.3% for *Ajegunle* and least level of 27.6% for *Ado-Odo*. The work outlay (L_M: machines, L_H: Human labour) were determined for various farm settlements and Table 2 presents various work outlays for the power sources investigated. The timeliness in operation for tractor power was determined by giving consideration to the width of cut (W) of the implement, operating speed, and machine efficiency. While for human labour, T_H, were determined by giving consideration to total resting period per hour of work per day as expressed in Equation (2). The index of mechanization for each farm was determined using Equation (3) and the result is presented in Table 3. Table 2 and 3 show 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 2 Energy used for mechanical operations in Ogun and Ondo States (kWhr/ha)

Farm Operations	Farm settlements (Ogun State)							
	Ajegunle	*Ado-Odo*	*Ibi-ade*	*Ikenne*	*Ilewo-orile*	*Coker*	*Ago-Iwoye*	*Sawonjo*
	Work Output							
Ploughing	0.06359	0.0245	0.0593	0.0837	0.0445	0.0277	0.0252	0.0442
Harrowing	–	0.0151	0.0323	0.0516	–	0.0171	0.0156	0.0272
Ridging	–	0.0038	0.0085	0.0134	–	0.0044	0.00396	0.0069
Planting	2.5	3	2.4	2.1	3.5	2.5	2.8	2.4
Herbicides Application	4.9	5	4	4	6	6	4.5	5
Fertilizer application	3.3	2.8	3	2.5	3.2	2.5	4	3.2
Harvesting	9	9	9	10.8	9	6	7	6
	Farm settlements (Ondo State)							
	Onisere	*Okiti-pupa*	*Ile-Oluji*	*Imariwo*	*Ifon-Isobe*			
Ploughing	0.0335	0.0397	0.0663	–	–			
Harrowing	0.02064	0.0245	0.0409	–	–			
Ridging	0.0053	0.0063	0.0104	–	–			
Planting	2.5	3	2.5	–	–			
Herbicide Application	4	5	5.5	–	–			
Fertilizer application	3.6	3.6	3.2	–	–			
Harvesting	9	7	7.5	–	–			

Table 3 Summary of the level of mechanization in relation to total output power, human productivity, machine productivity and total productivity per unit areas of cultivated land

Farm settlements	Area of land cultivated for arable crops/ha	Total actual tractor power /kW • ha^{-1}	Total human power /kW • ha^{-1}	Total output power /kW • ha^{-1}	Level of Mechanization /%	Productivity of machine A_M /ha • kWhr^{-1}	Productivity of human labour A_H /ha • kW/hr^{-1}	Total productivity A_T/ha • kWhr^{-1}
Ajegunle	200	94.2	1.8	96	40.3	0.0158	0.01064	0.0427
Ado-Odo	520	88.25	1.9	90.15	27.6	0.0689	0.0262	0.0951
Ibi-ade	236	88.25	1.6	89.85	28.8	0.0316	0.0128	0.0444
Ikenne	152	88.25	1.8	90.05	27.8	0.0216	0.0078	0.0294
Ilewo-Orile	88	94.2	2	96.2	36.9	0.0069	0.0046	0.0115
Coker	459	88.25	1.8	90.05	29	0.0611	0.0249	0.086
Ago-Iwoye	504	88.25	1.6	89.85	29.2	0.067	0.0275	0.0945
Sawonjo	288	88.25	1.8	90.05	31.2	0.0383	0.0174	0.0557
Onisere	380	88.25	1.8	90.05	28.3	0.0505	0.0199	0.0704
Okiti-Pupa	320	88.25	1.9	90.15	28.8	0.0426	0.0172	0.0598
Ile-Oluji	192	88.25	1.9	90.15	28.7	0.0255	0.0103	0.0358
Imariwo	—	—	—	—	—	—	—	—
Ifon-Isobe	—	—	—	—	—	—	—	—

