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Options for Enhancing Agricultural Productivity in Nigeria

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THE NIGERIA STRATEGY SUPPORT PROGRAM (NSSP)
BACKGROUND PAPERS

ABOUT NSSP

The Nigeria Strategy Support Program (NSSP) of the International Food Policy Research Institute (IFPRI) aims to strengthen evidence-based policymaking in Nigeria in the areas of rural and agricultural development. In collaboration with the Federal Ministry of Agriculture and Water Resources, NSSP supports the implementation of Nigeria's national development plans by strengthening agricultural-sector policies and strategies through:

- Enhanced knowledge, information, data, and tools for the analysis, design, and implementation of pro-poor, gender-sensitive, and environmentally sustainable agricultural and rural development polices and strategies in Nigeria;
- Strengthened capacity for government agencies, research institutions, and other stakeholders to carry out and use applied research that directly informs agricultural and rural polices and strategies; and
- Improved communication linkages and consultations between policymakers, policy analysts, and policy beneficiaries on agricultural and rural development policy issues.

ABOUT THESE BACKGROUND PAPERS

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Introduction

Since 2003, economic growth in Nigeria has been strong. Annual GDP grew by 9.1 percent per annum between 2003 and 2005 and by 6 .1 percent per annum between 2006 and 2008. Much of this growth can be attributed to the non-oil economy which has grown rapidly. This is due primarily to agriculture, which contributes approximately 35 percent to total GDP and supports 70 percent of the population (see Table 1).

Table 1: Key Economic Indicators

	1997–2000	*2003–05*	*2006–08**
	Average annual percent		
GDP growth**	2.9	9.1	6.1
GDP non-oil growth	3.5	9.2	9.3
Agriculture	4.2	6.8	7.2
Manufacturing	0.1	9.1	9.2
Services	3.2	13.8	13.1
Fiscal balance/GDP***	-0.7	4.5	4.5
Inflation	8.0	15.6	8.5

**A statistical break in national accounts distorts growth rates for 2002. The 2001 and 2002 data are therefore excluded from this table. The 2007 data is provisional; the 2008 data is estimated

Source: NBS, 2007.

But the recent agricultural growth has been driven mainly by expansion in areas planted with staple crops. Productivity has remained flat or declining. Yields of most crops have declined relative to a base period two decades ago. For that reason the Nigerian government's main focus at present is on raising agricultural productivity, both in staples for local and regional consumption and for a wide range of products. With the current fall in oil prices, the Nigerian government is increasingly giving agriculture a higher priority in its effort to reduce poverty, diversify the national economy away from oil and ensure food security (NPC 2005; World Bank 2005). To achieve these objectives, the government initiated the presidential initiative, which gives cassava, rice, vegetable oil, tree crops, livestock, fisheries and aquaculture special priority in resource allocation (FAO 2006). The government also put special emphasis on agriculture in its overarching rural development programs, the National Economic Empowerment and Development Strategy (NEEDS) and the New Agricultural Policy Thrust known as NAP (NPC 2005). However, the federal government's agricultural expenditure as a share of the total budget has remained low and declined from 2.2% in 2001 to 1.7% in 2005 (Mogues et al. 2008). Even though this trend reflects the need to increase investment in agriculture, the recent government policies and strategies have demonstrated a renewed commitment to agriculture (WDI 2007) and that more efficient use of the funds will significantly enhance effectiveness of public investment (Alpuerto, et al., 2009). Additionally, private investment in agriculture has increased in the past few years, leading to significant growth of the agricultural GDP from 3.3 percent in 1991–2000 to 6 percent in 2001–2006 (WDI 2007).

Agricultural research has been shown to be crucial in increasing agricultural productivity and reducing poverty. A study by Alene et al. (2007) showed that a 50 percent increase in the Nigerian research budget could lead to a substantial reduction of poverty across the country's three major agroecological zones. In the central part of the country (moist savannah), maize and yams had the highest potential to reduce poverty (by respectively 8 percent and 6 percent) while cassava and yams had the highest potential in the humid forest zone in southern Nigeria (Alene et al. 2007).

Another study by Ehui and Tsigas (2009) shows that agricultural investment can be as profitable as investment in any other sector of the Nigerian economy. They show that (after adjusting for size) some agricultural subsectors (such as cattle, fruit, grains, and vegetables) outperform some of the oil and manufacturing sectors in terms of investment returns..

Agriculture's large impact on poverty reduction and overall economic growth is because the majority of the rural poor depend heavily on agriculture and natural resources Alene et al. 2007; World Bank 2005). In order to effectively exploit agriculture's potential to reduce poverty and enhance economic growth, policymakers need clear and empirical evidence to formulate and implement poverty reduction policies and strategies. This study stems from the Agricultural Policy Support Facility (APSF), whose objective is to support evidence-based formulation and implementation of pro-poor, gender-sensitive, and environmentally sustainable agricultural policies and strategies. This study aims to provide empirical evidence for formulating policies and strategies that develop the agricultural sector as part of the government's poverty reduction and rural development efforts. The study determines the comparative advantage of major crops in different agroecological zones. It does this by using the profitability of the major crops in each of the agroecological zones. To understand the policies and strategies that could promote high productivity, this study also analyzes the determinants of profitability and crop productivity.

The remaining part of this report is structured as follows. The next section discusses major crops in Nigeria and their production trends across the country. This is followed by a discussion of data and analytical methods. The fourth section presents the results and the final part of the paper offers conclusions and policy implications.

Production trends across agroecological zones

Ceral, root, and tuber dominate Nigerian crop production. The most common cereal is the sorghum (guinea corn), which is grown mainly in the northern states. About 28 percent of farmers grow sorghum and 21 percent grow cassava (Appendix 1). Cassava contributes the largest share of daily per capita food consumption (1.6 kg) in Nigeria (FAOSTAT 2003) and is grown in the north and south. Nigeria is the world's largest producer of cassava, though the crop is grown largely for the domestic and regional markets. Nigeria is also the world's largest producer and consumer of yams. In 2004, Nigeria accounted for 70 percent of the 47 million tons of yam produced in the world (CGIAR 2007). Nigeria is also the world's leading producer of cowpea (Manyong et al. 2005).

Interestingly, a larger share (40 percent) of farmers in the richest quintile grow cassava compared with only 11 percent in the poorest quintile. About 8 percent to 11 percent of farmers are also reported to grow beans, yams, maize and millet. However, Maziya-Nixon, (2004) reported that maize is the most frequently consumed crop. FAOSTAT (2003) shows that the cereal is the ninth-most important contributor to daily food consumption in Nigeria (Table 2). The importance of maize has been increasing—reducing the dominance of the tuber crops in Nigerians' diets. Rice is the third-most frequently consumed crop in households (Maziya-Dixon et al. 2004) but it is only the sixth-most important contributor to daily per capita consumption of food (Table 2). Due to its increasing importance as a food crop— especially to the urban population, the government has designed a number of strategies to reduce the importation of rice. Maize is also among the presidential initiative crops.

The limited number of farmers who reported growing export crops like cocoa, cotton, rubber, oil palm, and ground nuts is noteworthy. As is the case in other African countries, commercial crop farmers are the richest farmers in Nigeria (Ojowu et al. 2007). Only 2.3 percent of farmers reported growing cocoa and less than1 percent grew cotton. This underscores the domestic orientation of Nigeria's agricultural production. Such an orientation is justified by the large urban market in Nigeria, which is one of the most urbanized countries in Sub-Saraham Africa (SSA). However, the need to increase production of export crops is also critical given the country's high agricultural potential and the number of poor Nigerians who depend on the agricultural sector.

Table 2: Contribution of different crops to daily food consumption in Nigeria

	Consumption of food (grams/person/day					
Crop	**1969-1971**	**1979-1981**	**1990-1992**	**1995-1997**	**2001-2003**	**Share of total consumption**
1.Cassava & its products	233	211	330	364	318	0.21
2. Yams	210	78	182	218	208	0.13
3. Vegetables & other products	123	92	109	130	133	0.09
4. Sorghum & its products	137	98	109	131	120	0.08
5. Fruits (citrus & other fruits)	132	129	128	128	121	0.08
6. Millet & products	118	77	102	110	97	0.06
7. Rice & prod (milled equivalent.)	12	49	66	60	74	0.05
8. Maize & its products	43	19	98	87	57	0.04
9. Wheat & its products	17	47	16	24	50	0.03
10. Plantains	56	44	41	45	47	0.03
11. Sweet potatoes	6	3	4	26	40	0.03
12. Sugar & its products (raw equivalent.)	8	31	16	20	30	0.02
13. Pulses, other & products	25	15	24	26	26	0.02
Total daily consumption (grams/person/day)						1545

Note: No data reported in 1993-95.

Source: FAOSTAT (http://www.fao.org/faostat/foodsecurity/index_en.htm)

Given the discussion above we focus on the following crops, which are the most important in terms of food and nutrition security and poverty reduction: cassava, yams, maize, rice, vegetables, and cowpeas to represent the edible seeds known as pulses. We do not discuss sorghum due to the limited data obtained from the key survey data used in this study. Production of these crops across zones differs significantly. We discuss the results using the three agroecological zones, which are the humid forest zone in the southern states, moist savannah in the central states, and the dry savannah that covers the northern states (Maziya-Dixon et al. 2004).

The dry savannah zone accounted for about 60 percent of the maize and rice production between 1994 and 2005, making it the most important cereal-producing zone. Figures 1 and 2 show that cereals contribute the largest share of the energy (45 percent) and the protein (50 percent) intake in Nigeria. This demonstrates the importance of the cereal crops and the need to develop the sector in the dry savannah, an area with the most severe poverty (Ojowu et al. 2007; Alene et al. 2007).The yield of maize is about 1.7 tons per hectare, which is only about 50 percent of the maize yield potential in the moist savannah (Jagtap and Abamu 2003) and 38 percent of the 4.5 tons per hectare yield obtained in the Sasakawa Global 2000 demonstration plots (World Bank 2008). As expected, the humid forest—with more abundant and reliable rainfall—reported the highest yield (1.78 tons per hectare) but the difference from the yield reported in the dry savannah (1.72 tons per hectare) is minimal.

The moist savannah is the leading producer of yams, accounting for about two thirds of the average total production of 22.9 million tons in 1994–2005 (Table 3). Mean gross yield of yams in Nigeria and Sub-Saharan Africa is about 10 tons per hectare (Table 3 and CGIAR 2006). The moist savannah is also the leading producer of cassava.

