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N2Africa Project, Borno State

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Cover photo: Farmers inspecting demonstration plot.

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Acronyms and Abbreviations

BNF	Biological Nitrogen Fixation
FGD	Focus Group Discussion
FGT	Foster-Greer-Thorbecke
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
LGAs	Local Government Areas
PROSAB	Promoting Sustainable Agriculture in Borno State
N2AFRICA	Putting Nitrogen Fixation to work for Smallholder Farmers in Africa

Executive Summary

In sub-Saharan Africa where agriculture is dominated by smallholder farmers, crop productivity is low because of poor soil fertility and other biotic and abiotic stresses. The N2Africa project seeks to improve soil fertility and increase crop productivity by using grain legumes to provide soil nitrogen through biological nitrogen fixation (BNF). The use of grain legumes in cropping systems also improves human nutrition and farm income while enhancing soil health. In Nigeria, one of the N2Africa intervention areas is in Borno State. The selected locations in Borno State were Bayo, Biu, Hawul, and Kwaya Kusar Local Government Areas (LGAs).

Among the project activities conducted by the N2Africa project is the promotion and dissemination of improved crop varieties. The process was accompanied by improved agronomic practices to help the crops disseminated fulfill their productive potential. One of the key crops promoted by the project is soybean. Since the inception of the project, there has been no information on the adoption and impact of the soybean being promoted. There was thus a need to undertake an adoption study on soybean and its impacts on the livelihoods of rural farming households in the project areas. This will enable the project to understand the progress made for far as its implementation progresses in Borno State.

N2Africa targeted female-headed households as beneficiaries of soybean technologies, thus this study will provide a gender-differentiated analysis to ascertain whether or not soybean has had an impact on their livelihoods. The objectives of the study, therefore, were to determine the level and rate of adoption of soybean varieties by both male-and female-headed households in the project area-; to examine their reasons for growing soybean varieties; to examine their constraints in growing soybean varieties; to examine the factors influencing their adoption and intensity of adoption of soybean varieties; to examine the productivity and income of soybean by male and female adopters of new varieties; to determine the impact of adoption of soybean varieties on their household incomes; and to determine the impact of adoption of soybean varieties on their household income, assets, and poverty.

To achieve the set objectives, a formal survey was carried out in the study area. Purposive selection of three LGAs was carried out. A total of 40 communities were selected randomly from Biu, Hawul, and Kwaya Kusar). The sample consisted of 400 (50%) female and 400 (50%) male respondents, making a total of 800 sampled respondents. The major instrument used for data collection was a structured questionnaire. Data collected were analyzed separately for male-and female-headed households using both descriptive and inferential statistics.

Socioeconomic characteristics of farm households

The study revealed that most respondents were mostly married as only 9% of males and 8% of females were single. Approximately 50.8% of males and 49.0% of females are monogamous; 40.3% of males and 17.8% of female respondents were in polygamous marriages. The average household size reported for all households is 7.94. The average household size is 8.16 for males while it is 7.71 for female-headed households. The total percentage of all household heads who had never received formal education is 45.45%. The literacy rate of female-household heads is much lower than that of male household heads, as 56.15% of females had no formal education while 25.7% of males had no formal education. Extension contact for male household head is low at 33.5% while 39.63% of female-household heads had no extension contact. Access to credit was low for both studied groups. Approximately 18.94% of male household heads had access to credit while only 16.125% of female-household heads had such access.

Adoption of soybean varieties

The soybean varieties grown in the study area are all improved as soybean is a relatively new crop and was introduced in the study area by PROSAB and N2Africa. According to the results, 92.9% of male-headed households and 90.2% of female-headed households grew soybean. Results from the study revealed that 75.4% of male household heads and 69.5% of female-household heads adopted the soybean varieties promoted by the project. The most adopted variety is TGX 1904-6F as it was adopted by 26.1% of males and 24% of females. The least adopted was TGX1835 (Danwuri) as it was adopted by only 8.75% of male and 6.3% of female-headed households. For both male-and female-headed households a high yield was the main reason why they adopted improved soybean varieties. Another major reason for adoption was less shattering. The third greatest reason for farmers adopting improved varieties was early maturity. This is not surprising as the climate is characterized by a low rainy season and intermittent drought. The greatest impediment to adoption is the high cost of inputs. Nearly 100% of female respondents quoted high input cost as a constraint to adoption. For male farmers 90.1% of them were also constrained by high input costs.

Production of soybean variety

According to the results, males on average planted 0.48 ha of soybean while females planted on average 0.27 ha. Although TGX1835-Danwuri had the lowest rate of adoption, farmers who adopted it planted more than other varieties. It has the highest mean area planted for both male and female farmers. TGX1835-Danwuri is an older improved variety and the higher proportion of mean area planted may signify that the seeds are more readily available than that of the other newer improved varieties. On average, male-headed households had slightly more yield than female-headed households across all varieties. Males harvested approximately 2363 kg/ha of soybean while females harvested approximately 2038 kg/ha.

Income of respondents

Soybean is the source of income that farmers most depend on as 86% of males and 81% of females cited soybean as their source of income. While a higher percentage of males have more income sources than females, groundnut is an income source that has a higher number of females than males depending on it. This importance is characterized by the fact that 61% of females depend on groundnut for income while only 39.8% of males depend on groundnut. According to the results, for those who adopted soybean, the sale of the crop provided the highest amount of income and it is true for both male and female farmers. Male adopters, on average, had a soybean income of N81,344 while females received N49,507 in the last 12 months from the sale of soybean. Male adopters had a much higher soybean income than their female counterparts. Groundnut is important to female farmers who did not grow soybean (non-adopters) that had a higher income (N49,914) from the sale of groundnut than both male adopters of soybean (N23,407) and male non-adopters (N34,905).

Factors influencing adoption of soybean varieties in Borno State

In determining factors influencing adoption, the Logit and Tobit econometric regression models were used to determine adoption and intensity of soybean varieties, respectively. Using the Logit model, results show that for male-headed households, level of education, membership of associations, participation in project activities, and access to credit significantly influenced the decision to adopt new soybean varieties. For the female-headed households access to credit and membership of associations influenced the adoption of new varieties. The results of the Tobit analysis showed that the factors that influenced male-headed households' intensity of adoption included household size, income, farm size, and access to credit. For female-headed households, household size, income, farm size, extension contact, and participation in associations significantly influenced the probability of intensity of adoption of new soybean varieties promoted by the project.

Poverty profile on household poverty by gender and adoption

The FGT index was used to calculate the poverty profile of household heads. The poverty headcount (α_0) results revealed that 38% of male farmers and 49% of female farmers were poor. The poverty gap index of male farmers shows that 31% of the value of the poverty line is required to lift males out of poverty while for females it was 37%, showing that females had a greater poverty burden than their male counterparts. In terms of poverty severity index, a greater value was also attributed to female respondents at 0.19 compared to their male counterparts at 0.13, which meant that nearly 20% of the poor female respondents were severely poor. This is to say that poverty was a bigger problem for female-headed household heads as they had a higher incidence, burden (gap), and severity of poverty, than their male counterparts.

The poverty headcount (α_0), for male adopters was 0.36 (36%) while for non-adopters it was 0.43 (43%). This means that 36% of the male adopters and 43% of the non-adopters were poor. Thus, male non-adopters were generally poorer than the adopters. The result for the poverty gap index shows that male household heads who adopted had a lower poverty burden than non-adopters. The poverty gap index for adopters shows that 30% of the poverty line is needed to lift male adopters out of poverty. For non-adopters 37% of the poverty line is needed to lift them out of poverty. For male adopters, 13% are severely poor while 14% of non-adopters are severely poor.

The poverty headcount (α_0), for female household adopters shows that 48% of the female adopters and 50% of female non-adopters are poor. The result for the poverty gap index shows that female-household heads who adopted had a slightly lower poverty burden than non-adopters. For adopters 18% are severely poor while 17% of non-adopters are severely poor.

Impact of adoption of soybean varieties on household income, assets, and poverty

The propensity score matching method was used to estimate the treatment effect of adoption of soybean varieties on farm income per capita, total income per capita, household assets, and poverty. According to the results, the adoption of soybean varieties had a positive and significant treatment effect on the farm income and assets of male farmers but there was no significant treatment effect on income per capita and poverty headcount. For female farmers there was no treatment effect on farm income per capita, income per capita, assets per capita, and poverty headcount. This is not surprising because for female farmers who did not grow soybean, many chose to grow groundnut and the income for female farmers for both sources was also the same. In addition, female farmers also had varying sources of income including non-farm incomes.

Conclusions and recommendations

The N2 Africa project was successful in raising awareness for soybean and in return helping to increase the level of adoption for both male and female farmers. The variety that was most adopted for both studied groups was TGX 1904-6F. For all varieties, male respondents had a larger mean area planted than their female counterparts. For all improved varieties male farmers also had a higher level of yield. Factors such as males having more access to land, credit, social capital in the form of membership of associations, and higher levels of non-farm income are some that possibly contributed to this disparity in yield. Farm income for male and female farmers including adopters and non-adopters of both genders was higher than their non-farm income; soybean income for male farmers was double that obtained by female farmers. Disparity in production and income outcomes can be attributed to female farmers having less access to land and other yield-increasing inputs and this limits their ability to be productive.

National agricultural institutions such as BOSADP in the study area need to do more to ensure that they deliver quality extension services that will see the continuation of improved farming technologies. The promotion of social capital through associations especially among the female population must be continued in order to help to spread future agricultural technologies. Policymakers must ensure that female farmers have access to land and other factors of production for them to expand their productivity and have higher farm incomes and enable them to escape poverty. Future intervention activities should identify the aspect of the value chain that females are mostly engaged in to target for gender mainstreaming activities. In areas where females are mostly engaged in processing, for example, targeting farmers that are engaged in processing would be very helpful. Policymakers must strive to ensure that male and female farmers with capital deficits have access to credit to be able to purchase new seeds and other inputs. The proliferation of peer-to-peer banking schemes like the rotating credit and savings association could be a solution to this.

Demonstrating added-value crop products.

Introduction

Background of the study

N2Africa is a large scale, science-based "research-in development" project funded by the Bill & Melinda Gates Foundation with a vision of developing sustainable, long-term partnerships to enable smallholder farmers to benefit from symbiotic nitrogen fixation by grain legumes through effective production technologies, including inoculants and fertilizers. The project seeks to enhance the yield of grain legumes and expand the farm area cropped with legumes by putting nitrogen fixation to work for smallholder farmers in Africa to improve incomes and food and nutrition security.

The charitable purpose of N2Africa is to increase atmospheric nitrogen from biological nitrogen fixation (BNF) through grain legumes, thereby improving crop and livestock productivity, human nutrition, and farm income, while enhancing soil health. This is achieved through uptake of state-of-the-art legume and rhizobia inoculant technologies by African smallholder farmers. This purpose is based upon the recognition that agricultural production in most parts of sub-Saharan Africa is dominated by smallholder farming systems that often have poor productivity due to a deficiency in the supply of nitrogen (Franke and de Wolf, 2011).

The project is currently being implemented in: Nigeria, Ethiopia, Tanzania, and Uganda (Core countries), and in DR Congo, Rwanda, Kenya, Mozambique, Malawi, and Zimbabwe (Tier 1 countries). In Nigeria it is implemented in four States - Niger, Kaduna, Kano, and Borno - by the International Institute of Tropical Agriculture (IITA); the focus crops are soybean, groundnut, and cowpea. The vision of success of the Borno State project is geared towards the realization of the project's vision of success, which is to reach more than 40,000 farming families and pioneer models for youth engagement in agribusiness through which job opportunities in agri-business would be created for at least 2,000 young adults living in the target area. The intervention areas (geographical coverage) in Borno are mainly in the south of the State and in the following Local Government Areas (LGAs): Bayo, Biu, Hawul, and Kwaya Kusar. N2Africa in Borno has since 2009 been actively involved in adapting existing technologies such as identifying the best matching rhizobia strains for different grain legumes. It has promoted these and other technologies, using demonstrations (demos), field visits, and training workshops, to help increase farm productivity. In addition, N2Africa has also been engaged in building the capacity of women and youth farmers and establishing new value chains via the creation of cooperative associations that has helped to provide input supply to farmers and create new market linkages.

Purpose of the study

The purpose of this study is to evaluate whether or not the N2Africa project in Borno was successful in achieving an increase in the adoption of soybean varieties promoted by the project and to ascertain whether or not the project significantly improved the welfare of those households who adopted the varieties. N2Africa targeted female-headed households to be beneficiaries of soybean technologies, thus this study will provide a gender-differentiated analysis to ascertain whether or not the project had an impact on the livelihood of these households. This will provide project staff, funders, and other stakeholders with detailed information on whether key project deliverables and related indicators were achieved.

Objectives of the study

The main objective of the study is to assess the project's impact on the livelihood of male and female farmers. The specific objectives of the study are as follows:

To examine the socioeconomic characteristics of male and female soybean farmers in the study area.

- To determine the level and rate of adoption of soybean varieties by both male and female farmers in the project area.
- To examine the reasons for growing soybean varieties by both male and female farmers.
- To examine the constraints in growing soybean varieties by both male and female farmers.
- To examine the factors influencing adoption and the intensity of adoption of soybean varieties by both male and female farmers.
- To examine the productivity and income from soybean for both male and female farmers that adopted new varieties.
- To determine the impact on household income of the adoption of soybean production on by both male and female farmers.
- To determine the impact on household poverty of the adoption of soybean varieties by both male and female farmers.

Scope of the study

The scope of the study includes the collection of quantitative and qualitative data on key milestones of the Borno Results framework, also of information on the impact indicators of the project. The field data collection was carried out in October and November, 2017. However, the data were collected to give information on the previous 2016 cropping season. The study area comprised Biu, Hawul, and Kwaya Kusar LGAs of Borno State, Nigeria. The main reference points of the study were the project document (project proposal), the baseline report, and the Borno Results framework.

Description of the survey area

The survey was carried out in the communities covered by the N2Africa project in Borno State. The communities are located in Biu, Hawul, and Kwaya Kusar LGAs. Borno State is located in northeast Nigeria; it covers an area of 69,435 km^2. The State is demarcated into four agro-ecological zones (AEZs), with southern and northern Guinea savanna in the south, Sudan savanna in the central parts, and the Sahel in the north. The project area covers two AEZs (southern and northern Guinea savanna), located between Latitude 10^o and 12^o north of the Equator and Longitude 11^o 30 and 14^o east. Numerous ethnic groups and cultures characterize the area, with approximately 80% of the population being small-scale farmers. Agriculture and trading constitute the major economic activities of the area (BOSADP, 1998).

