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AN ECONOMIC ANALYSIS OF DRY SEASON IRRIGATED FARMING IN ASA RIVER, KWARA STATE, NIGERIA: IMPLICATIONS FOR POVERTY REDUCTION

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ABSTRACT

Although irrigation in Nigeria has the potential to boost agricultural productivities and raise farm income, food production in Nigeria is almost entirely rainfed. The area equipped for irrigation in Nigeria is currently about 2 percent of the total cultivated area. The study present empirical findings on the profitability and efficiency among dry season irrigated farmers in Asa River, Kwara State. The study utilized primary data collected between 2011 and 2012 through a simple random sampling technique of 60 vegetable farmers. Profit efficiency and stochastic frontier production function were employed to analyse the data. The result revealed that labour costs accounted for approximately 63% of average variable cost for irrigated farming and more than 73.5% of rainfed, and 54% and 73% respectively of total cost. Average net margin was about 11% higher in irrigated unit (US$401) than the rainfed farming (US$362). Empirical estimate shows that the mean technical efficiency value of vegetable farmers was about 0.85. Technical inefficiency coefficient of farming experience (-0.540), adjusted household size (-0.184) and training (-0.342) revealed that these variables increased technical efficiency. It suffices to note that lack of access to water, high cost of equipments and inadequate finance were identified as lead constraints sum up to over half (51%) of the problems of vegetable farmers. Government policy should promote small scale irrigation scheme and educate the irrigated farmers through skill-enhance trainings by extension agents to adopt new innovations and techniques. This will enhance and improve the farmer's productivity, sustainable agricultural development, and apparently reduced poverty.

Keywords: Asa River, irrigation, labour, vegetable, Nigeria

INTRODUCTION

In spite of recent technological and scientific advancement, weather is still the most important variable in agricultural production. Daily, seasonal or annual variations in the values of the climatic elements such as water are of greater importance in determining the efficiency of crop growth (Ayoade, 2004). All living things on the earth depend on water and the earth is the only confirmed planet where water is present in liquid form, falling as precipitation and flowing through the landscape (Bruce in Adeniji, 2012). Water in all its forms plays a vital role in the growth of plants and the production of all crops. It provides the medium by which chemicals and nutrients are carried through the plant and above all, the main constituent of the physiological plant tissue and a reagent in photosynthesis. However, soil moisture is the source of water which is of importance to crop and the state of moisture is controlled by rainfall, the evaporation rate and soil characteristics. Despite high variability and insufficient rainfall, high incidence of droughts and of recent occasional torrential rainfall leading to flooding, food production in Nigeria is virtually rainfed. For example, Nigeria irrigated area as a share of total cultivated area is estimated at about 2 percent (Svendsen *et al*., 2009) which is lower than average of only 6 percent for Africa, and 37 percent for Asia and 14 percent for Latin America (FAOSTAT, 2009). It suffices to note that African countries such as Djibout, Egypt and Madagascar irrigated about 98%, 95% and 32% respectively of their total cultivable area and more than two-thirds of existing irrigated area in Africa is concentrated in five countries viz. Egypt, Madagascar, Morocco, South Africa, and Sudan which each have more than 1 million hectares of irrigated area (Svendsen *et al*., 2009; FAOSTAT, 2009).

Irrigation is a science of planning and designing a water supply system, usually man made, for agricultural land to produce crops where there is virtually little or no precipitation, and to protect the crops from bad effect of drought or low rainfall. Grigg in Cai *et al*. (2006) observed that the real crisis in water is a creeping crisis as it comes on slowly but it demands a response right now. Sustainable development, that is, development that meets the needs of the present without compromising the ability of future generations to meet their own needs is a concept that has gained popularity since publication of the 1987 Brundtland Commission Report {World Commission on Environment and Development (WCED), 1987}.

Several studies (Loucks, 2000; Cai *et al*., 2005; Inger *et al*., 2005; Liangzhi *et al*., 2010; Adeniji, 2012) advocate sustainable development as the best approach to today's and future water problems, and effective water resources management. This implies a notion of equilibrium that simultaneously satisfies water demands and the preservation of the water resources system without endangering future generations.

Cai *et al*. (2006) and several studies also identified broad guidelines for sustainable water resources management. For example, the World Bank report (Serageldin, 1995) proposes a comprehensive approach, emphasizing economic behavior, the overcoming of market and policy failures, more efficient use of water, greater protection of the environment, and moving to demand management from the previously dominant supply management. The United Nations Conference on Environment and Development (UNCED, 1992) in Rio de Janeiro arrived at the conclusion that water should be considered an integral part of the ecosystem as well as natural resource and social and economic good.
The American Society of Civil Engineers (ASCE) and the United Nations International Hydrologic Program (UN/IHP, 1998) published a monograph on sustainable water resources management with assertion that sustainable water resource systems are those designed and managed to fully contribute to the objectives of society, now and in the future, while

maintaining their ecological, environmental and hydrological integrity. Further, Houghton (1999) noted rightly that sustainable development means the long term survival of the planet earth and its process of dynamic evolution, including the wide range of species which currently lives on it, not least the human kind. For human kind, it specifically requires achieving a position which allows for living in harmony with nature, that both life and resources including water are managed efficiently for optimum support of man and other life forms.