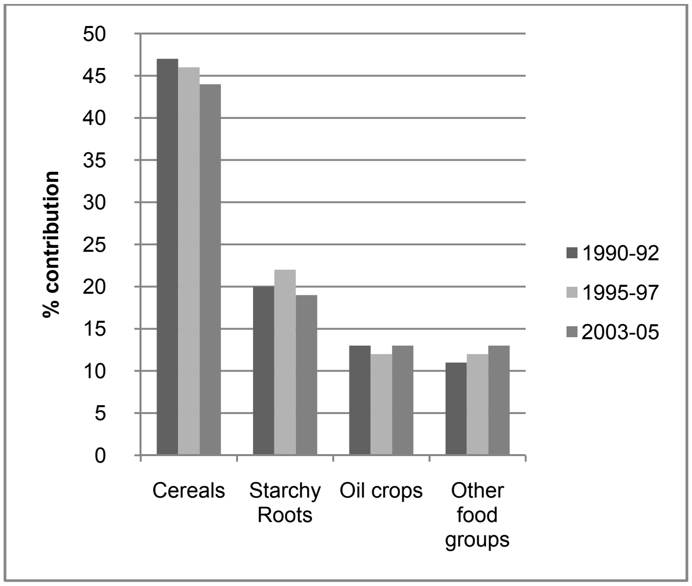
Table 3: Productivity and contribution of crops across agroecological zones (1994 – 2005 average)

	Total production	Humid forest	Moist savannah	Dry savannah
Maize				
Zonal level yield (tons/ha)		1.78	1.67	1.72
Zonal level per capita production (kg/capita)		22.57	44.83	54.95
Zonal level production (000 tons)	5268.989	877.47	1444.99	2946.54
Contribution to total production		0.2	0.3	0.6
Rice				
Zonal level yield (tons/ha)		2.1	2.1	1.9
Zonal level per capita production (kg/capita)		8.7	34.7	35.0
Zonal level production (000 tons)	2959.776	240.0	987.3	1732.6
Contribution to total production		0.1	0.3	0.6
Yams				
Zonal level yield (tons/ha)		10.5	11.7	9.9
Zonal level per capita production (kg/capita)		193.0	426.5	122.8
Zonal level production (000 tons)	22894.63	6497.2	12833.7	3563.7
Contribution to total production		0.3	0.6	0.2
Cassava				
Zonal level yield (tons/ha)		14.4	11.2	12.7
Zonal level per capita production (kg/capita)		277.8	337.8	175.5
Zonal level production (000 tons)	29214.58	9545.7	11420.1	8248.8
Contribution to total production		0.3	0.4	0.3

Source: NBS raw data

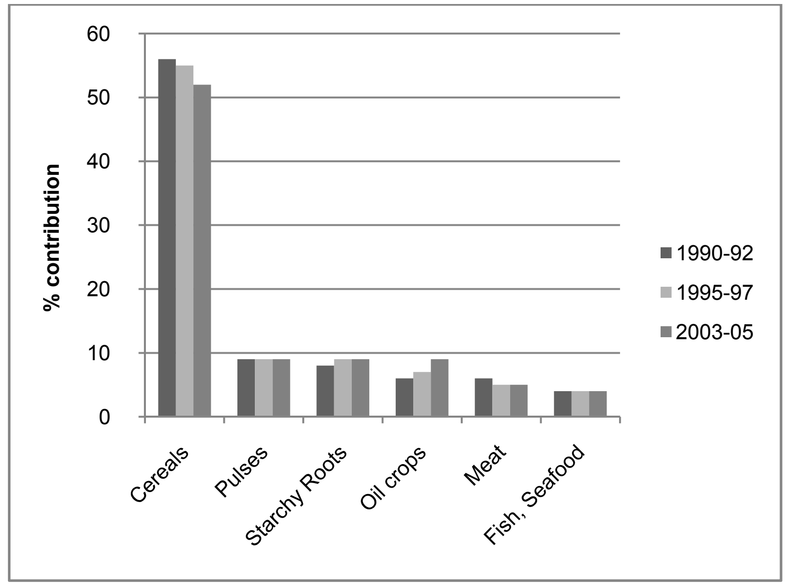
According to data gathered by the Food and Agriculture Organization of the United Nations (FAO), per capita production of the food commodities has increased (Figure 3). Holmen (2005) also observed an increasing per capita food production in Nigeria—a trend that is contrary to what is taking place in most other African countries. The upward trend is also not reflected by the less-spectacular crop area expansion (Figure 4) and stagnant or declining yields (Figure 5–8) and the declining per capita production of individual crops as reported by the National Bureau of Statistics (NBS) data (Figure 5-8). The yield of tubers (cassava and yams) shows a more significant upward yield trend (Figure 7 and 8). However, other studies have shown a generally flat or declining yield trend of roots and tubers. For example, the area planted with roots and tubers quadrupled while yield decreased by more than 40 percent from the mid–1980s to 2005 (World Bank 2006).

Figure 1: Food group contribution to energy consumption



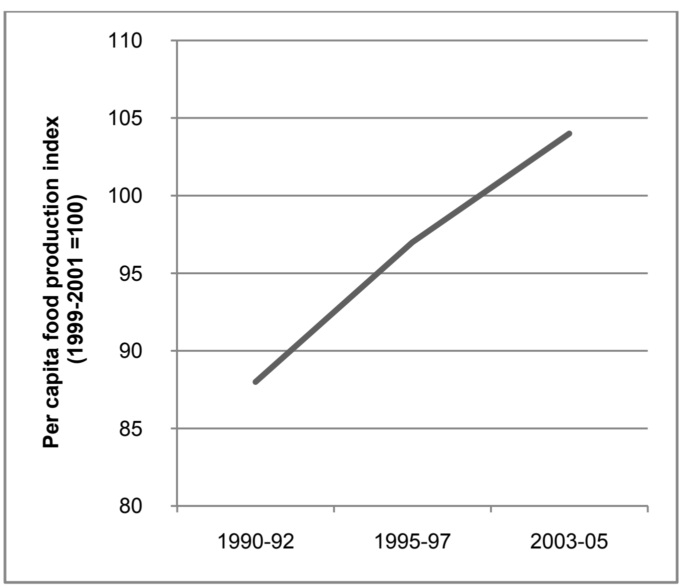
Source: FAOSTAT
http://www.fao.org/faostat/foodsecurity/index_en.htm

Figure 2: Contribution of food groups to protein consumption



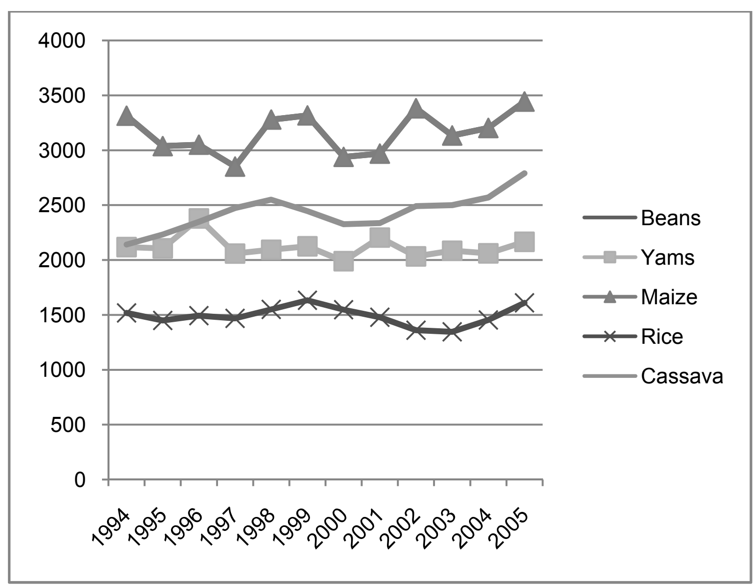
Source: FAOSTAT (http://www.fao.org/faostat/foodsecurity/index_en.htm

Figure 3: Per capita food production index



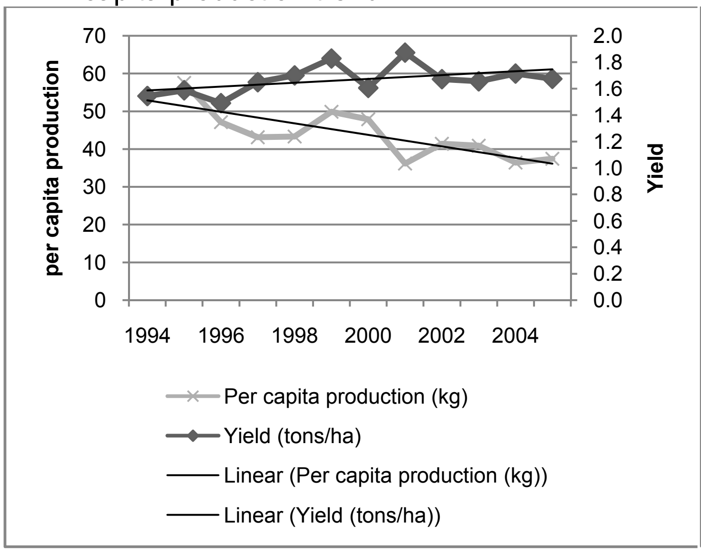
Source: FAOSTAT
(http://www.fao.org/faostat/foodsecurity/index_en.htm)

Figure 4: Trend of area under staple food crops (hectares)



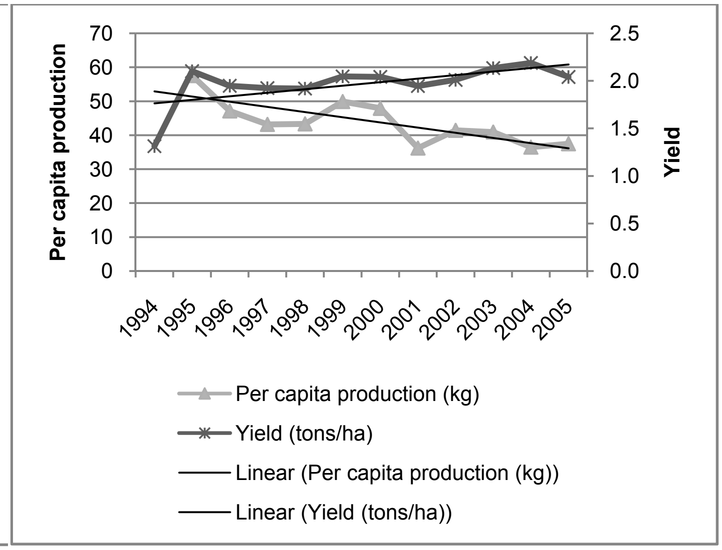
Source: FAOSTAT (http://www.fao.org/faostat/foodsecurity/index_en.htm

Figure 5: Trend of maize yield and per capita production



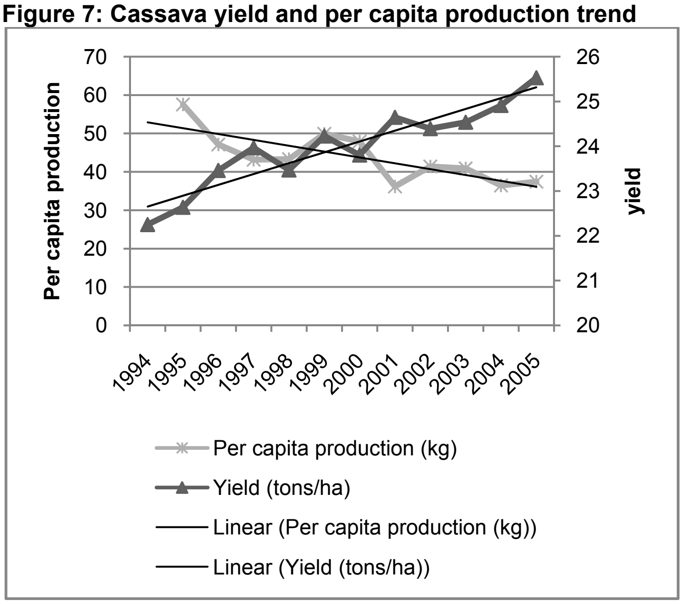
Source: NBS raw data.

Figure 6: Rice yield and per capita production trend



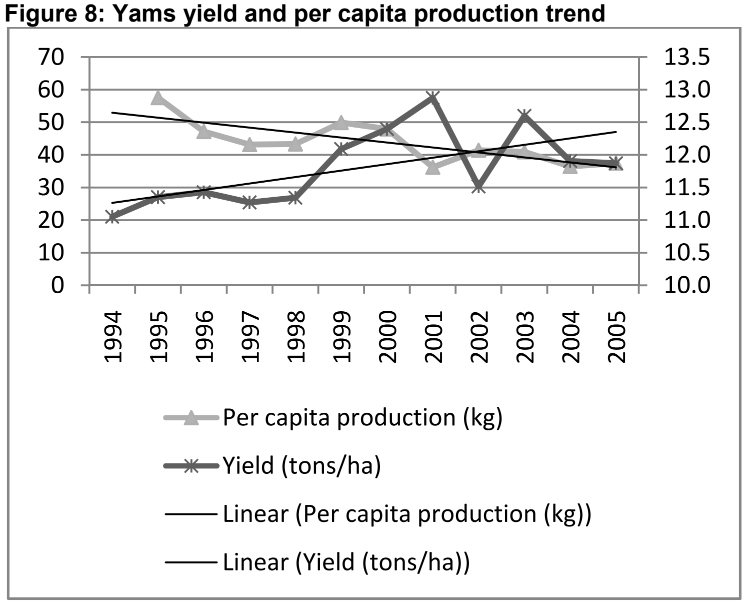
Source: NBS raw data.