The study area is characterized by relatively wet and humid weather as compared with the drier northern part of the State. The annual rainfall ranges from 600 mm in the north to 1200 mm in the south, and extends over a growing season of between 100 and 180 days. Annual rainfall varies from year to year, with decreasing trends during the past two decades. According to the 2006 census, Borno State has a population of 4.2 million people who depend mainly on agriculture (Amaza et al., 2007). In the north, major crops grown are millet, sorghum, and cowpea. In the savannas of the southern part of the State, major crops are maize, sorghum, cowpea, groundnut, rice, and recently soybean. Crops may be grown as sole, multiple, mixed, or relay. Crops may also be grown in rotations, depending on preference. The vegetation of the study area is of the northern and southern Guinea savanna types, consisting of shrubs interspersed with trees and woodland. Most parts of the area are mountainous with abundant rivers which are, however, seasonal in nature. The categories of agricultural activities include crop production and animal husbandry.

Famers inspecting demonstration plot.

Methodology

Sampling technique and data collection procedure

The study followed accepted statistical sampling procedures and collected adequate samples that reflected important characteristics of the population under study. Random sampling and non-random sampling methods were used to select samples. For the random sampling technique, the following sampling formula was used to determine the sample size for the study.

$$n = \frac{(1.96)^2 \times N}{(1.96)^2 + I^2 \times (N-1)}$$

Where;
n = sample size
N = study population
I = confidence interval

For the male farmers in the study area a 95% confidence interval was applied. For 40,000 households, questionnaires were administered to **381** randomly selected male-headed households based on the formula. However, the sample size was increased by 5% to 400 samples when allowance was introduced to account for the non-response rate during data collection.

An equal sample of 400 female-headed households was also sampled for the study area, **(**giving us a total sample of **800 households** for the survey). Household surveys were undertaken in communities participating in N2Africa.

A multi-stage sampling was used in this study. The first stage was the purposive selection of three LGAs, Biu, Hawul, and Kwaya Kusar. These three LGAs were selected because interventions promoting improved agricultural technologies including soybean varieties had been undertaken there by the PROSAB and N2Africa projects. The second phase included the random selection of forty communities where these interventions were carried out. In Biu LGA 12 communities were selected, 16 in Hawul, and 12 in Kwaya Kusar. In the third and final stage there was the random selection of small-scale farmers by use of random numbers. In each community 10 male farmers were randomly selected. Out of them, five were randomly selected participants and the other five were randomly selected non-participants of the all project activities. An equal number of 10 female farmers comprising five randomly selected participants and five randomly selected non-participants was selected as well. A total of 20 farmers (10 males, 10 females) were selected per community, thus giving a total sample size of 800 respondents across all the communities. The summary of the sampling frame is presented in Table 1.

Table 1. Summary of sample frame and sample size.

LGA	No. of Communities	Names of Communities		Sample
		Filin Jirgi	Kinging	
		Yamarkumi	Maina Hari	
		Tum	Yawi	
Biu	14	Kigir		280
		Yaulari	Tabra	
		Nzukuku	Kabura	
		Mirnga	BCG	
		Sakwa	Ghuma	
		Marama	Azare	
		Fumwa	Dusu	
Hawul	14	Tanga Ramta	Kuburdugu	280
		Kidang		
		Hema	Yimirshika	
		Mbulatawiwi	Ngwa	
		Grim	Vina Dam	
		Kwaya Kusar	Midla	
		Gashina	Peta	
Kwaya Kusar	12	Gadam	Jalingo	240
		Wandali	Yimirthalang	
		Kulthidika Nguda	Guwal	
		Kurba Gayi	Gusi	
Total	40	40		800

Method of data collection

Data for the N2Africa Borno Situational survey were obtained through a survey of 800 households conducted in October, 2017. The main instruments for data collection were well-structured, electronic questionnaires administered on households by trained enumerators under the supervision of consultants from the Department of Agricultural Economics, Bayero University Kano, Nigeria, and researchers from IITA. Information collected included variables on sex, age, marital status, farm size, family size, quantity of input, income of farmers, awareness and adoption of soybean varieties, expenditure of farmers on food and non-food items, expenditure on productive and household assets, and crop production based on the 2016 farming season. A survey research design was employed to capture all these variables. Data were collected from 40 communities and settlements spread across the four LGAs in the project area (Table 1).

Analytical techniques

A combination of analytical tools was employed in this study. These included descriptive statistics, (means, frequencies, etc.). The Statistical Package for Social Sciences (SPSS) version 20 was used in the analysis of descriptive statistics. Using means, percentages, and frequency distribution; the level of education of household heads, the age of household heads, their years of farming experience, the level of household income, the level of awareness, and adoption of soybean were all measured. Inferential statistical methods (such as regression techniques) were used; Logit to model the determinants of adoption and Tobit to model intensity of adoption. Additionally, a poverty profile for households was measured using the Foster, Greer, and Thorbecke (FGT) index.

The Propensity Score Matching method was used to measure the project's impact on household income, assets, and poverty. The Stata, statistical data software, version 14 was used to measure the inferential statistical methods.

Descriptive statistics

Descriptive statistics were used to examine the socioeconomic characteristics of the respondents' households and basic features of the existing crop production system in the study area. The need for such analysis is based on the fact that households' food security and poverty are largely functions of farmers' social and economic characteristics. The estimation of poverty status involves the measurement of the standard of living of the households, estimation of the poverty line, and the computation of the poverty profile. The Foster-Greer-Thorbecke (FGT) indices, which include the headcount index, poverty gap index, and poverty severity index, were used to measure the poverty profile of the sampled households.

Determinants of level and intensity of adoption of soybean

The adoption process begins with farmers gaining awareness of a new technology by hearing about it. Afterwards they go through a time of acquiring knowledge about the technology, which would leave an impression about the technology, either a positive or negative, and ultimately lead them to decide whether or not to adopt that technology. After adoption farmers may also choose to increase the intensity of use of the new technology as well or to dis-adopt entirely (Rogers, 2004). Understanding the factors that determine the adoption and intensity of adoption of soybean varieties during the adoption process is critical in knowing the factors that stimulate and hinder the adoption of these varieties. Policymakers, research institutes, and donor organizations will find this information helpful in planning future soybean interventions better and in responding to the needs of farmers who may have been hindered by certain socioeconomic or institutional variables (Ebojei et al., 2012)

Empirical model for determinants of adoption
Logit models

Adoption is usually dichotomous in nature and thus binary, with farmers having the option of adopting a new technology or not.

$$Y = \begin{cases} 1 \; if \; adoption \\ 0 \; otherwise \end{cases} \quad \text{...} (1)$$

For binary models to regress the dependent variable on the independent variables using ordinary least squares such as a linear probability models would produce nonsensical results as the disturbances are not normally distributed. (Gujarati, 2009). The other problem an ordinary least squares approach would pose is that its distribution function can exceed 1 or go below zero. For binary models a distribution function must be chosen that lies between 0 and 1. An example of such a function is a cumulative distribution function and the logit model is an example of a model that has a cumulative distribution function.

Meaning for

$$P(Y|X) = F(\beta_0 + \beta_1 X) \quad \text{...} (2)$$

As $F(\alpha + \beta X)$ approaches $-\infty$, $P(Y|X)$ becomes 0

and as $F(\alpha + \beta X)$ approaches ∞, $P(Y|X)$ becomes 1 the logit model has the properties that the model above has

$$F(Z) = \frac{\exp}{1+\exp} = L(Z) \quad \text{…(3)}$$

$$= \beta_0 + \beta_1 X \quad \text{…(4)}$$

Gujarati (2009)

To apply logit to adoption, a decision rule must first be established, based on the assumption of monotonic relationship between utility and some measure of monetary benefits (Ayanwale et al,. 2008).

$$U_{1X} = X\beta_1 + \varepsilon_{1X} \quad \text{…(5)}$$

$$U_{0X} = X\beta_0 + \varepsilon_{0X} \quad \text{… (6)}$$

U_{1X} is an individual's utility from adopting the new variety, X is the vector of adoption determinants. is the utility without adoption while and are response coefficients and are random disturbance terms.

Let P be the probability function. Then, the incremental benefit proposition is actualized as follows:

$$P(Y=1) = P(U_{1x} > U_{0x}) = P(X\beta_1 + \varepsilon_{1x} > X\beta_0 + \varepsilon_{0x}) \quad \text{… (7)}$$

$$= P[X(\beta_1 - \beta_0) > \varepsilon_{1x} + \varepsilon_{0x}) \quad \text{… (8)}$$

$$= F(X\beta) \quad \text{… (9)}$$

$$\varphi = \varepsilon_{1x} - \varepsilon_{0x} \quad \text{… (10)}$$

and

$$\beta = \beta_1 - \beta_1 \quad \text{… (11)}$$

is some measure on the net influence of X on adoption.
F(Xβ) is the cumulative distribution function for φ evaluated at Xβ.

Thus, the probability of adoption is

$$P(Y=1\,|X) = \frac{\exp(X\beta + \varphi)}{1+\exp(X\beta+\varphi)}, \; -\infty < X\beta < \infty \quad \text{… (12)}$$

And

$$P(Y=0\,|X) = 1 - P(Y=1\,|X) = \frac{1}{1+exp\,(X\beta+\varphi)} \quad \text{… (13)}$$

The estimating relationship is now specified as

$$Ln\left\{\frac{P(Y=1\,|X)}{P(Y=0\,|X)}\right\} = X\beta + \varphi \quad \text{… (14)}$$

The explicit model is defined as

$$Y_i = \beta_0 + \beta_1 AGE + \beta_2 HHS + \beta_3 EDU + \beta_4 INC + \beta_5 FARMSIZ + \beta_6 FARMEXP + \beta_7 EXTCON + \beta_8 PROCMACH + \beta_9 DSTMARK + \beta_{10} CREDIT + \beta_{11} MEMASSOC + \beta_{12} PART \quad \text{… (15)}$$

(Uaiene et al.,, 2009; Tura et al., 2010; Ayanwale et al., 2011)

Empirical model for determinants of intensity of adoption

Tobit model

The Tobit model would be used to determine the intensity of adoption.

The Empirical Tobit is expressed as

$Y = \{ \begin{matrix} Y_i^* \\ 0 \end{matrix}$ ……………………………………………………………………………(16)

If

$y = y_i^* \;\; if \;\; y > 0$ ……………………………………………………………………(17)

and

$y = 0 \;\; if \;\; y \leq 0$………………………………………………………………….......... (18)

$Y_i = X_i\beta + u_i$ If $X_i\beta + u_i, > 0$ ……………………………………………………………….(19)

and

$Y_i = 0$ if $X_i\beta + u_i, \leq 0$…………………………………………………………………….(20)

Where X_i is a vector of independent variables, *N* is the number of observations, Y_i is the dependent variable, b is a vector of unknown coefficients, and u_i is an independently distributed error term assumed to be normal with zero mean and constant variance .

u_i =random error term [iid$\sim(0, \delta^2)$]……………………………………………………… (21)

Thus, the model assumes that there is an underlying, stochastic index equal to $(X_i\beta + u_i)$ which is observed only when it is positive, and hence qualifies as an observed, latent variable.
$Ey = X\beta F(z) + \sigma f(z)$………………………………………………………………… (22)

Where, $Z = X\beta/\sigma$, $f(z)$ is the unit normal density and $F(z)$ is the cumulative normal distribution function. Furthermore the expected value of y for observation above the limit y^* is $X\beta$ plus the expected value of the truncated normal error term (Amemiya, 1984)

$Ey^* = E(\frac{y}{y} > 0)$…………………………………………………………………...…….. (23)

$= E(\frac{y}{u} > -X\beta)$…………………………………………………………………..……... (24)

$= X\beta + \sigma f(z)/F(z)$…………………………………………………………...…….. (25)

Therefore, the basic relationship between the expected value of all observations. Ey, the value conditional upon being above the limit Ey^*, and the probability of being above the limit, $F(z)$ is

$Ey = F(z)Ey^*$…………………………………………………………………………... (26)

According to McDonald and Moffit (1980), the equations (24-25) can be decomposed by considering the effect of a change in the ith variable of X on y:

$\delta Ey/\delta X_i = F(z)(\delta Ey^*/\delta X_i) + Ey^*(F(z)/\delta X_i)$…………………………………………… ...(27)

Thus, the total change in y can be disaggregated into two very inituitive parts: (1) the change in y

in those above the limit, weighted by the probability of being above the limit and (2), the change in probability of being above the limit, weighted by the expected value of y if above.

The two partial derivatives are also calculable (McDonald and Moffit, 1980):

$$\delta F(z)/\delta X_i = f(z)\,\beta_i/\sigma \quad (28)$$

And from equation (10)

$$\delta Ey^*/\delta X_i = \beta_i + (\,\sigma/F(z)\delta f(z)/\delta X_i - (\sigma f(z)/F(z)^2 \sigma\, F(z)/\delta X_i) \quad (29)$$

$$= \beta_i[1 - zf(z)/F(z) - f(z)^2/F(z)^2] \quad (30)$$

Using $F'(z) = f(z)$ for cumulative normal density and $f^1(z) = -zf(z)$ for a unit normal density

The explicit model of the Tobit is defined as

$$Y_i = \beta_0 + \beta_1 AGE + \beta_2 HHS + \beta_3 EDU + \beta_4 INC + \beta_5 FARMSIZ + \beta_6 FARMEXP + \beta_7 EXTCON + \beta_8 PROCMACH + \beta_9 DSTMARK + \beta_{10} CREDIT + \beta_{11} MEMASSOC + \beta_{12} PART \quad (31)$$

(Cragg, 1971; Burke, 2009; Ayanwale et al., 2011)
For both the Logit and Tobit Table 2 presents the definition of variables

Table 2. Variable for adoption models.

Variable Name	Variable
AGE	Age
HHS	Household size
EDU	Education
INC	Income
FARMSIZ	Farm size
FARMEXP	Farm experience
EXTCON	Extension contact
PROMACH	Processing machine
DSTMARK	Distance to market
CREDIT	Credit
MEMASSOC	Membership of association
PART	Participation in N2Africa project

Measuring the poverty profile of households

Poverty was measured using a relative poverty approach. This was done to account for differences in the prices, resources, and demographic compositions faced by households in rural Borno. To achieve this, a relative poverty line was drawn based on the per capita household expenditure adjusted using adult equivalent nutritional scales. After the poverty line was drawn the FGT indices were used to measure the poverty headcount, gap, and intensity of male-and female-headed households.

Measuring the standard of living

The standard of living of households in the area was measured based on the expenditure of the households. Household expenditure was converted into per capita expenditure by dividing it by the number of members of the household. This was further converted into adult equivalents based on the nutritional requirement, sex, and age of household members, using the nutrition-based adult equivalent scales provided by FOS (2004) shown in Table 3. To get the monthly mean/adult equivalent household expenditure (MAHE) the nutrition equivalent scales were multiplied by the number of household members that fall in any of the age-by-sex categories (Amaza, 2016).

Table 3. Nutritional (calorie based) equivalent scales.

Years of Age	Male	Female
0 – 1	0.27	0.27
2 – 3	0.45	0.45
4 – 6	0.61	0.61
7 – 9	0.73	0.73
10 – 12	0.86	0.78
13 – 15	0.96	0.83
16 – 19	1.02	0.77
20 ≥	1	0.73

Measuring the Poverty Line

The poverty line for the study was calculated from the MAHE of the sampled households where two-thirds of the MAHE was used. This approach was used by several researchers (FOS, 1999, 2004; Bandabla, 2005; Amaza et al., 2007; 2009).

