Adoption of Stress Tolerant Maize Varieties in Nigeria: Does Gender Matter?

Paper Presented by

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ABSTRACT

The broad objective of the study was to examine the factors influencing the adoption of stress tolerant maize varieties in Nigeria. Our study attempts to uncover some of the factors that explain low STMA adoption rates in Nigeria, focusing on gender differences. This question is particularly relevant given, that women account for nearly 50% of the Nigerian agricultural labor force. Our study is based on data collected from a longitudinal survey conducted between 2016 to 2019 as well as focus group meetings conducted separately for men and women during that period. The subjects consisted of 840 men and women farmers spanning six states and two agro-ecological zones of Nigeria, all randomly selected from among farmers who had participated in the International Institute of Tropical Agriculture Farmers Census Survey. Our calculations indicated that our sample size exceeds that necessary to achieve a Minimum Detectable effect with a power of 0.80.

Our study employs a robust, stratified random sampling procedure, using triple-differencing quasi experimentation techniques. We stratified our sample population into four strata: Experimental Villages in which on-field trials of Stress Tolerant Maize Variety (STMA) have been carried out; Near-Neighbor Villages between 1-5km distance to the experimental villages; Formerly Experimental Villages for which STMA trials had been conducted, but subsequently discontinued; and Control Villages within 35km to the experimental villages to control for spill-over effects. Data collected were analyzed using percentages, ordinal ranking, safety-first risk behavioral model and logit. regression model

Background of the study

Agriculture is the art and science of cultivating the soil, growing crops and raising livestock. It includes the preparation of plant and animal products for human use. Agriculture can help reduce poverty, raise incomes and improve food security for 80% of the world's poor, who lives in the rural areas and work mainly is farming (world bank, 2018). According to National Geographic report, (2019), agricultural development is one of the most powerful tools to end extreme poverty, boost shared prosperity and feed a projected 9.7 billion people by 2050. It also talked on Growth in the agriculture sector to be two to four times more effective in raising incomes among the poorest compared to other sectors. 2016 analyses found that 65% of poor working adults made a living through agriculture (National Geographic report, 2019). The size (or GDP) of the world economy is $113.7 trillion and agriculture as an industry contributes 6% of this amountthis means the value of the world agriculture industry is $6.822 trillion and despite just contributing 6% to the size or value of the world economy, the agriculture industry employs 34.6% of the worlds labor force (Agricdemy, 2019). According to National Bureau of statistics (2017), agriculture contributed 29.15% to the Gross Domestic Product in Nigeria.

Recently, growth in the agricultural sector is being driven by Crop Production output, which accounted for 93.45% of overall nominal growth in the agriculture sector (agridemy, 2019).The grassland zone of African nation is characterized by a variable weather. The precipitation distribution ranges from a unimodal pattern shows that annual rainfall ranges from 1400-2700mm in the guinea zones ,950-1400mm in the savannah zone and 450-1050mm in the sahelian zone over the entire 90years of study. Sudan has a tropical sub-continental climate, extending from desert climate in the north through a belt of summer-rain climate to semi-dry climate. The average rainfall is 250mm, but ranges from 25mm in the dry north and up to 700mm in the south (FAO, 2016).

Despite this nice potential, the frequent occurrence of stress occasioned by erratic precipitation distribution and or halt of rains throughout the season is that the greatest hindrance to" redoubled production of those food and industrial crops (NARPS,1996). Small-scale irrigation, flood recession cultivation and seasonal exploitation of high water-tables in several elements of the grassland have remittent the assembly of those food crops, majority of the resource-poor farming communities within the grassland still rely on natural precipitation to cultivate their crops. The result of drought is most severe within the dry grassland zones and particularly the acute northern zone where the chance of stress is highest at the beginning and finish of the season (Kamara et al, 2006). Despite slow progress, maize productivity in sub-Saharan Africa is still the lowest in the world due to factors such as drought, poor soil fertility, diseases, insect pests and parasitic weeds that have crippled smallholders yield potential. All of this is compounded by the high price of inputs and a lack of financial resources. Agriculture-driven growth, poverty reduction, and food security are at risk: Climate change could cut crop yields, especially in the worlds most food-insecure regions.

One of the Crops greatly affected by climate change is maize. Maize is changing into more and more necessary as a food security crop within the dry grassland zones of African nation. Maize production of Nigeria increased from 1,426 tonnes in 1969 to 11,000 tonnes in 2018 growing at an average annual rate of 6.72% (KNOEMA, 2018). There's the requirement to maneuver deliberately, however with urgency, to induce stress-tolerant varieties from the breeders to the farmers, as a result of their potential to avert crises is goodish.

The Stress Tolerant Maize for Africa (STMA) project seeks to develop maize cultivars with tolerance and resistance to multiple stresses for farmers, and support local seed companies to produce seed of these cultivars on a large scale. STMA aims to develop a new generation of over 70 improved stress tolerant maize varieties, and facilitate production and use of over 54,000 metric tons of certified seed. This will be achieved through close partnerships with local seed companies and national agricultural research organizations across the 12 target countries. By 2020, the project aims to reach 5.4 million households with enough improved maize to cover 2.2 million hectares in eastern (Ethiopia, Kenya, Tanzania, Uganda), southern (Malawi, South Africa, Zambia, Zimbabwe) and western Africa (Benin, Ghana, Mali, Nigeria).STMA will build on the successes and lessons of the Drought Tolerant Maize for Africa project, the Improved Maize for Africa Soils project and other related projects, which facilitated the production of 60,000 metric tons of certified seed, enough to plant more than 2.4 million hectares and benefit more than 6 million households (more than 53 million people) in 2015 alone. Based on this work, STMA will prioritize the replacement of obsolete varieties more than 15 years old with new, improved, stress tolerant varieties to change the current low use of modern varieties, which stands at 58 percent in all the maize area in sub-Saharan Africa (CIMMYT, 2018).

The STMA varieties can only achieve it's aim if adopted by maize farmers. Adoption of STMA Can improve farmers' income, level of living and food security generally. It is an undeniable fact that Nigerias agriculture remains in crisis as a result of very few of its citizens are often thought to be either food-secured or food independent. There is thus, an ever increasing concern that despite the massive quantity of money endowed in breeding maize like SAMMAZ 18, 20, 33, 23, 24, 25 varieties to fulfill the challenges of food security, still, this goal is yet to form the required impact. In spite of the huge investment in STMA programme, there are still many maize farms suffering from the effect of drought. Attention has solely been given on developing stress tolerant maize varieties while not birth stress on finding out farmers‟ adoption of the STMA and its effects on their sustenance. Nigerian smallholders rely primarily on rainfed agricultural production practices, exposing them to adverse of natural shocks, most notably severe droughts. Production decisions are therefore, generally made under significant risk and uncertainty which can be expected to worsen over time. Risk impedes investment in agriculture. Hence government policymakers and development practitioners have become increasingly interested in finding ways to manage and mitigate production risk in order to increase production. Scientific breakthroughs, most notably the development of Stress Tolerant Maize (STMA) varieties, have brought about dramatic productivity gains throughout the developing world. However, the adoption of STMA varieties in Nigeria remains low, and the causes of this remain thinly researched from gender and risk-behavioural perspective.

