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Application of Psuedo-Profit Function in Estimating Profitability of Energy Inputs used in Small-Scale Maize Enterprise in Niger State, Nigeria

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Abstract: The research examines profitability in maize production in Niger state, Nigeria with particular reference on energy inputs employed. Multi-stage sampling technique was used to draw 120 respondents and information elicited through administration of pre-tested questionnaire. Data used were collected during the 2014 cropping season. Pseudo profit function which incorporates gross margin and financial-economic ratios, and energy index models were used to analyze the data collected. Results showed that total inputs energy in maize production was 2227.81 MJha^{-1}, with 85.2% of input energy contributed by agrochemical input or coming from biological energy and energy ratio was 4.5 in the production systems. Results suggest that reduction in agrochemical consumptions are important for energy saving and decreasing the environmental risk problem in the area. Furthermore, total energy cost incurred per ha^{-1} in maize production was ₦39, 799.10, with labour costs accounting for the highest percentage. The enterprise recorded a gross margin of ₦ 16,211.21 and net farm income of ₦4613.23 ha^{-1}, respectively. This result clearly indicated that maize production is a profitable venture and so farmers in the study area should be advised to venture into it.
Keywords: Energy input; Psuedo-profit function; Profitability; Maize; Niger State; Nigeria

INTRODUCTION

Maize (*Zea mays L.*) is important cereal crop that is grown widely throughout the world in a range of agroecological environments. More maize is produced annually than any other grain. The crop was introduced into Africa in the 1500s and has since become one of Africa's dominant food crops and an important staple food for more than 1.2 billion people in SSA and latin America. It has a worldwide production of 785 million metric tons and consumption of about 116 million tons. The age old necessities of life are food, clothing and shelter. The 20th and 21th century dramatized a fourth-energy. Energy starvation of the technological complex that maintains modern society may soon be as crucial as feeding the world's hungry. Therefore, energy starvation could well precipitate more wide spread food starvation. Solution to the energy crisis is strongly dependent on the technology of how energy is used. As such to make a physical change in the world it is necessary to use four resources: Energy, matter, space and time. Energy has been a key input of agriculture since the age of subsistence agriculture. It is an established fact worldwide that agricultural production is positively correlated with energy input [1]. Agriculture is both a producer and consumer of energy. It uses large quantities of locally available noncommercial and commercial energies as direct and indirect forms, such as seeds, manure and animals, diesel fuel, electricity (mostly for irrigation), fertilizer, biocides, chemical fertilizers, and machinery [2]. Energy input–output analysis is usually used to evaluate the efficiency and environmental impacts of production systems [3,4]. Energy use in agriculture has been increasing in response to increasing population, limited supply of arable land, and a desire for higher standards of living [5]. Choudhary *et al.* [6], cited that in modern agriculture system input energy is very much higher than in traditional agriculture system, but energy use efficiency has been reduced in response to no affective use of input energy. Efficient use of energies helps to achieve increased productivity and contributes to the economy, profitability and competitiveness of agriculture sustainability in rural areas [4]. Furthermore, in order to meet the ever increasing demand for food production, energy use in agriculture production has become more intensive. However, more intensive energy use has brought some important human health and environment issues forcing humans to make more efficient use of inputs to maintain a sustainable agriculture production [11]. The objective of this study is to provide empirical information on profitability of energy use in maize production in Niger state, Nigeria given that the era of cheap energy is now ending with the populace becoming energy conservation conscious; rising cost of energy already showing serious signs of the strain.

THEORETICAL REVIEW OF ENERGY IN AGRICULTURE

The age old necessities of life are food, clothing and shelter. The 20th century has dramatized a fourth-energy. Energy starvation of technological complex that maintains modern society may soon become a crucial problem as feeding the world's hungry, with it precipitating more widespread of energy starvation. Solutions to energy crisis are strongly dependent on the technology of how energy is utilized. Therefore, to make a physical change in the world, it is imperative and necessary to use four resources: energy, space, matter and time. Furthermore, how well a task is performed can be measured in terms of fuel amount consumed, mass of material used, space occupied, labour hours required to accomplish it, and the ingenuity with which these resources are utilized. Squandering of irreplaceable energy sources, material waste, or large expenditures on space and time cannot longer be tolerated and warranted if the necessities of life are to be provided for all. Technology addresses itself to the efficient utilization of these ingredients. The era of cheap energy is now ending and it will become necessarily for the populace to be conscious of energy conservation; first because of the rising cost of energy, and later the dire consequences in placing additional stresses on our biosphere, which is already showing serious signs of the strain. The introduction of high-yielding varieties for crops in Nigeria paved the way for important technological changes and led to unprecedented rise in the crop yield and land productivity in many parts of the country. These new production technologies require large quantity of inputs such as fertilizers, plant protection, chemicals, petrol, diesel, electricity, etc. The application of these inputs demands more and more use of energy in the form of human, animal and machinery. With improved rural transportation system, the rural unskilled labour has become more mobile which makes the agricultural labour supply more elastic. Therefore, the energy scenario of crop production has taken a dimension with the introduction of modern inputs.