The respondents' mean per adult equivalent household expenditure was used in classifying them into two, namely:

1. Non-poor: These are farmers whose mean per adult equivalent household expenditure is above two-thirds of the poverty line, i.e., NP >2/3 of the mean expenditure.
2. Poor: These are farmers whose mean per adult equivalent household expenditure is below the poverty line, i.e., P <2/3 of the mean expenditure.

The poverty line was set at 2/3 of the mean per adult equivalent household expenditure (FOS,1999; Amaza, 2016).

Poverty indices

The FGT indices were used to both identify and aggregate the poor and non-poor from the sampled household respondents. These indices include the headcount index, poverty gap index, and poverty severity index.

a) Headcount index

The headcount index measures the proportion of the population that is counted as poor and is often denoted by P_0

$$P_0 = \frac{1}{N}\sum_{i=1}^{N} I(y_i \leq Z) = \frac{N_p}{N} \qquad (32)$$

Where N is the total population, N_p is the total number of poor, y_i is expenditure and z is the poverty line. i is an indicator function that takes the value of 1 if the bracketed expression is true, i.e., the household is poor (Bandabla, 2005).

b) Poverty gap index

According to the Filmer and Scott (2008), the poverty gap is the mean shortfall from the poverty line (counting the non-poor as having zero shortfall), expressed as a percentage of the poverty line. The poverty gap is used to measure the depth of poverty of households by measuring how far the poor are below the poverty line.

Thus, the poverty gap (P_0) may be expressed as follows,

$$P_1 = \frac{1}{N}\sum_{i=1}^{N}\frac{G_n}{z} \qquad (33)$$

where $G_n = (z - y_i)I(y_i \leq z)$ ……(34)

(Bandabla, 2005)

c) Poverty severity index

The poverty severity index or the squared poverty index is used to measure inequality among the poor and it may be defined as

$$P_2 = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{G_n}{z}\right)^2 \qquad (35)$$

The squaring of the poverty gap puts more weight on observations well below the poverty line in order to measure the severity of poverty (Bandabla, 2005).

Measuring the impact of soybean technologies on income and poverty

The final analysis of this report seeks to measure the impact of the adoption of soybean on income, assets, and household poverty using the Propensity Score Matching method.

Impact evaluation studies attempt to measure the mean effect of a program or treatment. For this to be achieved an inference has to be made. About the outcome of the treatment group if they had not been treated. In experimental studies to measure such inference a control group with similar characteristics is simply generated and compared to the treatment group. But in social sciences where the studies are usually observational creating such control groups is difficult. Part of the reason is that some observational studies like adoption studies involve self-selection (Pufahl and Weiss, 2009). This self-selection leads to self-selection bias because individuals may be motivated by some unobservable benefits that determine their decision to adopt. Selection bias is also found in the fact that treatment and control groups differ with respect not only to participation but also to other characteristics or covariates. This problem is usually referred to as a model having high dimensionality. This implies that outcomes could have been determined not by the treatment program alone but by other variables or covariates. Thus, calculating the mean outcome between the treatment and control groups would yield both the average causal effect and some degree of selection bias in observational and non-experimental studies (Cameron and Trivedi, 2005). In addition to this, households (partly) determine whether they adopt a new technology and their decision may be related to the benefits derived from technology adoption. In other words, the relationship between technology and poverty is likely to be a two-way relationship whereby technology can help poverty reduction and poverty reduction can foster the adoption of new technologies. This problem of simultaneity makes it difficult to establish the causal effect of farming technology on income and poverty (Mendola, 2007).

To overcome these inferential challenges, the propensity score matching method is used. This is because propensity score matching is a semi-parametric estimation technique that helps eliminate selection bias by reducing the dimensionality of covariates, so that one may measure the average causal effect of a treatment. It does this by taking all the vectors of observed covariates and converts them into a propensity score. Treatment and control groups are then matched, based on the propensity score, in order to find the average causal effect.

A propensity score $P(x_i)$, for subject i,,$(i =1 ,\dots , N)$ is the conditional probability of an individual choosing a particular treatment given a vector of observed covariates .(x_i).

$P(x_i) = \mathrm{Pr}(z_i = 1|x_i)$... (36)

And

$\Pr(z_1,\dots , z_n|x_1,\dots , x_n) = \tilde{0}_{i=1}^{N} e(x_i)^{z_i}\{1 - e(x_i)\}^{1-z_i}$.. (37)

Where

$z_i =1,$ for treatment and $z_i =0,$ for control...(38)

Propensity scores are usually measured by the Probit or Logit model. Propensity Scores Matching allows for the measure of average causal effects between the treatment and control groups because of the conditional independence assumption. The Propensity Scores theorem states that if the conditional independence assumption is true, then the values of the outcome variable (Y_{1i} , Y_{0i}) are themselves conditionally independent of the treatment if we condition on the propensity score of an individual.

$Y_{1i} , Y_{0i} \perp\!\!\!\perp D_i \mid P(x_i)$.. (39)

Conditioning on the propensity scores allows for random assignments because it assumes that there is no correlation between outcomes and treatment. Randomization is important because it ensure that the treated population is not very different from the overall population. Also, the use of propensity score $(P(x_i))$ counters the problem of high dimensionality because it is a scalar value taking on the value between zero and one. Scalar values are one dimensional and hence are less confounding than using highly dimensional covariates. In order for one to identify some population measures of impact, the overlap assumption must be also satisfied. It states that

$0< P[D = 1 |x] <1$ .... (40)

This assumption satisfied by Propensity Scores Matching ensures that for each value of x there exists both treated and untreated cases. It allows for matching based on the propensity score to take place because for each individual there is another matched untreated individual with a similar value of x.

The main average causal effect measured in this paper will be the Average Treatment Effect on the Treated. The term treatment effect here is defined as the causal effect of a binary variable on the outcome variable of scientific or policy variables.

$P (Z)= Pr\{D =1 |Z\}= E\{D|Z$... (41)

$ATT = E\{H_1 - H_0|D =1$ .... (42)

$ATT = E\{E\{H_1 - H_0|D =1 , P(Z)\}\}$.. (43)

$ATT = E\{E\{H_1|D =1 , P(Z)\}\} - E\{H_0|D =0 , P(Z)\}|D =0 \}$.......................................(44)

Where,

H_1 = value of the outcome for adopters of the new technology, H_0 = value of the outcome for non-adopters of the new technology, D = Adoption (1 for households who fall below the poverty line, 0 for households who do not fall below the poverty line) Z = vector of explanatory variables.

There are several matching techniques in the literature; this study employed Nearest Neighbor Matching (NNM) in which individuals from the adopters and non-adopters that are closest in terms of propensity scores are matched (Ali and Abdulai, 2010).

Questionnaire session.

Results

Descriptive analysis of household characteristics

In this section some important household socioeconomic characteristics are presented. Their statistics are represented by frequency, means, and percentages and are disaggregated by gender. Some of the variables measured are age, marital status, level of education, and household size. Also included are household assets, ownership structures, size distribution of household farms, sources of farm credit, types of crops grown, household farm income distribution, household non-farming employment and income distribution, level of awareness of soybean varieties, and the level of adoption.

Age and age distribution of household heads

Most studies have shown that age has the potential to influence people whether or not to adopt an innovation. Older household heads have a tendency, on average, to trust their old methods and technologies thus decreasing their willingness to adopt new ideas. However, their vast experience may also have taught them the benefits of adoption and thus increase the likelihood of them adopting a new technology. Younger household heads have been found to have a willingness to try new technologies and innovation and are thus ready to take a chance on a new technology (Bamire et al., 2010). Table 4 shows the ages of male and female-household heads with the results further disaggregated by participation in N2Africa project activities.

The average age of all household heads was found to be 45.45 years. The female-household heads were older than the males with an average age of 50.41 years while the average age for male household heads was found to be 45.45 years. This result is logical because in Northern Nigeria, households become headed by female usually as a result of the female spouse becoming a widow. There is no age disparity based on participation as both male and female participants and non-participants have approximately the same average age.

Table 5 shows the distribution of the age of household heads according to age ranges. Across the entire population 25% of household heads were young adults (18 to 35 years). This result agrees with the baseline study by Amaza (2016) which reported that 27.6% of household heads in N2Africa project areas were young. Less female respondents (20%) were young compared to male household heads who had 31% of respondents that were young. More female (36.25%) than male household heads (22%) were over the age of 55 years. This is an indication that male household heads were generally younger than female-household heads. Also, since male household heads were younger there is a greater possibility of them being more energetic and doing more farm work which could make them more productive than their female counterparts. It may also indicate that they would be more open to adopt new technologies promoted by N2Africa.

Table 4. Age of male and female-household heads.

	Male			Female		
	Mean	Male Participants	Male Non-participants	Mean	Female Participants	Female Non-participants
Age	45.45	42.55	48.34	50.41	50.26	50.56

Table 5. Distribution of household heads by age.

	Female		Male		Mean	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
18–25	22	5.5	28	7	25	6
26–35	58	14.5	97	24.25	78	19
36–45	94	23.5	107	26.75	101	25
46–55	81	20.25	80	20	81	20
over 55	145	36.25	88	22	117	29
Young (18–35)	80	20	125	31	103	26
Non-young	320	80	275	69	298	74

Level of Education

Education enhances a farmer’s capacity to learn and exploit a new technology effectively. Thus, household heads with a higher level of education are more likely to adopt a new technology (Amaza, 2016). In addition to this, household heads with a higher level of education have a higher capacity to understand new technologies and improved managerial skills to successfully implement them in their farming activities. This can, in turn, lead to greater gains in productivity and farm income, thus reducing poverty.

The baseline study (Amaza, 2016) reported that 23.8% of household heads were without education in the project areas which is almost the same as the 26.25% obtained in this study. The results below indicate that male household heads have a lower incidence of illiteracy at 25.7% with female-household heads having a much higher incidence of illiteracy at 56.15%. This is especially true for female-household heads who were non-participants in project activities with 65.2% of them having no formal education. This result is a reflection of the fact that in Northern Nigeria fewer resources are invested in female education as a result of their adherence to patriarchal norms and values (Makama, 2013). Male participants and non-participants are not too different in terms of education level and they are have nearly the same level of education. But female participants have a much lower incidence of illiteracy (47.1%) than non-participants (65.2%).

Table 6. Level of education.

		Male (%)			Female (%)		
Category	**Population Mean**	**Mean**	**Participants**	**Non-participants**	**Mean**	**Participants**	**Non-participants**
No formal education	26.25	25.7	26.8	24.6	56.15	47.1	65.2
Adult education	3.48	2.45	3.3	1.6	2.45	4.4	4.5
College of education	11.15	20	19.6	20.4	4.45	9.6	2.3
Completed primary education	9.55	11.5	10.5	11.5	8.95	10.3	7.6
Completed secondary education	16.28	23.85	26.8	20.9	11.35	14.0	8.7
Completed vocational	0.125	0.25	0	0.5	0.35	0.7	0.0
Some primary education	12.73	17.15	25.4	8.9	6.7	5.1	8.3
Some secondary education	4.4	6.1	3.8	8.4	5.05	7.4	2.7
Some vocational training	2.48	4.55	8.6	0.5	0.2	0.0	0.4
University education	1.33	2.25	1.9	2.6	0.95	1.5	0.4

Marital status of household heads

The marital status of both male and female-household heads is presented in Table 7. Approximately 50% of male household heads are in a monogamous marriage, 40.3% are in a polygamous relationship, and just 9% of them are single. There are no male household heads who are widowed, divorced, or separated. For female-household heads their marital status is more diverse as 29% of them are widowed with approximately 2% of them either divorced or separated. However nearly 50% are also monogamously married like their male counterparts with 17.8% being in a polygamous marriage.

Table 7. Marital status of household heads.

Marital Status	Male		Female	
	Frequency	Percentage	Frequency	Percentage
Single	36	9	8	2.0
Married (monogamous)	203	50.8	196	49.0
Married (polygamous)	161	40.3	71	17.8
Separated	0	0	2	0.5
Divorced	0	0	7	1.8
Widowed	0	0	116	29.0
Total	400	100	400	100

Household size

Household size has the ability to influence adoption and poverty. For farmers in rural LGAs a larger household size can increase the likelihood of adoption because farmers with large households have the labor capacity to intensify the use of a new technology. But larger household size also results in household having an increase in the incidence of poverty as households would need more resources to surpass the absolute or relative poverty line. Nonetheless, a large household size also contributes to increasing agricultural productivity as it allows the labor force to cultivate different crop enterprises and reduce post-harvest losses.

Results for household size are tabulated in Table 8. The average household size across all households is 7.94; male-headed households had a bigger household size at 8.16 with female-headed households having a slightly smaller household size of 7.71. The implication of this is that male-headed households have, on average, more labor to be used from planting to harvest (production), packaging, and even marketing. From the results it is easy to see that most households, both male and female, have the highest frequency of children that ranges from 10 to 15. This could have a negative implication for poverty as it means that a greater level of resources is required for households to be able to lift their children out of poverty.

Table 8. Household size and structure.

Household Size	All farmers			Males		Females
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1.0	18	2.25	13	3.25	5	1.25
2.0	23	2.875	7	1.75	16	4
3.0	45	5.625	18	4.5	27	6.75
4.0	68	8.5	30	7.5	38	9.5
5.0	101	12.625	44	11	57	14.25
6.0	90	11.25	36	9	54	13.5
7.0	86	10.75	35	8.75	51	12.75
8.0	71	8.875	34	8.5	37	9.25
9.0	62	7.75	35	8.75	27	6.75
10 to 15	178	22.25	110	27.5	68	17
16 to 20	35	4.375	27	6.75	8	2
21 or more	23	2.875	11	2.75	12	3
Total	800	100	400	100	400	100
Mean	7.94			8.16	7.71	

Access and control of productive resources disaggregated by gender

Table 9 below is a summary of gender differences in access to and control of productive resources. It gives an idea of whether male-and especially female-headed households have access to land, one of the most crucial factors of production required for a farmer to gain entry and be competitive in the farming industry. Another important factor of production, entrepreneurship, is measured by proxy here as farming experience. This is because the higher the number of years farmers have spent in farming, the greater their ability to improve their farm management skill.

Table 9 shows that males have a higher level of farming experience than females by 2 years, on average. This disparity is minimal but male-headed households have approximately 1 ha of total farm size and total land under cultivation more than female-headed households. This disparity is significant as it means that female-headed households have a lower capacity to expand their production compared to their male counterparts. This alone can translate to lower farm income, lower food security, and increased vulnerability to external shocks, such as climate change, for them.

Table 9. Control of productive resources disaggregated by gender.

