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Full Length Research Paper

A study of the efficiency in the use of resources by small-scale *fadama* irrigation farmers in the northern zone of Sokoto State, Nigeria

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This study examined the resource use efficiency in small-scale *fadama* irrigation using motorized-hand pump in the Northern Zone of Sokoto Agricultural Development Project (SADP). A field survey was conducted in which data were collected from 100 farmers randomly selected from five purposively selected Local Government Areas (LGAs). The data generated were subjected to descriptive statistical analysis and econometric estimation. The results show that resources were generally inefficiently utilized. Land, labour, seed and chemicals were over-utilized, while fertilizer, irrigation water, fuel and lubricants were generally under-utilized. For the farmers to improve the levels of the farm outputs at the present level of technology, adjustment in the use of the resources are required.

Key words: Resource use, *fadama*, irrigation, small-scale, motorized pumps, vegetables.

INTRODUCTION

Being located in the dry Sahel, surrounded by sandy savannah, Sokoto state has inadequate and erratic rainfall. Annual rainfall in some parts of the state is about 600 mm, with non-uniform distribution. Frequent droughts are common. Both the time of commencement and cessation of the rainfall are unpredictable. The implication of the rainfall characteristics is that large areas of land are left uncultivated, while only crop varieties that are early-maturing and/or drought tolerant are grown even if they are not the most productive in terms of yield and income (Baba and Adedibu, 1998). Therefore, to check this menace of drought and at the same time put the cultivated land into more intensive use (through multiple cropping), irrigation is necessary. Initially, the governments favoured the development of large-scale irrigation as can be seen from the large-scale irrigation projects established in Bakalori and Goronyo. However, with the failure of these projects to make the desired impact, attention has, in recent times, shifted towards small-scale *fadama* irrigation based on motorized pumps (Baba, 1993).

The demand for irrigation water for the fast growing agriculture is always outstripped by the supply potential created under limited and uncertain natural precipitation. Empirical evidence suggests that irrigation projects have positive impacts on agricultural production and reduction of poverty for farmers (Hussain and Hanjra, 2004; Smith, 2004; Lipton, 2007).

One of the main reasons for low productivity in agriculture all over the world, including Nigeria is the inability of farmers to fully exploit the available technologies,

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resulting in lower efficiencies in production (Goni et al., 2007).

Hassan et al. (2010) explained that efficiency in agricultural production is very critical and for the optimum level of production to be achieved, resources must be available and used efficiently. Bello et al. (2010) noted the importance of studying resource use efficiency in agriculture as many of the resources employed by farmers ranging from land to seeds, chemicals, labour and fertilizers could inappropriately be allocated without proper evaluation. This study was therefore designed to investigate the efficiency in the use of resources by small-scale *fadama* irrigation farmers using motorized pumps in the northern zone of Sokoto Agricultural Development Project (SADP).

MATERIALS AND METHODS

The study area

The study area is located in the Northern Zone of the SADP. The zone was purposively selected because of the predominance of dry season farming in the area. Sokoto State is located between latitude 11° 30' to 13° 50' North and longitude 4° 00' to 6° 40' East. It is bordered in the north by Niger Republic, Zamfara State to the east and to the south and west by Kebbi State (Sokoto State Diary, 1999). The annual rainfall in the state ranges from 400 to 750 mm and usually lasts for about five months, beginning in May and ending in September (Sokoto State Diary, 1999). Annual temperature ranges from 23 to 43°C. Both evaporation and evapotranspiration are high. As a result, the zone is prone to different risks ranging from strong to moderate drought risks (English, 1994).

Sampling procedure and sample size

Five Local Government Areas (LGAs) were purposively selected based on the extent to which small-scale *fadama* irrigation, using motorized-pump, was practiced. From each of the LGAs, 2 villages were purposively selected using the same criteria. From each village, 10 respondents were randomly selected, thus giving a total of 100 small-scale *fadama* irrigation (motorized-pump) farmers as the sample size.

Data collection

Data were collected from the farmers by the use of a structured questionnaire. The data collected for this study were of two types. The first deals with information on socio-economic characteristics of the respondents such as age, sex, family size, occupation, level of education, etc. The second deals with input-output information on agricultural production such as the types and quantities of output obtained, farm size, labour inputs, irrigation water usage, fertilizer, chemicals, etc.