METHODOLOGY

Study Area

This study was based on the farm level data on small scale maize farmers in Niger State, Nigeria. Niger State is located in the Guinea Savannah zone of Nigeria and lies between latitudes 8°20'N and 11°30'N of equator and longitude 3°30'E and 7°20'E of the Greenwich Meridian .The land area is about 76,363 square kilometre with varying physical features like hills, lowland and rivers. The state enjoys luxuriant vegetation with vast Northern Guinea savannah found in the North while the fringe in mostly southern guinea savannah. The people are predominantly peasant farmers cultivating mainly food crops such as yam, maize, rice, millet for family consumption, market and cash .Farming activities are usually carried out using hand tools and other simple implements.

Sampling Technique

The study made used of multi-stage sampling technique. Data mainly from primary sources were collected from one out of the three Agricultural zones, namely, Kuta zone which was purposively selected given its conspicuous importance in maize crop production. The second stage involved purposive selection of three LGAs, namely, Shiroro, Bosso and Paikoro LGAs, respectively based on the preponderance of small-scale maize farmers' in the areas. The third stage involved random selection of four villages from each LGA. The final stage involved simple random selection of 10 farmers from each of the villages, thus making 120 respondents. Data were collected with the aid of pre-tested questionnaire to collect input-output data of the farmers defined within cost content. Both energy index models and pseudo profit function were used to analyze the data collected.

Table-1: Energy sources grouped under different categories of energy

Category energy	Sources of energy
Direct Energy	Human, Animal, Fuel wood, Agricultural waste, Petrol, Diesel, Kerosene, Electricity, etc
Indirect Energy	Seeds, Farm yard manure, Chemicals, Fertilizer, Machinery, etc
Renewable Energy	Human, Animal, Fuel wood, Agricultural wastes, Seeds, Farm yard manure, etc
Non-Renewable	Petrol, Diesel, Electricity, Chemicals, Fertilizers, Machinery, etc
Commercial Energy	Petrol, Diesel, Electricity, Chemicals, Fertilizers, Machinery, Seeds, etc
Non-Commercial Energy	Human, Animal, Fuel wood, Agricultural wastes, Farm yard manure, etc
Biological Energy	Diesel, Pesticides, Fertilizers, Machinery, Electricity, etc
Industrial Energy	Human, Seeds and H_2O for Irrigation

Table-2: Equivalents for various sources of energy

Particulars	Units	Equivalent energy, MJ	Remarks
Adult man	Man-hour	1.96	
Women	Woman-hour	1.57	
Child	Child-hour	0.98	
Nitrogen	Kg	60.60	
P_2O_5	Kg	11.1	
K_2O	Kg	6.7	
Herbicides	Litre	120	
Improved seed	Kg	15.2	Processed
Maize product	Kg (Dry mass)	14.7	The main output is grain

MODEL SPECIFICATION

Energy standard equation

Standard equations were used to determine the following energy model index:

Energy ratio = output energy ($MJha^{-1}$)/Total input energy ($MJha^{-1}$) …………………. (1)

Energy productivity = Grain yield ($kgha^{-1}$)/ Total input energy ($MJha^{-1}$) ……………... (2)

Net energy = Total output energy ($MJha^{-1}$) – Total input energy ($MJha^{-1}$) ……………...(3)

Specific energy = Total input energy ($MJha^{-1}$)/ Grain yield ($kgha^{-1}$) …………………… (4)

Gross margin

Gross margin is the difference between the Total value of production and the Total variable cost. Gross margin analysis is used to study the performance of an enterprise. It is a very useful tool in a situation where fixed capital is a negligible portion of the farming enterprises as in the case of subsistence agriculture.