More recently, Adeniji, (2012); Seleshi *et al*. (2010); Cai *et al*. (2006); Inger *et al*. (2005) and previous studies have set out several guidelines for sustainable water resources management. These include:

(i) successfully accomplish multiple social, economic, and environmental objectives in terms of adequate water quantity and quality;

(ii) maintain stability and flexibility in water supply so as to deal with extreme events such as flooding, drought, excessive waste discharge, and other anticipated stochastic events;

(iii) minimize negative environmental impacts;

(iv) to realize equity, to make equitable water rights possible among spatially distributed water demand sites and between current and future generations;

(v) achieve financial and economic efficiency; and adapt to new technology.

Problem Statement

Agriculture is the world's largest use of land, occupying about 38% of the Earth's terrestrial Surface (Foley *et al*., in Dobermann and Nelson, 2013). Yet, the 1996 World Food Summit (WFS) brought to centre stage in the development debate the issue of hunger and food insecurity as both cause and effect of poverty and slow growth (Damisa *et al*., 2011a). For example, an estimated 870 million people globally still lack sufficient caloric intake, while a billion or more suffer from micronutrient deficiencies (FAO, 2012). In a bid to address these problems, we must call for a new approach that ensures success and food sustainability under this new set of constraints. The climatic variation of Nigeria has a distinct wet and dry season. Majority of farming households only engage in agricultural activities during the wet season which has a short life cycle in some regions, though could extend to 7- 8 months in other areas. Therefore, the Nigerian farming households usually experience double barrel problems of incidence of hunger few months after harvest, since they hardly produce to meet domestic food demand, yet they sell most of their farm produce at harvest time and may or may not be able to engage in any other subsidiary paid job during the dry season. Thus far, the food shortage experienced by the farming households is expected because the agricultural resources were largely untapped and underutilized in Nigeria. The cycle of seasonal food shortage, experienced by farming households in Nigeria as examined by Damisa *et al*. (2011b) and inability of rural farming households to overcome caloric and nutrition insufficiencies (Dobermann and Nelson, 2013), and their failure to fulfil their domestic obligations could be surmounted by practising irrigation during off farm season. The post-2015 goals for sustainable agriculture and food production canvass by United Nations among others encourage farmers to use farm inputs like irrigation to take advantage of rising food prices to earn additional revenue.

Nigeria has a land area of 98.3 million hectares, out of which 79 million hectares is arable land. Between 60-70% of about 160 million people are involved in agriculture and agricultural related industries which maintain a steady contribution of 35 to 40% to total Gross Domestic Product (GDP) between 2008 and 2012 (FAO, 2013). Suffice it to note that the country has rich vegetation and abundant water resource with about 214 billion m^3 of surface water and 87 km^3 of ground water both of which can be used for irrigation (FAO, 2013). According to Ita, (1985); Oladimeji, (1999) and FAO, (2013), the full extent of water resources cannot be accurately stated as it varies with season and from year to year depending on rainfall. However, Nigeria is endowed with coastline of about 800 km, a continental shelf of about 256,000 km^2 and exclusive economic zone area of 210,900 km^2.

In addition, the topography of the coastal area is straddled by the drainage systems of Rivers Niger and Benue as well as their main tributaries (Akande and Tobor, 1992; Oladimeji, 1999). And rivers are indispensible freshwater systems that are necessary for agricultural production such as crop husbandry and inland fishery. The country is also blessed with about 14 million of hectares of reservoirs, lakes and major rivers estimated at 12.0% of the total surface area of Nigeria (FDF, 2007), capable of been irrigated to produce both arable and permanent crops for both home consumption and export. The water system of Nigeria is dominated by two great river systems, the Niger-Benue and the Chad systems. With the exception of a few rivers that empty directly into the Atlantic Ocean such as Cross River, Ogun, Oshun, Imo, Qua Iboe and a few others, all other flowing waters ultimately find their way into the Chad Basin or down the lower Niger to the sea. The approximate extent and distribution of the major inland water system is given in Table 1.

Table 1: Major inland water resources of Nigeria

Types of Water Bodies (Inland)	**Approximate Surface Area (Ha)**	**Fraction of each River Component (%)**
Anambra River	1,401,000	12.0
Benue River	129,000	1.1
Cross River	3,900,000	33.4
Imo River	910,000	7.8
Kwa iboe River	500,200	4.3
Niger River less kainji lake	169,800	1.5
Ogun River	2,237,000	19.2
Oshun River	1,565,400	13.4
Lakes & Reservoirs	853,600	7.3
Total	11,666,000	100.0
Mean	2333200	–
STDEV	3288422	–

Source: Ita, (1985); Oladimeji, (1999)

Therefore, it can be concluded that Nigeria is endowed with ample irrigable water resources over a wide range of agro ecologic zones to produce enough crop and crop products not only for domestic consumption but also for export.