There is broad-based agreement among development economists that women and men farmers do not generally face the same production decision making opportunities and, as a result, do not necessarily make the same production choices, which in turn have implications for output and incomes. Limited access among women to basic agricultural inputs such as land, labor, knowledge, fertilizer, and improved seeds contributes immensely to their low coping and adaptive capacities in response to weather-related shocks. Women also tend to have less decision-making authority and face additional social, cultural, and institutional barriers to accessing and adopting improved agricultural technologies. Understanding the constraints on women farmers and the forces that drive gender gaps in agricultural productivity therefore important are critical for designing effective policies aimed at increasing agricultural production and reducing smallholder vulnerabilities to weather and climate change. In particular, we need to better understand whether gender-related differences in technology adoption can be attributed to innate characteristics of the technology itself or other external factors. Our study hence attempts to uncover some of the factors that explain low STMA adoption rates in Nigeria, focusing on gender differences.

THEORETICAL FRAMEWORK

This study is guided by the Diffusion and adoption theory and Impact assessment perspectives.

Agricultural technologies embody both inputs like fertilizer or seeds, and also new farming strategies. The technology might not be new itself, but unfamiliar to the farmer. Thus, Rogers (2003) noted that a new technology (or innovation) is as an idea, practice, or object that's perceived as new by an individual or other unit of adoption. Rogers (2003) identified two attribute of innovations (from the angle of the farmer) that best justify different adoption rates, i.e. the perceived relative advantage of using the technology vis-à-vis the technology it supersedes, and its perceived compatibility with existing values, needs and experiences (Rogers, 2003). Additionally, Rogers notes that innovations are more likely to be adopted if they're less complicated, lend themselves to being triable and whose results are noticeable to others.

Adoption of a technology is also measured by both the timing and extent of new technology utilization by individuals (Sunding and Zilberman, 2001). The extent of adoption can be measured by intensity of cultivation for instance, in terms of number of farmers, total area, area within farms or harvest (CIMMYT, 1993). Two main strands of technology adoption research have emerged (Marra et al., 2003). Sociologists have traditionally centered on the characteristics of the adopters, their perceptions of the innovation, adoption rates and communication channels in the decision process.

Griliches" seminal study of the diffusion of hybrid corn in Iowa was one of the first economic studies in this area that shifted the emphasis towards economic variables as the most important determinants of technology adoption (Griliches, 1957). Since the 1960s and particularly since the publication of the Griliches studies, S-shaped diffusion curves became widely used (Sunding and Zilberman, 2001).

According to this theory, innovations are first adopted by some early adopters. Then adoption rates accelerate because the majority adopts the technology before it step by step slows again as fewer and fewer remaining people adopt the innovation the so-called laggards (Rogers, 2003). In this sudy, diffusion studies have centered on the differences between early and late adopters, the perceived characteristics of an innovation that affect its rate of adoption and why a critical mass of early adopters is required for an innovation to become widespread.

Experience has shown that a new technology might not be acceptable in every context, but rather its suitableness depends on however well it fits the particular farming context (CIMMYT, 1993). However, much of the focus of the adoption literature has been on the individual farmers for instance, (the socio economic characteristics like wealth, education or the personality of the farmers) and the characteristics of the technologies, rather than the context in which technology adoption and diffusion takes place (CIMMYT, 1993; Marra et al., 2003). It is conjointly necessary to note that the adoption process is a dynamic one, not only in terms of the diffusion of new technologies over time and space, but also from the perspective of the individual farmer.

As a result, the willingness and ability to adopt new technologies, the relative weight of the influencing factors and the associated needs for support may change over time. For instance, the disposition to adopt may change with age and experience (CIMMYT, 1993). Older farmers may be less willing to take up a new technology that solely pay off in the long run (Feder and Umali, 1993) however can also have a lot of resources to take invest in new technologies. Younger farmers on the other hand may be more educated or open to making an attempt in trying out new technologies. Moreover, farmers typically modify their perceptions of the menace of latest technologies over time as they acquire more information (Marra et al., 2003).

Also, adoption isn't necessarily a binary decision. Rather, the intensity of adoption may change over time, let's say as a results of learning or through better access to farm resources. Some technologies can also be abandoned again (CIMMYT, 1993). There are, also some proof of a technological ladder". Kaliba et al. (2000) reported that the majority of adoption studies had found that small holder farmers tended to adopt easy technologies first before moving on to the complex ones, while cheaper technologies is also adopted before the costly ones. Moreover, over the past two decades researchers are progressively recognizing the necessity to view agricultural technologies as a package where farmers might adopt components at completely different times and speeds (Feder and Umali, 1993). This theory would be used to guide the analysis of the factors influencing the adoption of STMA by maize farmers.

From the view of theory of adoption, a conceptual model for the study was derived from the synthesis of the theories to ensure that the findings of this study get substantial evidences. The model for exploring this study is made up of dependent variable (adoption of STMA varieties) and the independent variables (socio-economic, institutional and technological attributes). For this study, the conceptual model suggests that socio-economic, institutional, and technological variables would influence adoption of STMA varieties. From the model, the interaction of the dependent and independent variables is expected to have an effect on yield, income and level of living of maize farmers.

Conceptual Framework on Measurement of Gender in Agriculture

The main goal of investigating the risk behaviour to technology innovation usage is to increase male and female farmers productivity. However, to understand how gender variable included in the measurement, this study builds on existing studies on gender measurement in productivity differentials to properly conceptualise how gender can be measured in relevance to the Nigeria agricultural environment.

The majority literatures that are available on gender differences in agriculture emphasised that the gap in gender relations persists. These literatures also agreed that in many cases analysed, women yield is mostly lowered compared to men (Croppenstedt, et al., 2013; FAO, 2011). Methodological approaches used in measuring gender gap varies, when the analysis of gender gap is ran, either at the plot level or at the household level, the result showed that different conclusion can be reached (Chavas, et al, 2005; Tiruneh, et al., 2001). Study conducted at the household level, employ the "sex of the household head as the gender indicator" Using this proxy, "it analyse the gender differences in market conditions and imperfections faced by the household as a whole, as well as the vulnerabilities associated to female headship". Their method of gender measurement gave insight to understanding gender gaps. However, it makes it difficult to explain the specific constraints female farmers faces on their plots. Peterman et al., (2010) submitted that "the nuances of different typologies of households lead to mixed results". Horrell & Krishnan, (2007) find that yield in Zimbabwe, is lower in "poorer *de jure* female-headed households (e.g., households with widowed, separated or divorced female heads) as opposed to *de facto* female-headed households (e.g., wives of male migrants) with similar incomes to male-headed households". Doss, (2002) argued that "using the sex of the household as the variable of choice is also problematic because the variable does not indicate who makes decisions in agriculture or who owns the assets". This also creates greater confusion for policymakers in enacting policies that aimed at getting a particular results. The usage of sex of the household head as a variable either assumes that "only the characteristics of the household head influence household decisions or that all decision-makers in the household have the same preferences" (Kleinjans, 2013). These studies conclude that, "while it still useful to analyze differences based on household typology (namely male, female, widowed, single-headed households) progress in gender studies must find a way to build more evidence at the plot level, where management decisions by gender are better captured".