Figure 7: Cassava yield and per capita production trend



Source: NBS raw data

Figure 8: Yams yield and per capita production trend

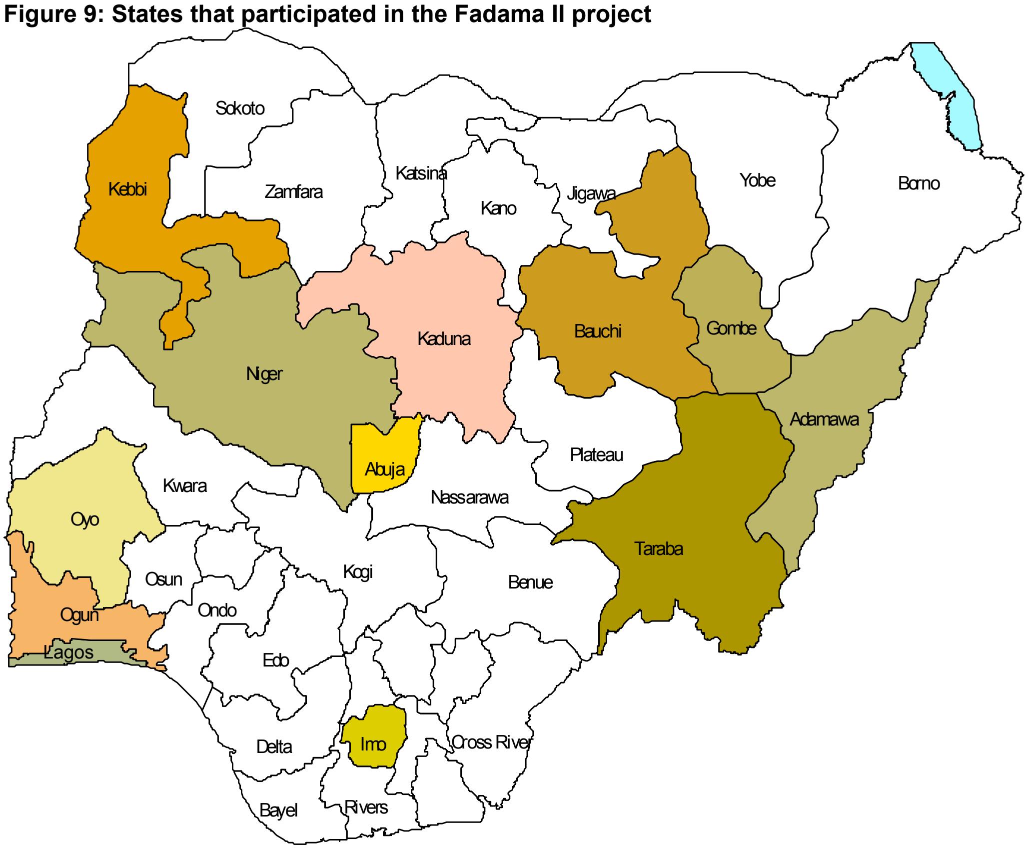


Source: NBS raw data

Methodology

We analyze the value of production per hectare (hereafter simply referred to as productivity) and the profitability of crops using data from the Fadama II survey, which covered 3,750 households in *fadama* (low lying floodplains) regions of Nigeria, and was conducted in late 2006 to early 2007 (Nkonya, et al. 2008). T The survey randomly drew the sample households from those who participated in the project (Fadama II beneficiaries) and those who did not. The 12 states where the Fadama II project operated are shown in Figure 9.

Figure 9: States that participated in the Fadama II project



The purpose of this sampling approach was to evaluate the impact of the Fadama II project on participants compared with non-participants. Nkonya et al. (2008) provided details of the sampling method, survey design, and analysis used to evaluate the impact of Fadama II.

Please note that the sampling frame we used in this study is not nationally representative or even representative of the 12 states where Fadama II operated. Rather, the sample is representative only of *fadama* areas within those 12 states. We could not use the 2005 agricultural household survey conducted by the NBS or the 2006–07 socioeconomic survey data since the data did not show the allocation of inputs for each specific crop. However, we did use these data to verify some of the results of the Fadama II survey. Our findings therefore will not provide information on which crops and production practices are profitable in Nigeria or the Fadama II states as a whole, but rather are limited to providing such information only for *fadama* areas in those states.

We computed profitability using the gross margin, estimated as the value of crop production minus cash expenses (that is, for purchased inputs and hired labor). Profitability as used in this study—is the return to family labor and other household-owned resources used in production (such as, livestock, equipment, own-produced seeds), which are not included in the calculation. This is an imperfect indicator of profitability as it does not include all costs of production. We use this indicator primarily because of the limitations of the data—the survey did not collect the amount of family labor and other household-owned resources used in crop production. Our results should also be interpreted with this data limitation in mind; that is, recognizing that we have not estimated profits net of all costs. This may lead to biases such as higher gross margins being estimated for crops and production practices that use more farm resources. This suggests lower profitability if all costs were accounted for.

The analysis uses simple descriptive statistics and econometric regression to identify differences in the value of production and in gross margins across different crops, agro-ecological zones, genders, and Fadama II project participation categories.

Analytical methods

In this study, we analyze the determinants of productivity for the major crops using econometrics methods. Our crop productivity model follows Prasad et al. (2006), Reardon and Vosti (1995), Carter and Barrett (2006), and the livelihood framework by Carney (1998). These models show that crop yield is a function of production technology and biophysical characteristics (rainfall intensity and pattern, soil characteristics, altitude or temperature or both and so on). We used the Ordinary Least Square (OLS) methods to estimate the determinants of crop productivity and profitability. The general empirical model is:

$\mathbf{Y} = f(\mathbf{X}, \mathbf{Z}, \mathbf{M}, e)$ …………………………………(1)

Where **X** = a vector of household socioeconomic characteristics (human, physical, natural, financial, and social capital).

M = production technologies used [expenditure on fertilizer used, use of fertilizer (intercept shift dummy), use of irrigation, crop cover, and water and harvesting and moisture conservation practices].

Z = conditioning factors beyond the household that affect productivity, namely distance to roads and markets and fixed effects. For the NBS data, which is large, we will use states to represent fixed effects. For the Fadama II data, we will use the agroecological zones (humid forest in southern Nigeria, moist savannah in central Nigeria and dry savannah in northern Nigeria). We tested for the exogeneity of the potentially endogenous **M** variables using the C-statistic test (Baum et al. 2003) and found that most of the **M** variables were endogenous. However, we did not find good instruments given that we were using only household-level data. Hence for the crop productivity model, we estimated the structural model and the reduced model and compared the sign and significance of the coefficients. This is the model that we used to compute the value cost ratio of fertilizer. The results generally showed robustness as the signs of the structural and reduced models were the same. Only one variable (area of irrigated land) of the 28 variables for eight crop models showed the opposite sign for the maize structural and maize reduced form models. We estimated all the profitability models as reduced models since the major endogenous variables (type of fertilizer and manure used) were estimated as costs of production and hence used to compute the dependent variable.

For the NBS data, we used the microfinance, commercial bank, cooperative and tenure (family land, rented, squatter) as instruments and they passed the relevancy tests. C-statistics also showed that the Instrumental Variable (IV) was better than the OLS model.

Other estimation and the data issues we considered were heteroskedasticity, multicollinearity, and outliers. Multicollinearity was a problem between the intercept dummy (use of fertilizer) and the expenditure of fertilizer (variance inflation factor >10) as shown by Mukherjee et al. (1998). However, since we wanted to estimate the elasticity of fertilizer expenditure, inclusion of the intercept shift dummy was important in the model to avoid losing observations with zero expenditure on fertilizer (Ln(0) = infinite). However, the multicollinearity did not significantly affect the results since the reduced model gives comparable results. The distribution of the continuous variables was skewed for most of the continuous variables. We log-transformed the continuous variables and this greatly improved the explanatory power of the crop yield variables. Log-transformation also simplifies the interpretation of the regression results.

Results

Land management practices

Use of fertilizer in Nigeria is generally higher than is the case in other Sub-Saharan Africa (SSA) countries. Nigeria accounts for 14.2 percent of the 1.3 million tons used in SSA in 1989–2002 (Morris et al. 2007). Ojowu et al. showed (2007) that only 18 percent of farmers in the first poverty quintile (the poorest) used fertilizer. About a fifth of the other quintiles used fertilizer (Ojowu et al.). Nigeria is the only SSA country that used more than 150,000 tons (Gregory and Bumb 2006). Over half of the farmers in the dry savannah and a third of the farmers in the moist savannah used fertilizer (Table 4). Farmers in the dry savannah zone used about 12 percent of the total value of crop production per hectare to buy fertilizer (Table 5). This is the highest share (of value of crops produced) used to buy fertilizer. The equivalent share in the humid forest zone is about 0.1 percent. The humid forest, with reliable rainfall and high organic matter, reported the lowest share of farmers using fertilizer (11 percent). Part of the reason for the low use of fertilizer in the humid forest zone is the extensive production of root and tuber crops, which are well-adapted to low soil fertility.

Adoption of agroforestry practices is lowest in the dry savannah, where agroforestry needs to be promoted given the low vegetation. The low adoption of agroforestry practices could be due to the difficulty of planting trees in the dry areas, where survival of seedlings and germination rates are low. Development of agroforestry technologies and their promotion in the arid and semi-arid areas has also been limited—compared to the more humid areas (Ryan and Spencer 2001; Ajayi et al. 2005). Use of agrochemicals (herbicides and pesticides) is generally low and farmers mainly use them on vegetables and other high-value crops.

Table 4: Land management practices

	Dry savannah (n=3210)	**Moist savannah (n=3201)**	**Humid forest (n=2214)**	All (n=8265)	**Pair wise comparisons**
Land management practices (Proportion)					
Used fertilizer	0.52 (0.49)	0.31 (0.46)	0.11 (0.31)	0.34*** (0.47)	a,b,c
Used agroforestry	0.11 (0.32)	0.23 (0.42)	0.22 (0.41)	0.18*** (0.39)	a,b,c
Used herbicide	0.03 (0.17)	0.12 (0.32)	0.01 (0.08)	0.06*** (0.21)	a,b,c
Used pesticide	0.07 (0.25)	0.02 (0.15)	0.01 (0.08)	0.04*** (0.19)	a,b,c

Note: numbers in parenthesis are standard deviations

a= significant difference between dry savannah and moist savannah (p<0.05)

b= significant difference between dry savannah and humid forest (p<0.05)

c= significant difference between moist savannah and humid forest (p<0.05)

Source: NBS socioeconomic survey data, 2006

The value of crop production is lowest in the dry savannah and highest in the humid forest. The value of production per hectare in the dry savannah (₦76,272) is only 1.7 percent of the equivalent value in the humid forest. This reflects the high population density in southern Nigeria and the corresponding high demand and hence prices in the southern states. The results also underscore the low agricultural potential and poor market access of the dry savannah—both of which tend to reduce productivity and the value of production. As observed earlier, the dry savannah contributes a large share of agricultural production due to the large area cultivated and irrigated. Hence there is a need to increase efforts to help farmers adopt low-cost technologies that can greatly improve their productivity. This is especially crucial for rainfed crops, which have lower yields and are riskier than irrigated crops. For example, agroforestry practices can significantly increase agricultural productivity in dry areas by fixing nitrogen, reducing soil erosion and other economic and ecological services (Jama et al. 2006). Agroforestry research and extension services for dryland areas are currently weak (Ajayi et al. 2005; Ryan and Spencer 2001) and therefore need to be enhanced to support the marginal areas, where farmers are investing and contributing significantly to food production in Nigeria.