Variables	Mean	Male	Female
Number of soybean plots	1.38	1.43	1.32
Mean no. of farming experience (years)	20.35	21.63	19.09
Total land under crop cultivation (ha)	2.782	3.21	2.36
Total farm size (ha)	2.983	3.59	2.38

Institutional variables of households

Table 10 presents some institutional variables attributed to households in the study area. The first variable—credit—is of high importance because credit is required by households with capital deficits to purchase sufficient farm inputs to start or expand agricultural output. Credit also enables households with capital deficits to adopt new technologies, such as seeds, promoted by the N2Africa project. Social capital refers to the collective value of all social networks (who people know), and the inclinations that arise from these networks to do things for each other (norms of reciprocity). Membership of associations is a form of institutionalized social capital that promotes farmer-to-farmer technology transfer and could thus have an influence on adoption. Extension contact, on the other hand, is part of the agricultural research value chain, delivering scientific output and knowledge from agricultural research centers to households. Contact with extension workers or other extension service providers is a key for households to adopt new technologies. As extension service exposes workers to these technologies.

Access to credit is low for male-headed households with only 18.94% of them having access to credit. The situation is worse for female-headed households as only 16.12% of them have access to credit. Almost the same percentage of male participants and non-participants have access to credit, but female non-participants have more access to credit. This implies that less than 20% of households have the ability to expand their production when their own resources are exhausted. This lack of access to credit makes it more difficult for them to adopt new technologies promoted by N2Africa.

Membership of associations is also very low with fewer than 40% of households belonging to any association. For females the figure is 27.25%. This is to say that approximately 70% of female-headed households do not belong to any association. This leaves them more vulnerable to shocks as it means that they have less social support that can aide them when external factors, such as droughts or pest attacks. It also means that fewer households have the networks that will expose them to new forms of knowledge, a process crucial for the transmission of technology within the local population. There is no disparity between male and female participants and non-participants in terms of their membership in associations.

Extension contact, another crucial institutional variable, is also relatively low in the N2Africa project areas. Extension contact is available to only about 30% of male-and female-headed households. The Borno State Agricultural Development Program (BOSADP) has to do more to reach farmers in the project areas for them to be better acquainted with new agricultural technologies. This low level of extension will be sure to have a negative impact on adoption. The disparity in extension contacts between male participants and non-participants is also low but for the female-headed households, the participants have a considerable higher level of extension.

Table 10. Institutional variables.

	Male (%)			**Female (%)**		
Variables	**Mean**	**Participants**	**Non-participants**	**Mean**	**Participants**	**Non-participants**
Access to Credit	18.94	19.25	18.63	16.125	12.5	19.75
Membership of Association	37.13	35.75	38.5	27.25	28.0	26.5
Extension Contact	33.5	32.5	34.5	26	31.75	20.25

Adoption of improved crop technologies and practices

The interventions conducted by N2Africa in collaboration with partner institutions are centered on the provision of improved crop varieties and the practices required to enable those crops to attain their potential. Thus, this section presents awareness and adoption of improved crop varieties and the requisite practices for the management of those crops. It also gives an analysis of the sources of this information to analyze N2Africa's role in the promotion of these technologies. In addition, a detailed breakdown of the adoption of soybean varieties is presented to determine those that are most popular among those households who grow the crop.

Awareness of crop technologies and management practices

The process of adoption starts with farmers' first hearing about a technology or innovation. They then go through a period of gaining knowledge about the technology, which would leave an impression, either positive or negative, about the technology and ultimately lead them to decide whether or not to adopt it (Rogers, 2004; Jones, 2005). Hence the first table (Table 11) in this section presents the frequency distribution of farmers' awareness of improved crop varieties and the requisite management practices.

According to the results presented in Table 11, households have a very high awareness of improved varieties of cowpea, groundnut, and maize in the project area. This can be attributed to the fact that N2Africa and PROSAB have worked tirelessly in promoting these varieties to farmers. The households' awareness of sorghum and millet is comparatively lower than for the crops promoted by IITA across all groups. Participants and non- participants are equally matched on most crop management practices for both male-and female-headed households but participants have a much larger awareness of row planting and rhizobium inoculants than non-participants.

Table 11. Frequency distribution of households' awareness of improved crop management practices.

	Male			Female		
Crop technologies and practices	Mean	Participants	Non-participants	Mean	Participants	Non-participants
Improved cowpea	87.0	90.4	83.2	86.3	94.1	82.2
Improved maize	97.5	98.6	96.3	97.0	98.5	96.2
Improved sorghum	54.5	56.0	52.9	47.8	44.9	49.2
Improved millet	37.3	37.8	36.6	29.8	30.9	29.2
Improved groundnut	81.8	86.1	77.0	80.8	82.4	79.0
Fertilizer application	91.8	93.8	89.5	92.5	91.9	92.8
Pest and disease management	90.35	93.3	87.4	88.05	89.0	87.1
Weed management	91.4	94.3	88.5	92.15	94.1	90.2
Row planting and seed rate	44.65	77.0	12.3	45.0	69.9	20.1
Rhizobium inoculants	43.1	72.7	13.5	38	64.0	12.0

Institutional source of extension services

Table 12 details the institutions that have provided the households with extension information on crops and management practices. N2Africa is the greatest source of extension information for male-and female-headed households and for participants and non-participants of both genders. N2Africa, BOSADP, and NGOs were a source of extension information to more participants than non-participants for both male-and female-headed households. But when a gender comparison is made it becomes obvious that females received slightly less information from the sample of households interviewed. BOSADP is the institution that provides the most information to households after N2Africa but its coverage is very poor when one considers that BOSADP is tasked with providing agricultural extension services to farmers. Only 31.75% of male-headed households and 25.75% of female-headed households received extension information from BOSADP.

Table 12. Source of extension information.

Source of Information	Male			Female		
Institution	Mean	Participants	Non-participants	Mean	Participants	Non-participants
N2Africa	45.9	69.9	22.0	31.8	61.8	14.4
BOSADP	31.75	37.8	25.7	25.75	38.2	13.3
NGO	4.85	8.1	1.6	5.9	11.0	0.8
Ministry	1.0	1.0	1.0	0.6	0.3	0.8
Others	2.9	1.0	4.8	3.4	1.5	5.3

Frequency of extension contact

Frequency of contact was also measured (Table 13) to provide an understanding of the rate at which new information comes to farmers. This is because farmers who come more frequently into contact with extension agents are able to give feedback on their production constraints and their gaps in knowledge or practice. This in turn will allow them to receive adequate information from the extension agents based on this feedback which will help improve production outcomes.

According to the information provided in Table 14, one-third of male-headed households and approximately 50% of female-headed households have never received extension services. BOSADP, the institution responsible for promoting extension activities, has to do more to ensure that households' extension needs are met, so as to hasten the pace of technology dissemination. A large percentage of households who do receive extension services receive them quarterly. On average, 45.5% of male-headed households and 36.3% of female-headed households receive extension quarterly. Very few of them receive services weekly or bi-weekly.

Table 13. Frequency of extension contact.

	Male		Female	
Period	Frequency	Percentage	Frequency	Percentage
Never	132	33.0	192	48.0
Weekly	6	1.5	2	0.5
Bi-weekly	8	2.0	3	0.8
Monthly	49	12.3	44	11
Quarterly	182	45.5	145	36.3
Other	23	5.8	14	3.5

Households' use of and access to inputs and their adoption of improved varieties

An analysis of households' access to inputs will give an understanding of whether they have the resources and capital to obtain those inputs required to expand their farm production. The results are presented in Table 14 below.

The use of chemical fertilizer is high for both male-and female-headed households as over 80% of households in both categories used chemical fertilizer. Compared to the baseline report by Amaza (2016) there has been a substantial growth in the use of chemical fertilizer. This can be attributed to the N2Africa project that has increased awareness of fertilizers. The high use of chemical fertilizer could also mean that households are buying more P fertilizers as the soil in Southern Borno is not rich in phosphorus. The use of organic manure is low as only 26.87% of male-and 25.8% of female-headed households used manure for soil fertility purposes. Compared to the baseline (Amaza, 2016) where 51.9% of female-and 44.8% of male-headed households used organic manure, there was a lower use of organic manure in 2016. This also suggests that households' uptake of more grain legumes such as soybean with complementary technologies has seen them transfer some of their soil fertility needs to legumes because these crops are able to fix atmospheric nitrogen.

The use of rhizobium inoculants is a complementary technology that assists legumes in nitrogen fixation yet few households adopted this crucial technology. This may be as a result of market forces as there is not a high density of businesses that retail inoculants as a product to farmers (Manyong et al., 1996). It could also be that the project is yet to convince households on the importance of this technology. Both studied groups used herbicides at the same high rate but their use of improved storage facilities is low at 25.75% for male-and 23.5% for female-headed households.

Table 14. Frequency distribution of households' use of agricultural inputs.

Inputs	Mean		Males		Females	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Improved millet seeds	4	0.5	2	0.5	2	0.5
Improved cowpea seeds	319	39.875	173	43.3	146	36.5
Improved groundnut seeds	245	30.625	94	23.5	151	37.8
Improved maize seeds	551	68.875	302	75.5	249	62.3
Improved sorghum seeds	49	6.125	26	6.5	23	5.8
Improved storage facilities	206	25.75	112	28.0	94	23.5
Chemical fertilizer	673	84.125	341	85.3	332	83
Organic manure	215	26.875	112	28.0	103	25.8
Rhizobium inoculants	231	28.875	142	35.5	89	22.3
Herbicide	612	76.5	306	76.5	306	76.5

Awareness and adoption of new soybean varieties

This section gives a detailed description of the adoption pattern for soybean varieties in the project area disaggregated by gender and participation in N2Africa activities. The project has promoted soybean varieties to help achieve its core mandate of improving soil fertility in the project area. Hence information on adoption in comparison to the baseline is very important for an understanding of whether or not the project was successful in promoting soybean varieties. As part of the project activities new soybean varieties were introduced. New soybean varieties are defined as those promoted by N2Africa which include TGX1904-6F, TGX 1448-2E, TGX 1951-3F, and TGX 1955-4F. These varieties especially TGX 1448-2E are all early maturing and high yielding.

The results for awareness and adoption of soybean varieties are presented in Table 15. Nearly all male-and female-headed households were aware of and grew soybean in 2016, including both participants and non-participants. In 2016, in the N2Africa study areas, 75.4% of male-headed households adopted soybean varieties while in the baseline report by Amaza (2016) 66.7% of male-headed households adopted soybean varieties. Approximately 70% of female-headed households grew soybean; in the baseline, adoption for female-headed households was 67.7%. Thus, in general there was an improvement in the rate of adoption for male-and female-headed households.

Adoption by male non-participants is still high with 79.6% of them using the new soybean varieties promoted by N2Africa but at the same time, female adoption by non-participants was markedly lower than that of participants. Their awareness of the new varieties is high, thus the reason for their lower rate of adoption could be constraints faced by female non-participants such as insufficient capital and low access to land.

Table 15. Awareness and adoption of soybean varieties in 2016.

	Male			Female		
	Mean	Participants	Non-participants	Mean	Participants	Non-participants
Did you grow soybean? (%)	92.9	89.5	96.3	90.2	95.6	84.8
Awareness of new soybean varieties (%)	93.8	92.8	94.8	87.1	94.9	79.2
Adoption of new soybean varieties (%)	75.4	71.3	79.6	69.5	79.4	59.5

Adoption analysis of soybean varieties

Table 16 presents an analysis of the adoption of the different soybean varieties. Farmers sometimes choose more than one of the varieties listed below. Most of the varieties are liked in equal measure. The most adopted variety is TGX 1904-6F. This variety was in existence before the N2Africa project and was promoted by PROSAB and thus will have had a higher exposure to farmers. The least often adopted is TGX 1835 (Danwuri) probably due to the fact that it is low yielding although early maturing.

Table 16. Adoption analysis of soybean varieties.

Varieties	Male	Male participants	Male Non-participants	Female	Female participants	Female Non-participants
TGX 1835	8.75	8.6	8.9	6.3	8.1	4.5
TGX 1951-3F	20.9	21.5	20.3	17.0	21.2	12.8
TGX 1955-4F	17.1	18.6	15.6	18.5	19.2	17.8
TGX 1448-2E	20.0	21.4	18.6	16.7	17	16.4
TGX1904-6F	26.1	26.3	25.9	24.0	29.5	18.5
I don't know	0.3	0.2	0.4	1.5	1.5	1.5
TOTAL	93.15	96.6	89.7	84	83.9	84.1

Most preferred soybean varieties intended for cultivation

For a better understanding of their preferences for the various soybean varieties, household heads were also asked which varieties they would be most likely to adopt next season (2018). This would help in understanding whether their perception of the previous variety had been changed. According to the results in Table 17, more household heads are going to increase their production of all the varieties especially TGX 1951-3F and TGX1904-6F. This means that, *ceteris paribus,* household heads are going to increase their adoption of soybean varieties in the coming seasons. This may be explained by increases in the household heads' reliance on soybean as a cash crop. Females have a high preference for TGX 1955-4F, a variety that is recent and has been promoted by N2Africa. This is to show that great gains have been made in convincing household heads to accept the new varieties.

Table 17. Most preferred soybean varieties intended for cultivation.

Varieties	Male	Male participants	Male Non-participants	Female	Female participants	Female Non-participants
TGX 1835 (Danwuri)	16.5	17.2	15.8	19.5	20.4	18.6
TGX 1951-3F	34.5	32.8	36.2	28.0	29.5	26.5
TGX 1955-4F	26.1	25.4	26.8	30.4	31.6	29.2
TGX 1448-2E	21.2	23.1	19.3	16.4	18.5	14.3
TGX1904-6F	28.1	29.7	26.5	29.2	32.6	25.8
I don't know	5.8	4.5	7.1	5.8	6.2	5.4

Gender differentiated reasons for adoption

Household heads were also asked about some of the benefits they derived from growing soybean. These benefits are interpreted as the reason why they grow improved soybean. (Table 18). An understanding of why household heads adopt soybean varieties will help to foster understanding of the technology characteristics that household heads want in soybean. This will help to improve future interventions by encouraging breeders to create and agronomists to promote new varieties that are more suited to household ' needs.

For both studied groups (male 77.1%, female 64.7%) high yield was the main reason why they adopted soybean varieties. This reason is straightforward as their primary objective would be to maximize their productivity. Another major reason for adopting particular varieties is reduced shattering (males 62.7%, females 57.8%). This is because households run the risk of losing some of their harvest to shattering and so seek varieties that tend to shatter less to preserve their harvest.

The third main reason for households adopting improved varieties was early maturity. This is not surprising as the climate is characterized by a low rainy season and intermittent drought. Early maturing varieties are more likely to escape drought and thus are more suited for the climate, helping households to adapt to the increasing threat of climate change. A high cash income which is linked to high yield was another major reason for why households adopted improved varieties. The results show that 37.1% of male and female adopters gave high cash income as the reason for adopting soybean. This is logical as soybean is more of a cash crop than a food crop.

Table 18. Reasons for adoption of soybean varieties.