The report of Quisumbing & Maluccio, (2003); Udry, (1996) showed that in the last twenty years, many studies have shown that intra-household decision-making exists in the allocation of resources used within the household. These understanding of this gender dynamics is important because the process involve in making decisions related to agriculture are partially dependent on women and men's differentials in privileges and bargaining power (Goldstein & Udry, 2008; Agarwal, 2003). Especially, in the context of the West-African social environment where different sex categories of the household members manage iand work on different plots that are owned by the family (Udry, 1996). "Therefore, the transfer and adoption of agricultural technologies depend on these intrahousehold decisions" (Tiruneh, et al., 2001). Many studies conducted in the sub-Saharan Africa have employed this approach in their analysis (Kilic, et al., 2015; Oseni, et al., 2014; Aguilar, et al., 2014; Peterman, et al., 2010; Alene, et al., 2008; Oladeebo & Fajuyigbe, 2007). Many of these studies uses varieties of data that ranges from regional or program-level data, while in recent cases, nationally representative data have been used. The analysis of these research showed that in many of the studies conducted nationally in Sub-Saharan Africa, difference in gender persists with the bias in favour of males. The choice variable when performing a gender analysis also varies as reported by several studies conducted at the plot-level. Aside using the sex of the plot manager, attempt have been made to use the plot holder as well as the owner of the farm plot as the choice variable. Peterman et al., (2010) however, reported that "the using the plot owner as the choice variable is the least common approach used in gender analysis. He further explained that the less usage of plot owner may be as a result of little or unavailability of sex-disaggregated data on asset endowment. "The implications of using the plot holder versus the plot owner as the gender variable of choice have not been widely studied in Nigeria". Also, depending on the existing tenure systems, the idea of ownership, holdings and management may be confusing for farmers if used synonymously in the same context and also used differently in another concept. It is also important to note that production responsibilities by household members may differ given these definitions. Conclusively, the influence of attitudes and behaviour captured by intra-household dynamics on co-managed plots or plots that are jointly owned by the members of the household have not been widely analysed either.

De la O Campos, et al., (2016) concludes that “since gender inequalities in agriculture are recurrent and recognized as a major area for policy action, gender analysis should be able to identify every aspect in intra-household dynamics”. This study builds on these existing studies by developing a multi-dimensional concept of studying gender by combining analysis at the household level with plot-level intrahousehold dynamics.

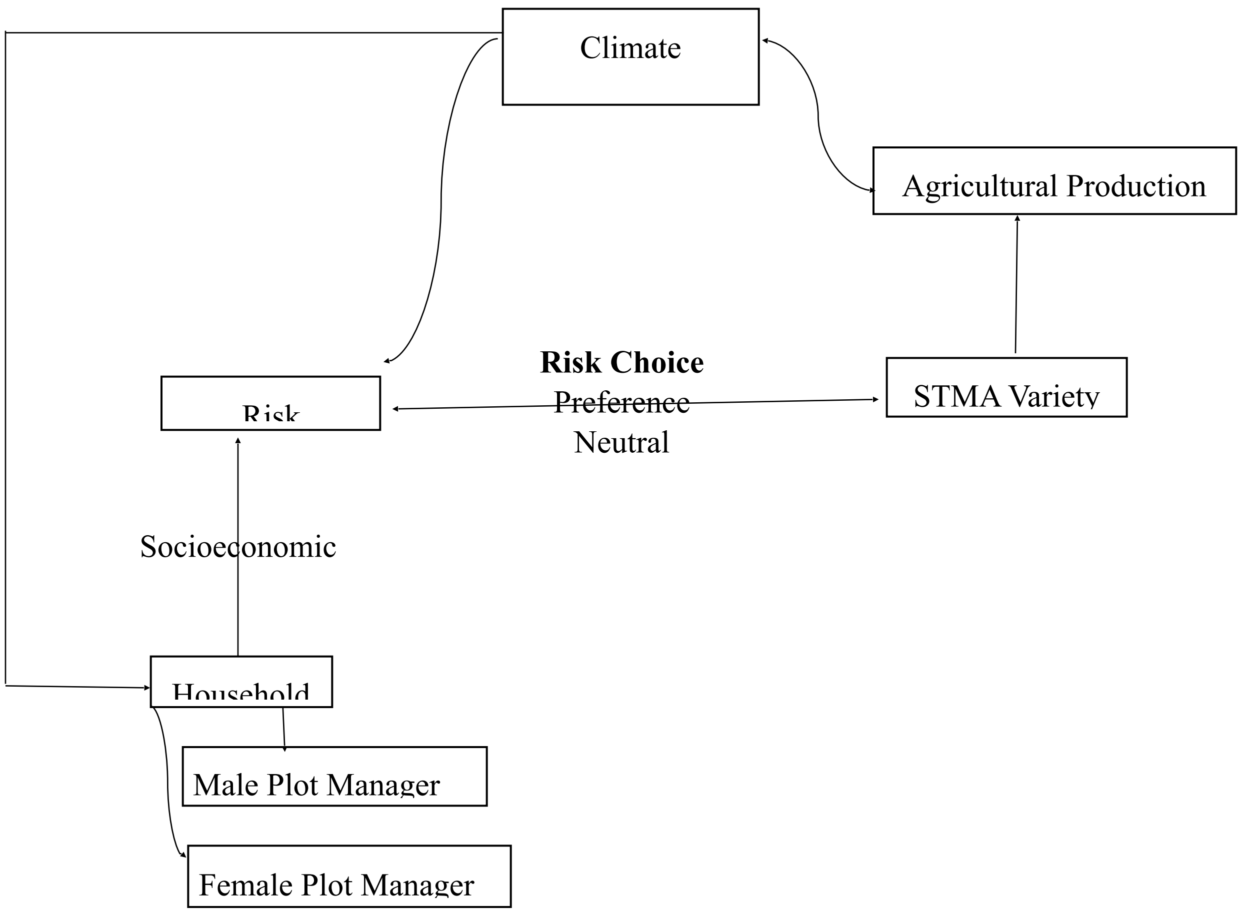

Figure 1: Conceptual Framework on household decision-maker. Source: Author 2018

Conceptualizing Gender in Agriculture

The conceptualization of ‘gender’ underscores potential differences/similarities across members of a social system, not necessarily specific to a particular or opposite sex. Gender is a ‘socially defined’ (Ridgeway & Correll, 2004) concept of female and male members of a particular society in a way different from sex. Roles assumed by gender differs among various communities, classes, cultures and ages at a given time period in history. "Gender-specific roles and responsibilities are often conditioned by household structure, access to resources, specific impacts of the global economy, and other locally relevant factors such as ecological conditions" The concept of gender used in the study is not, basically, all about women. Peterman *et al.,* (2010) also conclude that "gender represents a social construction of what it means to be of the male or female sex, including cultural, ethnic, economic, religious, and ideological influences". Gender issues, nonetheless, usually concentrate on "female concerns and on the dynamics of inter-relationship between women and men's roles, access to and control over resources, division of labour, interests and needs". Gender relations affect well-being, production, planning, household security and other decision-maker's way of life. In the context of this study, gender is defined as a social construct and will be contextualized as a combination of two dimensions: one relates to role, who makes decision on productive household resources, particularly land; and two pertains to status, relationship to head of the household (as head or spouse). Household heads can be either *de jure* (such as a bachelor, widow) or *de facto* (a wife in polygamous marriage, a wife whose husband is away for more than half of the year).

The Theoretical model for estimating gender-disaggregated risk choice

The risk behaviour of a farmer (men and women) to new technology can be viewed as a decision problem that exists when decision-makers (men and women farmers) have more than one choice available to them. The decision problem can be conceived as the selection of an action from among a set of options available to men and women farmers. Each category of farmers' according to their sex select from the available action choices (including new innovation and technology) represents their risk choice and also, depends solely upon the magnitude of the outcomes with the largest or safest outcome being preferred.