Despite this large natural and irrigable water resource endowment and agricultural potential in Nigeria, poverty and hunger remain critical developmental challenges. The Millennium Development Goals (MDGs) were established by the United Nations in 2000 to combat poverty, hunger, disease, illiteracy, gender inequality, environmental degradation and biodiversity. Poverty is the key to the achievement of all the MDGs goals, and the fulfillment of this international commitment by 2015. Meeting the MDGs of halves, the proportion of people in poverty and hunger would require investing in small scale irrigation. This will require a renewed interest in agriculture as a whole, being renewable resources and due to its ability to facilitate a sustainable labour intensive growth with provision of employment for the ever increasing population in the State in line with new global agenda for poverty eradication. Given that irrigated crop yields are double or more of comparable rainfed yields on the continent, irrigation development is considered by many as an important cornerstone for agricultural development in Africa. The 2005 Commission for Africa report (2005), for example, called for a doubling of the area of irrigated arable land by 2015.

This paper focuses on achieving a sustainable food production through irrigation. Specifically, to identify socio-economic characteristics of respondents and an economic analysis of irrigated farming in Asa River settlements of Ilorin, Kwara State, Nigeria. The findings elucidated some solutions to the constraints to dry season farming and provide technical suggestions (estimated technical efficiency) for enhancing productivity, profitability and sustainability of dry season farming and apparently improved welfare and poverty reduction.

Study area

The study was carried out in Asa River and their main tributaries around Ilorin metropolis. The river originate from Oyo state and flows through Asa Local Government Area (LGA) towards South-North of Ilorin direction forming a dividing boundary between Eastern and Western Ilorin (Figure 1). It flows almost South- North divides the city of Ilorin to almost two equal halves. The irrigation potential includes Asa River and its tributaries in Ilorin metropolis such as River Osere, Olokonro, Iyandudu, Oyun, Isale Asa, Agba and Aluko. The River was dam to supply the basic water needs of the Ilorin city and its environs. Ilorin has a land mass covering about 100 km^2, a population of 1,008,602 in 2007 according to the National Population Census (NPC, 2006). The population and average density per square kilometre were projected in 2014 to be about 1,277,677 and 12777 respectively representing 3% annual growth rate. The study area falls within Ilorin sheet 223NW (1:50,000) (GSN) lying between longitudes 4°30' to 4°37'E and latitudes 8°27' to 8°32'N. It is a humid tropical area characterised with both wet and dry seasons. The mean annual rainfall is 1150 mm, while the mean annual temperature ranges from 25-30°C with relative humidity which ranges from 65-80% (NPC, 2006).

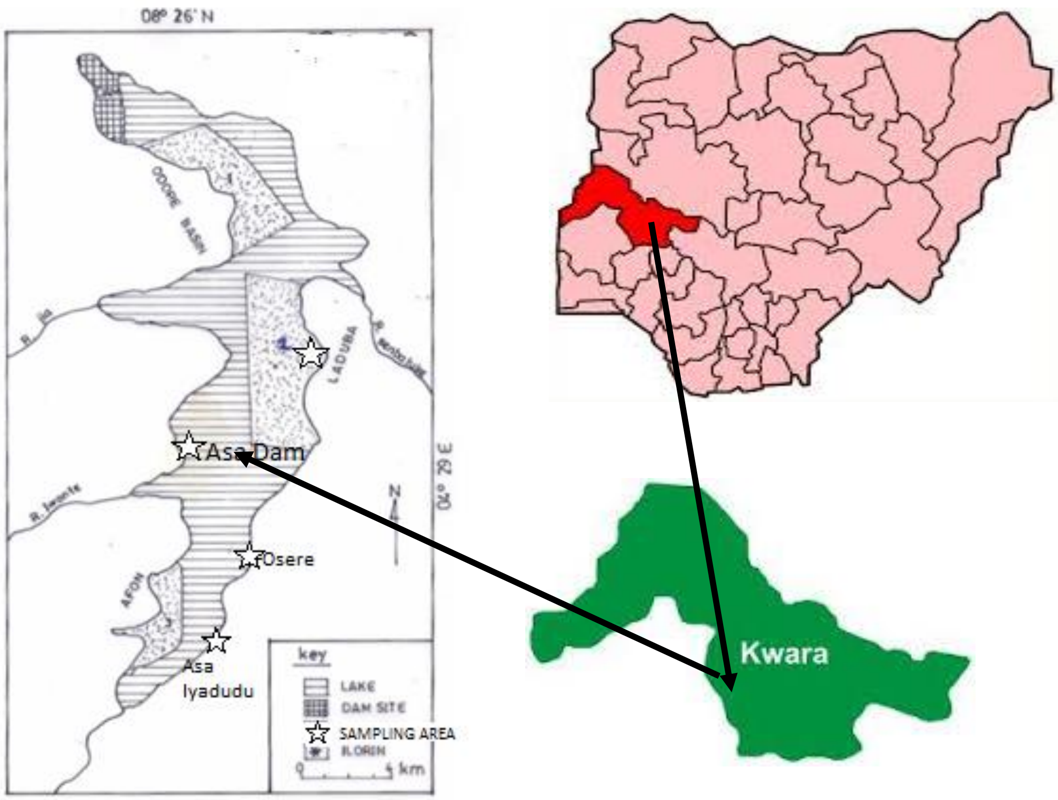

Figure 1: Map showing (a) Nigeria insert Kwara Sate (NPC, 2006) (b) Kwara State inserts Asa and Ilorin LGAs and (c) Asa LGA (adapted and modified from Araoye, 2009) showing study area