Irrigation practices across the zones are reported in Table 6. As expected, the share of farmers using irrigation in the dry savannah is highest (26 percent) with tomato and pepper as the most irrigated crops in the zone (over 80 percent of farmers reported to have used irrigatationfor the two crops). In the humid forest, over 50 percent of farmers reported irrigating leafy vegetables. The Fadama II project supported the acquisition of irrigation equipment (Nkonya et al. 2008). Consequently, a higher share of Fadama II beneficiaries irrigated their crops than was the case with non-beneficiaries (Table 7).[1]

Table 5: Cost of land management practices and value of crop production (₦/ha)

	Dry savannah (n=3210)		**Moist savannah (n=3201)**		**Humid forest (n=2214)**		**All zones (n=8625)**		**Pair-wise comparisons**
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	
Fertilizer	16,612 (26,476)	6,756 (0.12)	7,780 (16,853)	2,464 (0.02)	6,390 (7,325)	3,733 (0.00)	12,973*** (23,268)	4,532 (0.05)	a,b
Seeds	15,003 (74,103)	2,571 (0.05)	57,963 (176,164)	7,455 (0.06)	26,332 (51,526)	16,374 (0.00)	33,587*** (128,250)	4,130 (0.05)	a,c
Pesticides	2,281 (2,158)	1,487 (0.03)	1,256 (1,937)	491 (0.00)	689 (669)	448 (0.00)	2,032*** (2,147)	1244 (0.01)	a
Machinery	11,725 (29,076)	2,618 (0.05)	8,027 (21,950)	2,072 (0.02)	7,025 (19,714)	2,087 (0.00)	9,477*** (25,088)	2,305 (0.03)	a,b
Fungicides	1,140 (2,046)	257 (0.00)	6,761 (9,561)	6761 (0.05)	-	-	1,843** (3,661)	257 (0.00)	a
Value of crop production	76,272 (188,728)	55,821	962,316 (1,942,424)	130,603	4,634,289 (4,257,833)	3,423,220	1,202,546*** (2,690,321)	83,282	a,b,c

Note: Numbers in bracket under means are standard deviations and those under median are cost of the equivalent input as a share of total value of crop production per hectare
a= significant difference between dry savannah and moist savannah (p<0.05)
b= significant difference between dry savannah and humid forest (p<0.05)
c= significant difference between moist savannah and humid forest (p<0.05)
Source: NBS socioeconomic survey data, 2006

Tomato, pepper, and onions were the most irrigated crops for both Fadama II beneficiaries and non-beneficiaries. Accordingly, yields of irrigated crops were significantly higher than the

[1] Except for cowpea, in which a larger share of non-beneficiaries irrigated the legume than did beneficiaries.

equivalent rainfed crops (Table 8). However, yields of irrigated and rainfed cassava and yams—both of which are drought tolerant—and of leafy vegetables—which are probably grown in areas with adequate moisture—were not statistically different. Leafy vegetables are grown in small fertile plots. For example, many farmers in SSA countries prefer to grow off-season vegetables in plots in valley bottoms (Yahaya 2002; Kay 2001). The irrigated maize yield is 3.2 tons per hectare, which is about 94 percent of the exploitable yield potential of maize in the dry savannah (Jagtap and Abamu 2003).[2] Yield of irrigated rice (1.9 tons per hectare) is about 40 percent of the 5 tons per hectare yield potential of the improved rice variety (New Rice for Africa, NERICA) under fertilizer and 80 percent of 2.5 tons/ha yield potential with no fertilizer (WARDA, 2001; 2005). Irrigation increased rice yield by 180 percent and tomato, pepper, and onions by over 300 percent. The results demonstrate the large impact that irrigation could have on crop production in the dry and moist savannahs.

Table 6: Irrigation practices across agroecological zones and crops

Crop	Humid forest	Moist savannah	Dry savannah	Pairwise comparison (p-value)
	% Irrigating			
Irrigation (any crop)	10.0	9.6	25.9	b, c
Maize	12.3	12.9	18.6	
Tomato	-	-	86.1	
Pepper	-	-	82.5	
Yam	-	12.0	-	
Cassava	5.8	-	25.9	
Rice	-	26.7	21.8	
Leafy vegetables	50.6	-	-	

a= significant difference between dry savannah and moist savannah ($p<0.05$)

b= significant difference between dry savannah and humid forest ($p<0.05$)

c= significant difference between moist savannah and humid forest ($p<0.05$)

Source: Fadama II household survey, 2006.

Table 7: Adoption of irrigation practices of Fadama II beneficiaries and non-beneficiaries (unmatched sample)

Crop	Fadama II beneficiaries	Non-Fadama II households	Pairwise comparison (p-value)
	% using irrigation		
Maize	26.3	13.0	0.000**
Rice	28.3	20.6	0.042**
Cowpea	1.27	8.6	0.409
Tomatoes	85.5	70.9	0.040**

[2] Exploitable yield potential is the highest possible yield that a farmer can achieve using improved varieties and growing crops under recommended management practices (Cassman 2003).

Cassava	6.9	4.8	0.537
Pepper	82.0	77.0	0.480
Yams	5.9	4.3	0.665
Leafy vegetables	64.2	44.1	0.010***
Onions	93.5	90.4	0.583

Source: Fadama II household survey, 2006

Table 8: Crop yield under irrigated and rainfed conditions (kg/ha)

Crop	Rainfed	Irrigated	Pairwise Mean Comparison (p-value)	% difference between irrigated & rainfed yield
Maize	1,147	3,175	0.000***	180
Rice	984	1,893	0.058*	90
Cowpea	326	1,348	0.016**	310
Tomatoes	1,509	9,312	0.000***	520
Cassava	3,211	2,506	0.544	-20
Pepper	940	4,438	0.000***	370
Yams	2,867	2,372	0.495	-20
Leafy vegetables	2,821	2,894	0.953	00
Onions	789	3,348	0.000***	320

*, **, *** = difference statistically significant at p=10%, 5%, and 1% levels, respectively

Source: Fadama II household survey, 2006.

Profitability of crops and fertilizer

Given that the Federal Government of Nigeria used 42 percent of its agricultural budget to support a fertilizer subsidy (Mogues, et al., 2008)[3], there is a need to analyze the returns to fertilizer use at the household level to determine whether the public investment in fertilizer is justified. The analysis will also help to determine the type of crops for which fertilizer should be subsidized in order for fertilizer to be profitable. Table 9 reports the value of production, cost of fertilizer, and the value cost ratio (VCR) of fertilizer use on the major crops.

Fertilizer use is profitable for all crops except maize, whose VCR is less than one.[4] This is not surprising given that maize is the second-least profitable crop reported in Table 9. The low profitability of fertilizer used on maize could be due to the low adoption rate of improved varieties. The application of fertilizer to unimproved maize varieties may not lead to a significant yield response due to their low yield potential. Only 40 percent of farmers used improved varieties (Manyong et al. 2000). Even for farmers who use improved varieties, the recycling of these varieties is a common problem in Nigeria and other African countries.[5] This also contributes to the low productivity of improved varieties. Please note that the results are not representative of Nigeria since they are drawn from the Fadama areas—the low-lying flood plains. A study by Alene et al. (2007) showed that maize production has the highest potential to

[3] Nigeria subsidized fertilizer price by 25% in the 2006–07 season (Mogues et al. 2008).
[4] VCR for onion is also less than one though the corresponding mean is 27 – due to outliers.
[5] Recycling improved seeds means using seeds harvested from certified improved seeds crop.

reduce poverty in the moist savannah. Hence the low profitability of fertilizer used on maize justifies the use of a subsidy to promote maize production in Nigeria.[6] Unfortunately, maize is not among the presidential initiative crops even though its consumption in the country has been increasing significantly. For crops with VCR greater than two, a subsidy is not necessary since fertilizer profitability provides a significant incentive for small farmers to use fertilizer (CIMMYT 1988). These crops are: Rice, cassava, yam, leafy vegetables, pepper, and tomato.[7]

The full sample results show that pepper, tomato, yams, and leafy vegetables are the most profitable crops. Other studies (Singh 2002; Minot and Nigigi 2004) observed the high profitability of horticultural crops. This profitability demonstrates their potential to lift farmers out of poverty. For example, growing one hectare of any of the horticultural crops and yams could more than double the rural household income of ₦ 42,644 (FOS 2004). Surprisingly, Ojowu et al. 2007) observed that farmers growing horticultural crops are the poorest and those growing commercial crops (cocoa, coffee, and cotton), had the lowest incidence of poverty. This could be due to the small area used for growing horticultural crops.[8] The presidential initiative crops (rice and cassava) have much lower profitability, reflecting the food security—rather than profitability—objective in choosing the crops for the initiative. The high returns for yams— which are also not among the presidential initiative crops— show the crop deserves to be on that list since it can achieve both food self-sufficiency and help to lift rural households out of poverty.

Table 9: Value of production and profit per hectare and returns to fertilizer application of major crops

	Mean values (000 ₦)		**Returns to fertilizer**		
	Mean value of production/ha	**Profit (gross margin)[1]**	**VCR[2] (mean)**	**VCR[2] (median)**	**VCR[2] (50% fertilizer price increase)**
Maize	27	23	0.35	0.6	0.17
Rice	84	69	3.02	5.6	1.51
Cassava	79	79	5.41	10.2	2.70
Yam	210	194	16.44	15.0	8.22
Cowpea	21	20	-	-	
Leafy vegetables	157	131	2.01	2.5	1.00
Pepper	593	384	577.16	256.4	288.58
Tomato	361	236	541.50	267.9	270.75
Onions	143	96,618	27	0.8	0.32

[1] Profit = Total value of production per hectare – total cash costs.

[2] Note: Obtained using elasticity of fertilizer (see regression results reported in Table 12-15) VCR = $\frac{\beta \bar{y}}{\bar{x}}$.

Where $\bar{x}$ = average cost of fertilizer per hectare; $\bar{y}$ = average value of production per hectare; $\hat{\beta}$ = estimated elasticity of cost of fertilizer per hectare (x)

Source: Fadama II household survey, 2006.

[6] One of the justifications of fertilizer subsidies is the high price that makes it less profitable. Hence fertilizer subsidy lowers the price of fertilizer, making it more profitable.

[7] Onion mean is VCR>2 but its median is VCR<2, hence the crop is not listed.

[8] Average area (in ha) of the horticultural crops (including farmers who did not grow the crops) was: Leafy vegetables (0.07); pepper (0.07); tomato (0.06); onion (0.05). Average area (in ha) (including farmers who grew each crop) was: leafy vegetables (0.9); pepper (0.5); tomato (0.05); onion (0.9). Area for other crops, including only farmers who grew each crop ,is: Maize (2.8), rice (2.5), cassava (1.7), yam (1.3) (Fadama II Survey 2006).

Cowpea and maize reported the lowest profits. This is partly due to the low yield of the two crops under rainfed conditions. As discussed earlier, the two crops contribute significantly to energy and protein requirements in Nigeria. Hence, the two crops need greater investment in order for them to play a leading role in ensuring food and nutrition security. Additionally, cowpeas enhance soil fertility by fixing nitrogen. Studies have shown that using leguminous crops to fix nitrogen reduces the need for nitrogenous fertilizer by 50 percent (Roy et al. 2002). Hence despite their low yields, the government should make efforts to improve their productivity. These results demonstrate the need to emphasize both horticultural crops to reduce poverty and the cereal and tuber crops to ensure food and nutrition security for the poor rural households.