In such decision problems, as implied under the theory of farm household, besides the decision, a proper understanding of the men and women farmers makes the modelling more informative. Following the works of Udry, (1996) this study seeks to relax the tenets of the unitary model by considering the intra-household decision dynamics. The study understands that there are other members of the household who make separate decisions on plots management (Duflo & Udry, 2004). But the focus is placed on the men and women head of the household plots since they have management access. They are assumed to operate based on a safety-first framework-using behavioural rule and their expected utility. They primarily endure survival by avoiding any risk that may lead income to fall below a certain minimum threshold (subsistence level), and then make choice from available alternatives based on their expected utility. Thus, when faced with a choice between two alternative technologies in the face of climate variability and variabilities (modern versus traditional), we expect farmers (men and women plot managers) to be risk-taking to adopt the new one only if it is the safest option and the utility expected from its use exceeds that of the traditional technology. Such a decision within the household may vary between male and female managers as a result of social role.

Mathematically, the relationship between the choice and underlying variables can be shown as follows. Considering that men and women farmer who manages a given plot under this study has two alternative outcomes; i.e., improve cereal varieties denoted by "*I*" and other traditional cereal varieties "*T*", the probability (*Pr*) that either of them is chosen can be given by:

$$Pr(IT) = Pr(U_{DN} = \max(U_D, U_N) \quad (1)$$

Hence, the probability of each case being selected depends on the maximum utility *(U)* derived. Therefore, the probability that each household will choose Improved cereal varieties can be given by:

$$Pr(I > 0) = Pr(U_D > (U_N) \quad (2)$$

The utility that each man and woman plot manager derives from either of the choices (*IT*) subject to farm internal and external factors can be given as:

$$U_{DN} = f(h, i, nh) + \varepsilon \quad (3)$$

where, U represents utility, *h,* represent the components of the household (which include income, food security, etc.) *i* represent the individual characteristics of men and women (including assets, social connections etc.) and *nh* non-household-specific characteristics respectively influencing risk decision to improve varieties or not; *I* and *T* are notations as indicated earlier, and ε is the error term.

Defining Equation (2.2) in terms of equation (2.3) above we have,

$$Pr(I > 0) = Pr\ [\ (\omega I f(h, i, nh) + \varepsilon I > \omega T f(h, i, nh) + \varepsilon T)] \quad (4)$$

$$= Pr\ [(\varepsilon I - \varepsilon T) > (\omega T - \omega I)\ (f(h, i, nh))] \quad (5)$$

$$= Pr[\upsilon > f(\beta X)] = F\ (X\beta) \quad (6)$$

where, ω is weight associated with each choice, $v = (\varepsilon I - \varepsilon T)$, $\beta = (\omega T - \omega I)$, X includes *h, i, nh* and $F(X\beta)$ refers to cumulative distribution function which assumes a cumulative normal distribution when the error term is normal.

A similar pattern of choice based on the expected utility framework can be applied to the categorical dependent variable with more than two choices. The decision-maker opts for an alternative that can maximize his/her expected utility over all other possible specified choices. The risk behaviour of women and men according to Ayinde, et al., (2012) can be categorised as risk-loving, risk-averse and risk-neutral

METHODOLOGY

Study Area

Federal Republic of Nigeria is a constitutional unity of thirty six (36) States and has Abuja as the Federal Capital Territory. The country followed Tanzania as the 32nd largest nation, has a total area of 923,768 km^2 (356,669mi^2) and lies on the western part of Africa on the Gulf of Guinea. "Nigeria is a huge country with a diverse climate and terrain; it ranges from the equatorial climate of the southern lowlands (Adebayo *et al.,* 2011), through the tropical central hills and plateau, to the arid northern plains which mark the southernmost extent of the Sahara desert" (Abdulkadir, et al., 2015). The interaction between climate variables such as rainfall, temperature, soil and humidity gave Nigeria her natural vegetation zones (Oyenuga, 1967; Iloeje, 2001). Nigeria has six (6) agro-ecological zones by division. The climate is humid and semi-arid in the Southern and Norther regions respectively. The soil types and climate in the Northern and Southern states are mostly well adapted to cereal and grains production which accounts for why the bulk of grains and cereals are produced in the Northern part of the country. "About 70% of the population are engaged in agricultural production, with cocoa, peanuts and palm oil being the main cash crops. However, the largely subsistence agricultural sector has failed to keep up with rapid population growth, and Nigeria, once a large net exporter of food, now must import food" (World Bank, 2015).

Sampling Technique

From the six (6) "agro-ecological zones" of Nigeria; a division based on climate region, two (2) were randomly selected; The Derived Guinea Savannah and the Northern Guinea Savannah. Of each of these zones, three states were randomly selected. For the Northern Guinea Savannah; Kaduna, Kano and Katsina State were selected; for the Derived Savannah, Kwara, Niger and Oyo States were randomly selected. Villages in these six States were further stratified to four categories base on the IITA Stress Tolerant Maize experimental activities and the expected risk behaviour of farmers to Stress Tolerant Maize Varieties. The first stratum is the *Experimental Villages*; these are villages where STMA varieties have been tried and still being used for trials. Farmers in these villages are actively cultivating STMA varieties. The second stratum is the experimental villages *near-neighbour;* these are villages that trials were not done in their villages but have the tendencies of using the STMA variety due to proximity to experimental villages and expected technology spillage from the experimental villages into neighbouring villages.

Capturing these villages is projected to give clearer understanding of the risk behaviour of farmers in such villages. The third stratum is the *formerly experimental villages;* these are villages that experimental trials of the STMA varieties have been done in the past but have been discontinued officially by the IITA. These villages were captured to help understand if these villages are still actively planting or have discontinued planting the STMA varieties. These will also better help in understanding the risk behaviour of farmers to STMA varieties in the study area. The fourth stratum is the *control villages;* these villages are measured for at least 35km away from the experimental villages. They also have no knowledge of STMA varieties. Sampling these villages also give detailed knowledge of how farmers in these villages will behave to the STMA variety. In each of the States and 4 village strata, a random selection of 30 farmers comprising of 15 males and 15 females were selected giving a total of 120 male and female farmers per State. However, STMA activities were more intense in Kwara State, a proportionate sampling was done for Kwara State. As a result, eight (8) villages were selected across the 4 strata and a total of 30 women and men farmers per stratum making an overall sample of 240 women and men farmers in Kwara State. The total number of farmers sampled for the research equals 840 respondents.