4.3 Productivity

Productivity of the machine and labour were determined using Equation (11) to (13). The variability between productivity was compared to the areas of cultivated land and index of mechanization for each farm to identify the contribution and efficiency of the variable input power sources in terms of returns to the factors of production (Figure 2). Data on the physical productivity of land (crop yields) is a function that depends on the magnitude of the mechanization inputs. These were recorded to justify whether the quality of land degradation, erosion and effects on environmental pollution can be improved over time. The estimate of crop yields ranges from 1.2 to 1.7 tonne/ha for maize and from 11 to 13 tonne / ha for cassava tubers (Table 4 and 5). Figure 2 shows that productivity of variable inputs increases proportionately with the increase of farm area. The indication is that the level of economic resources available to farmers determines production technology for crops under farmers' production conditions, that is, the probability of adopting technology and effective utilization of the said energy sources are expected to increase beyond the mean level as the farm size increases. This serves as a tool to identify from farmers' perspective the contribution, effectiveness and efficiency of the variable inputs including power sources in terms of returns to the factors of production. The highest productivity recorded is 0.0951 ha/kWhr for *Ado-Odo* with a farm size of 520 ha and the least was recorded for *Ilewo-Orile* as 0.0115 ha/kWhr for a farm size of 88 ha. While the average physical productivity (crop yield) on maize ranges between 1.2 and 1.7 tonne per ha and that of cassava ranges between 11 and 13 tonne per ha.

Lack of information and inability of the settlers to conduct operative performance of their activities based on the structural and functional capabilities of the available power options were the reasons for the low production level as observed from the study areas.

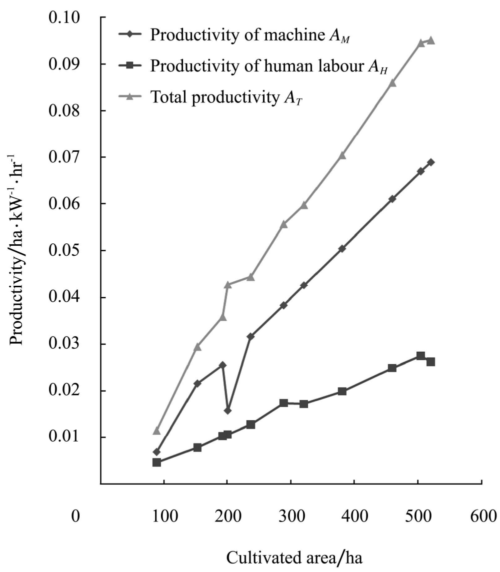

Figure 2 A graphical representation showing the relationship between human productivity, machine productivity and total productivity per unit area of cultivated land

Table 4 Gross margin analysis on maize production

Items	Price ₦ /kg • lt^{-1}	Average price ₦ /kg • lt^{-1}	Recommended input/kg • lt^{-1} • ha^{-1}	Yield/output tons/ha	Average yield tons/ha	Average yield (y) /kg • ha^{-1}	Input ₦ /ha	Output ₦ /kg (P) (Farm gate price)	Output (P×Y) ₦ /ha
Improved varieties of maize seed	120–120	120	10	1.2 – 1.7	1.45	1450	1,200	32 – 35 = 33.5	48,575
Fertilizer application	50	2,500	8*	–	–	–	20,000	–	–
Labour: Ploughing Harrowing Ridging	–	–	–	–	–	–	10,000++	–	–
Weeding/fertilizer application: twice weeding	850–1,500	1,175	5**	–	–	–	2350	–	–
Labour	–	–	–	–	–	–	6,000	–	–
Harvesting + transportation	7,000–9,000	8,000	–	–	–	–	8,000	–	–
Shelling	130–150*+	140	–	–	–	–	2,170	–	–
Land charge	–	–	–	–	–	–	500&	–	–

Note: * Eight bags of Fertilizer each of 50 kg comprise of 6 bags of N:P:K + 2 bags of Urea for top dressing; ** Quantity of herbicide per 20 to 25 litres of water; *+ Shelling rate per 100 kg of harvested grain crop; ++ This includes cost of diesel; & Cost per year.