The empirical model is specified below

GM = GI – TVC

Where

GM = Gross Margin

GFI = Gross Farm Income

TVC = Total Variable Cost

The Net farm income (NFI) was computed using the formula below:

NFI= GM –TFC

Where:

NFI = Net Farm Income

GM = Gross Margin

TFC = Total Fixed Cost

RESULTS AND DISCUSSION

Source-wise energy consumption

Table 3 revealed source-wise energy consumed in maize production in the studied area. The total input energy requirement for producing maize crops was 2227.81 $MJha^{-1}$, with indirect energy used accounting for the highest share in total energy input consumed (11942.27$MJha^{-1}$). Among the different energy sources nitrogen fertilizer was the highest energy consumed, and the average use of the nitrogen fertilizer was 23.62 $Kgha^{-1}$. It is a common belief that increase in fertilizer use will lead to an increase in yield. Therefore, because of the high Nitrogen fertilizer used in the production, it account for the highest value in total energy input used in maize production (1431.07 $MJha^{-1}$). Comparatively, from this finding, the total input energy required for production of maize per hectare in Nigeria was lower than the reported total input energy (29307.74$MJha^{-1}$) required for maize using little high technology in Dezful in Iran [7]. Therefore, on the basis of maize output ratio, farmers in the study area in Nigeria will be judicious in energy use and output better-off if they will operate on the same technological level, given that they required just five times of their present total input energy to produce the same level of output obtained in Dezful, Iran, which used thirteen times energy input estimated equivalent used in maize production in Nigeria to obtained their present output level. However, other inputs applied in the growing process, and percentage of each input to the total energy inputs are given in the table-3.

Yield and energy requirement in different form for maize production

Table 4 shows the energy requirement in different forms for maize production Agro-ecosystems. The energy productivity, energy ratio, specific energy, net energy and Agrochemical energy ratio of maize production in the study area were identified. Energy ratio in maize production was 4.51; therefore, raising the crop yield and decreasing energy inputs consumption the energy ratio can be increased. This findings is greater than the amount recorded for maize production by Canakci *et al.* [8] in Turkey (3.66) and Lorzadeh *et al*. [7] in Iran(1.86), respectively. This high energy ratio implies efficient use of energy in maize production. Energy productivity and specific energy in maize production systems were 0.31 $KgMJ^{-1}$ and 3.26 $MJKg^{-1}$ respectively. This means that produced maize grain yield per input energy unit was 0.13kg/MJ 1, or in other word, in maize production, 3.26MJ energy was used for producing one kg of grain yield. Also, Net energy per hectare for maize production was 7820.23 $MJha^{-1}$. Furthermore, the agrochemical energy ratio in maize production was 85 percent which implies high energy quantum consumed from fertilizer and herbicides inputs in the production. However, distribution of other inputs used in the production according to the industrial and biological; renewable and non-renewable; and, commercial and non-commercial are also identified. The total biological energy input consumed was 85.4%, while industrial energy accounted for 14.6%. Moreover, several researchers reported the ratio of industrial energy to be greater than biological energy consumption in crops production [9,10,7]. In modern crop production systems large amount of industrial energy has been replaced instead of biological energy therefore energy use efficiently has been reduced in response to use of agrochemical input with high energy cost and effective use of input energy.

Table 3: Source-wise energy consumption in maize production

Variables	Quantity units ha^{-1}	Total energy equivalents ($MJha^{-1}$)	% of Total energy
a. Inputs			
Direct energy			
Family labour	84.88 manhours	166.37	7.5
Hired labour	60.80 manhours	119.17	5.5
Sub-total		**285.54**	
Indirect energy			
Seeds	2.67	40.58	1.8
Nitrogen	23.62	1431.07	64
Phosphorus (P_2O_5)	11.81	131.09	5.9
Potassium (K_2O)	11.81	79.13	3.6
Herbicides	2.17	260.40	11.7
Sub-total		**1942.27**	
Total input energy ($MJha^{-1}$)		**2227.81**	**100**
b. Output			
Maize	683.54	10048.04	
Total energy output ($MJha^{-1}$)		**10048.04**	