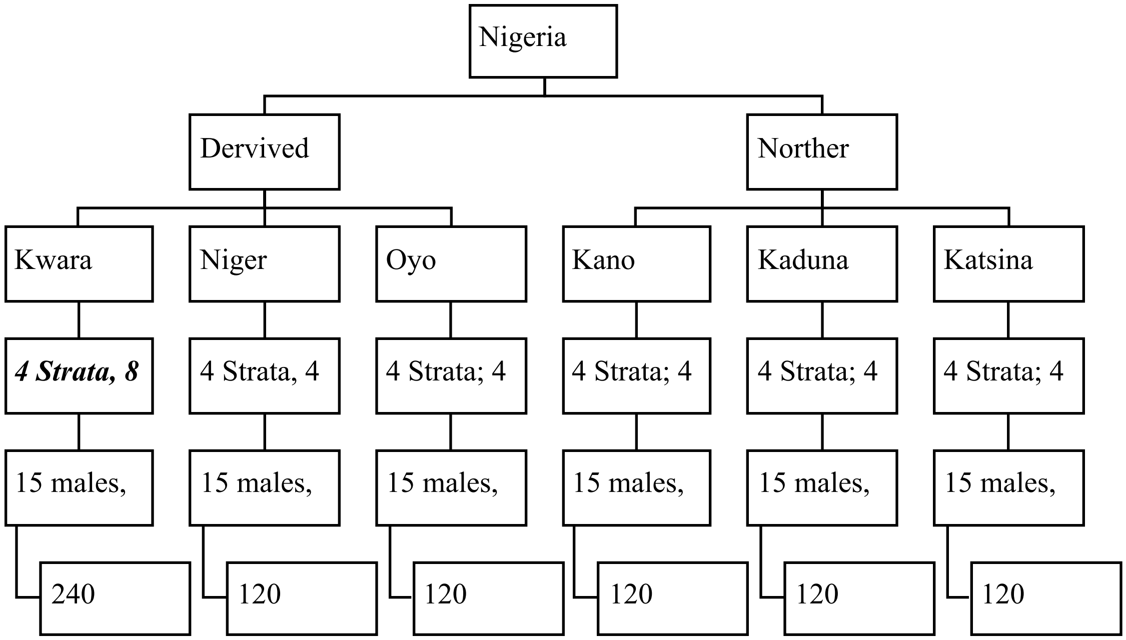

Figure 9: Diagrammatic Representation of the Sampling Procedure.

Power Calculation and Sample Size Determination.

The Sample size of the study will be determined by our own calculation of simple power calculation. According to Cohen (1988), and Murphy, Myors and Wollach (2014), the sample size for the random experiment can be determined using:

$$n = \frac{\left[\phi^{-1}(\beta) + \phi^{-1}\left(1 - \frac{\alpha}{2}\right)\right]^2}{\left[\frac{\gamma^2}{\sigma_y^2}\right]\lambda(1-\lambda)} \quad (7)$$

Where:

$\beta =$ the power of the test (probability of rejecting a true hypothesis when it is false)

$\alpha =$ the size of the test (type 1 error, probability of rejecting the true hypothesis when it is true)

$\phi^{-1}(\beta)$ = cumulative probability of standard normal variate associated with β

$\phi^{-1}\left(1-\frac{\alpha}{2}\right)$ = cumulative probability of standard normal variate associated with $\left(1-\frac{\alpha}{2}\right)$

$\sigma_y^2 =$ conditional outcome variance in each treatment assumed to be equal over the treatment levels

$\gamma =$ value of effect to be found, a substantial amount given the pre-program earnings of the individuals. (

$\lambda =$ proportion of treated units

In order to assess whether the proposed experiment has a reasonable chance of finding result of the size that one might reasonable expect, we calculate the Minimum Detectable Effect. To Calculate the sample size, we will use maize production data from the on-farm trial from 2016 to 2019 STMA project. With Minimum Detectable effect size of 1t/ha (yield for the control was estimated to be 3.5t/ha and 4.5t/ha for treatment groups) and Standard deviation of 5.04 and a power of 0.80, we required sample size of, as shown in the n calculated below, to detect the effect at standard level of confidence

In this study, β and α are to be taken according to Cohen (1988), and Murphy, Myors and Wollach (2014); $\beta = 0.8$, $\alpha = 0.05$. $\hat{\sigma}_y^2 =$ 25.407 (obtained from previous study of on-farm

trial of Stress Tolerant Maizs in the same study from 2015 2016 session); γ =1 and $\lambda = 0.6$;

Therefore,

$$n = \frac{\left[\phi^{-1}(\beta)+\phi^{-1}\left(1-\frac{\alpha}{2}\right)\right]^2}{\left[\frac{\gamma^2}{\sigma_y^2}\right]\lambda(1-\lambda)} = \frac{[0.8416+1.96]^2}{\left[\frac{1}{25.407}\right]x0.6x0.4} = \frac{7.84896256}{0.009446} = 830.93 \approx 831$$

Given this calculation of n to be 821, Our study sample size of 840 is not underpowered.

Method of Data Collection and Data Description

The data used for this study originated from primary sources, collected over a 2-phase period. The first phase was done to investigate the variety of maize and identify major simulation variables needed for the system dynamic analysis. The second phase involves the main collection of primary data with a structured questionnaire. Data collected include; Socioeconomic data, climate adaptive innovation and technology data, risk behavioural data, income data, production data, decision-making data. A pre-test were conducted before the actual administration of the questionnaire to ascertain that the survey instrument was adequate for the study before the actual field survey. Well-trained enumerators with a minimum of first degree in agriculture and the language proficiencies needed for the study area were used to administer the questionnaire through face-to-face interviews with respondents. The study ensured that plot managers within the households were interviewed and any household whose male plot manager have been interviewed were not interviewed for the female household to reduce the bias in the data. This is assumed to collect gender-disaggregated data by including the characteristics of the men and women plot managers will be interviewed separately.

Risk Behavioural Model for Plot Level Analysis as its Relate to the STMA Technology:

The Safety-first risk elicitation procedure propose that farmers always envision a level of catastrophic even in mind when making decisions. As a result, the farmer try to minimize or opmitize the level of disaster . “The safety-first criterion is used to assess the risk behaviour of farmers, as farmers’ manage to mobilize his/her productive resources and choosing among technological options depends on the security of generating returns large enough to cover subsistence needs" (Ayinde, et al., 2012).

$V = f(J_1, J_2, J_3, J_4, U)$ (9)

Where V = Maize output (kg); J_1 = Seed volume (kg); J_2 = Quantity of Herbicide (litre), J_3 = Quantity of labour (man/day); J_4 = Farm size (ha) and U = Error term

The risk behaviour of farmers are estimated using equation (18)

(10)

= y/y

Where "y is the standard deviation, is the mean of the risk situation, is the coefficient of variation $\boldsymbol{F}_1$ is elasticity of production of the i^{th} output, Ks is the risk aversion parameter estimated by percentage". The K(s) gives the "measure of risk aversion that will be derived for each farmer from the knowledge of production function, the coefficient of variation of yield, product and factor prices and observed levels of factor use". The risk-aversion estimates K(s) were then used to group the farmers into three distinct categories.

Risk-loving – $(0 < K(s) < 0.4)$

Risk-neutral – $(0.4 < K(s) < 1.2)$

Risk-aversion –$(1.2 < K(s) < 2.0)$

Logit regression analysis

logistic regression is a statistical technique used to predict the relationship between predictors (independent variables) and a predicted variable (dependent variable), the dependent variable is a binary. In the terminology of economics, it is an example if a qualitative response model. The logistic formula has each continuous predictor variable, and each dichotomous predictor variable with a value of 0 or 1, and a dummy variable for every category of predictor variable with more than two categories. This model will be used to analyze objective iv , which is to identify the factors that influence farmers adoption of STMA varieties in the study area. It can be specified as follows;

$Logit(P) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots\ldots\ldots\ldots\ldots + \beta_n X_n + U_i.$

To identify the factors that influence farmers adoption of STMA varieties ,the dependent variable which is adoption was measured using descriptive count by each respondent.

$Logit(P_t) = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} \ldots\ldots\ldots\ldots\ldots + \beta_6 X12t + U_i$

Where; (P) = Adoption of the each recommended maize technologies (Yes = 1, No.= 0)

β_0 = intercept term

$\beta_1 - \beta_6$ = logistic regression coefficient

X_1 – X12 = independent variables are the socioeconomics, institutional and technological attribute over time and U= Error term.

