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Risk Analysis in Innovation System: A Case Study of Production of Vitamin A Cassava Variety among Farmers in Oyo State, Nigeria.

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Abstract: Every innovation is targeted towards adoption - a process which involves several levels of risks. Bio-fortified vitamin A cassava variety is an innovation targeted not only to solve the yield of farmers but to increase the nutritional intake of Nigerian household. The research specifically seeks to investigate the risks involved in the adoption of vitamin A cassava variety, the risk attitude of cassava farmers, and the factors that affect farmers' risk attitude to the production of vitamin A cassava. A three-stage random sampling procedure was used to select 240 farmers used for the study. Descriptive statistics, Likert scale, safety first utility approach and ordinary least square regression model were used for the analyses. The study revealed that the risks that are involved in the adoption of the cassava variety include animal invasion, price fluctuation, and poor storage facilities. The majority of the farmers were risk-neutral while only 16% were risk-takers. The study further revealed that the significant determinants of risk attitude among farmers were age, income from other activities and estimated annual income. It is therefore recommended that efforts should be geared toward making adequate vitamin A bio-fortified cassava varieties available to young farmers, grazing reserved should be provided to reduce the risks and efforts should be intensified to reduce price volatility for improved Vitamin A cassava.

Keywords: Innovation, Nigeria Risk, Vitamin 'A' Cassava.

1. Introduction

Cassava (*Manihot esculenta*) is an important crop in Africa, as more than 250 million Africans rely on the starchy root crop as their staple source of calories (Sayre *et al*., 2011). The importance of cassava to resource-poor farmers in Nigeria cannot be overemphasized. The latest data available on the Food and Agricultural Organization database showed that Nigeria is the world's largest producer of cassava with production at 54.8 million metric tons and an average yield of 48.2 tons/ha (FAOSTAT, 2017). A typical cassava-based diet, however, provides less than 30% of the minimum daily requirement for the protein and only 10%-20% of that for iron, zinc, and vitamin A. Vitamin A deficiency (VAD) is widely prevalent in Sub-Saharan Africa. VAD can lower immunity and impair vision, which can lead to blindness and even death (Tumuhimbise et.al., 2013). It is scientifically agreed that innovation holds the key to combat the prevalence of VAD and also increase farmers' productivity considering the importance of cassava in Nigerian's diet (Hotz and McClafferty, 2007).

Innovation is a key element in the sustainability of any industry. Innovation is not just a discovery of new knowledge, or development of new product, procedure or services, but a process where we can find all the elements from research to service and all these have an integrated effect on the collective aim of the element, most especially aimed at solving problem(s) (Ayinde et. al., 2012a; Morton et. al., 2006; Drucker, 1998; Lundvall 1992). According to Diagne et.al. (2009), agricultural innovation development in Nigeria led to the creation of

agricultural technology centres aimed at breeding improved seeds of crops - early maturing, high yielding, resistant to pests and diseases and are adaptable to the local environment. This is channeled to bring about improvement in socio-economic status and the quality of life (Nwabu et. al, 2006).

Vitamin A bio-fortified cassava variety is a new innovation in cassava production in Nigeria. It was released in to address the problem of VAD among the growing population and maintain its lead as the world's largest producer of the root crop and improve incomes of farmers. Both varieties now known as UMUCASS 42 and UMUCASS 43 are reported to have performed well in different cassava production regions of Nigeria with high yield, high dry matter, and good disease resistance (Lukuyu, et.al., 2014).

Every innovation is targeted towards adoption. However, in real life, many of the choices farmers make; including the adoption of innovation involve considerable uncertainties and risks (Das and Sarker, 2008). Agricultural risks are prevalent throughout the world and they are particularly burdensome to small-scale farmers in developing countries (Ayinde, 2008). Some still believe that rural households are risk averse; especially in the face of a new technology (Ayinde et. al. 2012a). Considering the potential benefit of Vitamin A bio-fortified cassava variety on Nigerian diet and farmer's productivity, it is important to investigate; (i) the risks involved in the adoption of vitamin A cassava variety by cassava farmers; (ii) the risk attitude of cassava farmers; and (iii) the factors that affect farmers' risk attitude to the production of vitamin A cassava in the study area. Adequate knowledge of these objectives will enhance ready adoption of this innovation which will facilitate the realization of the objective of the development of these cassava varieties.