Table 5 Gross margin on cassava production

Items	Price ₦ / Bundle	Average price per Bundle	Recommended input Bundle/ha	Yield/output tons/ha	Average yield tons/ha	Average yield (y) /kg • ha^{-1}	Input ₦ per ha	Output N/kg (P) (Farm gate price)	Output (P×Y) ₦ /ha
Improved varieties of cassava stem cuttings	120–140*	130	50**	11–13	12	12,000	6,500	3,500– 4,000 = 3,750*+	45,000
								4,000 – 5,000 = 4,500++	54,000
Harvesting + hired labour	–	–	–	–	–	–	8,000	–	–

Note: * Price per bundle of Stem Cutting; ** Bundles of Stem Cuttings per Hectare; *+ Output ₦ / kg in Ogun State; ++ Output ₦ / kg in Ondo State.

4.4 Economic justification of gross margin analysis

The small size of farm holdings of (2 - 4) ha allocated to each settler 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 holdings as allocated to each settler failed to take recognition of variance in settlers' income potential, farming experience, and innovation adoption skills. Table 4, 5 and 6 show that for the same rate of agronomic inputs and the total cost of production inputs, including the cost of performing field operations was found to be ₦ 64, 580 per hectare for the selectively mechanized system (₦ 145 = $1). Lack of a guaranteed price level of farm produces at the farm gate constitutes the main constraints discouraging settlers from cultivating at a reasonably large scale.

Breakeven analysis showed the financial efficiency in the two states to be 145% and 159%, respectively. Based on the rates determined by Anazodo (1985), a project is not economically viable to be invested in if the financial efficiency is less than 100%. Although this implies that selectively mechanized system of arable crops production in the two states is economically justified but with relatively low benefit cost ratio despite the subsidies given to them as cooperative unit on tillage operations. This analysis can provide a basis for a more systematic recommendation and estimation of the type, size, number and capital investment for selectively mechanized rural farm projects in order to increase farmers' income. Muchow et al. (2002) reported that a mechanized system must be used to serve a large area to produce benefits of a reasonable scale. If the planning scale is too small, the fixed cost per unit area would be too high and result in an economical loss. Possible solutions to increase the gross margin can be achieved through additional cultivated area, favourable input price changes, additional product values per area (additional yields or output price changes) and additional production / processing values. All these means can contribute to profitability increase.

Table 6 Estimation of gross margin (profitability) analysis

Given the same agronomic inputs for the two intercropped arable crops:	
Total variable cost of production, TC in Ogun State	= ₦ 64, 580
Total revenue, TR	=₦ 93,575
Gross margin	= (TR-TC) = ₦ 28, 995
Total variable cost of production in Ondo State	= ₦ 64, 580
Total revenue	= ₦ 102, 575
Gross margin	= (TR-TC) = ₦ 37, 995
Breakeven yield in the two states	$= \frac{total\ inputcosts}{total\ price}$ $= \frac{64,580}{1,200+6,500}$ = 8.39 ha
Financial efficiency in Ogun State	$= \frac{Total\ output \times 100}{total\ input}$ $= \frac{(48,575+4,500)\times 100}{64,580}$ = 144.9%
Financial efficiency in Ondo State	$= \frac{Total\ output \times 100}{total\ input}$ $= \frac{(48,575+54,000)\times 100}{64,580}$ =158.8%

5 Conclusions

Evaluation of the level of agricultural mechanization and agricultural productivity of some farm settlements in two states in the Southwest of Nigeria was carried out. The level of agricultural mechanization was established by deriving a relationship between the various sources of farm power and the level of human involvements. The Agricultural mechanization index was then deduced for the various sources of farm power and the level of 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).

The study revealed that low production efficiency, drudgery, under utilization of mechanical power, and uses of old tractors with its attendant constant break down during operation, contributed to low level of mechanization with the highest level of 40.3% for Ajegunle and least level of 27.6% for Ado-Odo.

The highest productivity recorded is 0.0951 ha/kWhr for Ado-Odo with a farm size of 520 ha and the least was recorded for Ilewo-Orile as 0.0115 ha/kWhr for a farm size of 88 ha. While the average physical productivity (crop yield) on maize ranges between 1.2 – 1.7 tonnes per ha, and that of cassava ranges between 11 – 13 tonnes per ha.

