Risk analysis in innovation system: a case - study of production of Vitamin A cassava variety among farmers in 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. 4-stage random sampling procedure was used to primarily select 240 farmers; descriptive statistics, Likert scale, Safety first utility approach and ordinary least square regression model were the tool of analysis. The study revealed that risks involved in adoption of the cassava variety include animal invasion, price fluctuation, and poor storage facilities. Majority of the farmers 88.3% are risk neutral, only 16% are risk takers; it also revealed that age, income from other activities and estimated annual income are the determinants of risk attitude. It is therefore recommended that; effort should be geared toward making adequate vitamin A bio-fortified cassava varieties available to young farmers; grazing reserved should be provided to reduce the risk and effort should be intensified to reduce price volatility for improved products

Keywords: Innovation, Nigeria Risk, Vitamin ‘A’ Cassava.

INTRODUCTION

Cassava is an important crop in Africa. More than 250 million Africans rely on the starchy root crop cassava (Manihot Esculenta) as their staple source of calories (Sayre *et al*., 2011). The importance of cassava to resource-poor farmers in Nigeria cannot be overemphasized. Currently, Nigeria is the world's largest producer of cassava. The total area harvested in 2009 was 3.13 million hectares (ha), with production estimated at 36.8 million metric tons and average yield at 11.7 tons/ha (FAOSTAT 2010). 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 is widely prevalent in Sub-Saharan Africa. It afflicts almost 20% of pregnant women and about 30% of children under-five in Nigeria. Vitamin A deficiency (VAD) can lower immunity and impair vision, which can lead to blindness and even death. It is scientifically agreed that innovation holds the key to combat the prevalence of VAD and also increase farmer's 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. It is carried out through generation of processes and services that are nurtured by competitive production leading to high-value products. Innovation is a purposeful focused change, an on-going process of learning, searching and exploring, which result in new products, new techniques, new forms of organization and new markets. It is not just a discovery of new knowledge, not just the development of new product, procedure or services, but it is all of the above. It is 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 aim at solving problem(s) (Ayinde et. al., 2012a; Morton et. al., 2006; Drucker, 1998; Lundvall 1992).

The development of agricultural innovation in Nigeria led to the creation of agricultural technology centre or agricultural research institutes; and the major role is to breed improved seeds of crops that are early maturing, high yielding, resistant to pests and diseases and are adaptable to local environment to increase the value of locally produced crops, generate local employment, stimulate local cash flow, and through processing, marketing, and related activities can bring about improvement in socio-economic status and the quality of life (Diagne et. al., 2009; 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 Vitamin A deficiency 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 is expected to perform well in different cassava production regions of Nigeria with high yield, high dry matter, and good disease resistance.

Every innovation is targeted towards adoption. However, in real life, many of the choices farmers make; including 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) and considering the potential benefit of Vitamin A bio-fortified cassava variety on Nigerian diet and farmer's productivity, it is important to investigate; the risks involved in the adoption of vitamin A cassava variety by cassava farmers; the risk attitude groups of cassava farmers; and 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.

LITERATURE REVIEW

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 suggested that the optimal behaviour of the decision maker is that which maximized expected utility and is cardinal measurable. 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.

In 1947, Von Neuman and Morgenstern demonstrated that the utility concept follows logically a set of assumptions or axioms about the individual's behaviour. The set of axioms is summarized as follows:

(i.) Rationality in ordering of choice: Prefers A_1 to A_2 or indifferent.

(ii.) Transitivity among choices: If A_1 is preferred to A_2, and A_2 is preferred to A_3, then A_1 must be preferred to A_3.

(iii) Substitution among choices: If A_1 is preferred to A_2 in some other choices,

then a choice is $P(A_1) + (1\text{-}P)A_3$ where P is the probability of occurrence.

(iv) Certainty equivalent among choices: If A_1 is preferred to A_2, and A_2 is preferred to A_3, then some probability (1-P). Thus A_2 is the certainty equivalent of $P(A_1) + (1\text{-}P)A_3$.