2. Methodology

This study was carried out in Oyo State, Nigeria. The state is composed of three local government Areas. The State lies between longitude 3° and 5° E and latitude 7° and 8° N and covers an area of approximately 26,500 km^2. The state enjoys a tropical humid climate with two climatic seasons. The climate in the state favours the cultivation of crops like maize, yam, cassava, millet, rice etc. The data were collected using three-stage random sampling technique. The first stage involved purposive selection of all the zones in Oyo state ADP (Oyo state ADP have four zones). The zones were purposively selected because cassava cultivation is prominent in the areas. The second stage involved random selection of one local government area from each zone. The third stage involved random selection of six villages from each local government area. The fourth stage involved random selection of 10 respondents in each village, giving a total of 240 respondents which constitute the sample size for the study in villages where the Vitamin A cassava adoption was promoted. The data collected were collected during the 2015 cropping season in the study area

Analytical Techniques and Model Specifications

The data were analysed with descriptive statistics Likert scale, safety first principle and the ordinary least square regression. They were used to determine the risks involved in the adoption of innovation; investigate the risk attitude of farmers as well as the factors that determine farmer's risk attitude.

In the risk analysis, there have been series of decision theories used in analyzing and measuring the 'riskiness' of a decision in the farm. The earliest of these theories is Bernoullian decision theory (1738). This represents a normalized approach of risk choice based upon the decision maker's personal strength of belief or subjective probability about the occurrences of uncertain events and personal valuation or utility of potential consequence (Dillion, 1971). The Bernoullian decision theory suggests that the optimal behaviour of the decision maker is that which maximizes expected utility and is cardinal measurable. This means that the decision maker should maximize his expected utility. The expected utility model provides a single valued

index, which orders action choices according to the preferences of the decision maker.

Direct elicitation of the utility function has been emphasized in a series of studies (Dillion and Scandizzo,1978; Hildreth and Knowles 1982; Lindley, 1985; Lichenstein, Fisch-off, and Philip, 1982; Fackler 1991; Van Lenthe 1993).Fackler (1991) proposed an alternative means of getting utility function through median deviation concordance probabilities. Ellis (2000) and Ayinde et.al. (2012b) used income variance approach to analyzing farmers' production decision behavior under risk and categorized them as follows: **- Risk-preferring/loving/taking**: a person is willing to take the risk of doing better than expected while being aware of the possibility of doing less-well than expected - **Risk-neutral**: a risk neutral person is indifferent be-tween certain and uncertain outcomes with the same expected value of income - **Risk-averse**: a person is described as being risk averse if he prefers a situation in which a given income is certain to a situation yielding the same expected value for income but which involves uncertainty. According to Safety-first criteria, investors have some disaster level in their minds and try to optimize or minimize the disaster level. Besides, the safety first criterion is used to assess the risk attitude of farmers, as farmers‟ management to mobilize his/her productive resources and choosing among technological options depends on the security of generating returns large enough to cover subsistence needs (Moscardi and de Janvry, 1977; Olarinde et al., 2007; Ayinde et al 2012b).

$Y = f(X)$

$Y = f(X_1, X_2, X_3, X_4, U)$

Where Y = output (kg); X_1 = Quantity of vitamin A cassava stem planted (kg); X_2 = Quantity of labour (man/day); X_3 = Quantity of pesticide (litre); X_4 = Farm size (ha); U = Error term

Then,

$K(s) = 1/ø\ [1-(PiXi/\ Py\boldsymbol{f}iUy)] = y/x$

Where y is standard deviation, is the mean of the risk situation, is the coefficient of variation $\boldsymbol{F}_1$ is the elasticity of production of the ith output, Ks is the risk aversion parameter estimated by percentage. K(s) provides a 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 parameters K(s) was used to classify farmers into three distinct groups;

Risk preferring – low risk – $(0 < K(s) < 0.4)$

Risk neutral – intermediate risk – $(0.4 < K(s) < 1.2)$

Risk aversion – high risk – $(1.2 < K(s) < 2.0)$

Ordinary Least Square Regression

$Y = f(X_1, X_2, X_3, ... X_7, U)$

Where Y = Risk parameter Ks; X_1 = Age; X_2 = Cost of Labour; X_3 = Income from other activities; X_4 = Primary occupation; X_5 = Farm size (ha); X_6 = Household size; X_7 = Estimated annual income; U = Error term