Reasons	Male adoption	Female adoption
High yield	77.1	64.7
Large seed size	33.9	28.3
Less shattering	61.7	57.8
Resistance to diseases	18.6	16.4
High oil content	7.0	5.5
High fodder yield	4.9	2.7
High cash income profit	37.1	37.1
Drought resistant	17.4	14.9
Early maturing	40.9	37.1
Less labor input	13.6	13.7
Resistance to pests	8.7	6.1
Soil fertility improvement	21.2	15.5
Striga control	4.9	2.7
Food security in the home	16.5	14.0
Less fertilizer use	17.4	16.4
Local food utilization	8.7	10.0
Others	0.3	1.2

Constraints to adoption

Constraints to adoption were measured for both male and female non-adopters to provide an understanding of some of the obstacles and limiting factors that hamper or reduce the adoption of new agricultural varieties. This will inform donors, policymakers, researchers, and development specialists on how best to design and implement future interventions by identifying and removing the impediments that minimize adoption (Ogungbile et al*.,* 1998). The greatest impediment to adoption from the results in Table 19 is the high cost of inputs. For females, nearly 100% quoted high input cost as a constraint to adoption while 90.1% of male-headed households quoted being constrained by high input costs. Lack of agricultural equipment for threshing is another major impediment. This is a restriction similar to high input cost as it describes the budget constraint faced by households and how it hinders their access to factors of production. Labor is another factor of production that is inaccessible to households due to budget constraints. The results reveal that 74.2% of males and 76.3% of females lack labor during the peak season.

Table 19. Constraints to adoption.

Constraints	Males	Females
Low fertility	16.5	13.1
Pests and diseases	26.1	28.0
Lack of seeds of improved varieties	36.2	62.9
Low access to fertilizer and inoculants	39.8	33.7
High cost of inputs	90.1	98.4
Insecure land tenure system	44.9	46.5
Lack of land	40.3	41.3
Lack of labor during peak season	74.2	76.3
Lack equipment for threshing	76.2	74.8

Production of soybean variety

After the collection of date on households and adoption, data were collected on the production of soybean in the study area and gender aggregated analysis was made to determine the area planted and the yield of each variety. This will enable an understanding of whether or not differences exist between male-and female-headed households in terms of production.

Mean area planted and proportion of land allocated to soybean varieties

Mean area planted was calculated for each soybean variety. This is to demonstrates the extent of adoption for those who adopted each variety and the results are tabulated in Table 20. According to the results, on average, males planted 0.48 ha of soybean while females on average planted 0.27 ha. This is understandable because according to Table 9 of this document men had a larger farm size and larger area under cultivation compared to their female counterparts. In addition to this, Table 19 pointed out that 62.9% of female-household heads listed a lack of improved seeds as a constraint to adoption. This lack of seeds also affects the extent of adoption as demonstrated in their low mean area planted. Although TGX1835-Danwuri had the lowest adoption rate, households who adopted it planted it on a larger scale than other varieties. It has the highest mean area planted for both male-and female-headed households and the highest area planted for female-headed households. Although adoption of this variety is low, households who chose to grow it, cultivated it on a larger scale. This may be because it is early maturing and less risky to grow in an area where rainfall can cease earlier.

Table 20. Varietal analysis of area planted.

	Male		Female	
Variety	Mean Area planted (ha)	Proportion of Area planted	Mean Area planted (ha)	Proportion of Area planted
TGX1955-4F	0.48	0.40	0.16	0.21
TGX1951-3F	0.43	0.33	0.31	0.41
TGX1904-6F	0.51	0.29	0.17	0.33
TGX1835-Danwuri	0.66	0.46	0.50	0.91
TGX1448-2E	0.30	0.38	0.19	0.48
Others	0.34	0.46	0.26	0.40
Mean	0.45	0.38	0.27	0.45

Grain yield of soybean varieties

The results for grain yield cultivated are presented in Table 21.

On average, male household heads had slightly more yield than female-household heads across all varieties. Male household heads had harvested approximately 2363 kg/ha of soybean while female-household heads harvested approximately 2038 kg/ha. Although the combined disparity for male household heads across all varieties was not very high, for TGX1835-Danwuri male household heads produced nearly 500 kg/ha more soybean than female-household heads. The disparity for TGX1955-4 is even greater at nearly 700 kg/ha. This result is not surprising as male household heads can afford to use more yield-increasing inputs than female-household heads. The reason for this disparity in yield between male and female-household heads may be as a result of male household heads having more extension contact than female-household heads (Table 10 and 13). This is because male household heads had more information on the use of the varieties from the extension service than female-household heads. To buttress this point, male household heads also had more formal education (Table 6), more awareness of improved crop varieties (Table 11), and the requisite management practices for the varieties than female-household heads. This knowledge gap and access to these varieties would have contributed to the yield gap between male and female-household heads.

Table 21. Grain yield (kg/ha) of soybean varieties cultivated.

	Male	Female
Variety	Mean yield	Mean yield
TGX1955-4F	2613.50	1962.82
TGX1951-3F	2278.88	2068.15
TGX1904-6F	2456.31	2082.29
TGX1835-Danwuri	2402.63	1973.09
TGX1448-2E	2438.28	2114.69
Others	1988.39	2031.26
Mean	2362.998	2038.17

Income of households

Improving the crop income of farmers is one of the targeted project deliverables, and the promotion of soybean technologies is one of the strategies used by the project to achieve this objective. Thus, to measure whether or not this outcome was achieved, this section analyzes the incomes of the respondents and disaggregates them by gender. This disaggregation is to know how male- and female-headed households compared with each other and the relative disparity or inequality between them. It looks at the sources of income of households and the amount earned from each income source. This will help to give an idea on how much the soybean contributes to the income of households in the study area.

Source of income of households

The source of income was first analyzed to determine the number of households who depended on soybean and other sources of income. Soybean is the source of income that households most depend on. This is because in Table 22, 86% of males and 81% of females have cited soybean as their main source of income. Cowpea and cereals such as maize, sorghum, and millet are the second most important source of income for both studied groups with 66.3% of males and 51% of females depending on them as a main source of income. Generally, households have a higher dependence on-farm income sources than on non-farm income sources. Although a higher percentage of males have more income sources than females, groundnut is an income source that has a higher number of females than males depending on it. This importance is characterized by the fact that 61% of females depend on groundnut for income compared to only 39.8% of males. The most important non-farm income source is own businesses with 40% of males and 34.5% of females depending on it as a main source of income. This source of income will have some aspects of the crop value chains such as the selling of fodder to livestock herders. The most important finding here is the confirmation that households depend heavily for crops as sources of income. It also validates the N2Africa focus on grain legumes as a source of income.

Table 22. Source of income.

Source of Income	Males (%)	Females (%)
Soybean	86	81
Cowpea	66.3	51.8
Groundnut	39.8	61
Maize/sorghum/millet	66.3	51
Firewood	6.3	3.8
Regular Employment	13.5	3.0
Casual Employment (agric)	8.5	3.8
Casual Employment (non-agric)	5.8	2.8
Running own business	40	34.5
Remittances from family members	16	32.3
Remittances from non-family members	5.5	3.3
Pension	4.0	5.5
Other sources	9.5	4.75

Mean income of households

This section examines the mean income derived from each source of income listed in Table 22 and the results presented in Table 23. The results are not disaggregated only by gender but also by adopters. According to the results, for those who adopted soybean, the sale of the crop provided the highest amount of income for both male-and female-headed households. Male adopters, on average, had an income of N81,344 while females received N49,507 in the last 12 months from the sale of soybean. Male adopters had a much higher income than their female counterparts and the reasons for this are multidimensional. First, from Table 21 it is easy to see that male-headed households had higher grain yields than female-headed households. These differences in yield would have been a factor contributing to differences in income. Male-headed households also had higher rates of membership of associations. Some of these associations would have helped these farmers to have the collective bargaining power which is far superior to when they had to negotiate prices individually. Women also use soybean as a source of protein for younger children and may thus choose to keep part of their harvest to incorporate into household dishes and make soybean food products such as soy milk and soy cheese (*Awara*).

In Table 22 it was established that female-household heads depend more highly on groundnut than male household heads. This is further backed by the fact that female non-adopters had a higher income (N49,914) from the sale of groundnut than both male adopters (N23,407) and male non-adopters (N34,905). Female non-adopters also had a higher income than female adopters. This is logical as it indicates that female non-adopters substituted the growing of groundnut for soybean. It implies that policymakers should emphasize the groundnut production and value chains when they seek to create other interventions to help female households. Male adopters and non-adopters have more income than female adopters and non-adopters. Both male-and female-headed households have more farm income than non-farm income.

Table 23. Mean income of soybean adopters and non-adopters.

Total income from last 12 months	Male adopters Mean (N)	Male non-adopters Mean (N)	Female adopters Mean (N)	Female non-adopters Mean (N)
Sale of soybean	81,344.36	1,509.43	49,507.34	2500.00
Sale of cowpea	47,093.64	34,905.66	19,825.69	22071.43
Sale of groundnut	23,407.51	35,754.72	20,833.79	49,914.29
Sale of maize/millet/sorghum	63,341.62	65,358.49	22,230.89	40,257.14
Sale of firewood	2,774.57	3,830.19	477.06	1271.43
Total Farm Income	217,961.7	141,358.5	112,874.8	116,014.3
Regular employment	25,746.82	18,698.11	4504.59	33,746.43
Casual employment(agricultural)	4,091.04	3,509.43	443.43	3571.43
Casual employment (Non- agricultural)	6,972.54	13,188.68	2541.28	1428.57
Running own business	59,306.36	85,028.30	24,503.98	35,235.71
Remittance from family members	10,066.47	660.38	11565.75	5871.43
Remittance from non-family members	3,657.51	94.34	1012.23	800.00
Pension	8,132.95	9,301.89	3021.41	.00
Other sources 1	5,424.86	12,358.49	1324.16	1428.57
Total Non-farm Income	123,398.6	142,839.6	48,916.3	82,082.1
Total	341,360.3	284,198.1	161,791.6	198,096.4

Modeling of adoption

Determinants of level of adoption of soybean varieties by male-and female-headed households

The Logit model was used first to measure the determinants of adoption of soybean varieties by male- and female-headed households in the study area. Knowing the determinants will help to ascertain the factors that can constrain or increase adoption and the extent of adoption (Asfaw et al., 2012; Ogunbameru and Madukwe, 2012). This information will enable policymakers to focus on advancing the factors that encourage adoption and mitigate those that inhibit adoption. This will help researchers and donors to create more impact by helping them to improve the design of interventions and research by targeting the factors that influence adoption in the planning phase. The factors that affect female-headed households may be separate from those that affect male-headed households due to the existence of several inequalities and constraints that affect male-and female-headed households separately. Thus, modeling was disaggregated by gender.

The result of the estimated Logit regression model for male-headed households (Table 24) shows that the Likelihood ratio (LR) of –110.90 for the fitted models was significant. This indicates the joint significance of the explanatory variables in influencing the adoption of the short-season maize varieties. The Probability chi squared (Prob > chi2) value of 0.0001 shows that the significance occurred at 1%. The result of the estimated Logit regression model for females shows that the Likelihood ratio (LR) of -125.26 for the fitted models was significant. This indicates the joint significance of the explanatory variables in influencing adoption of the short-season maize varieties. The Probability chi squared (Prob > chi2) value of 0.0000 shows that the significance occurred at 1%.

For male households, level of education, membership of associations, participation in project activities, and access to credit significantly influenced the decision to adopt new soybean varieties. For the female household, access to credit and membership of associations influenced the adoption of new varieties.

The estimated coefficient of education was positive and significant at the 5% level for male-headed households. This result shows that, on average, male-headed households who have had education who will increase the probability of adoption. This result is not surprising as education makes it easier for households to understand the technologies being promoted to them. This increase in understanding will give households the confidence to adopt technologies that were once unknown to them and so will lead to adoption.

The estimated coefficient of access to credit was positive and significant for both male-and female-headed households at the 10% level. This result shows that, on average, the presence of male-and female-headed households who had access to credit will increase the probability of adoption of soybean varieties. This result implies that access to credit is a form of capital as it allows households to expand production by buying inputs such as seeds, fertilizers, herbicides, and labor. Adoption of a new technology will require households to buy complementary inputs that will enable the efficient use of the new technology; credit will provide the capital to purchase these inputs. It is thus logical in this study for access to credit to have had a positive impact on adoption.

Membership of associations is another factor that influences adoption greatly as it is significant at the 1% probability level for both male-and female-headed households. That is to say the probability of adoption of a new soybean variety rises when the household is a member of an association. This is because members of an association are more exposed to the knowledge and practices of other farmers and have more access to resources gathered by the association for the needs of members. For example, it will also enable those farmers who have been exposed to IITA technology via participation to share this information with other farmers.

Participation in N2Africa activities is another variable that has a positive and significant influence on adoption, for male farmers alone. Male farmers who were engaged in N2Africa activities such as trainings, demonstrations, and workshops had a better understanding of the benefits of the soybean technologies and thus a higher likelihood of increasing adoption compared to farmers who did not undergo such activities. This variable is important as it can be used to directly attribute some degree of adoption to N2Africa activities. It shows to a certain degree that N2Africa had a direct impact on adoption, although more robust analysis must be done to ascertain this for sure.

Table 24. Logit estimates of determinants of adoption of soybean in N2Africa project areas.

	Males		Females	
Variables	Coefficient	P-Value	Coefficient	P-Value
Intercept	–0.229	0.863	1.19	0.25
Age	0.0043	0.746	–0.08	0.328
Household size	–0.026	0.246	0.025	0.250
Level of education	0.145	0.011**	–0.0595	0.315
Income	–0.531	0.828	–0.0892	0.672
Farm size	0.0654	0.127	0.0334	0.450
Farm experience	0.020	0.174	0.007	0.434
Extension contact	0.040	0.875	0.349	0.130
Processing machine	0.268	0.247	–2.411	0.212
Distance to market	0.022	0.264	–0.168	0.307
Access to credit	0.419	0.058*	0.346	0.069*
Membership of Associations	0.489	0.025**	0.598	0.001***
Participation	0.598	0.011**	–0.307	0.898
Early maturity	–0.229	0.863	0.432	0.242
Seed shattering	0.0043	0.746	0.217	0.871
Observation		329		313
LR chi2		40.78		68.78
Prob> chi2		0.0001		0.0000
Log likelihood		–110.90		–125.26
Pseudo R2		0.16		–0.3784

Source: Field Survey, 2016.
***, **, * implies significant at 1%, 5%, and 10% probability levels, respectively.

Determinants of Intensity of adoption of soybean varieties by male-and female-headed households in the study area

The Tobit model was used to measure the determinants of intensity of adoption of the soybean varieties by male-and female-headed households. The intensity of adoption is measured as the ratio of the area under cultivation for the new varieties to the total farm land cultivated. These analyses will help increase the understanding of the factors or variables that influence a household decision to increase the area under production of the varieties promoted by the project. The reason for this gender disaggregation is that the study wanted to find out the individual variables that affect the intensity of adoption of soybean varieties for male-and female-headed households.