Nature and measurement of input-output data

Labour

In traditional agriculture of northern Nigeria, labour can be classified into family and non-family labour. The family labour comprises the farmer himself and members of his household. This type of labour is not directly paid for by the farmer. However, it can be costed indirectly by finding its “opportunity cost”. The non-family labour input can be categorized into “Kwadago”, “jinga” and “gayya”. As the farmers have a clearly defined concept of man-day which is usually from 8.00am - 4.00pm. Man-day was used in measuring labour input in this study.

Land

In this study, land specifically refers to *fadama* which is a Hausa word referring to seasonally damp or flooded land in small depressions with moisture or water available through flooding, ground water pumping or surface lifting or otherwise simply inland valleys (English, 1994). The area of the *fadama* under cultivation by each farmer was measured in one of two ways: namely traditional and modern. In the traditional method, English (1994) noted that farmers estimated the size of their land by the use of *Gora* (6 *Gora* = about 1 ha) and/or number of ridges (100 ridges = about 1 ha). However, where this method proves unsatisfactory, a modern method of physically measuring the area under cultivation using measuring tape was adopted. The dimension obtained from the measurement was then used to compute the actual size of the *fadama* in hectares.

Capital

These are the produced means of production and in this study they are classified into “durable” and “non-durable”. The durable input are those items that last for more than one farming seasons, examples of which are tube-wells, pumps, hoes, etc. Using the initial cost price, the salvage value and the life span of the durable assets, a “straight-line” depreciation method was used to compute the value of these items used-up during the irrigation season under study. For the non-durable capital items, such as fertilizers and seeds, they were valued on the basis of their market prices at the time of purchase.

Irrigation water

This is the total volume of irrigation water applied by each farmer during the production period. In order to obtain this, the discharge rate of the pump used by the respondent was determined, which was then multiplied by the total number of hours the pump was operated during the season to obtain the total quantity of irrigation water applied during the season in litres. The resulting figures were then divided by 100,000 to obtain the total quantity of water applied in hectare-centimeters (ha-cm). It should be noted that where the discharge rate of the pump was not given by the manufacturers, it was manually determined. Following Michael (1998), this was determined by the use of a stop-watch to record the length of time it takes the pump to fill a 50 L container with water. This was done several times and the average discharge rate was then determined.

Analytical tools

Production function

The following general production function model was used:

$$y = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8) \text{ --------------------------------- } (1)$$

Where:

Y = total output of each crop (in kg);
x_1 = land input (in ha);
x_2 = labour input (in man-days);
x_3 = seeds input (in kg);
x_4 = fertilizer input (in kg);
x_5 = chemicals (in litres);
x_6 = irrigation water (in Ha-cm);
x_7 = fuel (in litres);
x_8 = lubricant (in litres).

Linear, Cobb-Douglas, semi-log and exponential forms of the production function model were estimated for each of the major crops produced by the respondents (onion, pepper, tomato, garlic and carrot) to determine the lead equations. The lead equation is characterized by the equation that has the best fit in terms of R^2, number of significant independent variables, the appropriateness and signs of the parameter estimates and coefficient of variation.

A Cobb-Douglas equation was chosen as a lead equation for onion, tomato and garlic enterprises. While linear equation was chosen as a lead equation for pepper and carrot enterprises. The linear model was specified as follows:

$$= b_0 + bi\,Xi + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + \sum \text{ -----}(2)$$

The Cobb-Douglas model was specified as follows:

$$= bo\, Xi^{bI} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} X_7^{b7} X_8^{b8} + \sum \text{ ------------}(3)$$

Where the variables were as previously defined: “bs” are parameter estimates and ∑ is a random disturbance term for a stochastic model (Gujarati, 1988).

Marginal value productivities are defined as the changes in the total value product as a result of a unit change in the variable input. The marginal value product (MVP) is:

MVP = Marginal value product
MPP = Elasticity of production
Py = Unit price of the output

Comparing each MVP with its corresponding acquisition cost (MFC) by taking the MVP/MFC ratio gives an indication of resource-use efficiency. If the ratio is less than 1, the resource is over utilized, while a ratio greater than 1 implies under utilization. However, if a ratio equals to 1, it implies that the resource is efficiently utilized.