3. Results and Discussion

Socioeconomic Characteristics of Cassava Farmers

The socioeconomic characteristic of cassava farmers in the study area is presented in Table 1. It showed that 50.8% of the respondents were old. This implies that it is the elderly farmers that are mostly engaged in the cultivation of vitamin A cassava in the study area. It is expected that the impact of age will influence their risk attitude (Ayinde et.al 2012b). About ninety-one percent of the vitamin A cassava farmers were male while the remaining 9.2% are females. Ninety percent of the farmers were married, only 3.3% of the farmers are single, 1.7% of them are divorced while the remaining 5% are widowed. 68.3% of the cassava farmers have a household size ranging from 1 – 6. The majority of farmers 65% have a farm size of between 6 and 10 ha; majority of them uses hired labours (74.2%). The socioeconomic characteristics of farmers is expected to affect their rational choice in the face of risk (Ayinde, 2008). The marital status of farmer and their household levels means they have responsibilities to provide for their home and manage the home resources, this will likely affect

the way day take risk, the lower education level also is likely to mean they may be reluctant to make risky decision but tend more to "play-safe".

Table 1. Socioeconomic characteristics of vitamin A Cassava farmers

Age	**Frequency**	**Percentage**
≤ 30	8	3.3
31 - 50	110	45.8
51 – 70	122	50.8
Total	240	100
Marital Status	**Frequency**	**Percentage**
Single	8	3.3
Married	216	90
Divorced	4	1.7
Widowed	12	5
Total	240	100
Household Size	**Frequency**	**Percentage**
1 – 6	164	68.3
7 – 12	76	31.7
Total	240	100
Farm Size (ha)	**Frequency**	**Percentage**
≤ 5	44	18.3
6 – 10	156	65
11 – 15	40	16.7
Total	240	100
Type of Labour	**Frequency**	**Percentage**
Family Labour	2	0.8
Hired Labour	178	74.2
Family and Hired Labour	60	25
Total	240	100
Income	**Frequency**	**Percentage**
≤ 100000	30	12.5
100,000 – 300,000	122	50.8
300,001 – 500,000	72	31.0
≥ 500,000	16	6.7
Total	240	100

Risks faced by Vitamin A cassava farmers

The risk facing farmers are presented in Table 2. The major risk faced by vitamin A cassava farmers was the invasion of animals on their farm, especially cow, which has been attributed to the presence of the Fulani nomads leading their cows to graze in their quest of looking for pasture. The second major risks being faced by the farmers are price fluctuation of farm produce and poor storage facilities for the produce, a similar finding was reported by (Olarinde, et.al, 2007). Adequate storage is important for maintaining quality, improper storage and the perishable ability of Vitamin A cassava will engender its sale at unstable prices leading to low farmers' income. Other risks facing the farmers are poor road network to transport their goods from the production site to the selling place, lack of adequate capital to get all the necessary things that will aid their production process, lack of processing facilities (Giroh et.al., 2013). The risks with fewer occurrences are lack of awareness about the product among people, unavailability of improved technology, inadequate access to planting materials, non-availability of readymade market for the produce, infestation of diseases and pest and theft.

Table 2. Sources of risks faced by vitamin A cassava farmers

Risks	5	4	3	2	1	Ranking	
	VS	**S**	**MS**	**LS**	**NS**		
Animal invasion (cow)	228(570)	0(0)	0(0)	0(0)	0(0)	570	1st
Price fluctuation of farm produce	218(545)	10(20)	0(0)	0(0)	0(0)	565	2nd
Poor storage facilities	218(545)	10(20)	0(0)	0(0)	0(0)	565	2nd
Poor road network	214(535)	7(28)	0(0)	0(0)	0(0)	563	4th
Lack of adequate capital	224(560)	0(0)	0(0)	0(0)	2(1)	561	5th
Lack of processing facilities	204(510)	24(48)	0(0)	0(0)	0(0)	558	6th
Low awareness about the product	94(235)	62(124)	72(108)	0(0)	0(0)	467	7th
Scarcity improved technology	130(325)	12(12)	48(72)	26(26)	0(0)	435	8th
Low access to planting materials	68(85)	0(0)	64(96)	126(126)	8(2)	309	9th
Non availability market	6(15)	12(24)	102(153)	52(52)	54(27)	271	10th
Infestation of diseases	0(0)	0(0)	6(9)	152(152)	70(35)	196	11th
Theft	0(0)	0(0)	0(0)	58(58)	170(85)	143	12th

VS- Very Severe; S-Severe; MS: Moderately Severe; LS-Less Severe; NS-Not Severe

Risk Attitude of vitamin A cassava farmers in the study area

The R^2 value reveals that the variables involved in the production process can explain about 87.5% of what happens in the overall production of the vitamin A cassava in the study area. From the table, the quantity of vitamin A cassava stem planted is significant at 1% and this implies that a unit increase in the quantity of vitamin A cassava will add about 91.7% increase to the overall output of the production process. Farm size is also significant at 5% and this also implies that as more land is added for the production of the vitamin A cassava, there will be about 12.8% increase in the overall output of the production process. The main factor needed in the production is the cassava stem cuttings that will be planted because it's the most significant factor.

