TECHNICAL EFFICIENCY AND RISK PREFERENCES OF CROPPING SYSTEMS IN KEBBI STATE, NIGERIA

By ABIGAIL JOHN JIRGI

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Department of Agricultural Economics
Faculty of Natural and Agricultural Sciences
University of the Free State
Bloemfontein, South Africa

Promoter:
Prof. M. F. Viljoen
Co-promoters:
Associate Prof. Bennie Grové
Dr Henry Jordaan

Department of Agricultural Economics
Faculty of Natural and Agricultural Sciences
University of the Free State
Bloemfontein, South Africa

External Co-Promoter:
Associate Prof. J. N. Nmadu

Dept. of Agric. Econs. and Ext, Technology,
Fed. Univ. of Tech. Minna, Niger State,
Nigeria

January, 2013

DECLARATION

I, Abigail John Jirgi declare that the thesis hereby submitted by me for the Philosophiae Doctor (PhD) degree in Agricultural Economics at the University of the Free State is my own independent work and has not previously been submitted by me at another University. I furthermore cede copyright of the thesis in favour of the University of the Free State.

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Abigail John Jirgi

Bloemfontein

January, 2013

DEDICATION

This work is dedicated to Mr John Jirgi Ushe, Mrs Lami John, Ezekiel (late), Dorcas and James.

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LIST OF ACRONYMS

ADP	Agricultural Development Programme
CBN	Central Bank of Nigeria
CE	Certainty Equivalent
CI	Condition Index
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DEA-MF	Data Envelopment Analysis-Metafrontier
DEAP	Data Envelopment Analysis Programme
DGP	Data Generating Process
DMU	Decision Making Unit
EMV	Expected Monetary Value
EU	Expected Utility
EUM	Expected Utility Model
ELCE	Equally Likely Certainty Equivalent
GDP	Gross Domestic Product
HIV/AIDS	Human Immune Virus/Acquired Immune Deficiency Syndrome
ILRI	International Livestock Research Institute
LGA	Local Government Area

MF	Metafrontier
N	Nitrogen
NBS	National Bureau of Statistics
NCSS	Number Cruncher Statistical System
ND	National Diploma
NF	National Fadama II Development Programme
NIMET	Nigerian Meteorological Agency
NPC	National Population Commission
₦	Naira (Nigerian currency)
OLS	Ordinary Least Square
OECD	Organisation for Economic Co-operation and Development
P	Phosphorus
PCR	Principal Component Analysis
PDF	Parametric Distance Function
RBDA	River Basin Development Authority
SF	Stochastic Frontier
SFPF	Stochastic Frontier Production Function
SE	Scale Efficiency
SEU	Subjective Expected Utility
TE	Technical Efficiency
TOL	Tolerance

UBE	Universal Basic Education
VIF	Variance Inflation Factor
Millet	Pearl millet

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ABSTRACT

The research investigated the risk attitude, risk sources and management strategies, and the technical and cost efficiencies of farmers in Kebbi State, Nigeria, with the aim of generating reliable information on the influence of risk attitudes of the decision-making behaviour of farmers and determinants of efficiency.

Various techniques were applied in order to achieve the objectives of the study. They include: the Experimental Gambling Approach, Factor Analysis, Logit regression, Data Envelopment Analysis, Double Bootstrapping procedure and the Metatechnology Approach.

Data to conduct the research was obtained mainly from primary sources through a questionnaire survey of 256 farmers, comprising 98 monocroppers and 158 intercroppers.

Some of the important findings from the research are:

- All the farmers exhibit some level of risk aversion. The intercroppers were statistically significantly more risk-averse than the monocroppers. Risk attitude influences the decisions farmers make in the production process and should be considered when formulating agricultural policies.

- The most important sources of risk for both monocroppers and intercroppers are diseases, erratic rainfall, changes in government policy, changes in climatic conditions, price fluctuation (of inputs and outputs) and floods/storms. The most important risk management strategies for monocroppers are spraying for diseases and pests, spreading sales, borrowing (cash or grains) and *fadama* cultivation. These factors should be considered when designing extension programmes and insurance schemes. The intercrop farmers perceived family members working off-farm, spreading sales, intercropping and borrowing (cash or grains) as the most important coping strategies.