According to Bernoulli's principle if a decision maker obeys these axioms, there exists a utility function U(A) which reflects the decision maker's preference among different alternative outcomes. If the alternative outcomes represent different levels of income U(Z), then the result is a utility function for the outcome U(Z). When enough utility values are available from repeated gambling questions, a utility index or function can be fitted to those values using graphical or statistical procedures. Graphically, a farmer's attitude to risk is inferred from the shape of his utility function as the shape of the utility function implies risk attitude. In figure 1, the concave segments of the function indicate changes in risk attitude for different monetary outcomes.

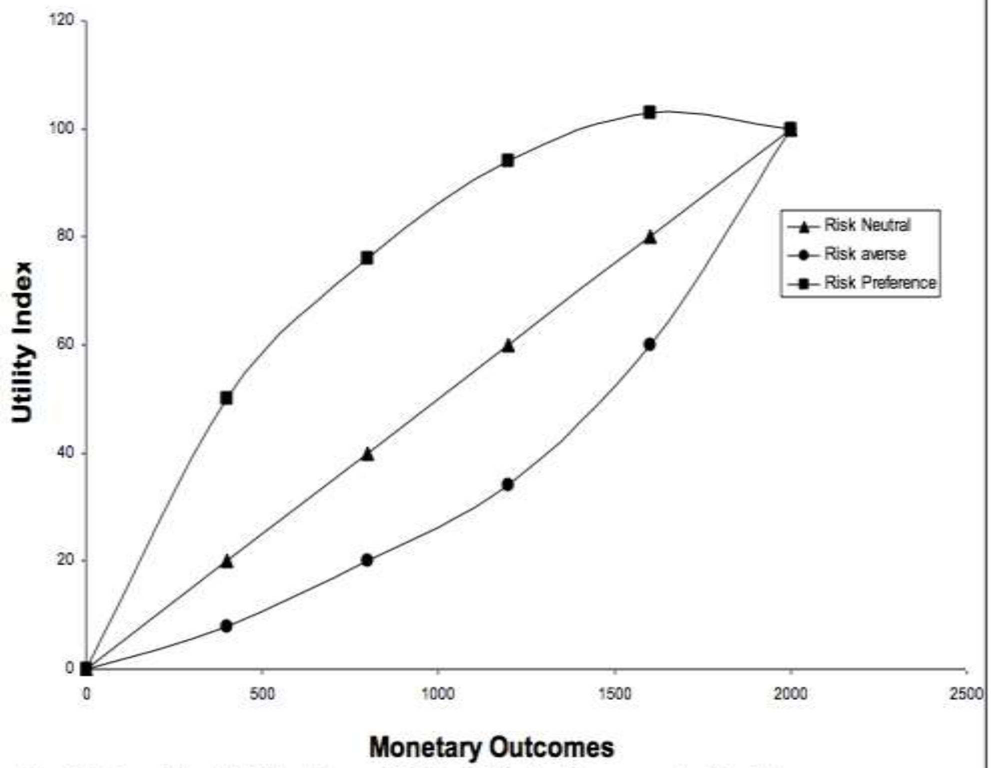

Fig.2.1 Graphical Estimation of Risk Attitude Represented by Three Utility Functions

An important characteristic of utility function is that they are monotonically increasing, i.e. $Z_1>Z_2$ implies U (Z_1) > U (Z_2). The implication of it increasing monotonically is related to the neoclassical axiom that more income is preferred to less, i.e. $\partial U/ \partial Z>0$. The first derivative of the utility function is positive. The second derivatives may be negative ($\partial^2 U/ \partial Z^2<0$), zero ($\partial^2 U/ \partial Z^2=0$) or positive ($\partial^2 U/ \partial Z^2>0$). These respectively imply that marginal utility of extra income is decreasing or constant or increasing. Hence, farmers with decreasing marginal utility of extra income are classified as risk-averters. Those with constant marginal utility of extra income are known as risk-neutral while those with increasing marginal utility of income are the risk takers.

The Bernoullian decision theory is characterized by the division of risky decision-making into two components of subjective probability and utility function of farmers. The latter component has been heavily criticized (Young 1979, Binswanger 1980).

Despite the fact that the Bernoullian Principle implies the existence of U(Z), it tells nothing of its precise form, nor does the decision maker intuitively know the algebraic form of his utility function. Dillion, (1971) argued that a variety of different functional forms such as polynomial, logarithmic or exponential utility functions might be suitable. However, he recommended using the functions that provide simple manipulation.