RESULTS AND DISCUSSION

The results show the coefficient of determination R^2 for onion to be 0.61, pepper as 0.661, tomato as 0.721, garlic as 0.93 and carrot as 0.99. This implies that 61 and 66% of the variations in the respective outputs of onion and pepper enterprises were explained by variations in the explanatory variables included in the respective models. The remaining proportions not explained by the explanatory variables were attributable to the error or random disturbances in the models. The percentage of explained variations attributable to explanatory variables included in the respective models for tomato, garlic and carrot enterprises were 72, 93 and 99%, respectively.

The values of the F-ratio for each of the enterprises were 18.36 (onion), 6.62 (pepper), 3.80 (tomato), 4.89 (garlic) and 615.33 (carrot). The F-values for onion and pepper enterprises were significant at the 1 % level, that of tomato at 5% level, while that of garlic and carrot enterprises were not significant. This significant F-ratio further confirmed the explanatory power of the independent variables in that the F-ratio is a measure of the joint significance of all the explanatory variables included in the respective models. In other words, this implies that for onion, pepper and tomato enterprises, the included explanatory variables taken together, significantly explained variations in the respective output of these enterprises.

For onion enterprise, the coefficients with respect to land, labour, seed, fertilizer and fuel inputs were all positive. Hence, any increase in the use of these inputs, holding other inputs constant, would increase onion by a proportion corresponding to the value of the parameter estimate, while the negatively “signed”: chemical, irrigation-water and lubricant implies that these inputs were over utilized resulting in a decline in output for any additional unit of these input holding all other inputs constant. It should be noted however, that only labour and seed inputs were statistically significant at 1 and 5% levels, respectively. The regression coefficients for the explanatory variables are as presented in the respective tables.

For pepper enterprise, the result shows that with the exception of labour, all the other variable inputs were positively “signed”, however, only seed input is statistically significant at the 5% level. For tomato enterprise, the regression coefficients with respect to labour, fertilizer, fuel and irrigation water inputs were all positive, while that of land, seeds, chemical and lubricant were negatively signed, but none of the parameter estimates were however significant. Also none of the parameter estimates were significant for garlic enterprise. Land, fertilizer, irrigation water and fuel were positively signed, while labour, seed, chemical and lubricant were negatively signed. For carrot enterprise, half of the inputs (labour, seeds, fuel and irrigation water) were positively signed, while the other half (land, fertilizer, chemical and lubricant) were negatively signed.

It should be noted that for each of the enterprise, an increase in any of the respective positively signed inputs, holding all other inputs constants would increase the output of the respective enterprise. While an increase in any of the respective negatively signed inputs, holding all other inputs constants would decrease the output of the respective enterprise. The general underutilization of purchased inputs especially fertilizer by *fadama* farmers reported in this study was also observed by Babatunde et al. (2008), they suggested that one of the reasons for the underutilization of purchase inputs is attributed to the high cost of such inputs. Similarly, the overutilization of labour in *fadama* farming was also reported by Babatunde et al. (2008) and noted that this may be as a result of excessive reliance on abundant family labour that is usually neither valued nor compensated. Also an earlier study by Mbanasor and Obioha (2003) reported that in *fadama* farming, resources were inefficiently allocated and that they were generally over utilized above their economic optimum levels.

Returns to scale

Bello and Abdu (1998) noted that one of the attractive features of Cobb-Douglas production function is its ability to determine the overall performance of the entire enterprise (returns to scale). The returns to scale measures the proportionate change in output, if all the inputs are changed simultaneously by 1%. It represents the sum of the elasticities of production with respect to all the inputs (Baba, 1989).

Using results from the Cobb-Douglas function (Tables 1 and 2), it can be seen that the sum of elasticities of production with respect to all inputs are 1.13 for onion enterprise, 1.01 for tomato enterprise and 1.24 for garlic enterprise. This means that if all the inputs used in the production of these enterprises were to be increased simultaneously by 1%, the total output of these enterprises will increase by 1.13, 1.01 and 1.24%, respectively. In other words, doubling the quantities of all the inputs, will be more than the double of the total output of these enterprises. Thus there was an increasing return to scale for these enterprises.