Source: Field survey, 2014

Table 4: Yield and energy requirement in different form for maize production

Items	Unit	Quantity
Yield	$Kgha^{-1}$	683.54
Total input energy	$MJha^{-1}$	2227.81
Output energy	$MJha^{-1}$	10048.04
Energy ratio		4.5
Specific energy	$MJkg^{-1}$	3.26
Energy productivity	$KgMJ^{-1}$	0.31
Net energy	$MJha^{-1}$	7820.23
Agro-chemical energy ratio	%	85
Industrial energy	$MJha^{-1}$	326.12 (14.6)
Biological energy	$MJha^{-1}$	1901.69 (85.4)
Renewable energy	$MJha^{-1}$	326.12 (14.6)
Non-renewable energy	$MJha^{-1}$	1901.69 (85.4)
Commercial energy	$MJha^{-1}$	1942.27 (87.2)
Non-commercial energy	$MJha^{-1}$	285.54 (12.8)

Source: Field survey, 2014

Costs and return estimates of energy used in maize production

Table 5 show the cost and returns estimates of energy used in maize production in the study area. The revenue from maize output ha^{-1} was found to be ₦44, 412.33. The total energy cost incurred per ha^{-1} in maize production was ₦39, 799.10, with labour costs accounting for the highest percentage (36.6%) of the total cost of production. The total variable cost accounts for 70.9% of the total cost, while fixed cost accounts for 29.1% of the total cost. The enterprise recorded a gross margin of ₦ 16,211.21 and net farm income of ₦4613.23 ha^{-1}, respectively. Furthermore, the result revealed that returns on Naira invested by farmers in the study area was ₦ 0.58, meaning that a farmer gain 58 Kobo on every one naira invested in maize production. This result clearly indicated that maize production is a profitable venture and so farmers in the study area should be advised to venture into it.. The rate of return per capital invested (RORCI) is the ratio of profit to total cost of production and it indicates what is earned by the business capital outlay. The results revealed that the RORCI of 12% is greater than the prevailing bank lending rate of 8%, thus, indicating healthy business going concern.

Table 5: Cost and Returns analysis of energy used in maize production ha^{-1}

Items	$MJha^{-1}$	Unit price MJ^{-1}(₦)	MJ Cost (₦)	% of MJ Total cost
Expenditure				
Variable Cost				
Cost of family labour	166.37	51.02	8488.20	21.3
Cost of hired labour	119.17	51.02	6080.05	15.3
Cost of seed	40.58	19.74	801.05	2.1
Cost of nitrogen	1431.07	0.74	1058.99	2.7
Cost of P_2O_5	131.07	4.05	530.92	1.3
Cost of K_2O	79.13	4.05	320.48	0.8
Cost of herbicides	260.40	7.50	1953.00	4.9
Cost of transportation			3876.73	9.7
Cost of storage			2546.88	6.4
Cost of processing			2544.82	6.4
Total Variable Cost			**28,201.12**	**70.9**
Fixed Cost				
Interest on loan payment (46923.10@8%)			3753.85	9.4
Rent on land			6240.00	15.7
Depreciation on capital equipment			1604.13	4.0
Total Fixed Cost			**11,597.98**	**29.1**
Total Cost			**39,799.10**	**100**
Income				
Revenue/Receipts from product	10048.04	4.42		
Total Income			**44,412.33**	
Gross Margin			**16,211.21**	
Net Farm Income			**4,613.23**	
Operating Ratio			**0.64**	
Gross Ratio			**0.90**	
Return on naira invested (ROI)			**0.58**	
Rate of return per unit of capital invested (RORCI)			**0.12**	

Source: Field survey, 2014

CONCLUSION AND RECOMMENDATION

The research examines profitability in maize production Niger state, Nigeria with particular reference on energy inputs employed. The total energy consumption in maize production was $2227.81MJha^{-1}$, with energy input from fertilizer recording the biggest share (73.5%) of total energy inputs. Averagely, 85.2% of total energy input used in maize production was biological energy, while the contribution of industrial energy was 14.8%. Results suggest that reduction in agrochemical consumptions are important for energy saving and decreasing the environmental risk problem in the area. Therefore, excessive application of chemical fertilizers would result in increased energy consumption in production systems; inefficient energy use, thus, causing environmental challenges, including global warming, soil and water pollution thereby affecting human health. This trend indicates that environmental challenges will worsen in the near future if there is absence of managerial consideration in fertilizer application pattern in these agro-ecosystems. Furthermore, total energy cost incurred per ha^{-1} in maize production was ₦39, 799.10, with labour costs accounting for the highest percentage. The enterprise recorded a gross margin of ₦ 16,211.21 and net farm income of ₦4613.23 ha^{-1}, respectively. This result clearly indicated that maize production is a profitable venture and so farmers in the study area should be advised to venture into it.

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