Gross Margin Analysis was established for the assessment of the average physical productivity (crop yields), and the returns from the resources engaged in agricultural production on major available crops in each of the state reflect that yields do not decline over time while the destruction of natural capital is avoided in each of the farm settlement studied. For the same rate of agronomic inputs, the total cost of production inputs including the cost of performing field operations was found to be ₦ 64,580 per hectare for the selectively mechanized system.

The studies showed that selectively mechanized system of arable crops production in the two states is economically justified but with relatively low benefit cost ratio despite the subsidies given to the settlers.

References

Anazodo, U. G. N. 1985. A study of traditional and mechanized systems for maize production in Nigeria. A M A. 15(3): 51－55.

Aragón-Ramírez, A., A. Oida , H. Nakashima, J. Miyasaka, and K. Ohdoi. 2007. Mechanization index and machinery energy ratio assessment by means of an artificial neural network: A Mexican case study. Agricultural Engineering International: CIGR Journal. Manuscript PM 07 002. Vol. IX

Clarke, L.J. 2000. Strategies for agricultural mechanization development. Agricultural Support System Division. FAO, Rome, Italy: 7－7.

FAO, 1981. Agricultural mechanization in development; guidelines for survey formulae FAO, Agricultural Services, Bulletin 45-77; Food and Agricultural Organization, Rome.

Gittinger, J. P. 1982. Economic analysis of agricultural projects; the economic development institute; International Bank for

Reconstruction and Development Johns Hopkins University Press, Baltimore.

Jhingan, M.L. 1997. Advance economic theory (Micro and Macro Economic). Macmilan Publisher, USA.

Kepner, R. A., R. Bainer, and E.L. Berger. 1978. Principles of farm machinery 3rd Edition. AVI P ublication Company Inc. Connect, Int. U.S.A.

Mrema, G. C., and E. U. Odibgoh. 1993. Agricultural development and mechanization in Africa. policy perspectives network for agricultural mechanization in Africa NAMA Newsletter, 1(3): 11－50.

Muchow, R.C., A.J. Higgins, and W.T Andrew. 2000. Towards improved havest management using a system approach. Proceedings of Australian Society of Sugar Cane Technologist, (22): 30－37.

Nowacki, T. 1974. Example of technical economic analysis of mechanized process in various agro-technical conditions: Economic commission for Europe AGRI/MECH/32.

Nwoko, S. G. 1990. Agricultural mechanization at a cross road-in Nigeria. Journal of Agricultural Mechanization in Asia, Africa, and Latin America, A M A 21(3): 78－82.

Odigboh, E. U. 1991. Continuing controversies on tillage mechanization in Nigeria. Journal of Agricultural Science Technology, 1 (1): 41－49.

Olaoye, J. O. 2007. An evaluation of farm power and equipment ownership and management in Niger State, Nigeria. Nigerian Journal of Technological Development, 5 (1 & 2): 94 – 102.

Ortiz-Canavate, and I. Salvador 1980. Effects of different mechanization levels in Spanish dryland farms. Journal of Agricultural Mechanization in Asia, 3(5):31－36

Ou Y.G., D. T. Yang, P. X. Yu, Y. X. Wang, B. X. Li, and Y. L. Zhang. 2002. Experience and analysis on sugarcane mechanization at a state farm in China. 2002 ASAE Annual International Meeting/CIGRXVth World Congress.

Ozmerzi, A. 1998. Mechanization level in vegetable production in Antalya region and Turkey. *A M A* 29(1): 43－ 43.

Starkey, P. 1998. Integrating mechanization into strategies for sustainable agriculture. Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen, Netherlands.

Tooy, D. and H. Murase. 2007. Behavioral interest identification for farm mechanization development using path analysis and Neuro-fuzzy models. Agricultural Engineering International: CIGR Journal. Manuscript IT 07 002. Vol. IX.