The spatial analysis shows where to emphasize such crops. Table 10 reports the profitability of the major crops across the three major agroecological zones. In the humid forest, leafy vegetables, yams and cassava show the highest profitability. Alene et al., (2007) also observed that cassava and yams have the largest potential to reduce poverty in the humid forest zone. This is the area that has high population density and better market access—and hence is suitable for producing the highly perishable leafy vegetables. Yams and cassava in the region also fetch high profits due to the local food tastes and preferences. Yams are especially profitable and show their potential to ensure food security and reduce poverty. In the moist savannah, yams, pepper, and cassava fetch high profit. In the dry savannah, pepper, tomato, and yams are the most profitable crops. It is evident from these results that yam profitability is high across all zones. One of the major problem that yam farmers face is the lack of improved varieties and the unavailability of planting material—minisett, which increases the multiplication rate by six times (Agbaje et al. 2005; Asare-Bediako et al. 2007).[9] A study by Agbaje also identified high labor intensity as one of the major problems of yam production in the humid forest zone where 96 percent of farmers reported that they prepare farms by hand-hoe).

Table 10: Profitability of major crops across agroecological zones

Crop	Humid forest	Moist savannah	Dry savannah	Pairwise mean comparisons
	Profit (000 ₦/ha)			
Maize	18.0	28.4	21.4	
Rice	-	41.4	75.8	
Cassava	73.8	144.1	8.7	a b c
Yams	124.5	230.7	162.1	
Cowpea	-	17.8	20.0	
Leafy vegetables	211.9	40.5	32.8	
Pepper	-	170.3	431.0	
Tomatoes	-	95.0	269.5	
Onions	-	-	96.6	

a=difference between humid forest and moist savannah is statistically significant (p<0.05)

b=difference between humid forest and dry savannah is statistically significant (p<0.05)

c=difference between moist savannah and dry savannah is statistically significant (p<0.05

Means sample of farmers growing the crop in the zone was small (<30).

Source: Fadama II Household Survey, 2006.

[9] Setts are the planting materials ("seeds") used to propagate yam. Minisetts are smaller setts with greater multiplication rates than the common sett.

Comparison of crops across different types of households reveals an interesting pattern. Table 11 shows that male-headed households obtained significantly higher profits from tomatoes and yams while female-headed households obtained higher profits from leafy vegetables. The hard labor of tomato and yam production could be one of the reasons for the comparative advantage of male-headed households. Female-headed households obtained higher profits for leafy vegetables only (though the difference was not significant at p = 0.10). This suggests that supporting horticultural crop production could help women and other vulnerable groups to reduce poverty significantly.

Table 11: Profitability of crops by type of household

Crop	Male-headed household	Female-headed household	Pair wise comparison (P-value)
	(000 Naira/ha)		
Maize	24.1	18.6	0.384
Rice	69.8	67.3	0.926
Cowpea	19.8	18.2	0.816
Tomatoes	251.2	86.0	0.002***
Cassava	80.7	74.4	0.704
Pepper	394.0	335.7	0.792
Yams	214.5	123.6	0.023**
Leafy vegetables	94.5	212.3	0.219
Onions	99.4	72.4	0.365

Regression results

Human capital endowment

Gender does not have a significant impact on profitability of crops, suggesting that female-headed households are as competitive as the male-headed households in crop production (Table 12–15). This is contrary to some of the descriptive statistics in which male-headed households obtained significantly higher tomato and yam profitability (Table 11). Ojowu et al. 2007 observed female-headed households were less poor than male-headed households, an observation that is contrary to many studies showing female-headed households to be poorer (such as Quisumbing 1996; Smith and Haddad 2000; Udry, et al. 1995). Nkonya et al. 2008 also observed that increase in income due to participation in the Fadama II project did not differ significantly between female and male beneficiaries. The results demonstrate that it is possible for programs targeting female and other vulnerable groups to enhance their competitiveness if they are well-targeted.

Charting the education level of household heads reveals an interesting pattern. While the number of years of education of household head is negatively related to the profitability of maize and cassava and the production value of rice, all of which are low value crops—as shown in Table 10—it is positively related to the profitability and production value of high-value crops, namely pepper, tomato, and onions. Econometric results using the NBS data, which covered all states, also showed that primary and post-secondary education is positively related to the value of production (Table 16). The results are consistent with McCulloch and Ota (2002) and demonstrate the positive impact of education on agriculture and reveal the potential that the agricultural sector provides for better-educated farmers. This is consistent with Vandenbosch, (2006) who observed that promoting high value crops could attract young and better-educated people into agriculture.

Family labor is generally positively associated with both the value of production and profitability but the relationship is significant only for the value of production of cowpea. The results demonstrate that family labor constraint is not a major constraint to producing profitable crops. The primary activity of the head of a householdsalso has significant impact on the productivity and profitability of crops. The value of production per hectare of maize, cassava, yams, pepper, and tomato is lower for households whose head's primary activity is non-farm than those whose primary activity is crop production. Similarly, profitability of rice and cassava is lower for households whose head's primary activity is non-farm activity. In general, crop productivity and profitability per hectare was lower for households whose head's primary activity was not crop production. The results reflect how weak labor and capital markets can allow farmers to produce a variety of crops with no trade-off on productivity and profitability.

Participation in cooperative organization increased the production value and profitability of maize, rice, and cassava, but reduced the value of production per hectare of pepper. Similarly, participation in non-Fadama farmer groups increased the production value rice and tomato and the profitability of pepper, but decreased the profitability of yams and cassava. The results demonstrate the importance of different farmer groups and organizations. Hence current efforts to promote community-driven development (CDD) programs through farmer groups are likely to succeed at increasing the productivity and profitability of crop production. For example, participation in the Fadama II–CDD project increased the production value of cassava. However, participation in Fadama II decreased the productivity of cowpea, pepper, maize, and rice. This could be due to the short time (one year) during which farmers used the productive assets that they acquired through the CDD project (Nkonya et al. 2008).

Physical capital endowment

Both rainfed and irrigated areas have mixed impacts on production value and profitability. Contrary to past studies (such as. Lamb 2003; Barrett 1996), rainfed areas are positively associated with cowpea productivity while irrigated areas are also positively related to pepper productivity. The positive relationship between irrigated areas and pepper productivity could be due to economies of scale. Pepper is the most profitable crop but like other horticultural crops, it is grown on small plots (less than one ha). However, consistent with the inverse area-productivity relationship (Lamb 2003), irrigated area is negatively associated with the profitability of maize, rice, cassava, and onion. Similarly, rainfed areas are negatively associated with the profitability of cassava, productivity of maize, and yam. The results from the NBS data also show a negative relationship between the value of production of crop per unit area (Table 16) and farm area. The results demonstrate that smallholder farmers are more efficient than larger farmers. This could be due to the imperfections of labor and credit markets that limit larger farmers from operating efficiently (Barrett 1996; Heltberg 1998).

Consistent with the primary activity results reported above, the value of livestock is negatively related to the productivity of maize and the profitability of cassava. Similarly, the value of buildings is negatively associated with the productivity and profitability of maize, the productivity of rice, yams and cowpeas and the profitability of onion—but is positively associated with the productivity of onion and cassava. The negative relationship between the value of buildings and productivity and profitability could be due to the high opportunity cost of the labor of well-off farmers.[10] The high opportunity cost of labor limits their investment in labor-intensive production practices.

The value of transportation assets (motor bicycle, bicycle, trolley, wheelbarrow, pickup truck, and the like) is positively associated with the productivity of rice. Ownership of transportation assets could reduce the transaction costs and could allow farmers to use their labor and other factors of production more efficiently. However, the value of transportation assets is also associated with lower profitability of maize, yams, peppers, and tomatoes. These results could be due to ownership of transportation assets that are not used for the production of these crops. Examples of such transportation assets are saloon cars and motor bicycles. Farmers owning transportation equipment—such as ox-drawn carts, tractors, and the like—may also be engaged in hiring out such equipment instead of producing their own crops.

Table 12: Determinants of cereal crop productivity and profitability (OLS)

Variable	**Maize value (full)**	**Maize value (reduced)**	**Maize profitability (reduced)**	**Rice value (full)**	**Rice (reduced)**	**Rice profitability (reduced)**
	Ln(value of crop ₦/ha)		**Profit (₦ /ha)**	**Ln(value of crop ₦/ha)**		**Profit (₦ /ha)**
Human resource						
Female headed household	0.098	0.095	-4.566	-0.025	-0.166	-0.036
Ln(years of formal education)	0.018	-0.057	-0.932*	-0.142*	-0.176**	-0.055
Ln(family labor)	0.117	0.083	0.564	-0.018	-0.037	0.041
Primary activity of household head (cf crops)						
Livestock	0.595	0.495	-24.09	-0.966**	-1.171**	-5.706
Non-farm	-0.709***	-1.010***	-12.672	0.058	-0.022	-15.207***
Other activities	-0.501**	-1.059***	-6.222	-0.388	-0.760**	-11.860***
Membership to community groups in 2005 (before Fadama II)						
Cooperative society	0.402*	0.558**	26.604***	1.256***	1.090***	4.526
Non-Fadama farmer group	-0.173	-0.059	-2.711	1.188***	0.885**	14.251
Fadama beneficiary	-0.515***	-0.330*	2.488	-0.409*	-0.437*	-6.059*
Physical asset endowment in 2005 (before fadama II)						
Ln(value of livestock, ₦)	-0.025*	-0.041**	0.000	0.009	0.005	0.000
Ln(irrigated area, ha)	-0.137	0.401***	-2.575**	-0.173	0.111	-1.364***
Ln(rainfed area, ha)	0.107	0.165*	-0.203**	0.073	0.007	0.042
Ln(value of productive assets, ₦)	0.018	-0.022	-0.004	-0.098	-0.117	-0.12
Ln(value of transport assets,₦)	0.021	0.031	-0.039*	0.230***	0.239***	0.009
Ln(value of building, ₦)	-0.272***	-0.296***	-0.010*	-0.304***	-0.378***	-0.001
Ln(value of processing assets, ₦)	-0.035	0.019	-0.04	-0.004	-0.035	0.009
Ln(irrigation and water assets, ₦)	-0.128**	-0.110*	-0.009*	-0.132*	-0.097	-0.028**
Land **management practices**						

[10] Please note that controlling for family labor does not reflect the opportunity cost of the labor since it does not reflect the cost of the individual members.