Sampling Methods

Primary data were used for this study. Farm level survey provided the basic cross-sectional data from 60 dry season farming in the study area. Data were collected from the farmers with the aid of structured questionnaire and interview. These include farm size, labour, quantity of fertilizer and chemical used as well as irrigation infrastructure. A two stage systematic random sampling technique was used to select the representative farmers that were used for this study. The first stage involved randomly selection of 4 irrigating farming settlements along Asa Rivers. These are: Laduba, Osere, Oyun and Iyandudu. The second stage was random selection of 15 farmers in each of the settlement to make a total of 60 in the study area.

Theoretical framework and Analytical Technique

Irrigation water delivery has a cost, although small-scale irrigation is assumed to be built within the pixel, and we assume no water delivery cost. For dam-based, large-scale irrigation, the estimate of the operating cost of water delivery makes two assumptions: a unit cost of water at the dam (CWu) and a conveyance cost (Liangzhi *et al.*, 2010). This is because water may have to travel a long distance to the dam-based irrigation scheme. Water costs at the dam and conveyance costs arise because of seepage, evaporation, and annual operations and maintenance (O&M) expenditures. The conveyance cost was based on two distances: from the impoundment to the nearest point on the river (Di) and from the nearest point on the river to the grid cell (di). The cost of irrigation water or cost of water at any pixel {CW_i (₦)} is then calculated as:

$$CW_i = CW_u[1 + b(d_i + D_i)^2] \quad (1)$$

b = 0.0005

The squared term is included to capture diseconomies of distance. This implies that rising cost with distance makes irrigating far away from pixels not viable. For small-scale irrigation, we assume no water delivery cost, and CWi = 0. Once the potential area of a given irrigate land has been delineated (a pixel), then optimization model, to maximize the potential addition to annual net revenue (**Total revenue less total fixed cost**) for the irrigated area could be derived. The irrigation water needed per unit area in pixel *i* for crop *j*, IW_{ij} (m^3/ha) can be estimated as **equation 2:**

$$IW_{ij} = \begin{cases} 0 & If \left(\frac{Y^*_{ij2}}{WP_j}\right) - ER_i \leq 0 \\ \frac{\left(\frac{Y^*_{ij2}}{WP_j}\right) - ER_i}{IE} & If \left(\frac{Y^*_{ij2}}{WP_j}\right) - ER_i > 0 \end{cases} \quad (2)$$

Where: WP_j is the crop water productivity for crop *j* (kg/m3); ER_i is the effective rainfall at pixel *i;* IE is the irrigation efficiency for the irrigation system and Y^*_{ijl} is the corresponding yield after the irrigation infrastructure is built

The potential additional net revenue from dam-based, large-scale irrigation investment is from three sources: (a) increased productivity due to the conversion of rain-fed into irrigated production; (b) new land brought into agriculture; and (c) gains from a new crop mix. The additional net revenue produced by irrigation investment can be estimated in equation 3

$$NetRevenue = \sum_i \sum_j (A^*_{ij2} Y^*_{ij2} + A^*_{ij1} Y_{ij1})\, P_j * ProfitRatio_j - \sum_i \sum_j (A_{ij2} Y_{ij2} + A_{ij1} Y_{ij1})\, P_j * ProfitRatio_j - \sum_i \sum_j (A^*_{ij2} - A_{ij2}) * IW_{ij} * CW_i \quad (3)$$

Where: A^*_{ijl} is the harvested area in pixel i for crop j at water source l (where l = 1 if rainfed, and 2 if Irrigated); Y^*_{ijl}. is the corresponding yield after the irrigation infrastructure is built.

The first part of equation (3) is the annual revenue from both irrigated and rain fed production after irrigation capacity is increased, the second part is the annual revenue from current crop production, and the third part is the Operation and Maintenance cost of irrigation water delivery (for small scale, it is zero, because $CW_i = 0$). $ProfitRatio_j$ is the ratio of net profit to the gross revenue for crop $_j$, reflecting labour and input costs. We use the same crop prices and profit ratios before and after the irrigation investment, although equation (3) could easily be modified to handle the different prices and profit ratios, if necessary. Therefore, *Net Revenue* represents the annual revenue increase after the irrigation investment, as compared with no such irrigation investment. There are three unknowns in equation (3):

We assume that irrigation expansion would first convert existing rain fed areas (A_{ij}) into irrigated areas before bringing new land into agriculture. With this assumption, A^*_{ij2} would be either zero (if we convert all rain fed area into irrigated area for pixel *i* and crop *j*) or the remaining rain fed area (if only a part is converted) as in **equation 4** below:

$$A^*_{ij1} = \begin{cases} 0 & If \left(A^*_{ij2} - A_{ij2}\right) \geq A_{ij1} \\ A_{ij1} - \left(A^*_{ij2} - A_{ij2}\right) & If \left(A^*_{ij2} - A_{ij2}\right) < A_{ij1} \end{cases} \quad (4)$$