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. Van lenthe (1993) developed eliciting uncertain function through his technique - a graphically oriented interactive computer program based on the application of a proper scoring rule in probability assessment.

Direct elicitation approach has been criticized as subject to bias from different interviewers, preference for specific probabilities, negative preference toward gambling, absence of realism in the game setting, lack of time and experience of the hypothetical choices and compounding of errors in the elicitation process (Roumasset, 1978; Lin and Chang, 1978; Young, 1979). Furthermore, studies by Binswanger, (1980); Dillion and Scandizzo, (1978), have indicated that eliciting individual or joint farmers' utility function is expensive, time consuming and may not be stable over time because they vary with the socioeconomic status of the households. More recently utility function has been shown to overestimate risk in the study by Just and Pope (2003).

Although there are some developments of the theory that seek to accommodate observed risk behaviour (Quiqqin 1993; Saha , Shumway and Talpaz, 1994, Roosen and Hennessy, 2003, Just and Lybbert, 2009, Chamber, 2015), these are yet to be widely applied. Therefore elicited utility functions must be used with special caution in risk analysis.

A definition of risk that is widely applied in the literature explains risk as a “chance of loss” or the probability (α) that net income (Y) will fall below some critical or disaster income level (d). Mathematically the definition can be expressed as:

$$Pr\ (Y<d) = \alpha \text{ --- } (2)$$

This definition relates to the “safety-first” models developed by Roy, 1952; Teaser, 1956; Baumol, 1963 and Pyle and Turnovsky, 1970). It specifies that a decision maker first satisfies a preference for “safety” in organizing a firm’s activities, and

then follows a profit-oriented course of action. The following discussion represents a probability of loss function criterion proposed by Baumol (1963).

Baumol (1963) criticized the E – V approach on the ground that many alternative farm plans along the efficiency frontier may be confusing to the decision – maker. In addition, plans which do not provide a high probability of meeting minimum level of income are likely to be rejected by farmer or decision makers. For example, assume a farmer’s minimum acceptable level of income is N1, 000. Therefore only farm plans which generate this income level at a reasonably high level of probability will be considered in the probability of loss analysis.

Baumol’s criticism was based on expected gain confidence limits for portfolio selection. The model can be defined as a set of confidence statements about achieving various levels of income. The income from every efficient plan is assumed to be normally distributed with mean E and variance V. The basic assumption is that the rational decision maker can base his choice for a particular plan on the expected income and the minimum acceptable level of income which could be obtained from that plan with a given value of probability. To compute the critical income level d* for every level of expected income E, we can use the following equation:

$$\text{Max } E \text{---} \quad (3)$$

$$\text{Subject to: } E - K_{\alpha}S \geq d^* \text{ ---} \quad (4)$$

Where,

d* = is the critical level of income;

E = is the expected income;

S = is the standard deviation of income; and

K = is a factor from the standard normal density function taken at the desired probability level.

There are other different approaches for eliciting attitudes toward risk (Antle, 1987). Ellis (2000) used income variance approach to analyze 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. Ayinde et.al. (2012b) studied Risk Analysis of Gender in Innovation System: A Case Study of Production of Downy Mildew Maize Resistant Variety using the safety first principle to categorize farmers to risk averse, risk neutral and risk preferring.

Moscardi and de Janvry (1977) classified these approaches into direct and indirect approaches. Dillon and Scandizzo (1978) classified the methods of measuring risk behaviours under the headings of: (i) economic anthropology (ii) econometrics (iii) farm risk programming (iv) sectoral risk programming (v) expected utility and safety-first theory. They used the expected utility and safety-first theory methods to measure the risk attitudes of subsistence farmers in northeast Brazil. Binswanger (1980) measured attitudes toward risk using two methods, an interview method eliciting certainty equivalents and an experimental gambling approach with real payoffs. He believed the interview method is subject to interviewer bias, and his study showed that the interview results were totally inconsistent with the experimental measures of risk aversion.