RESULTS AND DISCUSSION

Socio-economic characteristics of the Respondents

The socio-economic characteristics of the different farming households with male and female plot managers in the study area are presented in this section. The characteristics examined include; sex farming experience, household size, age, size of farm, farming output, religion, educational level, membership of association, extension access, and income

The study revealed that 51.76% of the respondents were male while 48.24% of the respondent were female. Considering farming as a profession where females were considered as wife of the farmer rather than as farmers themselves, the percentage probably represents a fair representation of female which can be used for gender analysis.

Age is very important in agricultural production due to the fact that it determines the physical strength of the farmer and their ability to venture into risk (Manandhar et al., 2015). The larger percentage of females (16.33%) between age bracket 0 to 25 years are more involved in maize farming as compared to 8.9% if the male. The modal age of male and female farmer is between 26 – 40 years, this represents 46.60% of male farmers and 53.27% of the female farmers. These showed that farmers cultivating maize are mostly youth. This implies that, the farmers probably have the needed energy and vigour needed for farming operation and they may be favourably disposed towards taking risk probably because of survival instinct to climate variability. The result affirms the findings of Fahad & Jing, (2018) who found that the higher the age of farmers the lower their willingness to take risk. Further statistics using the t-test also showed that difference between the age of the female and male farmers are significant in the study area.

Household Size of farmers serves as the primary labour supply for farming activities in many farming households. "The size of the household also have effect on the risk decisions of the household" (Bryan, et al., 2013). The result showed that, majority of the male and female (57.85% and 74.12% respectively) farmers have household ranging between 6 to 15 people. The mean household size for male respondent however is 9 members while the mean household size for female respondent is 7 members and further statistics using t-test revealed significant differences between the household size of male respondents and female respondents. The probable implication of the result is that, the male household have more family labour readily available for farming operations compared to the female household. “The larger the household size, the higher the probability of farming household to diversify their productions as a result of ready labour availability and hence the higher their willingness to take risk” (Van-Winsen et al., 2016).

The size of the farm is important to the farmer’s production process. It influences farmers decision and their willingness to take risk. The majority of the male and female farmers (90.16% and 97.99% respectively) revealed that majority of farmers have farm size lesser to 5ha. This agrees with the findings of Lu, Latif & Ullah, (2017) who found that increase in land size of farmer influence their willingness to take the risk of adopting contract farming. On the average, male farmers have 2.8ha of farmers compared to the female household with 1.35ha of farmers. t-statistics also showed that the amount of land available for male and female farmers are significantly difference with males having more access to land than women. “Furthermore, farmers who own and cultivate larger plots of farmland are expected to take more risk because they can spread the risk of technology failure by allocating a portion of their land to each”.

Farming experience is an important determinant in how men and women make farming decisions. It also expected that experience will influence farmers ability, especially on input usage, allocation of resources and imput combination. The analysis result showed that larger percentage of the farmers have between 6 & 15 years of farming experience. Twenty (20) years represent the average experience of the male respondents while that of the female respondents were 10 years. Further statistics showed that the male respondent’s years of experience is significantly different from the female. This showed that, comparatively, the average year of farming experience for men farmers are more than the women farmers. Findings by Van-Winsen, et al., (2016) that researched “the determinants of risk behaviour, the effects of perceived risks and risk attitude on farmer’s adoption of risk management strategies” showed that experience is a major determinant of farmer’s behaviour to risk The output of farmers is important to categorize their scale of production which in turn may influence the risk decisions of farmer. The result of the analysis revealed the average differences in the output of the male and the female respondents are 3843.04 kg and 1685 kg respectively. The analysis also showed that the male farmers’ output is significantly higher in comparison to the output of the female. This is probably due to their unequal productive resources such as land as previously shown in table (4). It could also be due to the effect of climate variability on the production process. The analysis also revealed that 4.27% of female farmers have maize output more than 5500kg as compared to about 15.93% of male respondents. The implication of lower output may mean lower agricultural income which may limit farmer’s willingness to take risk as reported by (Wainaina et al., 2012).

Educational attainment is a vital factor decision-making. It can also influence “the knowledge of farmers on variabilities and changes in climate, the possible advantages of modern farming techniques, innovations and farmer’s risk behaviour to innovations aimed at mitigating the effect of climate variability”. The analysis result indicated that the percentage of uneducated farmers are more (54.27%) among the female farming households compared to 29.04% the male farmers household. This will probably influence the knowledge of women farmers about using the STMA technology. The result confirmed the findings of Asravor, (2019) and the report of Kisaka-Lwayo, & Obi, (2012) who found that “education influence the farmer’s preference and adoption of risk management strategies”.

Farmer's participation in agricultural related group is of importance because it shows their level of social capital and knowledge sharing. It could serve as a means of pooling resources together to mitigate the influence of climate variability and could also serve as an avenue of accessing information, innovations and dividends of government policies on agriculture Majority of male farming households (54.10%) belongs to agricultural groups while majority of the female households (63.07%) does not belong to agricultural groups. The implication of this is that the benefits that group membership could provide in form of communal farming, pooling resources together, information sharing can elude the female farmers. Agustina (2016) found that farmers who belong to group have high probability of using tractor for their operation and hence increased productivity and diversification

Extension service, if accessible, is a veritable aspect of information sharing and awareness of latest technological development in agriculture. It can also serve as a way of informal education about the influence of climate variability on maize farming. The analysis result revealed that larger percentage of both the women and men farmers do not have access to extension service in the States (53.93% and 64.82% respectively). The average extension contact among the male farming household is 3 while that of female household is 2. The implication of this is that the information needed by farmers to make certain decisions related to risk preference may not be available at their disposal. This finding also agrees with the report of Meijer, et al., (2015) who found that information is a significant determinant of adoption of technologies and innovation.

The analysis perfomed on household income revealed that larger percentage of the women farmers earn lower income compared to the male farmers. A total of 64.82% of female farmers earn less or equal to ₦100,000 per season while the male farmer's majority earn between the range of ₦ 100000 and ₦ 600,000. The t-test analysis also showed that there is significant difference between the earnings of the female household compared to the male household. Higher income probably means that male farmers can diversify than the women farmers. Hence, the behaviour to take risk will risk will increase among the male farmers (Fahad & Jing, 2018).

Knowledge Differences in Climate Adaptive STMA Technologies

The knowledge of adaptive technologies for climate variabilities in maize farming is important if farmers will survive the effect of climate variabilities on their production. This section (table 1) presents the result of the analysis of the knowledge difference as well as the knowledge gap of these adaptive technologies among female and male farmers.

Many improved varieties that serves different purpose such as increase potential for higher productivity and yield have been released as a result of several intervention in maize farming by national and international bodies in Nigeria. The analysis result revealed that larger percentage of male and female farmers (78.22% and 81.91%) know the improved maize varieties that have been introduced and are available for production. The t-test result at $p<0.1$ also showed that "there is no significant difference in the knowledge of these varieties among men and women farmers in the study area". The result agree with the submission of Adimasu, (2014) for the Ethiopian Seed Association report that "there is not knowledge difference between men and women awareness of improved varieties in Ethiopia". This probably implies that women and men farmers are taking advantage of available innovations and technologies to ensure the attain productivity increase despite the pangs of climate variabilities.