Marginal value productivities and resource-use efficiency

The computed marginal value productivities (MVP) and the marginal factor costs (MFC) per unit of inputs for the enterprises are presented in Tables 3, 4 and 5. Comparing each MVP with its corresponding acquisition cost (MFC) by taking the MVP/MFC ratio gives an indication of resource-use efficiency. If the ratio is less than 1, then the resource is over utilized, while a ratio greater than 1 implies under utilization. However, if a ratio equals to 1, it implies that the resource is efficiently utilized.

Except for carrot enterprise, the results show the acquisition cost of labour input to be higher than its marginal value product, implying that in the study area, labour input was used above its economic optimum level in the production of onion, pepper, tomato and garlic enterprises. In other words, in these enterprises, farmers could raise profit by reducing labour employment. This over utilisation of labour input has been reported by Alimi (2000) and Baba and Etuk (1991) with the latter attributing the over utilisation of labour input to its low opportunity cost occasioned by its relative abundance during dry season (which is the production period); a period termed as “slack labour period” by Bello and Abdu (1998).

Except for pepper enterprise, the result shows an over-utilization of farm size in the production of onion, tomato, garlic and carrot enterprises. Thus profit could be increased by reducing the farm size. This over-utilization of farm size is not a surprising development as it is typical of less developed agricultural production scenario. Desai (1973) noted that in a technological stagnant and uncertain agriculture, the input that is more certain and inexpensive like farm size is a more certain source of increasing production, hence, farmers may tend to use such inputs excessively.

Also, the MFC of seeds for onion, tomato and garlic enterprises were all higher than their respective MVP. This was clearly illustrated by the ratios of MVP/MFC which were all less than 1. This therefore means that in the production of onion, pepper, tomato and garlic enterprises during the study period, the respondents used this input far above the economic optimum level and that profit could be increased by reducing the seed rate. In similar studies in Bauchi State, Nigeria, Baba (1989) reported over utilization of seed input by farmers. Since majority of the respondents reported lack of extension services, this over-utilization of seed input can be attributed to, among others, the respondent’s lack of knowledge as to the proper seed rate. Kanoma (1991) as cited in Bello et al. (1998) noted that extension services in *fadama* areas were generally inadequate.

Table 1. Least squares (Cobb-Douglass) estimates for onion, tomato and garlic enterprises.

Variable	Onion	Tomato	Garlic
	Regression coefficients		
Constant term	4.244(1.267)	--1.249(4.981)	4.213(9.541)
Farm size	0.281(0.178)	-0.142(0.398)	0.7542(1.335)
Labour	0.581**(0.195)	0.233(0.551)	--0.146(1.266)
Seed	0.158*(0.093)	--0.040(0.187)	--0.138(0.487)
Fertilizer	0.128(0.110)	0.348(0.357)	0.554(1.574)
Chemical	-0.050(0.110)	-0.350(0.397)	-0.183(1.000)
Irrigation water	--0.539(0.365)	1.028(0.472)	0.122(1.822)
Fuel	0.575(0.474)	3.613(2.183)	1.935(2.864)
Lubricants	-0.005(0.408)	-3.685(1.961)	-1.653(2.599)
F value	18.359**	3.798*	4.897
R^2	0.607	0.717	0.929

Values in brackets are the standard errors of regression coefficients.
*= Significant at 5 % level; ** = Significant at 1 % level.

Table 2. Least squares (Linear) estimates for pepper and carrot enterprises.

Variable	Pepper	Carrot
	Regression Coefficients	
Constant term	--4083.552 (3164.334)	--7379.361 (1140.920)
Farm size	3328.670 (871.115)	--5812.822 (5313.311)
Labour	--6.918 (25.541)	55.532(8.712)
Seed	1123.475* (465.525)	392.380 (165.335
Fertilizer	25.387(16.460)	--23.164(2.438)
Chemical	1415.468(840.405)	--14.082(94.111)
Irrigation water	642.805(553.334)	108.252 (104.878)
Fuel	--547.081(2251.062)	7623.368(456.748)
Lubricants	1946.084(8921.731)	--29.540(1826.214)
F value	6.662**	615.329
R^2	0.699	0.999

Values in brackets are the standard errors of regression coefficients.
*= Significant at 5 % level; ** = Significant at 1 % level.