Direct method, developed by von Neumann and Morgenstern, has serious difficulties resulting from the fact that the subjects have different levels of tolerance or intolerance for gambling (the method used to reveal their preferences) and that the concepts of probability are by no means intuitively obvious. Also, it is a time consuming method. For these reasons, they proposed and used an indirect approach in their study. In their model, risk was introduced into a model of economic decision making as a safety-first rule. This rule was used by Ayinde et.al (2012b) and was adopted for this study

METHODOLOGY

Oyo State comprises 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 4-stage random sampling techniques. 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 cultivate on 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 to give a total of 240 respondents, which constitutes the sample size for the study.

Analytical Techniques and Model Specifications

The data were analysed using descriptive statistics; likert scale to determine the risks involved in the adoption of innovation; safety first principle was used to investigate the risk attitude of farmers while ordinary least square regression was used to investigate the factors that determine farmer's risk attitude.

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 2012).

$Y = f (X)$

$Y = f (X_1, X_2, X_{3,} X_4, U)$

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***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 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

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 are 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 2012) 90.8%

of the vitamin A cassava farmers are male while the remaining 9.2% are females. 90% of the farmers are married, only 3.3% of the farmers are single, 1.7% of them are divorced while the remaining 5% are widowed. Most of the farmers had their education up to the secondary level with a percentage of 41.7%. 68.3% of the cassava farmers have household size ranging from 1 – 6. Majority of the farmers 65% have a farm size of between 6 and 10 ha; majority of them uses hired labours (74.2%)

Age	**Frequency**	**Percentage**
≤ 30	8	3.3
31 - 50	110	45.8
51 – 70	122	50.8
Total	240	100
Gender	**Frequency**	**Percentage**
Male	218	90.8
Female	22	9.2
Total	240	100
Marital Status	**Frequency**	**Percentage**
Single	8	3.3
Married	216	90
Divorced	4	1.7
Widowed	12	5

Total	240	100
Level of Education	**Frequency**	**Percentage**
No formal education	18	7.5
Primary education	68	28.3
Secondary education	100	41.7
Tertiary education	54	22.5
Total	240	100
Household Size	**Frequency**	**Percentage**
1 – 6	164	68.3
7 – 12	76	31.7
Total	240	100
Primary Occupation	**Frequency**	**Percentage**
Trader	18	7.5
Civil Servant	46	19.2
Farmer	176	73.3
Total	240	100
Years of crop farming experience	**Frequency**	**Percentage**
≤ 10 years	6	2.5
11 – 20	58	24.2

21 – 30	96	40
31 – 40	60	25
41 – 50	20	8.3
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

Source: Field Survey, (2015)

Risks faced by vitamin A cassava farmers

The risk facing farmers are presented in table (2). The major risk faced by the vitamin A cassava farmers is 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, this will affect the farmers income if there is a fall in the price of the produce due to perish ability or reduced value/quality of the product because of improper storage. 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. 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: Risks faced by vitamin A cassava farmers

	5	**4**	**3**	**2**	**1**		
Risks	**VS**	**S**	**MS**	**LS**	**NS**	**Ranking**	
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

Source: Field Survey, (2015)

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 about12.8% 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.

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%				

Source: Field Survey, (2015)

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 2012).

Risk attitude of Farmers

As showed in table (4), most of the farmers are risk indifferent or risk neutral (88.3%), 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 least proportion are the ones that are not willing to take risk at all no matter what is involved.

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

Table (5) shows that age, income from other activities and estimated annual income have significant effect on farmers' attitude towards risk taking. Age and income from other activities have negative values and this means that as the variables increase, there will be a proportionate decrease in farmers willingness to take risk. This also can be verified from the socioeconomic characteristics result gotten which showed that majority of the farmers are old. Estimated annual income has a positive value and this means that as income from vitamin A production increase, the farmer will be more willing to take risk so as to get more money.

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

CONCLUSION AND RECOMMENDATIONS

The study investigates the Risk in Innovation System using a case study of Production of Vitamin A Cassava Variety among Farmers in Nigeria. The study revealed 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. It is therefore recommended that price stability of technologically improved crops should be addressed by policy makers, grazing reserves should be provided for animal farmers and youths should be encouraged to participate more in agriculture in order to facilitate the adoption of new cassava technology in the study area.

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