Our goal is to maximize net revenue, *Net Revenue*, subject to certain constraints. To simplify the optimization, we focus on optimizing the irrigated crop areas (A^*_{ij2}), given the actual irrigated yields (Y^*_{ij2}). It is difficult, if not impossible, for irrigated crops to reach the potential yield. Therefore, we assume a yield reduction factor to estimate the actual irrigated crop yield Y^*_{ij2}) as depicted in **equation 5** below:

$$Y^*_{ij2} = Yieldfactor_j * PotY_{ij2} \quad (5)$$

Equations (4) and (5) would provide A^*_{ij1} and Y^*_{ij2}. Therefore, there would be only one set of unknowns: The problem can then be formulated in **equation 6** as follows:

$$MAX\{NetRevenue(A^*_{ij2})\}, \quad \textbf{(6)}$$

Subjects to

$$A^*_{ij2} \leq PotA_{ij2} \quad \forall i \forall j, \quad \textbf{(7)}$$

$$\sum_j A^*_{ij2} \leq Max(PotA_{ij2}) \quad \forall i, \quad \textbf{(8)}$$

$$A^*_{ij2} \geq A_{ij2} \quad \forall i \forall j, and \quad \textbf{(9)}$$

$$\sum_i \sum_i (A^*_{ij2} - A_{ij2})^* IW_{ij} \leq AvailWater \quad \textbf{(10)}$$

Where $PotA^*_{ij2}$ is the area suitable for irrigation production of crop *j* in grid cell *i*. *Avail Water* is stored water available for irrigation. For dam-based irrigation, we assume Avail Water is 30 percent of reservoir capacity. For small-scale irrigation, Avail Water is equal to the local runoff potential (Liangzhi *et al*. (2010).

Technical efficiency refers to the efficiency with which resources are used in production in terms of physical input and output ratios. Suffice to note that a technical efficient farm produces the maximum possible output from the inputs used, and it minimizes resource inputs from a given level of output.

The stochastic model that was used for the analysis obtained by the MLE method using the program FRONTIER version 4.1c (Coelli, 1996) is of the form **equation (11)**

$$Y_i = f(Xi, \beta).\ ev_i - u_i \quad \textbf{(11)}$$

Where: Y_i = output observed; $f(X_i, \beta)$ = frontier production function; X_i = vector of inputs; β= vector of parameter to be estimated; TE = technical efficiency and e = stochastic error term; v_i = random error and other factors not under the control of the vegetable farmer and u_i = stochastic error within the vegetable farmers control.

To estimate β, the stochastic production frontier model was linearised thus, **equation 12**

$$In\ Yi = \beta_o + \beta_1 In\ X_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_5\ InX_5 + \beta_6\ InX_6 + V - U \quad \textbf{(12)}$$

Where: The output (lnY_i) = Quantity of vegetable produced dry season: lnX_1= Area devoted for dry season farming (Hectare); lnX_2= Number of irrigated equipments including the pumping machine invested (Standardized); lnX_3 = Quantity of seedling materials/ha (Kg); InX_4 = Quantity of fertilizer used/ha (Kg); InX_5 = Quantity of pesticide/ha (litres); and InX_6 = Adjusted labour inputs/ha (labour-days).

The inefficiency of production was modelled in terms of the socio-economic and institutional factors that were assumed to affect the efficiency of production of the vegetable farmers. The determinants of technical inefficiency, (μ_i), is defined by **equation 13**

$$\mu_i = f(Z_i ; \omega) \quad \textbf{(13)}$$

Where: μ_i = technical inefficiency; Z_i = vector of vegetable farmer's specific factors and ω ω_0 = vector of parameters to be estimated as shown in **equation 14**

$$u_i = \omega_0 + \omega_1 Z_1 + \omega_2 Z_2 + \omega_3 Z_3 + \omega_4 Z_4 + \omega_5 Z_5 \quad \textbf{(14)}$$

Where: U_i = technical inefficiency of the ith vegetable farmers; Z_1 = farming experience (years); Z_2 = Adjusted household size of vegetable farmers (number); Z_3= Extension visits during dry season (number); Z_4= Years of formal education/training and Z_5 = years of membership of cooperative in farming.

RESULTS AND DISCUSSION

Socio-economic characteristics of **dry season vegetable farming**

Vegetables in form of *Vernonia amygdalina* (bitter leaf), *Talinum triangulare* (water leaf), *Spinacia oleracia* (spinach), *Amaranthus spinosus* (green amaranth), *Abelmoschus esculentus* (okra), *Lycopersicum esculentum* (tomatoes), *Lactuca sativa* (lettuce), *Telfairia occidentalis* (pumpkin), and *Capsicum annum* (pepper) are most commonly crops grown among the sample respondents in the study area. Though, vegetable growing are diverse, complex and management intensive, it raised the income of the farmers and reduce challenges of dry season unemployment. Along with fruits and nuts, vegetables and melons have long been recognized as vital components in the nutritional health and well-being of any nation (Mir and Gary, 2011). Spurred largely by irrigation potential of the State, demand by both rural and urban households, health and diet concerns of Nigerian citizens and lack of storage facilities, increases in vegetable consumption are daily expected.