- The main findings from the factor analysis for the sources of risk for the monocroppers and intercroppers are that the factors “social”, “rainfall” and “uncertainties” are important to both groups of farmers. Since farmers do not have control over the rainfall factor as a source of risk, there is, *inter alia*, a need to have an effective agricultural insurance scheme for the farmers in the study area. Farming experience, asset value, risk aversion and land degradation were found to have statistical significant influences on the choice of cropping systems in Kebbi State.

- The results from the technical efficiency analysis suggest that there is scope for increasing the technical efficiency levels of both monocrop and intercrop farmers and hence their ability to increase output levels at current input levels and within the existing technology set.

- Based on the metatechnology ratio, the millet/cowpea group were the more technically efficient, followed by the sorghum/cowpea group. The sorghum group were less technically efficient. This suggests that crop diversification, in order to manage risk sources, has the potential for improving crop productivity in Kebbi State. Crop combinations, however, prove to play an important role. Care should be taken to select the optimal combination of crops to include in the intercropping system.

- In terms of cost efficiency, farmers in the study area were relatively cost-inefficient. The metatechnology ratio for cost efficiency depicts that the sorghum/cowpea group were more cost efficient than their counterpart sorghum, and millet/cowpea group. Selection of farm inputs at minimum cost will help to reduce production cost and hence improve profitability of the farmers.

- Low levels of technical and cost efficiency suggest that major scope exists to increase performance of the farmers, even at their current output levels and within their existing technology set. Support services, such as subsidies on farm inputs, provision of credit and extension services of the new Agricultural Transformation Agenda Programme (ATAP), should be properly implemented and targeted at the small-scale farmers.

- The determinants of efficiency differ between the monocroppers and intercroppers, and also differ between the intercrop groups. This suggests that different groups of farmers operate under different technology sets.

- The results also suggest that the existing knowledge on the various factors that influence both technical and cost efficiency is not exhaustive and accordingly that there is a need to explore other characteristics that influence the farmers' decision process within their technology set.

OPSOMMING

Die navorsing is gerig op die vasstelling van die risiko-houdings, risikobronne en bestuurstrategieë, sowel as die tegniese en kostedoeltreffendhede van boere in die Kebbi Staat van Nigerië, met die doel om betroubare inligting oor die invloed van risiko-houdings op die besluitnemingsgedrag van boere en die determinante van doeltreffendheid te genereer.

Verskeie tegnieke is toegepas om die doelstellings van die ondersoek na te vors. Dit sluit in die Eksperimentele Dobbelbenadering, Faktoranalise, Logit-regressie. “Data Envelopment-” analise, “Double Bootstrapping” en die Metategnologie benadering.

Data benodig vir die navorsing is hoofsaaklik verkry vanaf primêre bronne met behulp van ’n vraelysopname by 256 boere, waarvan 98 enkelgewasbewerking en 158 tussengewasbewerking toepas.

Van die belangrikste bevindings is:

- Al die respondente vertoon vlakke van risikovermyding. Die tussengewasbewerkers was statisties betekenisvol meer risikovermydend as die enkelgewasverbouers. Risiko-houding beïnvloed die produksiebesluite van boere en behoort verreken te word by die formulering van landboubeleid.

- Die belangrikste risikobronne vir sowel enkelgewas as tussengewasbewerkers is siektes, wisselvallige reënval, veranderings in regeringsbeleid, veranderings in klimaat, prysfluktuasies van insette en uitsette en vloede/storms. Die belangrikste risikobestuur- strategieë vir enkelgewasverbouers is spuit van siektes en peste, verspreiding van verkope, leen (kontant en graansoorte) en *fadama*-bewerking. Die faktore behoort oorweeg te word wanneer voorligtingsprogramme en versekeringskemas ontwerp word. Tussengewasverbouers beskou gesinslede wat buite die boerdery werk, verspreiding van verkope, tussengewasverbouing en leen (kontant en graansoorte) as die belangrikste oorlewingstrategieë.