Farmers risk was calculated from the estimated production function using marginal product together with the coefficient of variation and prices of both input and output. The risk aversion parameter was used to classify farmers following the categorization of risk level by Moscardi and de Janvry (1977) and Olarinde et al (2007). Farmers are said to be low risk if $0<K<0.4$, risk neutral if $0.4\leq K\leq 1.2$ and high risk or risk averse if $1.2<K<2$. The result shows that most of the farmers fall in the risk neutral/indifferent group and this seems to be at odds with previous findings in the literature that reported that most farmers are risk averse. (Moscardi and de Janvry, 1977; Olarinde et al., 2007; Ayinde et.al 2012b).

Risk attitude of Farmers

As shown in Table 4, most (88.3%) of the farmers are risk indifferent or risk neutral, 6.7% of the farmers are risk preferring while only 5% are risk averse. This implies that most of the farmers can decide either to take the risk or not and this may depend on some factors or individual perception about the risk situation. Some of them are willing to take the risk whatever it entails while the smaller proportions are are not willing to take a risk at all no matter what is involved. This same result was reported by Dadzie and Acquah (2012) who got that majority of food crop farmers are risk averse

Table 3. Safety first principle of resource use

Variables	B	Std Error	t	Sig.
(constant)	-1.103	1.836	-0.601	0.549
Quantity of Vitamin A stem cutting	0.917***	0.037	24.907	0.000
Quantity of labour used	0.255	0.228	1.119	0.265
Quantity of pesticide	-0.018	0.102	-0.173	0.863
Farm size (ha)	0.128**	0.169	0.761	0.048
$R^2 = 0.875$; *** - significant at 1%, ** - significant at 5%				

Table 4. Risk attitude of farmers

Risk Group	Frequency	Percentage
Risk Preferring 0<K(s)<0.4	16	6.7
Risk Neutral 0.4<K(s)<1.2	212	88.3
Risk Averse 1.2<K(s)<2.0	12	5
Total	240	100

Source: Field Survey, (2015)

Factors affecting farmers' attitude towards risk taking

The behaviour of farmers towards risk is influence by several factors. These factors are presented in Table 5. It showed that age, income from other activities and estimated annual income have a significant effect on farmers' attitude towards risk taking (Dadzie and Acquah,2012). Age and income from other activities have negative values, implying that as the variables increase, there will be a proportionate decrease in farmers' willingness to take the risks. This also can be verified from the socioeconomic characteristics result obtained which showed that the majority of the farmers were old. Estimated annual income has a positive value, suggesting that as income from vitamin A production increases, the farmer will be more willing to take risks so as to get more income.

Table 5. Factors affecting farmers' attitude towards risk taking

Variables	B	Std Error	T	Sig.
(constant)	2.277	0.549	4.144	0.000
Age	-0.009**	0.172	-0.074	0.041
Cost of labour	-0.113	0.000	-0.623	0.535
Income from other activities	-0.026*	0.000	-0.142	0.087
Primary occupation	0.035	0.154	0.304	0.762
Farm size (ha)	-0.046	0.032	-0.396	0.693
Household size	-0.052	0.058	-0.415	0.679
Estimated annual income	0.113**	0.000	1.026	0.007

** - significant at 5%, * - significant at 10%; $R^2 = 0.73$, Adjusted $R^2 = 0.68$

4. Conclusions and Recommendations

Innovation is the key to solving productivity challenges among cassava farmers in Nigeria. However, before any innovation can be adopted, farmers will make rational decisions to examine their choices whether it fit into their production decisions. These decisions are made according to risk behaviour of farmers. The study in an attempt to investigate the risk behaviour of Vitamin A, cassava reveals that risks involved in adoption of the cassava variety include animal invasion, price fluctuation, and poor storage facilities; risk attitude of farmers showed that majority of the farmers are risk neutral; probably late adopters while age, income from other activities and estimated annual income are the determinants of risk behaviour of cassava farmers in the study area. As a result of the analysis obtained in the study, the study recommended that price stability of technologically improved crops should be addressed by policy makers. To forestall conflicts among farmers and nomads, government should provide grazing reserves for nomads. Farmers and youths should be encouraged through agricultural empowerment programmes to participate more in agriculture and create awareness in order to facilitate the adoption of new cassava technology in Nigeria.

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