Summary statistics of the data reported in Table 1 revealed that dry season farmers in the study area are males dominated (90%); average age of 45 years and married (83%) with mean household size of 7 and adjusted size of 6.5. The estimated mean years of schooling of sampled vegetable farmers were 3.6 years, skewed towards the informal education and below 2011 UNDP mean education index of 5 years for Nigeria. The study also revealed that 68% of the farmers had up to 15 years' experience in irrigated farming. The level of investment, area devoted to farming and average yearly income from either leafy or fruity vegetable (a proxy for output) farming depict in Table 1 also revealed that the irrigated farming is still not develop and largely subsistence and rudimentary.

Table 1: Dominance socio-economic indicators of the irrigated dry season farmers

Variables	Dominance indicators	Mean	Std dev	CV
Gender	90% were male	-	-	-
Marital status	83% were married	-	-	-
Age (yrs)	80% below 45 years	43	5.5	12.8
Level of Education (years)	51% had no primary schooling	3.6	2.9	80.6
Farming experience (years)	68% had up to 15 years	17	6.4	37.6
Household size (persons)	55% had 6-10 persons	7	3.0	42.9
Extension contact (numbers)	72% had no contact at all	2.6	1.5	57.7
Formal group (years)	87% agreed that is inactive	14.5	4.9	33.8
Irrigate farming area	75% had 0.5-1.5 ha	0.92	0.6	65.2
Level of investment(₦)	62% invested<₦150, 000	132500	18500	13.96
Type of crops	87% produce vegetables	-	-	-
Major occupation	89% engage in farming	-	-	-
Ancillary occupation	95% in rainfed crop farming	-	-	-
Labour components/year	69% used family labour	35	9.8	28.0
Average income/year (₦)	50% earned> ₦55, 500	62501	13400	21.4
Off-farm income/year (₦)	57% earned>₦51, 000	56500	5600	9.9

Source: *Field survey, 2011-2012; Note: ₦, Nigeria currency Naira and 1US$= ₦156 during field survey*

Note: The 60 sample farmers engaged in both rainfed and dry season farming in the study period

Majority of the pooled farmers (95%) had subsidiary occupations (rainfed arable crop farming) with average annual irrigated farm income of ₦62,501 compared to mean income from rainfed farming of ₦56, 500 per year. However, it shows that the vegetable farmers have developed capacity to cope with increasing vulnerability associated with fluctuating farming by diversifying to achieve high productivity leading to an appreciable increase in the income of the vegetable farmers and consequently reducing their poverty status.

Differential profitability analysis

The results of net margin and profitability analysis are presented in Table 2. The dry season farmers are primarily interested in selling their outputs to raise income and probably satisfied the household's food need or subsistence. Thus, the vegetable farmers like any other entrepreneur may have a profit motive. Both the variable and fixed costs of production were considered for irrigated farming because of the investment in irrigation equipments. Therefore, the profitability was measured as both the gross and net margins. Both total cost and gross margin showed that dry season irrigated farming was less cost and more profitable compared to rainfed farming. In fact, average net margin was about 11% higher among the irrigated unit than the rainfed farming. The result also revealed that labour costs accounted for approximately 63% of AVC for irrigated farming and more than 73.5% of rainfed and 54% and 73% respectively of Total cost (Table 2).

Profitability ratios also in Table 2 showed irrigated farming profit margin, gross ratio and return on investment to be 0.49, 0.51 and 1.96 respectively were found to be higher on the three count compare to 0.46, 0.54 and 1.84 respectively for rainfed farming. The return on investment means that for every one naira invested by irrigating or rainfed, a profit of ₦1.96 or 1.84 is made. This ratio reflects the return available to investments. It shows the returns to the capital investment over the production period, that is, a measure of the profitability of the investment capital (Engle and Neira, 2005). It reflects the true value of profit or gain that can be realized for every ₦1 investment made to the business. The ratio not only indicates substantial return to the enterprise, but also a high level efficiency in the use of capital.

Based on the findings in Table 2, as well as indicators computed, it can be concluded that proceeds from both farming units {net margins (profit)} has proved to be a strong relief in term of financial and employment. Therefore, rainfed farmers in the study area should continue to practise dry season farming as main and secondary occupation to increase their income which will ultimately improve their well-being and reduce the level of poverty in the study area. Although off-farm income plays an important role among rural farming households in Nigeria to sustain their living, but majority do stay unemployed during the off-farm season.

Further implication of this finding was that farmers who combine both rainfed and dry season irrigated farming may likely not experience cycle of seasonal food shortage, experienced by majority of farming households in Nigeria. And, likely to overcome caloric and nutrition insufficiencies, and earned more and stable income to fulfil their domestic obligations since the majority of Nigerian farm households depend on income from both farm and off-farm sources.