Ln(expenditure on fertilizer used, ₦/ha)	0.036			0.364***		
Use fertilizer	-0.164			-2.226***		
Use manure	0.199			0.274		
irrigate	1.446***		32.264***	1.180***		14.791***
Water harvesting/moisture conservation practice	-0.196			0.197		
Cover crops	-1.874***			-1.704***		
Rural services						
Ln(village wage rate in 2006, ₦/day)	-0.282***	-0.300***	0.005	-0.092*	-0.306***	-0.020***
Ln(distance to nearest town in 2006, km)	-0.065	-0.028	-0.065	0.032	0.062	-0.008
Ln(distance to all-weather road, km in 2006)	-0.101	-0.204***	-0.096***	-0.166*	-0.142	0.057
Agroecological zones (cf Dry savannah)						
Humid forest	1.236***	1.549***	-9.209	0.893	2.030**	36.763***
Moist savannah	1.244***	1.534***	8.942	-0.543*	-0.176	25.204***
Constant	3.228***	3.270***	19.863***	2.634***	4.160***	16.096***
N	821	821	887	495	495	451
R^2	0.319	0.208	0.06	0.394	0.27	0.156
max variance inflation factor (vif)=1.84				max vif Ln(fertilizer value) = 6.91; fertilizer use = 6.41		

Table 13: Determinants of value of root and tuber crop productivity and profitability

Variable	Cassava value (full)	cassava value (reduced)	Cassava (reduced)	Yam value (full)	Yam value (reduced)	Yam (reduced)
	Ln(value of crop, ₦/ha))		Profit (₦/ha)	Ln(value of crop, ₦/ha))		Profit (₦/ha)
Human resource endowment						
Female headed household	-0.083	-0.21	-7.804	-0.335	-0.323	-40.926
Ln(years of formal education)	-0.109	-0.124	-2.238*	0.008	0.034	-5.143
Ln(family labor)	0.138	0.185	0.564	0.339	0.325	2.839
Primary activity of household head (cf crops)						
Livestock	-0.655	-0.591	-19.553	0.32	0.174	-32.954
Non-farm	-1.245**	-1.031*	-45.842**	-0.961*	-1.120**	-55.406
Other activities	-0.481	-0.304	-3.253	-0.178	-0.335	-29.32
Membership to community groups in 2005 (before Fadama II project)						
Member of cooperative society	0.671**	0.602**	29.090*	-0.486	-0.525	16.066
Non-Fadama farmer group	0.277	0.325	-37.097**	-0.082	-0.085	-97.766*
Fadama beneficiary	0.637**	0.555*	2.006	-0.638*	-0.497	-133.144***
Physical asset endowment in 2005						
Ln(value of livestock, ₦)	-0.005	-0.014	-0.000*	0.001	0.028	-0.001
Ln(irrigated area, ha)	-0.033	-0.213	-9.729***	0.535*	0.339	0.347

Ln(rainfed area, ha)	0.129	0.098	1.297	-0.389**	-0.321*	-2.738
Ln(value of productive assets, ₦)	-0.291	-0.321	-0.289*	-0.148	-0.151	0.006
Ln(value of transport assets,₦)	-0.036	-0.072	0.026	-0.136	-0.128	-1.288*
Ln(value of building, ₦)	0.353**	0.331**	-0.009	-0.280*	-0.326**	-0.007
Ln(value of processing assets, ₦)	-0.103	-0.13	-0.026	-0.370*	-0.370*	0.134
Land management practices						
Ln(irrigation and water assets, ₦)	-0.12	-0.109	-0.004	0.147	0.099	0.187***
Ln(expenditure on fertilizer used, ₦/ha)	0.261**			0.217		
Use fertilizer	-1.884**			-1.264		
Use manure	-0.421			0.707**		
irrigate	-0.951		-8.79	-0.427		-57.278
Water harvesting/moisture conservation practice	0			-2.428***		
Cover crops	1.008*			0.322		
Rural services						
Ln(village wage rate in 2006, ₦/day)	-0.014	-0.015	-0.004*	-0.234**	-0.199*	-0.054
Ln(distance to nearest town in 2006, km)	-0.169	-0.152	-1.403**	-0.476***	-0.555***	0.052
Ln(distance to all-weather road, km in 2006)	0.034	0.039	-0.166	0.099	0.182	-1.201
Agroecological zones (cf dry savannah)						
Humid forest	1.045**	1.013***	48.055***	-0.122	-0.145	182.489*
Moist savannah	1.348***	1.346***	126.068***	1.014*	0.911*	165.646***
Constant	2.212***	2.153***	48.209**	6.036***	6.068***	237.011***
N	267	267	270	219	219	225
R^2	0.196	0.159	0.244	0.257	0.23	0.202
max variance inflation factor (vif): fertilizer use = 14.28; ln(fertilizer value) = 13.77				max vif: ln(fertilizer value) = 17.62; fertilizer use = 16.58		

Table 14: Determinants of cowpea and pepper productivity and profitability

Variable	Cowpea value (full)	Cowpea value (reduced)	Cowpea (reduced)	Pepper value (full)	Pepper value (reduced)	Pepper (reduced)
	Ln(value of crop ₦/ha)		Profit (₦/ha)	Ln(value of crop ₦/ha)		Profit (₦/ha)
Human resources						
Female headed household	0.305	0.367	1.826	0.462	0.434	187.152
Ln(years of formal education)	0	0.004	0.525	0.194	0.218*	20.484*
Ln(family labor)	0.253**	0.196	0.228	-0.01	0.188	-8.29
Livestock	0.019	0.277	9.282	-2.332***	-3.038***	-513.289
Primary activity of household head (cf crops)						
Non-farm	-0.305	-0.142	-9.398	-0.951**	-0.958**	-253.469
Other activities	-0.690***	-0.688***	-20.462**	-0.55	-0.465	-289.367
Membership to community groups (before Fadama II project)						

Cooperative society	0.338	0.344	11.965	-0.754**	-1.066***	90.679
Non-Fadama farmer group	0.053	0.048	56.965	0.364	0.671	319.019*
Fadama II beneficiary	-0.641***	-0.580***	6.037	-0.736***	-0.677**	8.995
Physical asset endowment in 2005						
Ln(value of livestock, ₦)	-0.015	-0.022	0	-0.032	-0.011	0
Ln(irrigated area, ha)	-0.084	0.035	0.252	0.361	0.642**	13.424
Ln(rainfed area, ha)	0.244***	0.292***	-0.173	-0.317	-0.404*	-1.635
Ln(value of productive assets, ₦)	-0.052	-0.007	-0.053	-0.330***	-0.454***	1.5
Ln(value of transport assets,₦)	0.006	0.007	0.04	-0.006	0.01	-3.499*
Ln(value of building, ₦)	-0.233***	-0.249***	-0.001	0.171	0.13	-3.233
Ln(value of processing assets, ₦)	0.108	0.139*	-0.065	-0.194*	-0.313**	-6.067
Land management practices						
Ln(irrigation and water assets, ₦)	0.013	0.031	-0.003	-0.126	-0.131	0.073
Ln(expenditure on fertilizer used, ₦/ha)	2.199***			0.505*		
Use fertilizer	-7.873***			-1.781		
Use manure	-0.228			0.562*		
irrigate	1.530**		69.676***	0.610*		202.141
Water harvesting/moisture conservation practice	0			-1.728***		
Cover crops	0			0.344		
Rural services in 2006						
Ln(village wage rate in 2006, ₦/day)	-0.188***	-0.214***	-0.03	-0.615***	-0.636***	-0.539*
Ln(distance to nearest town in 2006, km)	-0.091	-0.067	-0.064	0.114	0.064	-11.656**
Ln(distance to all-weather road, km in 2006)	-0.086	-0.11	-0.068**	-0.456***	-0.609***	-0.371
Agroecological zone (cf dry savannah)						
Humid forest	0	0	0	0.829	1.243*	326.498
Moist savannah	1.189***	1.016***	8.744	2.216***	2.110***	75.082
Constant	2.040***	2.171***	19.019*	6.457***	7.387***	427.454**
N						
R^2	290	290	312	241	241	276
Female headed household	0.305	0.257	0.129	0.543	0.465	0.128
Max variance inflation factor (vif): ln(fertilizer value) = 17.13; fertilizer use = 16.85				max vif: ln(fertilizer value) = 18.61; fertilizer use = 18.02		

Table 15: Productivity and profitability of horticultural crops (OLS)

Variable	Tomato value (full)	Tomato value (reduced)	Tomato (reduced)	Onion value (full)	Onion value (reduced)	Onion	Leafy vegetables (full)	Leafy vegetables (reduced)	Leafy vegetables
	Ln(value, ₦/ha)		Profit (₦/ha)	Ln(value, ₦/ha)		Profit (₦/ha)	Ln(value, ₦/ha)		Profit (₦/ha)
Human resources									
Female headed household	-0.175	-0.575	-77.031	-0.171	-0.305	-17.368	0.029	-0.005	116.943
Ln(years of formal education)	0.279**	0.294**	8.534**	0.168	0.278*	1.553	-0.053	0.015	7.415
Ln(family labor)	-0.014	0.202	-0.424	-0.254	-0.108	-1.479	-0.096	-0.078	1.453
Livestock	-2.900***	-2.409***	-173.305	0.34	0	14.654	1.455***	1.458***	254.904
Non-farm	-0.75	-1.035	43.136	0.33	-0.607	-24.301	-1.698***	-1.538***	-59.281
Other activities	-0.087	-0.632	-73.392	-0.722	-1.131**	-67.068***	-1.194**	-1.234***	-67.640*
Membership to community groups in 2005 (before Fadama II project)									
Member of cooperative society	-0.083	0.038	-6.694	-0.449	-0.813	-19.417	0.222	0.237	97.856
Non-Fadama farmer group	0.448	0.654*	40.884	0.225	0.271	53.752	-0.468	-0.404	-72.997
Fadama beneficiary	-0.325	-0.329	36.487	0.149	0.076	23.934	-0.274	-0.218	-34.02
Physical asset endowment in 2005									
Ln(value of livestock, ₦)	-0.025	-0.019	0	0.011	0.01	0	-0.132***	-0.131***	0
Ln(irrigated area, ha)	-0.033	0.354	-8.005	-0.266	0.248	-10.281*	0.266	0.239	1.334
Ln(rainfed area, ha)	-0.133	-0.256	-0.479	-0.053	-0.068	-1.601	-0.287	-0.255	-7.459**
Ln(value of productive assets, ₦)	-0.312***	-0.567***	0.314	-0.182*	-0.321***	0.03	-0.05	-0.053	1.453
Ln(value of transport assets,₦)	-0.096	-0.018	-1.251**	0.036	0.054	-0.383	0.016	0.017	0.679
Ln(value of building, ₦)	0.073	-0.017	0.296	0.240**	0.176	-0.381*	0.128	0.106	-0.632
Ln(value of processing assets, ₦)	0.238**	0.189	0.294	-0.041	0.046	0.307	0.199**	0.175*	-1.159
Land management practices									
Ln(irrigation and water assets, ₦)	-0.016	-0.096	-2.381*	0.061	0.057	-0.169	-0.059	-0.043	0.067
Ln(expenditure on fertilizer used, ₦/ha)	0.604***			0.118			0.127		

Use fertilizer	-2.481**			0.339			-0.647		
Use manure	1.007***			0.975***			0.399		
irrigate	1.770***		197.598***	2.046***		65.498**	-0.259		
Water harvesting/moisture conservation practice	-1.250*			0.06			-0.263		
Cover crops	-0.724			-1.407***			-1.125		
Access to rural services in 2006									
Ln(village wage rate, ₦/day)	-0.193*	-0.246**	-0.114	-0.220***	-0.365***	-0.06	-0.12	-0.084	-0.118**
Ln(distance to nearest town, km)	-0.073	-0.12	-1.585	-0.162	-0.199	-1.013	0.08	0.134	-1.139
Ln(distance to all-weather road, km)	-0.272**	-0.395***	-0.266	-0.008	-0.004	0.093	0.192	0.142	1.816**
Agroecological zone (cf dry savannah)									
Humid forest	-2.121	-3.218	-201.212	0	0	0	0.839*	1.023**	239.646***
Moist savannah	2.534***	0.829*	122.592	0	0	0	-0.462	-0.412	78.509*
Constant	2.806***	5.341***	54.567	2.181***	4.809***	55.508*	4.152***	3.692***	-31.431
N	271	271	310	148	148	172	221	221	221
R^2	0.49	0.315	0.133	0.518	0.346	0.125	0.407	0.391	0.146
max variance inflation factor (vif): ln(fertilizer value) = 20.10; fertilizer use = 20.09				max vif = 1.80			max vif lnfert = 14.50; fert_use = 14.85		

As expected, the value of processing assets (honey processing equipment, milling machines, refrigerators and the like) relates positively to cowpeas and tomatoes. Contrary to expectations however, the value of processing assets generally does not have a significant impact on the productivity and profitability of maize and rice. Additionally productivity of yams and pepper is negatively associated with the value of processing equipment. The limited impact of processing equipment on productivity and profitability could be due to the limited processing required for most of the crops or the low economies of scale for smallholder farmers who own processing equipment, or to both factors.. Farmers who own rice-shelling equipment may not have farms large enough to exploit the economies of scale that can come from owning such machines. Instead, using rented equipment to process produce could be more efficient for them. For example, the capacity of common rice-milling machines in Ghana is about 1.6 tons per day (Furuya and Sakurai 2003). The average yield of rice is only 2 tons per hectare (Table 3) and the average area growing rice is only 2.6 hectares, so that the 5.2 tons of rice will be processed for only three days. Hence most farmers who own processing machines tend to rent them out. Similar relationships can be observed for other types of processing equipment. This could explain the weak link and even negative relationship between the values of processing assets and crop values, and suggests the importance of renting out processing equipment. For example, Furuya and Sakurai (2003) observed that a commercial relationship between producers and rice millers increased the efficiency of rice production in Ghana. Consistent with this, the NBS results (Table 16) show the cost of renting machinery significantly increases the productivity of crops.