Table 3. Measures of resource-use efficiency for onion and pepper enterprises.

Resource	Onion (Cobb-Douglas)			Pepper (Linear)		
	MVP	MFC	MVP/MFC	MVP	MFC	MVP/MFC
Land	604	1,500	0.4	44,937	1,500	0.4
Labour	80.80	145	0.56	-93.39	168	-0.55
Seeds	43.82	1,351	0.03	15,166.98	2,090	7.26
Fertilizer	45.23	38	1.19	324.77	36	9.52
Chemical	-55.07	1,000	-0.55	19,108.85	1,000	19.11
Fuel	54.86	50	1.09	-7,385.58	50	123.09
Lubricants	15.88	60	0.26	26,272.08	60	437.87
Irrigation water	-222	110	-2.02	8,677.94	110	78.89

Source: field survey, 2000.

Table 4. Measures of resource-use efficiency for tomato and carlic enterprises.

Resource	Tomato (Cobb-Douglas)			Garlic (Cobb-Douglas)		
	MVP	MFC	MVP/MFC	MVP	MFC	MVP/MFC
Land	462	1,500	0.31	_6.042	1,500	-4.03
Labour	0.27	194	0.01	-8.33	18	-0.05
Seeds	-0.04	1,000	_0.00	-22.44	25	0.89
Fertilizer	10.21	36	0.28	143.99	36	4.0
Chemical	1.49	1,000	0.00	96.31	1,000	0.10
Fuel	176	50	3.52	1,812.91	50	36.26
Lubricants	517	60	8.62	-5,132.59	60	85.54
Irrigation water	53.7	110	0.49	27.64	110	0.25

Source: field survey, 2000.

Table 5. Measures of resource-use efficiency for carrot enterprise.

Resource	Carrot (Linear)		
	MVP	MFC	MVP/MFC
Land	-46,502.56	1,500	31.00
Labour	444.24	218	2.04
Seeds	3,139.04	2,000	1.57
Fertilizer	-185.28	36	5.15
Chemical	112.64	1,000	0.11
Fuel	60,986.96	50	1,219.73
Lubricants	7,623.37	60	127.06
Irrigation water	866	110	7.87

Source: field survey, 2000.

On the other hand, fertilizer input was underutilized by respondents in the production of onion, pepper, carrot and garlic. The MVP to MFC ratio for these enterprises were all greater than 1. Consequently, profit could be increased by increasing the quantity of fertilizer input applied to these enterprises in the study area. The under utilization of fertilizer input in irrigated agriculture has been well documented (Baba, 1993; Baba and Etuk, 1991). Bello et al. (1998) attributed the under utilization of fertilizer input to its exorbitant acquisition cost resulting in the inability of small-scale farmers to acquire this commodity sufficiently.

Although irrigation water availability was not a constraint during the study period, its application was however not uniform. This is because onion and garlic (especially the former) being the crop of first choice among *fadama* farmers (Kumar and Owonubi, 1987) made them to use an excessive amount of irrigation water in their production. Therefore, it is not surprising that the result of this study shows that irrigation water was over-utilized in the production of onion and garlic enterprises, while it was under utilized in pepper, tomato and carrot enterprises.

Chemical was over utilized by respondents in the production of onion, tomato, carrot and garlic enterprises. It was however underutilized in the production of pepper enterprise. The over utilization of this input may be attributed to the respondents' lack of knowledge as to the correct rates for these inputs, which may be attributed to the total lack of extension services in the study area. Fuel and lubricant were however underutilized in the production of all the enterprises. This underutilization may be attributed to the fact that there was an acute fuel scarcity during the study period. Consequently, most of the respondents were unable to acquire these inputs as and when required.

Conclusion

Land, labour, seeds, and chemicals were generally over-utilized in the production of most of the enterprises, while fertilizer, irrigation water, fuel and lubricants were generally under-utilized. In onion enterprise, labour and seed were statistically significant at 1 and 5% levels respectively, while only seed was significant at the 5% level in pepper enterprise. For the farmers to improve the levels of the farm outputs at the present level of technology, adjustment in the use of the resources is required.

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