Table 2: Differential average costs and revenue per hectare of vegetable production in Asa River**:** dry season (irrigated) and rainfed farming

Variables	**Dry season (Irrigated)**			**Rainfed**		
	₦ha^{-1}	**US\$ha^{-1}**	**%**	**₦ha^{-1}**	**US\$ha^{-1}**	**%**
Revenue from (₦):						
leafy vegetables	74, 600.5	478.2	58.6	28,500	182.7	23.1
Fruity vegetables	45800.5	293.6	36.0	24,508.5	157.1	19.8
Other crops	6,878	44.1	5.4	70,641.5	452.8	57.1
A. Total revenue	**127,279.1**	**815.9**	**100**	**123,650**	**981.3**	100.00
Variable cost (₦)						
Seedling materials	3708.5	23.8	5.7	4150	27.6	06.2
Fertilizer	8500.0	67.4	13.1	9600	62.5	14.3
Chemicals	2570.5	16.5	4.0	3600	23.1	05.4
Labour	35, 000	224.3	54.0	48, 000	307.7	71.5
energy	5500	35.3	8.5	-		00.00
B. Total variable cost	**55,279.0**	**354.4**	**85.3**	**65, 350**	**418.9**	97.3
C. Gross margin(A-B)	**72,000.1**	**461.5**		**58,300**	**373.7**	
Fixed cost items						
Land charges	2000	12.8	3.1	1800	11.5	2.7
Depreciation	7500	48.1	11.6	-	-	00.00
D. Total Fixed Cost	**9500**	**60.9**	**14.7**	**1800**	**11.5**	**2.7**
E. Total costs (B+D)	**64,779.0**	**415.3**	**100**	**67,150**	**430.5**	**100**
F.Net margin/ha (A-E)	**62,501.1**	**400.7**		**56,500**	**362.2**	
Profit margin (F/A)	**0.49**			**0.46**		
Gross ratio (E/A)	**0.51**			**0.54**		
ROI (A/E)	**1.96**			**1.84**		

Source: Field survey, 2011/2012; ***ROI indicate Return on Investment***

Technical Efficiency Results

The results of the stochastic frontier model estimated in Table 3 showed that there was significant difference in the technical efficiency among 60 vegetable dry season farmers in Kwara State. The estimated parameter of sigma-squared was 0.324 significantly different from zero at 1% level of probability, indicating a good fit and the correctness of the specified distributional assumption of the composite error term. The value of the gamma statistics 0.621, though statistically significant at 5% was attributable to vegetable farmers' inefficiency factors. The generalized likelihood ratio statistics was 151.7, exceeds the critical chi-square values at 1% level of significance which represents the value that maximizes the joint densities in the estimated model. Thus, the Cobb-Douglas used in this estimation is an adequate representation of the data.

The results also revealed that area devoted to vegetable farming (X_1), capacity of irrigating machine ((X_2), seedling materials (X_3) and labour input (X_6) were found to be significant variables in technical efficiency of vegetable farmers. The estimated coefficient of area devoted for dry season farming (0.046) was in line with *a priori* expectation and significant at 5% which implied that output would increase if vegetable farmers increase the irrigated area devote for vegetable farming. Similarly, the parameter estimates for irrigated materials (0.032) significant at 10%, and seedling materials (0.491) significant at 10%, and labour input (0.875) significant at 1% were all in line with *a priori* expectations. The positive signs of these variables are expected as the number of irrigation materials owned by a farmer and amount of labour used, being a subsistence venture, increases output of vegetable. The results also implied that a unit increase in the area devoted to farming, irrigated materials, seedling materials and labour would increase vegetable output by 0.046, 0.032, 0.491and 0.875 units respectively.

However, though not significant, the negative value of pesticide (X_5) implies that a unit increase in this variable will decrease output by 0.190 units. The regression coefficients of Cobb-Douglas production function are the production elasticities, and their sum indicates the return to scale. The sum of the elasticities of production of the inputs was 2.258, indicating increasing returns to scale. This means that with a percentage increase, all the inputs that showed positive relationship results in a greater percentage increase in output. Also, the sum of the elasticities of production obtained in this study implied that vegetable farmers were in stage one of production which is irrational stage, this is because at this stage farmers cannot maximize their profit. Resources at this stage were under-utilized; hence, there is need for the farmers to increase the use of inputs. The inefficiency sources modelled showed that all variables were in line with *a priori* expectations but, only years of experience, adjusted household size and, level of education were the significant factor affecting vegetable production in the study area.