Stress Tolerant Maize varieties are specifically designed to withstand climate related stress in maize farming. Such stress includes; high temperature, low rainfall, weed infestation, delayed maturity and inadequate nutrients. Although, STMA variety is also an improved variety but not all improved varieties are STMA varieties. The investigation about the knowledge of STMA varieties among farmers studied revealed that 64.64% of male farmers know STMA varieties and 63.57% of farmers know the STMA varieties. No significant difference exists at p<0.1 female and male farmer's knowledge of STMA varieties. The result probably mean that the advocacy being done by the STMA project is achieving the needed objectives in the study area. It also probably reflects the increasing capability of women and men farmers to mitigate the changes in climate conditions of the environment.

Use of STMA variety is a measure of adoption. Out of the population of farmers that have the knowledge of STMA varieties, further analysis showed that the usage of these analysis among male farmers are significantly higher (56.44%) than female farmers (46.23%) given the t-test score of 0.11 at (p<0.1). These STMA varieties come with agronomic practices that require technical knowledge to ensure that optimum productivity is achieved. Given that the socioeconomic characteristics of farmers revealed a significant lower education level compared to the male farmers, the probability of female farmers not having the technical knowledge needed for the use of the innovation may prime factor lower usage level of the STMA varieties despite being aware of the benefit of the innovation. The result comfort with the findings Kisauzi, et al., (2012) of who found that farmers have knowledge of improved variety but does not use due to adaptability issues (Gebre et al., 2019). It is also possible that the low usage of the STMA variety is occasioned by the differences in the behaviour of female and male farmers to innovation and technologies.

Table 1: Knowledge Differences in STMA

Know Improve maize variety	Male Freq	Percentage	Female Freq	Percentage	Total	t-test
No	93	21.78	72	18.09	165	
Yes	334	78.22	326	81.91	660	.037
Total	427	100.00	398	100.00	825	
Know STMA variety						
No	151	35.36	145	36.43	296	
Yes	276	64.64	253	63.57	529	.011
Total	427	100.00	398	100.00	825	
Usage of STMA	**Male**			**Female**		
No	186	43.56	214	53.77	400	
Yes	241	56.44	184	46.23	425	0.10**
Total	427	100.00	398	100.00	825	
Know Other Climate adaptive Technologies	**Male**		**Female**		**Total**	
No	410	96.02	385	96.73	795	0.007
Yes	17	3.98	13	3.27	30	
Total	427	100.00	398	100.00	825	
Know other Maize Technologies	**Male**		**Female**		**Total**	
No	363	85.01	337	84.67	700	
Yes	64	14.99	61	15.33	125	0.003
Total	427	100.00	398	100.00	825	

Source: Filed Survey, 2019

To further understand other farmers knowledge that could foster adaptation as relate to adoption of STMA, the result of farmer's knowledge of other climate adaptive technologies and maize technologies revealed that these knowledges are low among farming households. This may imply that there is probably a need for advocacy to raise farmer's awareness of available innovations and technologies that are crucial to mitigate the effect of climate variability on maize production in Nigeria.

Risk Behaviour of Maize Farming Household in Nigeria

To better grasp the variation in the technological behaviour of women and men maize farmers to STMA varieties in the study area, a simple ordinary least square regression analysis was performed to understand the output-input relationship of the production process. Based on Safety-first principle of risk elicitation, to model farmer's behaviour, it is assumed that the most significant production input will be the first consideration of farmers in making production related decisions. Therefore, the most important variable was used as the basis of modelling the male and female behaviour using the plot-level Safety-first approach (Sadiq, et al., 2018; Ayinde, 2008).

Table 2: Regression result of the Output-input production process for Male Farmers

Maize Output	Coefficient	Standard Error	t	Sig.
(Constant)	1161.967	785.739	1.479	.141
STMA Seed (kg)	17.117	8.475	2.020	.045
Herbicide (litres)	-.628	.499	-1.258	.210
Farm Size (ha)	938.741	138.544	6.776	.000
Labour (Man/day)	3.032	28.128	.108	.914
R-squared = 0.78	Adj R-squared = 0.69	Prob > F = 0.00		

Source: Filed Survey, 2019

Table 3: Regression result of the Output-input production process for female farmers

Maize Output	B	Std. Error	t	Sig.
(Constant)	1177.503	409.787	2.873	.005
STMA Seed (kg)	.177	1.740	.102	.919
Herbicide (litres)	-.203	2.908	-.070	.944
Farm Size (ha)	340.167	109.151	3.116	.002
Labour (Man/day)	5.716	12.949	.441	.660
(Constant)	Adj R-squared	Prob > F		
0.72	0.63	0.0470		

Source: Filed Survey, 2019

The regression result (Table 8 and 9) showed that farm size is the most significant variable of production of STMA variety. This variable was now used in the risk elicitation procedure

Table 4: Result of the Safety-first Principle of Male Farmer's risk behaviour

Male	Frequency	Percentage
Risk Preferring	42	9.8
Risk Neutral	385	90.2
Risk Averse	0	0
Total	**427**	**100**

Source: Filed Survey, 2019

Table 5: Result of the Safety-first Principle of Female Farmer's risk behaviour

Female	Frequency	Percent
Risk Preferring	39	9.8
Risk Neutral	359	90.2
Risk Averse	0	0
Total	**398**	**100**

Source: Filed Survey, 2019

The result of the risk modelling when categorized into behavioural characteristics in tables 5 and 11 showed that a small percentage of farmers (9.8% of both male and female plot managers) are risk preferring. However, contrary to *a priori* expectation, none of the farmers surveyed are risk-averse. The larger percentage of both male (90.2%) and female (90.2) plot managers in the household are risk-neutral. This result, although vary with *a priori* expectation where farmers have been reported in literature to be risk-averse (Sadiq, et al.,2018), it corroborate the findings of Asravor, (2019). Sadiq, et al., (2018) found that all the farmers surveyed in Benue State Nigeria in their analysis of measuring yam farmer's risk behaviour were risk averse. Asravor, (2019) however found that, risk-averse farmers behave differently at the imminent threat of market risk. The result of the findings concluded that already risk-averse farmers will take the risk of using improved seed varieties and inorganic fertilizer in Ghana. The result probably showed that both men and women farmers now see climate variability as a threat and they understand the risk posed by climate variabilities. As a result, they probably have realised that practicing maize production using the same method and input may not be the way to survive the onslaught of negative effects the climate variability risk may pose. The result also showed that farmers are not necessarily averse to technological adoption, especially when the benefits of such technology is evident to their production process.

Gender Disaggregated Determinants of Risk Behaviour Among Farmers

Before disaggregating the data by sex category, sex variable was included in the equation to analyze the data pooled and analysed to investigate if the Sex variable is significant in the equation. The analysis result presented in (table 12) revealed that Sex is a significant variable at $p<0.5$ in the model. The data were therefore disaggregated to understand the determinants of risk behaviour according to sex category.