The result of the estimated Tobit regression model for male-headed households in Table 25 shows that the Likelihood ratio (LR) of –147.67 for the fitted models was significant. This indicates the joint significance of the explanatory variables in influencing the intensity of adoption of the short-season maize varieties. The Probability chi squared (Prob > chi2) value of 0.0000 shows that the significance occurred at 1%. The result of the estimated Tobit regression model for female-headed households shows that the Likelihood ratio (LR) of –59.89 for the fitted models was significant. This indicates the joint significance of the explanatory variables in influencing the intensity of adoption of the short-season maize varieties. The Probability chi squared (Prob > chi2) value of 0.0000 shows that the significance occurred at 1%.

The results of the Tobit analysis showed that the factors that influenced male-headed households' intensity of adoption were household size, income, farm size, and access to credit. For female-headed households, household size, income, farm size, extension contact, and participation in associations significantly influenced the probability of intensity of adoption of new soybean varieties promoted by the project.

The estimated coefficient of household size was positive and significant at the 5% level for both male-and female-headed households. These results show that, on average, male-and female-headed households who had larger households will increase the probability of intensifying their adoption of soybean varieties. The implication of this result is that larger households have the labor that will enable them to increase their level of production. A larger household size will also reduce the amount of labor the households needs to hire to increase the level of production. This will thus release costs for the households to buy other inputs such as inoculants and fertilizers that are needed for the adoption of the varieties.

Income also has an estimated coefficient that is positive and significant at the 1% probability level for male-headed households and at the 10% probability level for female-headed households. The implication of this is that the probability of a household increasing the adoption of soybean varieties increases as the level of income increases. A higher income reduces the budget constraints of households, allowing them to buy more factors of production such as the seeds, labor, and the renting of land. The access to these factors of production will definitely allow households to expand their production by adopting more inputs.

Farm size has a coefficient that is positive and also significant at the 1% level for both male-and female-headed households. This is expected as the larger the farm size, the greater the ability of households to increase the area under production. In addition, a large farm size can be a proxy of wealth as land is one of the major assets that households in rural areas possess. This wealth would enable households to use the land as collateral to get the credit needed for them to buy inputs. Households usually grow a variety of crops for both food and income purposes. A larger farm size will enable households to grow food security crops such as maize and sorghum and at the same time grow cash crops such as soybean. Households with smaller farm sizes would usually have to prioritize food crops more to reduce the risk of food insecurity and this will reduce the level of cash crops grown.

The estimated coefficient of access to credit was positive and significant at the 1% level for male-headed households. Access to credit is a very important variable because it not only influenced adoption but the intensity of adoption as well. This result is not surprising as access to credit is a form of capital and it allows male-headed households to expand production by buying inputs such as seeds, fertilizers, herbicides, and labor. Adoption of a new technology will require households to buy complementary inputs that will enable the efficient use of the new technology; credit will provide the capital to purchase these inputs. It is thus logical in this study for access to credit to have had a positive impact on adoption.

The estimated coefficient of extension contact was positive and significant at the 1% level for female-headed households. This result makes sense as extension agents not only expose female-headed households to soybean technologies promoted by N2Africa project, they also do their best to convince households to adopt the technology. This result shows the high importance of extension agents in the technology adoption process.

Participation by female-headed households in N2Africa project activities from the results below is a variable that positively and significantly influences adoption at the 1% probability level. This is to show that female farmers who participated in trainings, demos, and other activities conducted by the project were persuaded to increase their area under soybean production.

Table 25. Tobit estimates of determinants of intensity of adoption of soybean and maize in N2Africa project areas.

Variables	Male		Female	
	Coefficient	P-Value	Coefficient	P-Value
Intercept	–0.285	0.745	–0.215	0.102
Age	0.00634	0.640	–0.00967	0.398
Household size	0.0042	0.050**	0.00697	0.015**
Level of education	–0.0048	0.373	0.117	0.146
Income	0.084	0.001***	0.602	0.053*
Farm size	–0.025	0.000***	0.0614	0.000***
Farm experience	–0.00073	0.646	0.00176	0.166
Extension contact	0.245	0.348	–0.842	0.009***
Processing machine	0.0207	0.332	0.0334	0.277
Distance to Market	–0.00152	0.331	0.00408	0.088
Access to credit	0.0567	0.007***	0.0402	0.132
Membership of Association	–0.000919	0.968	–0.0453	0.102
Participation	0.0214	0.537	0.114	0.001***
Early maturity	–0.00821	0.687	–0.0207	0.405
Seed shattering	–0.026	0.195	–0.0219	0.388
Observation		320		298
LR chi2		40.78		86.16
Prob > chi2		0.0152		0.0000
Log likelihood		–147.67		–59.89
Pseudo R2		0.078		–2.5619

Households' poverty status

The poverty line

To find the poverty line, the mean monthly household per capita expenditure (MPHE) was calculated for each LGA. To account for gender and age differences of expenditure within households, the per capita household expenditure was adjusted using adult equivalent scales (Amaza, 2016). Two-thirds of the mean MPHE of the sampled households was used as the poverty line (N7420). The result from this present study showed that any household with a per capita monthly expenditure greater than or equal to N7420 was considered to be non-poor, whereas any household with per capita monthly expenditure below N7420 was counted as being poor.

Current poverty profile of households disaggregated by gender

The poverty profile of both studied groups is presented in Table 26 and includes the poverty headcount or incidence (α_0), poverty gap or depth (α_1) and squared poverty gap or severity (α_2). The FGT index was used to generate the poverty profile. Analysis of poverty was also done for adopters and non-adopters for both male-and female-headed households and the results are presented in Table 27.

The poverty headcount (α_0), for male-headed households was 0.38 (38%) while for female-headed households it was 0.49 (49%). This means that 38% of male-and 49% of the female-headed households were poor. The difference in the mean of the head count index between both groups is significant at the 1% level, showing a very strong statistical significance. This result is to be expected as previous analysis have shown that male-headed households had more access to land, a higher crop yield, larger farm sizes and total income. A combination of these inequities has contributed to male-headed households having a lower incidence of poverty than female-headed households.

The poverty gap index (α_1), shows the percentage of poor households' income or expenditure that falls below the poverty line. According to the result in Table 26, for male household heads who are poor their expenditures fall below the poverty line by 31% while for female-household heads who are poor their expenditures fall below the poverty line by 37%. This result shows that while male-headed households needed 31% of the poverty line is, on average, to escape poverty female-headed households needed37% of the poverty line to escape poverty. The consistency of female-headed households having not only a higher incidence of poverty but a greater poverty burden is further evidence of how the disparity in access to basic resources such as land, labor, and social capital (membership of associations) has led to female-headed households being more affected by poverty than households headed by males.

The poverty severity index (α_2), which measures the percentage of those who are severely poor by measuring the distance of each poor person to one another, was found to be 0.13 for males and 0.19 for females. This indicates that 13% of males and 19% of females were severely poor. This result is also indicative that female-headed households had less command over resources as they fared worse in poverty depth, and were the most severely poor.

Table 26. Poverty profile of male-and female-headed households.

Index	Males	Females
MAHE	11,130.61492	11,130.61492
2/3MAHE	7420	7420
Head count index	0.38	0.49
Poverty gap index	0.31	0.37
Poverty severity index	0.13	0.19

Current poverty profile of male-and female-headed households disaggregated by adoption

The study also disaggregated the poverty profiles of both male-and female-headed households by adoption. Although it is not a formal measure of impact this section will try to understand whether or not there were differences in poverty between those who adopted these varieties and those who refused to adopt in 2016.

According to the results in Table 27, the poverty headcount (α_0), for male household adopters was 0.36 (36%) while for non-adopters it was 0.43 (43%). This means that 36% of the male adopters and 43% of the male non-adopters were poor. The poverty headcount (α_0), for female household adopters was 0.48 (48%) while for non-adopters it was 0.5 (50%). This means that 48% of the female adopters and 50% of the female non-adopters were poor. The incidence of poverty is very high between female-headed households who were adopters and non-adopters and there is very little difference between both groups.

The result for the poverty gap index shows that male household heads who adopted had a lighter poverty burden than non-adopters. The poverty gap index for adopters at 0.3 shows that on average 30% of the poverty line is needed to lift male adopters out of poverty. For non-adopters, 37% of the poverty of the poverty line is needed to lift them out of poverty. Among adopters 13% are severely poor while 14% of non-adopters are severely poor.

The result for the poverty gap index shows that female-household heads who adopted had a slightly reduced poverty burden than non-adopters. The poverty gap index for adopters at 0.37 shows that, on average, 37% of the poverty line was needed to lift female adopters out of poverty but for non-adopters 41% of the poverty line was needed. Thus, the poverty burden of poor female non-adopters is heavier than of their counterparts who adopted. For female adopters 18% are severely poor while 17% of non-adopters are severely poor. This is to say that nearly 20% of female adopters and non-adopters are severely poor.

Table 27. Poverty Profile of male and female adopters and non-adopters of soybean production.

	Male		Female	
Index	Adopters	Non-adopters	Adopters	Non-adopters
MAHE	11,130.61492	11,130.61492	11,130.61492	11,130.61492
2/3MAHE	7420	7420	7420	7420
Head count index	0.36	0.43	0.48	0.5
Poverty gap index	0.30	0.37	0.37	0.41
Poverty severity index	0.13	0.14	0.18	0.17

The Impact Pathway of Adoption of soybean varieties

Soybean is a cash crop and thus the adoption of improved varieties can have a positive impact on farm income. Farm income with a significant contribution from soybean can increase the overall levels of incomes of households, which will enable them to acquire more commodities and assets. The acquisition of more assets and other food and non-food commodities would lead to a relative rise in the average households' command over resources, thus leading to poverty reduction. This section uses the propensity score matching method to determine for male-and female-headed households whether or not the adoption of soybean varieties had an impact on farm income per capita, income per capita, assets per capita, and poverty headcount (measured using household expenditure per capita) for both male-and female-headed households. A per capita measure was chosen for all variables to account for differences in household size with the understanding that larger households need more resources to meet their livelihood needs.

According to the results shown below for male-headed households, the adoption of soybean varieties had a positive and significant treatment effect on farm income and assets but not on income per capita and poverty headcount. This result is understandable as it agrees with the income results where soybean was the highest source of farm income for male respondents. At the same time male-headed households had diverse sources of income including non-farm income and thus many did not rely only on soybean as an income source. This is partly because soybean is grown on a seasonal basis depending on the onset of the raining season and so they have to rely on other sources of income during the dry season. For those households who did have income from soybean, many chose to buy assets as they received income from soybean in bulk.

For female-headed households there was no impact on farm income per capita, income per capita, assets per capita, and poverty headcount. This is not surprising because for those female-headed households who did not grow soybean many chose to grow groundnut and the income for female-headed households from both sources was also the same. In addition, female-headed households also had varying sources of income including non-farm incomes. The non-farm income for female-headed households was higher than that of their farm income and this is because females have greater constraints in getting access to agricultural factors of production such as land, capital in the form of credit, and labor compared to their male counterparts.

Table 28. Impact of soybean on income per capita, asset per capita and poverty.

	Male				Female			
	Farm Income per capita	Income per capita	Assets per capita	Poverty headcount	Farm Income per capita	Income per capita	Assets per capita	Poverty headcount
N	400	400	400	400	400	400	400	400
Treated	30,773.0348	51,473.4835	9732.97218	0.4215	19,645.0898	27,614.6149	9655.8916	0.4633
Controls	89,88.41605	42,015.6014	6631.23	0.4342	15,868.6786	39,335.5772	7985.57093	0.3775
ATT	21,784.6188	9457.8821	1592.1332	–0.1268	3776.4111	–13069.88	1670.32524	0.085
T-Stat	4.55***	0.62	1.95**	–0.13	0.84	–0.61	0.72	0.77

Conclusions and Recommendations

Conclusions

The N2Africa project has had successes in making significant contributions on most of the project indicators measured in this study. It has been successful in raising awareness of crop technologies and requisite crop management practices. Activities conducted by the project in conjunction with partner institutions such as BOSADP have been successful in raising the adoption of these improved technologies and crop management practices that have in turn helped in raising soybean yield and increasing farm incomes.

The N2Africa project has been successful in raising awareness for soybean and cowpea varieties. In the baseline approximately 89.1% of households were aware of soybean varieties. This high awareness was due to interventions conducted by PROSAB which promoted soybean varieties in the study area. The N2Africa project was able to raise awareness to 92.7% among male-headed households and 90.25% among female-headed households. This shows that since their activities began N2Africa has helped to raise the level of awareness of soybean varieties in the project area. The level of awareness for improved groundnut is lower than that of the baseline (75%) with 41% of male-headed households having awareness of improved groundnut while only 47.5 % of female-headed households have this awareness. Cowpea, another focus crop, has a high level of awareness for both male-and female-headed households but does not differ much from the baseline. Analysis of the extension service shows a majority of male-and female-headed households have their extension information from N2Africa, far outstripping the reach of BOSADP, the State institution responsible for extension service. The analysis of frequency of extension contact indicates that nearly 50% of female-headed households and one-third of male-headed households have never had any form of extension. For those who did receive extension contact, this contact was done quarterly as 45.5% of male-headed households and 36.3% of female-headed households receiving extension contact three times in a year. This is sufficient evidence to suggest that many households have very little exposure to extension services.

The use of chemical fertilizer is high for both groups as over 80% of household heads used chemical fertilizer. This is a dramatic increase compared to the baseline report by Amaza (2016). A plausible explanation for this is that the project was successful in creating awareness for households on the need for and use of chemical fertilizers. The use of organic manure is low as only 26.87% of male and 25.8% of female-headed households used manure for soil fertility purposes. Compared to the baseline (Amaza, 2016) where 51.9% of female-and 44.8% of male-headed households used organic manure, there was a lower use of organic manure in 2016. This also suggests that households' uptake of more grain legumes such as soybean with complementary technologies has seen them transfer some of their soil fertility needs to these legumes, as a result of them being able to fix nitrogen.

The study revealed that over 90% of male-and female-headed households were aware of soybean varieties. In addition to this, more than 90% of male-and female-headed households also grew soybean. The rate of adoption of new soybean varieties promoted by N2Africa is 75.4% for males and 69% for females. Compared to the baseline report there is a slight increase in the rate of female adoption from 66.7 to 69% but compared to the PROSAB baseline report, adoption has increased significantly. This is because in 2004 when the PROSAB baseline survey was conducted the adoption rate was as low as 0.0% (Amaza et al*.,* 2007). At the same time there is a more significant increase in the rate of male adoption from 67.7 to 75.4%. The variety that was most adopted for both male- and female-headed households is TGX 1904-6F. The most preferred variety for the next season for male-headed households is TGX 1951-3F while for females it is TGX 1955-4F. The major constraints to adoption of soybean varieties are high input cost, lack of labor during the peak season, and lack of threshing equipment. For females, lack of threshing equipment was the major constrain to adoption.