Controlling for irrigation, the value of water equipment—which includes potable water pumps, irrigation pumps, bore holes, and tubewells—is negatively associated with the productivity and profitability of maize and rice. The negative relationship could be due to inclusion of water equipment that is not used for irrigation.

The value of production assets (ox-plow, oxen, and tractor) are either negatively associated with productivity (pepper, tomato, and onion) and profitability (cassava) or do not significantly affect productivity and profitability. This reflects the small areas in which farmers grow these crops and the lack of economies of scale for using such equipment on their own farms. For example, the production of horticultural crops— in areas of less than one hectare— is done efficiently using hand-hoes. This is especially true if the crops grow on small plots in valley bottoms where tractors and ox-plows may not be used due to the limited space and accessibility.

In summary, ownership of assets does not increase the productivity or profitability of crops, and this is due to a lack of economies of scale. Farmers are better off renting machines instead of owning them.

Land-management practices

Consistent with the descriptive statistics reported in Table 8, irrigation increases the productivity and profitability of maize, rice, cowpeas, tomatoes and onions. Similarly, expenditure on fertilizer increases the productivity of rice, cassavas, and tomatoes. The use of manure increases the productivity of yams, tomatoes, onions, and peppers. However, expenditure on fertilizer is negatively related to the productivity of cowpeas, a leguminous crop that fixes its own nitrogen and is rarely fertilized by African farmers (Hess and Bliss 2005). The negative association between fertilizer expenditure and cowpea productivity reflects the poor soils that farmers attempt to correct without fully addressing the low fertility. The use of cover crops increases the productivity of cassavas but reduces the productivity of maize, rice, and onions. This reduction of crop productivity stemming from the use of cover crops could be due to the competition for moisture and nutrients or the lower planting density for farmers using cover crops or to both competition and lower density. In West Africa, farmers often plant cover crops, such as velvet beans, on poor soils as a strategy to ameliorate poor fertility (Eberlee 2003.) We also did not take into account the benefits of the cover crop products—such as fodder—since we are just considering one crop at a time. So we did not collect the benefits of cover crops, which could change the productivity when taken into account.

Water and moisture conservation practices are associated with negative yam, pepper, and tomato productivity. This could be due to the poor rainfall in areas where such practices are required—mainly the northern dry states. The agroecological zones could not have fully captured the impacts of the moisture stress on some farms.

Community level characteristics

Village level wages are negatively associated with productivity of maize, rice, yam, cowpea, pepper, tomato, and onion and profitability of rice, and pepper. High wage rate reflect the high opportunity cost of labor and the lower propensity to use labor intensive practices that increase productivity and profit. Consistent with expectation, distance to nearest urban center is negatively related with productivity of yam and profitability of cassava, and pepper. Similarly, distance to all-weather road is negatively associated with productivity of maize, rice, pepper, and tomato and profitability of maize, and pepper. The results suggest the key role that rural infrastructure play in increasing productivity and profitability of agricultural enterprises. The rural roads in northern Nigeria are in poor condition compared to those in the moist savannah and humid forest zones. Given that the dry savannah zone is the breadbasket of the country, there is need to improve rural infrastructure in the northern states as part of the strategy to achieve the country's objectives stated in the NEEDS and other poverty reduction programs.

Compared to the dry savannah zone, the productivity of maize and cassava is higher in the moist savannah and humid forest zones. Similarly, productivity of rice, cowpea, pepper and tomato is higher in the moist savannah than the equivalent productivity in the dry savannah. Profitability of rice and yam is higher in the moist savannah and humid forest zones than in the dry savannah zone. However, productivity of rice is higher in the dry savannah than in the humid forest. The results demonstrate the lower agricultural potential in the dry savannah and the need to improve productivity in the zone using irrigation programs – such as the Fadama II project that promoted acquisition of irrigation and other productive assets. Promotion of water harvesting and moisture conservation structures could also enhance productivity and profitability in the dry savannah. For example, Kunze (2000) observed that water harvesting in Burkina Faso increased returns to labor by 10 percent and a 45 percent internal rate of return (IRR) to investment in the water harvesting technologies. Similarly, Abdoulaye and Ibro (2006) reported an 82 percent IRR for investment in *zai* – planting pits that harvests water and stores compost – on millet production plots in Niger.

Table 16: Determinants of value of production (NBS data)

Variable	OLS	2SLS
Ln(value of crop production, ₦/ha)		
Irrigation	-0.04	-0.045
Educ primary (c.f no formal education)	0.106***	0.122***
Secondary education	0.033	0.052
Post secondary education	0.117**	0.120**
Ln(machinery cost, ₦/ha)	0.024***	0.022***
Ln(crop area, ha)	-0.179***	-0.176***
Log seed cost (₦ /ha)	0.016***	0.017***
Fertilizer use(1=use)	-0.007	-0.004
Log herbicide cost (₦ /ha)	0.019***	0.020***
Log fungicide cost (₦ /ha)	0.015	0.012
Log pesticide cost (₦ /ha)	-0.010*	-0.010*
Log labor cost (₦ /ha)	-0.008	-0.01
Planted trees on cropland	0.012	0.008
Constant	9.730***	12.084***
N	6268	6106
R^2	0.804	0.803
State fixed effects (Joint significance)	0.000***	0.000***
Relevancy test:		
-Log machinery cost/ha		0.002***
-Log seed cost/ha		0.000***
-Fertilizer use		0.001***
-Log herbicide cost/ha		0.000***
-Log fungicide cost/ha		0.911
-Log pesticide cost/ha		0.001***
Hansen. J- Over identification test (P-value)		0.315
Exogeneity tests:		
C-Statistic (P-value)		0.314
Wu-Hausman F-test		0.379
Durbin-Wu-Hausman Chi-square		0.375

Note: For brevity, fixed effect (states) results are not reported but are available upon request from authors

Instruments used were: membership to a cooperative, age, credit access (microfinance, commercial bank, cooperative) and land tenure (family land, rented, and squatter).

Conclusions and policy implications

Crop yield and per capita production of the major food crops in Nigeria have been declining. This threatens the food security of the country's poor households and the Nigerian government has initiated a number of efforts to address this challenge. One such effort is the presidential initiative, which selected cassava, rice, oil crops, and tree crops as priority crops. Our results show that within the area under review, the presidential initiative crops are not the most profitable in any zone—demonstrating the limited consideration of profitability in selecting the crops. Food security might have been the overarching criterion used in selecting the initiative crops. However, there is a need to look beyond these initiative crops and include those which can effectively ensure both food security and high profitability. Our study shows that horticultural crops and yams are the most profitable crops in the dry savannah, a zone that has the lowest agricultural potential but contributes significantly to the country's cereal production. In the moist savannah zone, pepper, yams, and cassava were the most profitable while in the humid forest zone, leafy vegetables and yams were the most profitable. The results demonstrate that horticultural crops and yams can significantly contribute to poverty reduction across all zones. Unfortunately, the two are not among the presidential initiative crops.

A comparison of the productivity and profitability of crops across gender show that male-headed households obtained higher profitability for tomatoes and yams while female-headed households obtained higher profitability for leafy vegetables. The results demonstrate the difficulties that women face in producing tomatoes, the second-most profitable crop, and yam, the third most profitable and the only one with high profitability across all three agroecological zones. The results also show how leafy vegetables can lift women out of poverty. Promoting education and irrigation could help women farm high value crops that could lift them out of poverty.

Horticultural crops were the most irrigated and increased yield several fold. This was true even for maize, which is not commonly irrigated in Africa. This reveals irrigation's potential to reduce poverty and ensure food and nutrition security. Past irrigation efforts by the Nigerian government have been on a large scale (Adams 1996), but were not sustainable (Kay 2001). Small-scale irrigation in the floodplains (fadamas) that uses tube wells to lift water from shallow aquifers has been successful in northern Nigeria (Kay 2001). These small-scale irrigation systems still face a number of challenges including poor market access and weak water-management institutions and extension services (Kay 2001). Efforts such as the Fadama II project show how a single program can simultaneously address a number of constraints. Fadama II, for example, supported the acquisition of irrigation equipment and infrastructure, the development of feeder roads, and the provision of demand-driven extension services. It also supported an increase in the capacity of local institutions to resolve natural resource conflicts.. The per capita household income of the Fadama II project beneficiaries increased by about 60 percent in only one year (Nkonya et al. 2008), demonstrating the effectiveness of such an approach.

Similarly, fertilizer adoption is low even for crops with VCRs greater than 2.0. The probable reason for this is the poor market for agricultural produce, which reduces any incentive to produce large surpluses. A good example of this is the Sasakawa-Global 2000 (SG2000) project. The SG2000 promoted the adoption of improved production technologies and led to significantly large production surpluses in several African countries. This led to low consumer prices for maize, especially in remote areas (Howard et al. 2003). This in turn led a considerable share of the adopters to abandon the improved production technologies once the SG2000, which also bought the surplus to recover the credit given to farmers. This suggests that the current large government investment (42 percent of the federal agricultural budget) will not likely yield high returns in remote areas where the poorest farmers grow crops. Again, a multi-pronged approach like the Fadama II project is required to increase the returns to investments in rural services in Nigeria.

Our results also show that smallholder farmer groups increase farmers' productivity and profitability. This underscores the key role farmer groups play in increasing the capacity of small farmers to produce and market their produce. The farmer groups could also help small-scale farmers to pool resources and acquire large production and processing equipment that can be rented out to members and non-members.

Road development increases the productivity and profitability of crops. Similarly, the higher education of heads of farming households is positively related to the profitability of horticultural crops and yams. (It is negatively related to the profitability of maize and cassava and the production value of rice, but these are low value crops.) This further demonstrates the importance of education in efforts to reduce poverty and modernize agriculture.

Adopting multi-pronged investments poses a challenge in developing countries with limited resources. However, experience from China and Vietnam has shown that while such synergistic investments are expensive, they have rapid and high payoffs and can be achieved by countries with a level of poverty equivalent to Nigeria's (Fan et al. 2008). The oil sector could finance such an investment, which in turn would boost the entire economy and help achieve the country's objective of drastically reducing poverty, as stated in the National Economic Empowerment and Development Strategy and other government policies and strategies. Even with the fall in oil prices, Nigeria could use the Excess Crude Account to finance such investments and generate growth. But Nigeria will need to maintain a conducive policy environment to spur investment in agriculture. Based on this study, some of the issues that the federal government of Nigeria could address include but are not limited to: (1) reducing the overbearing influence of the federal government on states and local governments; (2) delineating appropriate roles among the actors in the agricultural sector; (3) supporting agricultural research, technology, and the extension system; (4) reformulating fertilizer policy to ensure its effectiveness and efficiency; (5) creating an agricultural information system that will enhance the flow of agricultural information at a low cost; (6) revitalizing farmers' associations to enhance their bargaining power ; and (7) employing the community driven development (CDD) approach to implement rural development programs that target vulnerable groups.