Table 12: Pooled Determinant of Risk Behaviour of Men And Women Farmers

Equation	RMSE	Chi^2	P
Risk Score	0.218617	11.38	0.0181
Climate Variability	0.164729	21.91	0.0005
Price of STMA Seed	1.789535	34.61	0.0000

Risk Score	Coef.	Standard Error	Z	P>z	[9 5 % Confidence	Interval]
Age	0.073	0.049	1.49	0.137	-0.023	0.170
Sex	-0.052	0.034	-1.54	0.023	-0.118	0.014
Household Size	0.001	0.020	0.07	0.944	-0.038	0.041
Access to climate information	-0.065	0.033	-1.96	0.050	-0.130	2.74E-05
Household Income	-0.015	0.014	-1.02	0.306	-0.043	0.014
Price of other Seed	-0.004	0.026	-0.14	0.889	-0.054	0.047
Level of Education	-0.012	0.014	-0.88	0.377	-0.040	0.015
Climate Variability Index	-0.271	0.269	-1.01	0.314	-0.797	0.256
Constant	0.764	0.327	2.33	0.02	0.123	1.405
Climate Variability Index						
Output	-0.040	0.012	-3.38	0.001	-0.063	-0.017
Herbicide	7.26E-05	0.000	1.19	0.234	-4.7E-05	0.000
Price Labour	-0.028	0.012	-2.25	0.025	-0.052	-0.004
Credit availabiltiy	0.079	0.029	2.69	0.007	0.021	0.136

Labour Availability	-0.017	0.027	-0.63	0.528	-0.071	0.036
Constant	0.696	0.113	6.17	0.000	0.475	0.917
Price of STMA Seed						
Risk Score	4.719	1.525	3.09	0.002	1.729	7.709
Climate Variability Index	-3.817	1.726	-2.21	0.027	-7.200	-0.433
Farming Experience	-0.205	0.170	-1.21	0.227	-0.539	0.128
Price of Herbicide	0.494	0.153	3.23	0.001	0.194	0.794
Price of Insecticide	0.185	0.149	1.25	0.212	-0.106	0.477
Expected Income	-0.091	0.085	-1.07	0.284	-0.258	0.076
Constant	1.362	1.499	0.91	0.364	-1.577	4.300

Source: Filed Survey, 2019

Disaggregated Determinant of Risk Behaviour of Men Farmers

The robust mean square estimate probability of Chi^2 showed that the 3SLS model fitted for the risk score at the first state, climate variability at the second stage and were "significant at $p<0.5$, $p<0.5$ and $p<0.1$ respectively". This indicate that the model fitted is sufficient to predict the accurate estimation of the exogenous variables.

At the first stage of the equation for the male plot manager in table 13, the analysis result revealed that education level and climate variability were the significant variable that affect the farmers risk behaviour. The result further revealed that education is an important determinant for male farmers in taking risk. At 5% level of significance, the result revealed that "a unit marginal increase in the level of education of farmer will lead to a higher 7% chance of male farmers taking risk". This also agree with the findings of (Asravor, 2019). The result also showed that at 5% significant level, a unit increase in climate variability will reduce farmer's willingness to take risk by 2% (Gebre et al., 2019). The second stage estimation of the equation explained the determinant of farmer's view of climate variability. The analysis result showed that output and the labour price paid were the significant variables at 5% and 1% respectively. The result revealed that, 0.34% reduction in output is probably caused by a unit increase in climate variables. The result is also in agreement with the report of Ayinde, et al., (2010) and the submission of Anand & Khetarpal, (2015) who found that increase change in climate variables reduces the output of farmers. The analysis result further revealed that, a marginal unit increase in climate variable will lead to 0.41% increament in the price of labour that will be engaged for farming operation. The result affirmed the outcome of the work of Lee, et al., (2017) who found that increase in temperature affect labour supply in agriculture. The third stage equation explained the role of STMA in risk behaviour, the analysis result further revealed that the farmers' willingness to take the risk of using the STMA seed. The result of the third-stage, at 1% level of significance showed that the risk behaviour of men farmers is the sole reason for their "willingness to pay for the seed of the STMA varieties". A unit increase in their risk behaviour will lead to 7.43% increase in the use of STMA variety. Generally, the result showed that the determinants of risk behaviour were, level of education, climate variability perception, the output of the farmers as well as the price paid for labour activities on the farm

Table 13: Disaggregated Determinant of Risk Behaviour of Men Farmers

Equation	RMSE	chi2	P
Risk Score	0.247287	17.04	0.0171
Climate Variability Index	0.165639	11.28	0.0462
Price of STMA Seed	2.288487	20.56	0.0022

Risk Score	Coef.	Standard Error	Z	P>z	[95% Confidence	Interval]
Age	0.056	0.097	0.58	0.563	-0.134	0.247
Household Size	0.008	0.031	0.25	0.801	-0.053	0.068
Access to climate relate information	-0.040	0.041	-0.97	0.332	-0.120	0.041
Household Income	0.294	0.358	0.83	0.407	-0.401	0.989
Price of other Seed	-0.008	0.018	-0.47	0.641	-0.042	0.026
Level of Education	0.073	0.027	2.70	0.007	0.020	0.127
Climate Variability Index	-0.003	0.019	-0.13	0.019	-0.040	0.035
Constant	-0.058	0.370	-0.16	0.875	-0.782	0.666
Climate Variability Index						
Output	-0.034	0.017	-2.02	0.043	-0.067	-0.001
Herbicide	-0.001	0.002	-0.54	0.590	-0.005	0.003
Price Labour	0.041	0.016	2.61	0.009	0.073	0.010
Credit availability	-0.010	0.042	-0.24	0.808	-0.092	0.071
Labour Availability	0.014	0.041	0.34	0.735	-0.067	0.095
Constant	0.719	0.164	4.40	0.000	0.399	1.040
Price of STMA Seed						
Risk Score	7.430	1.743	4.26	0.000	4.015	10.846
Climate Variability Index	-3.428	2.911	-1.18	0.239	-9.132	2.278
Farming Experience	-0.259	0.263	-0.98	0.325	-0.775	0.257
Price of Herbicide	0.102	0.215	0.48	0.634	-0.319	0.523
Price of Insecticide	0.268	0.220	1.22	0.222	-0.162	0.698
Expected Income	-0.005	0.126	-0.04	0.968	-0.253	0.242
Constant	1.1581	2.142	0.54	0.589	-3.041	5.357

Source: Filed Survey, 2019

variety". Also, at $p<0.1$, a unit increase in herbicide price will influence the female farmer's willingness to risk the use of STMA variety in the study area.

Factors influencing farmers adoption of STMA varieties

Table 8: The Factors Influencing Farmers Adoption of STMA Varieties

Adopt STMA	**Coef.**	**Std. Err.**	**z**	**P>z**	**[95% Conf.**	**Interval]**
Farming Experience	-0.011	0.006	-1.870	0.062	-0.023	0.001
Years of Schooling	0.049	0.013	3.930	0.000	0.025	0.074
Farm size	-0.030	0.019	-1.610	0.107	-0.067	0.007
Farming Association Membership	0.640	0.123	5.190	0.000	0.398	0.881
Access to Extension	0.695	0.122	5.710	0.000	0.456	0.934
Household Size	0.073	0.016	4.470	0.000	0.041	0.105
Gender	-0.388	0.112	-3.460	0.001	-0.608	-0.168
time thread	-0.030	0.077	-0.390	0.696	-0.182	0.122
_cons	-0.618	0.302	-2.040	0.041	-1.211	-0.026
Prob > chi2 = 0.0000; LR chi2(7) = 173.50; Number of obs = 1303						

Conclusion and Recommendations

The research established that, given the challenges created by climate variability, the farming household cannot be viewed as risk averse. In term of knowledge, both the men and women farmers are neither different in their production knowledge of maize nor vary in their adaptability procedures. In order to ensure a comprehensive mitigation procedure through adoption of STMA, women farmers are not to be neglected

Men and women smallholders should also be motivated to get involved in extension/ dissemination programmes and trainings, especially the younger and agile farmers who still have the strength to take risk that can in turn help in boosting their production through the adoption of STM technology.

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