For all varieties male-headed households compared to their female counterparts had a larger mean area planted. For all varieties male-headed households also had a higher level of yield. Factors such as males having more access to land, credit, social capital in the form of membership of associations, and higher levels of non-farm income possibly contributed to this disparity in yield. In general, more households rely more on sources of farm income such as the production of crops than on non-farm incomes. Soybean is an income source to more than 80% of male-and female-headed households. As a whole, soybean is the most important source of income for households as it has the highest number of households citing it as a source of income. This is important because cowpea in the baseline had a larger proportion of households depending on it as a source of income; according to this study, soybean has come to replace cowpea as the dominant source of income. In addition to this, in the baseline soybean was quoted as a source of income by only 55% of male and 72% of female-headed households. Now over 80% of both male-and female-headed households reported soybean as a source of income. Farm income for male-and female-headed households including adopters and non-adopters of both genders was higher than their non-farm income. Soybean income for male-headed households was double that obtained by female-headed households. This is partially because male-headed households had, on average, more yield than female-headed households. In addition to this, males are able to command a greater price for their harvested produce because they have more social capital than females as a result of their higher enrollment in agricultural associations. Women's use of soybean as a source of protein for their children will mean that for them a smaller fraction of their harvest would be used to generate income. Finally, the poverty profile of households in the study was conducted to compare the level of deprivation between growers of soybean and those households who chose not to grow soybean. This analysis was desegregated by gender to determine whether or not there were differences in the impact of soybean on both male-and female-headed households. Male-headed households had a lower incidence of poverty compared to female-headed households. The incidence of poverty was lower for male adopters of soybean than for non-adopters of soybean. For female-headed households the adopters of soybean had a lower incidence of poverty than non-adopters but the difference is marginal.

The treatment effect analysis that was also conducted using the propensity score matching approach revealed that the adoption of soybean had a positive and significant treatment effect on farm income per capita and assets per capita for male-headed households. For female-headed households there was no treatment effect.

Recommendations

The N2Africa project is coming to an end and the findings of this study can guide policymakers on the achievements of the project to scale out and scale up some of the successes. In addition, it can also guide policymakers, development specialists, and donor organizations on how to improve on its limitations. Recommendations based on the findings of the study will thus be suggested to guide these different stakeholders on how future programs can be conducted.

1. Adoption of crop technologies and management practices.

   The project will soon come to an end and although the project has been successful in disseminating new varieties and practices, the sustainability of agricultural technologies uptake has to be maintained. For this to happen BOSADP has to do more in ensuring that households have regular contact with extension agents. A performance-based system in conjunction with frequent monitoring of the performance of extension agents must be made. This is especially crucial just before and during the planting season. Extension agents can be made to give weekly reports on their activities supported by evidence in the form of audio recordings and GPS coordinates. In addition to this policymakers can encourage the proliferation of private extension services. Private extension driven by the profit motive will be more efficient in the delivery of its services than public extension.

2. Social Capital

   A major determinant of adoption for soybean technologies is membership of associations and the results show that households who belong to associations have a higher likelihood of adopting new soybean technologies. This means that both groups and especially female-headed households should be encouraged to have greater participation in agricultural cooperatives and associations in order to develop social capital and the synergy required to develop strategies that will improve their collective productivity, marketing power, and livelihood. This will help to spread future technological innovations by word of mouth as it would bring them closer together. Social capital through agricultural associations will also solve the lack of labor during the peak production season, a constraint affecting approximately three-quarters of all households. These associations will help facilitate members to pool their numbers and work on each other’s farms.

3. Gender Mainstreaming

   Access to factors of production was a big constraint to female-headed households which hindered or limited their ability to adopt new varieties and the agronomic practices necessary to efficiently use these crop varieties. A part of this reason is because female-headed households in the study area are not encouraged by social norms and customs to engage in crop production. As a result female-headed households are usually engaged in other aspects of the soybean value chain such as processing and retailing. New gender mainstreaming initiatives should seek to target areas in the soybean value chain that are occupied by women.

4. Access to credit was for female-headed households an important factor that determined adoption of improved varieties. Thus, policymakers must strive to ensure that female-headed households with capital deficit should have access to credit to be able to purchase new seeds and other inputs. More has to be done in the future to bring about microfinance schemes, rotating savings and credit associations, and other forms of peer-to-peer banking should be to help households with capital deficit.

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Soybean seed farm in Borno State.

Annex

Questionnaire for the Adoption and Impact of Soybean among Smallholder Farmers in Borno State, Nigeria

1. Enumerator: ______________________ 2. Date of interview: ____________

3.LGA: ______________________

4. Village/Community: _________________

GPS coordinates at the house of respondent

5. Latitude: _______________ 6. Longitude: _____________7. Altitude: ______________

1. GENERAL HOUSEHOLD INFORMATION

NB: The "household" refers to all members of a common decision-making unit (usually within one residence) that are sharing income and other resources. 2016.

Variable	**Response**	**Codes**
Demographic data		
Sex of respondent		1= Male 2= Female
1. Gender of household head		1= Male 2 = Female
2. Age of household head in years		
3. Marital status of household head		1 = Single, 2 = Monogamously married, 3 = Polygamously married, 4 = Widowed, 5 = Separated/Divorced, 6 = Other, (Specify)
3. Education level of household head		1 = no formal education, 2 = adult education, 3 = some primary, 4 = completed primary education, 5 = some vocational training, 6 = completed vocational training, 7 = some secondary education, 8 = completed secondary education, 9 = college of education, 10 = university education
4. Highest level of education attained by any family member in years		
5. Number of children 0-5 years		
6. Number of members aged 6-15 years		
7. Number of males aged 16 to 64 years		
8. Number of females aged 16- 64 years		

9. Number of members aged 65 years and above		
10. Household size		
11a. Number of children of age 3 to 17		
11b. Number of children of age 3 to17 who are in school		
11.c Number of household members below 18 years who are involved in agricultural labor supply to generate income		
11d. Number of household members below 18 years who are involved in non-agricultural labor to generate income		
11e. Number of household members below 18 years who live outside the household with a relative/family friend due to the households' financial constraint		
12. How long has the household head been farming as an independent household? (*Number of years*)		
13. Type of household		1= male-headed (monogamous), 2 = male-headed (polygamous), 3 = female-headed (husband absent), 4 = female-headed (widowed), 5 = female-headed (divorced), 6 = female-headed (single), 7 = male-headed (single), 8 = male-headed (divorced), 9 = male-headed (widowed), 99 = other (specify)
14. Occupancy status		1 = landlord, 2 = tenant, 3 = rent, 4 = others, specify
15. Total number of rooms in the house (minus kitchen and bathrooms)		
16. Roofing material of household's most important residence		1 = straw/thatch, 2 = mud, 3 = wood/ planks, 4 = iron sheets, 5 = asbestos, bricks/tiles, 7 = tin, 8 = cement, 9 = other roofing, 10 = other walls, 11 = other floors
17. Sources of water supply to the household		1= river/stream, 2 = wells, 3 = borehole, 4 = pump, 5 = other (specify)
18. Household's main sources of light:		1 = lamp, 2 = generator, 3 = electric power, 4 = candles, 5 = solar panels, 6 = firewood, 7 = other (specify)
19. Main source of fuel used for cooking:		1 = agricultural bye-product, 2 = charcoal, 3 = firewood, 4 = gas, 5 = electric power, 6 = kerosene, 7 = other

2. LAND OWNERSHIP

NB: 1 ha = 2.47 acres, 1 acre = 0.405 ha, 1 ha = 10000m^2, NB: Please use only hectares.

How much land this household own now?

Row	Holdings	(a) Homestead land	(b) Upland away from home	(c) Wetland (if applicable)	(d) Total	(
1	Owned					
2	Sharecropped					
3	Borrowed in					
4	Rented out (for money)					
5	Lent out (free)					
6	Under crop cultivation (2015/16)					
7	Total land under other uses (fallow, pasture, etc) (2015/16)					

Household soybean plots/fields

Soybean plot(s)	Area
1. Main soybean plot	
2. Second soybean plot	
3. Third soybean plot	
4. Fourth soybean plot	
5. Fifth soybean plot	

3.0 AWARENESS AND ADOPTION OF SOYBEAN VARIETIES AND SOYBEAN PRODUCTION TECHNOLOGIES

3.1 Access to extension service

Variable	Response	Codes
1. Have you ever participated in any soybean related extension activities promoted by PROSAB/ N2AFRICA during the implementation of its activities?		1=Yes, 0=No
2. If yes, indicate the extension activities		1=Training in soybean production (training in row planting and pests and diseases management), 2=Training in soybean processing, 3=Fertilizer application, 4=Soybean varietal demonstration trials, 5=Others (specify)

3. If yes, with which extension institution or agency?		1=PROSAB/ N2AFRICA, 2=BOSADP 3=NGO, 4=Ministry, 5=Others (specify)
4. Do you have extension contact?		1=Yes, 0=No
5. If yes, from which institution (s) or source (s)? (multiple answers)		1=PROSAB/ N2AFRICA, 2=BOSADP 3=NGO, 4=Ministry, 5=Others (specify)
6. How often were you visited by extension agents in the last cropping season?		1=Weekly, 2=Bi-weekly, 3=Monthly, 4=Quarterly, 5=Others (specify)
7. How would you rate the usefulness of your contact with extension activities?		1=Very useful, 2=Useful, 3=Not useful, 4=Can't tell
8. Did you get any kind of assistance or information from the Extension Agents on:		**1=Yes, 0=No**
	a. Use of fertilizer	
	b. Use of improved varieties	
	c. Pest and disease management	
	d. Soil management	
	e. Weather information	
	f. Marketing advice	
	g. Credit	
	h. General crop production advice	
	i. Other (specify)	

3.1.2. Membership of Associations/Social Capital

Do you belong to any Association? **1=**Yes; 0 =No
If yes which of the Association below?

Voluntary Organizations, Groups, Networks or Associations	Indicate if you are a member of any of this type of group: **1=Yes; 0 =No**
1. Village committee	
2. Village NGO or Civic group	
3. Political group or movement	
4. Agricultural association	
5. Finance, credit or savings group	
6. Health group	
7. Education group	
8. Religious or spiritual group	
9. Cultural group or association	
11. Sports group	

3.1.3. Access to Credit

Do you have access to any of the following sources of credit? Yes = 1, No = 0

If yes source?

Source of Borrowed Money	Have you ever borrowed?	Amount borrowed in the last 12 months	Purpose of borrowing[1]
1. Relative and friends			
2. Informal savings and credit group			
3. Money lender			
4. Government credit schemes			
5. NGO/Mosque			
6. Bank or micro-finance institution			
7. Input and output dealers			

Purpose of borrowing: 1 = Purchase of food, 2 = Purchase of household assets, 3 = Payment of fees, 4 = Cover medical costs, 5 = Agricultural production, 6 = Other (specify)

3.1.4. Interaction with other farmers and farmers' groups

1. In the last 12 months, has a member of your household participated in any of the following?

Aspect	**1=Yes, 0=No**
1.Participated in community development activity	
2.Made financial contribution for community activities or collective problems	
3.Been involved in settling conflicts or disputes among people	
4.Visited other farmers within your community to learn about agriculture	
5. Visited other farmers outside your community to learn about agriculture	
6.Visited a research station to learn about agriculture	

3.2 Growing Improved Soybean Varieties

	Variable	**Response**	**Codes**
1.	Do you grow soybean?		1=yes, 0 = no
2.	Number of years of growing soybean		
3.	Are you aware of improved soybean varieties?		1=yes, 0 = no
5.	If aware, do you grow improved soybean varieties?		1=yes, 0 = no
6.	If no, do you receive information on improved soybean varieties?		1 = yes, 0 = no

4.	What are the sources of information on varieties?		1: bulletins or handbooks, 2: radio, 3: extension agent from BOSADP, 4: neighbor, 5: market,6: village or community organization,7: IITA,8: seed company,9: other (specify)
7.	Did you grow improved soybean variety in?		1 = yes, 0 = no
		2014	
		2015	
		2016	
8.	Which of the improved varieties did you grow from 2014 to 2016? 1) TGX1740, 2:) TGX1835 (*Danwuri)* 3:) TGX1951-3F, 4) :TGX1955-4F, 5) :TGX1987-10E, 6) :TGX1987-60E,7) :TGX1448-2E,8) :TGX1904-6F Others (specify)…………..		2014
			2015
			2016

9	Will you grow any of these varieties in future? 1) TGX1740, 2:) TGX1835 (*Danwuri)* 3:) TGX1951-3F, 4) :TGX1955-4F, 5) :TGX1987-10E, 6) :TGX1987-60E,7) :TGX1448-2E,8) :TGX1904-6F Others (specify)…………..		
10	If no to 9 above, give reasons for your answer. 1) TGX1740, 2:) TGX1835 (*Danwuri)* 3:) TGX1951-3F, 4) :TGX1955-4F, 5) :TGX1987-10E, 6) :TGX1987-60E,7) :TGX1448-2E,8) :TGX1904-6F Others (specify)…………..		Codes 1 seed snot available 2 low yielding 3 no market 4 poor taste 5 low grain prices 6 other, specify
11	In 2016, how many *mudus* did you plant?		
12	How many *mudus* or 100 kg bags did you harvest in 2016?		
13	Which of the farming systems is commonly practiced by your household? 1= monocropping/solecropping: 2=mixed cropping: 3= mixed farming: 4= livestock/pastoral:		
14	Which of the following cropping pattern is commonly practiced in soybean production in your household? 1= soybean as sole crop: 2=soybean as major crop in mixture: 3= soybean as minor crop in mixture:		

3.2.1: Reasons for Growing Improved Soybean Varieties in 2016

Reasons	Please tick
1. High yield	
2. Large seed size	
3. Less shattering	
4. Resistance to disease (s)	
5. High fodder yield	
6. High oil content	
7. High cash income/profit	
8. Drought resistant	
9. Early maturity	
10. Less labor input	
11. Resistance to pests	
12. Soil fertility improvement	
13. Makes better local foods/utilization	
14. Striga control	
15. Food security in the home	
16. Less fertilizer required to grow	
17. Others (specify)	

3.3. Do you keep livestock? **------------(**1=Yes, 0=No)

1.If yes, state the five major kinds of livestock kept in your household, their number, purpose, and ownership

Livestock		Number	Ownership: 1=mainly men, 2=mainly women, 3=men and women equally	Purpose 1=for food, 2=cash income, 3=both cash and food, 4=work, 5=social prestige, 6=transport, 7=others (specify)---
1.				
2.				
3.				
4.				
5.				