References

Adoulaye, T., and G. Ibro. 2006. Analyse des -impacts socioéconomiques des investissements dans la gestion des ressources naturelles: Etude de cas dans les régions de Maradi, Tahoua, et Tillabery au Niger. Niamey et Amsterdam: Centre Régional d'Enseignement Spécialisé en Agriculture et l'Université Libre d'Amsterdam.Adams, W. 1991. Large-scale irrigation in northern Nigeria: Performance and ideology. *Transactions of the Institute of British Geographers*. S16: 287–300.

Agbaje, G., L. Ogunsumi, J. Oluokun, and T. Akinlosotu. 2005. A survey of yam production systems and the impact of government policies in southwestern Nigeria. *Journal of Food, Agriculture & Environment* 3(2): 222–229.

Ajayi, O., F. Place, F. Kwesiga, P. Mafongoya and S. Franzel. 2005. Impact of fertilizer tree fallows in eastern Zambia. A study of impacts of agroforestry. World Agroforestry Centre External Program and Management Review. Nairobi, Kenya.

Alene, A.D., V.M. Manyong, E. Tollens, and S. Abele. 2007. Targeting agricultural research based on potential impacts on poverty reduction: Strategic program priorities by agroecological zone in Nigeria. *Food Policy* 32(3): 394–412.

Alpuerto, V., X. Diao, S. Salau, and M. Nwafor. 2009. Agricultural Investment for Growth and Poverty Reduction in Nigeria. Nigeria Strategy Support Program (NSSP), Background Paper No. NSSP 001. IFPRI, Abuja Nigeria.

Asare-Bediako, E., F. Showemimo, Y. Opolu-Asiama and D. Amewowor. 2007. Improving sprouting ability of white yam minisetts (*Dioscorea alata* Poir) var Pona and Dente using different disinfectants and protectants in sterilized saw dust. *Journal of Applied Sciences* 7(20):3131–3134.

Barrett, C.B. 1996. On price risk and the inverse farm size–productivity relationship. *Journal of Development Economics*. 51:193–215.

Becker, M., D. Johnson, M. Wopereis, and A. Sow. 2003. Rice yield gaps in irrigated systems along an agroecological gradient in West Africa. *Journal of Plant Nutrition and Soil Science* 166 (1): 61–67.

CGIAR (Consultative Group on International Agricultural Research). 2008. Impact assessment of CGIAR. http://impact.cgiar.org/ Accessed August 2009.

Cassman, K., A. Doberman, D. Walters and H. Yang. 2003. Meeting cereal demand while protecting natural resources and improving environmental quality. *Annual Review of Environmental Resources* 28:315–58.

CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo). 1988. From agronomic data to farmer recommendations: An economics training manual. Mexico City: CIMMYT.

Eberlee, J. 2003. Cover crops: Improving soil fertility in Africa. http://www.idrc.ca/es/ev-5554-201-1-DO_TOPIC.html. Accessed August 2009.

Ehui, S. and M. Tsigas. 2009. The role of agriculture in Nigeria's economic growth A general equilibrium analysis:. Paper presented at the 2009 Conference Conference of the

International Association of Agricultural Economists (IAAE), 16-22 August 2009, Beijing, China

Fan, S. 2008. Public expenditures, growth and poverty: Lessons from developing countries. Baltimore: Johns Hopkins University Press.

FAO. 2006. Follow up of the implementation of the World Food Summit Plan of Action. National report. ftp://ftp.fao.org/docrep/fao/meeting/010/ag368e.pdf

FOS (Federal Office of Statistics). 2004. Nigeria living standard survey 2003/04. Unpublished draft report.Abuja.CD-ROM.

Furuya, J. and T. Sakurai. 2003. Interlinkage in the rice market of Ghana: Money-lending millers enhance efficiency. Paper presented at the 23rd Conference of the International Association of Agricultural Economists. August 16–23. Durban, South Africa.
Gregory, D. I., and B. L. Bumb. 2006. *Factors affecting supply of fertilizer in Sub-Saharan Africa.* Agriculture and Rural Development Discussion Paper 24. Washington, D.C.: World Bank.Heltberg, R. 1998. Rural market imperfections and the farm size–productivity relationship: Evidence from Pakistan. *World Development* 26 (10): 1807–1826.

Hess, R. and F. Bliss. 2005. Effects of Nitrogen fertilizer application timing on common bean production. *Nutrient Cycling in Agroecosystems* 29 (2):133–138.

Holmen, H. 2005. “Spurts in production—Africa’s limping green revolution. In *African food crisis. Lessons learnt from the Asian green revolution.*ed. G. Diurfeldt, H. Holmen, M. Jirström, and R. Larson. London: Commonwealth Agricultural Bureaux International (CABI) Publishing.

Howard, J., E. Crawford, V. Kelly, M. Demeke and J. Jaime Jej. 2003. Promoting high-input maize technologies in Africa: The Sasakawa-Global 2000 experience in Ethiopia and Mozambique. F*ood Policy* 28 (4):335–348. .Jagtap,S. and F. Abamu. 2003. Matching improved maize production technologies to the resource base of farmers in a moist savanna. *Agricultural Systems* 76 (3): 1067–1084.

Jama, B., E. Eyasu and K. Mogotsi. 2006. Role of agroforestry in improving food security and natural resource management in the drylands: A regional overview. *Journal of the Drylands* 1 (2): 206–211.

Kay, M. 2001. *Smallholder irrigation technology: Prospects for Sub-Saharan Africa.* United Nations Food and Agriculture Organization (FAO) Knowledge Synthesis Report 3, Rome: FAO. .

Kunze, D. 2000. Economic assessment of water harvesting techniques: A demonstration of various methods. *Quarterly Journal of International Agriculture* 39 (1): 69–91.

Lamb, R.L. 2003. Inverse productivity: Land quality, labor markets, and measurement error. *Journal of Development Economics* 71(1): 71–95.

Manyong, V.M., A. Ikpi, J.K. Olayemi, S.A. Yusuf, B.T. Omonona, V. Okoruwa, and F.S. Idachaba. 2005 Agriculture in Nigeria: Identifying opportunities for increased commercialization and investment. Ibadan, Nigeria: International Institute of Tropical Agriculture.

________., J.G. Kling, K.O. Makinde, S.O. Ajala, and A. Menkir. 2000b. Impact of IITA-improvedgermplasm on maize production in West and Central Africa. , International Institute of Tropical Agriculture, Ibadan, Nigeria. Mimeo.

Maziya-Dixon, B., I. Akinyele, E. Oguntona, S. Nokoe, R Sanusi and E. Harris. 2004. Nigeria food consumption and nutrition survey 2001–2003. International Institute of Tropical Agriculture (IITA) Report submitted to the Nigerian government

McCulloch, N. and M. Ota. 2002. Export horticulture and poverty in Kenya. Institute of Development Studies, University of Sussex, Brighton, U.K. Mimeo.

Minot, N. and M. Ngigi. 2004. *Are horticultural exports a replicable success story? Evidence from Kenya and Côte d'Ivoire*. Environment and Production Technology Discussion Paper 120/Markets, Trade and Institutions Division Discussion Paper 73. Washington, D.C.: International Food Policy Research InstituteMogues, T. 2008. *Nigeria agriculture public expenditure review* IFPRI Discussion Paper 789. Washington, D.C.: International Food Policy Research Institute.

Morris, M., V. Kelly, R. Kopicki, and D. Byerlee. 2007. *Fertilizer use in African agriculture: Lessons learned and good practice guidelines*. Washington, D.C.: World Bank. .Mukherjee, C., H., White, and M. Wuyts. 1998. Econometrics and data analysis for developing countries. London: Routledge.

Nigeria. National Bureau of Statistics. 2007. *National Accounts of Nigeria*. 1981–2006. Abuja, Nigeria: National Bureau of Statistics

Nigeria. National Planning Commission. 2004. *Meeting everyone's needs: National Economic Empowerment and Development Strategy*. Abuja, Nigeria: National Planning Commission.

Ojowu, O., H. Bulus and B. Omonona. 2007. Nigeria Poverty Assessment. National Bureau of Statistics. Unpublished report.

Quisumbing, A. 1996. Male–female differences in agricultural -productivity. *World Development* 24: 1579-1595.

Roy, R., R. Misra, and A. Montanez. 2002. "Decreasing reliance on mineral nitrogen—yet more food" Ambio 31(2):177-183.

Ryan, J.G. and D.C. Spencer. 2001. Future challenges and opportunities for agricultural R&D in the semi-arid tropics. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Singh, B. 2002. Nontraditional crop production in Africa for export In *Trends in new crops and new uses*. ed. J. Janick and A. Whipkey. Alexandria, Va., U.S.A..: ASHS Press.

Smith L., and L. Haddad. 2000. *Explaining child malnutrition in developing countries: A cross-country analysis*. Research Report 111. Washington, D.C.: International Food Policy Research Institute.

Udry, C., J. Hoddinott, H. Alderman, and L. Haddad. 1995. Gender differentials in farm productivity: Implications for household efficiency and agricultural policy, 20: 407-423.

Vandenbosch, T. 2006. Post-primary agricultural education and training in Sub-Saharan Africa: Adapting supply to changing demand. ICRAF (International Centre for Research in

Agroforestry)., Nairobi, Kenya. Mimeo.WARDA (West Africa Rice Development Association). 2001. NERICA, rice for life. : http://www.warda.cgiar.org/publications/NERICA8.pdf

WARDA (West Africa Rice Development Association). 2005. NERICA: Origins, nomenclature and identification characteristics. Online at http://www.warda.org/publications/nerica-comp/module%202_Low.pdf.

World Bank. 2004. *Agriculture and rural institutions support project: Appraisal report*. Federal Government of Nigeria and African Development Fund. Washington D.C.: World Bank..

World Bank. 2007. *World Development Indicators.* Washington, D.C.: World Bank.

Yahaya, M. K. 2002. Development and challenges of Bakolori irrigation project in Sokoto state, Nigeria *Nordic Journal of African Studies* 11 (3): 411430.

Appendix 1: Crops grown across poverty quintiles in Nigeria

Poverty quintile						
	1	2	3	4	5	Overall
Percent quantile						
Sorghum	7.8	31.9	27.5	19.3	12.7	28.0
Cassava	11.2	17.4	22.3	29.9	36.9	21.3
Beans	16.3	13.2	8.6	6.1	5.3	10.8
Maize	8.2	8.8	8.9	9.2	11.2	9.0
Yam	5.6	6.6	10.1	12.8	13.4	8.9
Millet	1.9	9.7	8.5	5.5	2.6	8.5
Groundnuts	3.8	4.5	4.3	3.9	3.2	4.0
Cocoa	1.1	1.6	2.2	3.5	5.3	2.3
Rice	0.6	1.8	2.0	1.8	1.5	1.5
Oil palm	0.3	0.9	1.4	1.4	2.1	1.1
Cotton	0.8	0.9	0.5	0.5	0.6	0.7
Avocado pears	0.8	0.9	0.4	0.2	0.9	0.6
Bananas	0.1	0.2	1.0	1.1	1.0	0.6
Mango	0.3	0.3	0.4	0.5	0.7	0.4
Leafy vegetables	0.1	0.0	0.2	0.7	0.5	0.3
Okra	0.2	0.2	0.4	0.5	0.2	0.3
Pepper	0.5	0.1	0.2	0.1	0.1	0.2

Source: National Living Standard Survey. 2004.