Table 3: MLE of the cobb–douglas stochastic frontier model for dry season farming

Variables	Parameters	Coefficients (β)	(SE)	t-ratio
Frontier production function				
intercept	β_o	0.852	0.117	7.29
ln farm size (X_1)	β_1	0.046	0.021	2.24
In Irrigated equipments (X_2)	β_2	0.032	0.019	1.71
In Seedling materials (X_3)	β_3	0.491	0.311	1.58
In Fertilizer (X_4)	β_4	0.152	0.158	0.96
ln Pesticide (X_5)	β_5	-0.190	0.186	-1.02
In Labour input (X_6)	β_6	0.875	0.302	2.90
Technical inefficiency function				
Constant	ω_0	-1.052	-0.523	-2.01
Farming experience (Z_1)	ω_1	-0.540	-0.180	-3.00
Adjusted household size(Z_2)	ω_2	-0.184	0.062	-2.95
Extension contact(Z_3)	ω_3	-0.099	0.095	-1.04
Level of education(Z_4)	ω_4	-0.342	0.197	-1.74
Cooperative society (Z_5)	ω_5	0.042	0.029	1.43
Diagnostic statistics				
Sigma square ($\sigma_v^2 + \sigma_u^2$)	σ^2	0.324	0.105	3.08
Gamma (σ_u^2 / σ_u)	γ	0.621	0.297	2.09
LR test		151.7		
log likelihood		49.5		
no of observation		60		
average Technical efficiency		84.9		

Source: Field survey, 2011/2012

Note: The result of estimated technical efficiency considered only dry season vegetable data

The distribution of technical efficiency scores, relative to the best practice frontier score and relative efficiency indices are reported in Table 4. The result revealed the mean technical efficiencies to be approximately 0.85. This implies that vegetable farmers could increase output level if the efficiency of inputs usage is increased by 0.15. Thus, opportunity still exists for increasing vegetable productivity and income through increased efficiency with the use of existing resources. Suffice to note that the bulk of farmers (about 70%) were above sixth quartile distribution efficiency.

Table 4: Deciles distribution of technical inefficiencies of irrigated farmers

Efficiency index	No. of farmers (F)	Percentage (%)
0.01– 0.10	1	01.7
0.11 – 0.20	2	03.3
0.21 – 0.30	-	00.0
0.31 – 0.40	3	05.0
0.41 –0.50	6	10.0
0.51 – 0.60	6	10.0
0.61 – 0.70	7	11.7
0.71 –0.80	17	28.3
0.81 – 0.90	15	25.0
0.91 – 1.0	3	05.0
Total (1)	60	100.0
Mean	84.9	
Minimum	0.19	
Maximum	92.5	

Source: Field survey, 2011/2012

Constraints faced by dry season vegetable farmers in the study area

The result of analysis of constraints encountered by dry season vegetable farmers in the study area ranked from most critical to the least showed that lack of access to irrigable land (water) took the lead indicated by 21.3%. This was followed by the high cost of equipments (14.4%) and inadequate finance (13.3%). It suffices to note that these three constraints identified as most important constraints sum up to over half (51%) of the problems of vegetable farmers in the study area.

Table 5: Constraints encountered by dry season irrigated farmers in Asa River Kwara -State

Constraints	Frequency	Percentage (%)	Rank
Inadequate irrigable land and water	42	23.3	1st
High cost of irrigated equipments	26	14.4	2nd
Inadequate credit facility	24	13.3	3rd
Pest and disease problem	21	11.7	4th
Polluted water	18	10.0	5th
Inadequate inputs	14	07.8	6th
Transportation	13	07.2	7th
Pilfering	9	05.0	8th
Marketing problem	5	02.8	9th
High cost of hired labour	5	02.8	10th
Others	3	01.7	11th
Total	180	100	

Field survey, 2011/202; **** The most three critical constraints per irrigated farmer were analysed***

It may be concluded that if these three constraints are looked into and their farming cooperatives are resuscitated, other impediments such as 4th, 6th, 7th, 8th, and 10th constraints may cease to exist or reduce to minimum in the study area.

POLICY IMPLICATIONS

To accelerate self sufficiency in food production and the country's Gross Domestic Product rate of growth to above average (50%), it is essential that small scale irrigation potential should be harnessed. This will guarantee agricultural production both wet and dry seasons, and has the potential to catalyze socio-economic transformation of rural masses and alleviation of poverty. Improvements in the current irrigation infrastructure such as provision of pumping machine, access to underground water through well and boreholes, conserving surface run off during precipitation, improving water conveyance and distribution efficiency, upgrading irrigation efficiency and drainage systems, and enact public law on industrial pollutants and dumping refuse near river bank are recommended to sustain agricultural production via irrigation and the environment.

Further, ministry of environment could collaborate with relevant agencies such as the State ministry of agriculture (through extension agents) to educate and monitor the public, and fresh water stakeholders on the problems of indiscriminate dumping of domestic and industrial effluent, obnoxious fishing equipments (fishermen) and pesticide discharged by farmers. In this way, the present and future agricultural production is enhanced through conservative and sustainability of water resources. Finally, a suitable indicator could be developed through community's watchdogs in collaboration with all water users to measure activities of industries, fishing and other river users too, and to ensure that the water resources are managed sustainably and transparently to support inclusive economic and human development.
Above all, investing in irrigation could be an impetus to achieving sustainable food and water security and improve living standard among farming households. And possible transition of this sector from subsistence to commercial production, to achieve the first Millennium goals of halve the percentage of people in extreme poverty and hunger, fifth goal of improved health and balance nutrition, and the seventh goal of ensuring environmental sustainable development policy of global objective.

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