3.4. Soybean Production and Processing Technologies

3.4.1. Use of crop management, soil conservation, and other land management options (Technology/Management Practice)

NB: Technology refers to any practice including traditional and improved agricultural practices

Did you use this technology during the 2016 season?	1= Yes 0 = No	Did you use this technology during the 2016 season?	1= Yes 0 = No	Did you use this technology during the 2016 season?	1= Yes 0 = No
1. Organic manure		9. Fungicide		17. Processing into:	
2. Cover crops		10. Herbicide		(a):soymilk	
3. Crop rotation		11. Varietal selection		(b):dadawa	
4. Intercropping		12. Drying		(c):awara (soybean cake)	

5.Rhizobia inoculation		13. Threshing/shelling equipment		(d):Other (specify)1	
6. Chemical fertilizer		14. Improved storage facilities		(e): Other (specify)2	
7. Row planting		15. Pest control		(f): Other (specify)3	
8. Plant Spacing		16. Grading			

3.5: Traits and Preferences

What are your three most preferred improved soybean varieties (in order of importance)?	**Rating**	What are the three main characteristics (in order of importance) that make the variety a preferred variety for you? (***WRITE CODE***) 1:Earliness, 2:High Yield, 3:grain size, 4:Disease resistant, 5: Non-shattering
1 =TGX1740		
2 =TGX1835		
3 =TGX1951-3F		
4 =TGX1955-4F		
5 =TGX1987		
6 =TGX1987-60E		
7 =TGX1448-2E		
8 =TGX1904-6F		

1=Most preferred, 3 least preferred

4. SOYBEAN PRODUCTION FOR THE LAST SEASON (2016)

4.1 Land preparation and weeding cost for soybean in 2016

	Land preparation for soybean					**Weeding-soybean**					
Row (Farm)	Total family labor for land preparation (days)		Total hired labor for land preparation (days)		Total cost of land preparation including hired labor (N)	Number of weedings	Total family labour for weeding (days)		Total hired labor for weeding (days)		Total cost of weeding including hired labor (N)
	Days	No. of people	Days	No. of people			Days	No. of people	Days	No. of people	
1.											
2.											
3.											
4.											
5.											

Row (Farm)	Fertilizer application for soybean					Harvesting soybean					
	Total family labor fertilizer application(days)		Total hired labor fertilizer application (days)		Total cost of fertilizer application (N)	Number of harvests	Total family labor for harvesting (days)		Total hired labor for harvesting(days)		Total cost of harvesting labor (N)
	Days	No. of people	Days	No. of people			Days	No. of people	Days	No. of people	
1.											
2.											
3.											
4.											
5.											

4.1.2: Which of the following methods did you use for land preparation, weeding. and harvesting in the last cropping season? ***Use CODE below***[1]

Land Preparation	Weeding	Harvesting

[1] **Methods:** 1 =hand hoe; 2=oxen; 3=tractor/mechanized; 4=chemical; 5=tractor and oxen; 6=slash and burn; 7=Sickle; 8=other (specify)

4.2. Inorganic and Organic Fertilizers Inputs in soybean Production (2016)

	Fertilizer									
Row	Used chemical fertilizer? 1=yes 0=no	Type of fertilizer used [2]	Amount used (kg)	Did you buy it? 1=yes 0=no	Total value (N)	Used organic fertilizer? 1=yes 0=no	Did you buy it? 1=yes 0=no	Type of organic fertilizer 3	Amount in kg	Total value (N)
1.										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

[2] **Chemical fertilizers:** 1=NPK *(Kamfa)*, 2=SSP*(super)*, Urea=3

[3] **Type of organic fertilizer:** 1=Green manure, 2=Animal manure, 3=Compost, 4=Leaf litter, 5=Crop residue, 99 other (specify)

4.3. Seed cost: soybean 2016

	Seed		
Plots/fields	kg	Mudus	Total value (N)
1. Main soybean plot			
2. Second soybean plot			
3. Third soybean plot			
4. Fourth soybean plot			
5. Fifth soybean plot			

4.4. Soybean Yield in 2016

Plots/fields	**Yield in Mudus Harvested**	**Yield in 100 kg bags**
1. Main soybean plot		
2. Second soybean plot		
3. Third soybean plot		
4. Fourth soybean plot		
5. Fifth soybean plot		

4.4.1. Assess your soybean yield vis-a-vis quantity of seeds used in the past 3 years (2012-2016) *(QTY= Quantity Planted), (YLD= Yield Harvested)* **(EVERY MEASUREMENT SHOULD BE IN MUDU)**

Varieties	**2016**		**2014**		**2012**	
	QTY	YLD	QTY	YLD	QTY	YLD
1.TGX1740						
2.TGX1835						
3.TGX1951-3F						
4.TGX1955-4F						
5.TGX1987-10E						
6.TGX1987-60E						
7.TGX1448-2E						
8.TGX1904-6F						

4.4.2. Have you received or given out improved seeds of soybean? -------------(1=Yes, 0=No)

If yes, please state quantity received or given out and year?

Varieties	Received 1:BOSADP, 2:PROSAB/N2AFRICA, 3:EAs, 4:Other farmers,5:Seed dealer, 6:Relatives, 7:Friends, 8:Cooperatives, 9:Others (specify)			Given Out 1:CBO members, 2:EAs, 3:Other farmers, 4:Seed dealer, 5:Relatives, 6:Friends, 7:Cooperatives, 8:Other (specify)		
	FROM	QTY	YEAR	TO	QTY	YEAR
1.TGX1740						
2.TGX1835						
3.TGX1951-3F						
4.TGX1955-4F						
5.TGX1987-10E						
6.TGX1987-60E						
7.TGX1448-2E						
8.TGX1904-6F						

4.5. Soybean production constraints

1. What are the priority constraints to soybean production?

Constraints to crop production	**Rank the top three constraints (1 being the topmost constraint)**
1. Low soil fertility	
2. Pests and diseases	
3. Lack of improved varieties	
4. Low access to inputs	
5. High cost of inputs	
6. Insecure land tenure	
7. Lack of land	
8. Lack of labor during peak season	
9. Lack of/expensive agricultural equipment	
10. Lack of market for soybean	
11. Distance to market	

5. ACCESS TO INPUT/OUTPUT MARKETS FOR SOYBEAN

5.1. Access to market information

Variable	Response	Codes
1. Do you regularly have information on market price for soybean?		1=Yes, 0=No
2. If yes, indicate the source(s) of your market information.		1=Market visits, 2=Media (TV/ Radio), 3=Other farmers, 4=Middlemen, 5=Friends/relatives, 6=Extension agents, 99 Others(specify)
3.Did you receive information on:		**1=Yes, 0=No**
	a: soybean prices in different markets	
	b: soybean demand in different market	
	c: soybean supply in different markets	
	d: availabilty of services e.g. transport	
4.What is your assessment of the market price of soybean over the past 12 months?		1=good market price, 2=not so good, 3=low market price

5.2. Access to Inputs and Machinery

Variable	**Response**	**Codes**
1. Do you have any agro-chemical dealer in this village? (fertilizers, insecticides etc.)		1=Yes, 0=No
2. If no, what is the distance to the nearest agro- chemical dealer? (km)		
3. Do you purchase agrochemicals for soybean production?		1=Yes, 0=No

4. Where do you purchase your agro-chemicals? 1=open market, 2=BOSADP, 3=input dealer, 4=other farmers, 5=friends/relatives, 6=farmers' cooperative, 7=seed company, 99= others (specify)		
5. Which of the chemicals do you purchase?		**1=Yes, 0=No** NPK: SSP: Urea: Fungicide: Herbicide: Seed dressing:
7. Is there an improved seed dealer in this village?		1=Yes, 0=No
8. If no, what is the distance to the nearest seed dealer? (km)		
9. What are the sources for seeds for your household?		1=own produced, 2=open market, 3=seed company, 4=community seed producers, 5=neighbor/ friends, other farmers, 99=other (specify)
10. Do you have food processing machines for soybean in this village?		1=Yes, 0=No

5.3. General Access to Inputs: 1. Indicate your access to the following inputs

Variables	**Ever heard** **1=yes 0=no**	**Ever used** **1=yes 0=no**	**Used in 2016?** **1=yes 0=no**
Improved cowpea varieties			
Improved groundnut varieties			
Improved maize varieties			
Improved sorghum varieties			
Improved millet varieties			
Fertilizer			
Herbicide (Pre- and/or post-emergence)			
Insecticide			
Treated seeds (fungicide)			

5.4. Marketing strategies and linkage with agricultural traders (Soybean)

1. If soybean is sold in more than one form, enter each form on a separate row

2. Price is to be given in Naira

3. Please leave every unit used in mudu or 100 kg bag

		Market 1 (main market)					Market 2 (in case of other market)					
Soybean Forms	(a) Did you sell? 1=Yes 0=No	(b) If yes, Quantity sold (100 kg bag)	(c) Type of market[1]	(d) Price per unit in market[1]	(e) In what form did you sell?[2]	(f) How did you sell?[3]	(g) Did you sell? 1:Yes 0:No	(h) If yes quantity sold (100 kg bag)	(i) Type of market[1]	(j) Price per unit	(k) In what form did you sell?[2]	(n) How did you sell?[3]
Form 1												
Form 2												
Form 3												

[1] **Type of market:** 1 =on the farm, 2= middlemen, 3=local/village market, 4=distant market,

[2] **Form** 1=grain, 2=seed, 3=processed into food products

[3] **How?** 1=individually, 2=collectively

5.5. Constraints of Soybean Marketing

Constraints of Soybean Marketing	**Rank (1 being the topmost constraint)**
1. Low quality of produce	
2. Low market prices at the time of selling	
3. Unavailability or limitations of markets	
4. Lack of market information	
5. Difficulties in processing	
6. Difficulties in storage	
7. Transport to the market	
8. Farmers are not organized to market collectively	
9. Difficulties in setting prices	
10. Others (specify)	

6. IMPACT OF PROJECT ACTIVITIES ON FARMERS' INCOME, POVERTY

6.1. Household Major Sources of Income

1.What are your priority sources of income and what is the income estimated from these sources for the last 12 months?

Row	**Income source**	Do you get income from this source? Yes=1 No=0	How regularly do you get income from this source **(see codes)***	Estimated amount from this source in the last 12 months (Naira)	What is the importance of this source to total house-hold income? **(Codes)****
1.	Sale of soybean				
2.	Sale of cowpea				
3	Sale of groundnut				
4.	Sale of Maize/sorghum/ millet				
5.	Sale of other products e.g. firewood, trees				
6.	Regular employment				
7.	Casual employment (agriculture- related)				
8	Casual employment (non-agriculture-- re-lated)				
9.	Running own business				

10.	Remittances from family members				
11.	Remittances from non-family members				
12.	Other (specify)				
.	**TOTAL INCOME**				

******Regularity of income source** 1=Do not get at all, 2= Occasionally, 3=Regularly 4=All the time*

*****Importance of source**: 1=Not important, 2=Moderate importance 3=High Importance 4=Very High Importance*

6.2. Household food security

1. Were there any month (s), January to December 2016), in which you did not have enough food to meet your family's needs? This includes any kind of food from any source, such as own production, purchase or exchange, food aid, or borrowing. 1**=Yes, 0 =No: ----------------------**

Months	Which month (s) in the last 12 months you did not have enough food to meet your family's needs? Record 1 in identified month. 1=Yes, 0 =No	Why? List up to 3 major reasons. **See codes*****.**
January, 2016		
February, 2016		
March, 2016		
April, 2016		
May, 2016		
June, 2016		
July, 2016		
July, 2016		
August, 2016		
September, 2016		
October, 2016		
November, 2016		
December, 2016		

CODE**** *1=drought; 2=flooding; 3=pest/diseases; 4=irregular rain; 5=high food price; 6=high cost of agricultural input; 7=loss of employment; 8=illness of household member; 9= death of household member; 10=theft of productive asset; 11=erosion/landslide; 12=livestock disease; 13=large family size; 14 =others(specify)*

6.3 Coping Strategy for Food Shortages

1. If you faced any food shortage in the past 12 months, what coping strategies did you use?

Coping mechanism	Did it happen? 1=Yes, 0=No	If you used coping strategy, how often did you use it?
1.Borrowed money to buy food or got food on credit		
2.Reduced the number of meals		
3.Mother ate less		
4.Father ate less		
5.Children ate less		
6.Replaced commonly bought foods with cheaper kind		
7.Modified cooking method		
8.Mortgaged/sold assets		
9.Borrowed from neighbors		

Code****1=regularly; 2=occasionally

6.4. Household Expenditure or Household Dietary Diversity

(*Here, the person involved in purchases should be the principal respondent/s)*

No	Item	**Unit** (e.g. kg, liter, packet, bundle, number, basket, mudu, cup)	Bought in the last 12 months: Frequency of buying (e.g., once per year, twice weekly, etc.)	Average quantity each time (e.g., 2 kg; 4 bundles etc.)	Total quantity per week	Average price per unit **(Naira)**	Total cost of purchases **(Naira)**
1	**2**	**3**	**4**	**5**	**6=4x5**	**7**	**8=6x7**
	FOOD AND BEVERAGES						
1	Soybean						
2	Cowpea						
3	Other legumes						
4	Maize						
5	Others cereals						
6	Roots and tubers						
7	Other foods/snacks						
8	Fruit and vegetables						
9	Meat, poultry and fish						
10	Food additives and condiments						
11	Grocery food (bread, milk, egg, oils, nuts, snacks)						
12	Non-alcoholic beverages (coffee, tea, water, juices)						
13	Tobacco/kola nut/cigarettes						
14	Others (Specify) 1 ……………………						
	Total food expenditure						
	NON-FOOD EXPENDITURES						
1	Clothing/ footwear						
2	Fuelwood, paraffin, generators, etc						
3	Housing (rent, water and light) and household services (wages for servants)						
4	Transport and communications						
5	Education						
6	Health expenses						

7	Repairs (bicycle, motor-cycles, car, etc)						
8	Recreation, entertain-ment and cultural activi-ties						
9	Other ad hoc (rarely) expenses (remittances, weddings, funerals, cer-emonies, politics, etc)						
10	Others (Specify) 1………………						
	Total non-food expen-diture						
	Total expenditure						

6.5 Household Assets

Which of the following assets do you have?

Code	**Equipment**	**Does your HH own** **Yes=1 No=0**	**If yes, total number**	**Estimated average NAIRA value for one item**
A				
a1	Hoes, cutlasses			
a2	Ox-plows			
a3	Draft cattle			
a4	Draft donkeys			
a5	Tractor/tractor plow			
a6	Wheelbarrows			
a7	Farm equipment			
a8	Water pumps			
a9	Sprayers			
B				
b1	Sewing machine			
b2	Ox-cart			
b3	Car			
b4	Bicycle			
b5	Motorcycle			
b6	Radio			
b7	Television			
b8	Fishing boat			
b9	Mobile phone			
b10	Paraffin stove			
b11	Sofa chairs			
b12	Others			

7. IMPACT OF SOYBEAN ADOPTION ON FOOD CONSUMPTION AT HOUSEHOLD LEVEL

7.1. How many times did your household eat the following food items?

(if eaten=1, not eaten=0).

Item	Yes=1 No=0	No. daily	No. weekly	No. monthly
Soybean related meals				
Cereal related meals (maize, millet, and sorghum				
Cowpea/ groundnut related meals				

7.2. In what form is soybean consumed in your household? **Use CODE (Yes=1; No=0)**

Form	**Response**
1.Soybean cake (Fried bean cake) (awara)	
2.Soy flour	
3.Soy tum-brown	
4.Soy milk	
5.Soy cheese	
6.Soy meat	
7.Soy dadawa	
8.Soy bread	
9.Soy kunun	