- Die vernaamste bevindings van Faktoranalise ten opsigte van die risikobronne van die enkel- en tussengewasverbouers is dat die faktore “sosiaal”, ”reënval” en “onsekerhede” belangrik is vir albei groepe. Aangesien boere nie beheer het oor die reënvalfaktor as ’n risikobron nie, is daar onder andere ’n behoefte aan ’n effektiewe versekeringskema vir die boere in die ondersoekgebied. Boerderyondervinding, batewaarde, risikovermyding en grondagteruitgang het ’n statisties beduidende invloed op die kies van ’n gewasstelsel in die ondersoekgebied.

- Die bevindings oor tegniese doeltreffendheid dui op ruimte vir verhoging in tegniese doeltreffendhede vir sowel enkel- as tussengewasverbouers deurdat hulle gewas-opbrengste kan verhoog teen huidige insetpeile en binne die bestaande tegnologie-raamwerk.

- Gebaseer op die Metategnologieverhouding, is die giers/akkerboon-kombinasie die tegnies doeltreffendste, gevolg deur die sorghum/akkerboon-kombinasie. Sorghum as enkelgewas was tegnies die minste doeltreffend. Gewasdiversifikasie om risikobronne te bestuur het dus potensiaal om gewasproduktiwiteit in die Staat Kebbi te verhoog. ’n Poging moet egter aangewend word om die beste tussengewas-kombinasie te vind.

- Boere in die ondersoekgebied is relatief koste-ondoeltreffend. Die Metategnologie-verhouding vir kostedoeltreffendheid dui daarop dat die sorghum/akkerboon-kombinasie meer kostedoeltreffend is as net sorghum of die giers/akkerboon-kombinasie. Aanwend van boerderyinsette teen minimumkoste sal help om produksiekoste te verlaag en winsgewendheid te verhoog.

- Lae vlakke van tegniese en kostedoeltreffenheid impliseer groot ruimte om die prestasie van boere te verhoog, selfs teen huidige opbrengste en binne die bestaande tegnologie-stel. Ondersteuningsdienste soos subsidies op boerderyinsette, voorsiening van krediet- en voorligtingsdienste van die nuwe landboutransformasie-agenda moet reg geïmplementeer en op die kleinboer gerig word.

- Die determinante van doeltreffendheid verskil tussen die enkel- en tussengewas-verbouers en ook tussen die tussengewas-kombinasies. Dit dui daarop dat verskillende boerderygroepe met verskillende tegnologiestelle funksioneer.

- Die bevindinge dui ook daarop dat beskikbare kennis oor die faktore wat beide tegnies en kostedoeltreffendheid beïnvloed, onvoldoende is. Daar is dus ’n behoefte om ander eienskappe wat boere se besluitnemingsprosesse binne die verskillende tegnologiestelle beïnvloed verder na te vors.

CHAPTER 1
INTRODUCTION

1.1 Background and motivation

The current concern of stakeholders in agricultural development in Nigeria is the onerous task of feeding over one hundred and sixty million people in the nation. The continual increase in the nation's population without a matching increase in food production signals a possible future scenario of widespread hunger, malnutrition and poverty. The National Bureau of Statistics reported that 69% of the population was poor in 2010 (NBS, 2012). In spite of the country's vast resources it has a low gross domestic product (GDP) per capita, high unemployment rate, low industrial capacity utilisation, high birth rate and high dependence on agriculture (Jhingan, 2005). Agriculture is the economic mainstay of the majority of households in Nigeria (Udoh, 2000). The agricultural sector employs 70% of labour force in the country (NBS, 2005). The agricultural sector is central to households and the national economy. This makes it a critical component of programmes that seek to reduce poverty and attain food security in Nigeria. Thus, it is often seen as important for reducing poverty (Agénor, 2004). The Nigerian agricultural sector contributed about 41% of the GDP per annum during the 2000-2010 period and grew at 7% - 8% per annum during the same period (CBN, 2009, 2010, 2011). The increase in agricultural production was propelled largely by the favourable weather conditions and the sustained implementation of various agricultural programmes initiated in 2009. Despite the growth in the agricultural sector, Nigeria's food imports are growing at an untenable rate of 11% per annum (Adesina, 2012). Growth targets should be productivity driven, especially since growth through land expansion to boost agricultural production will be costly and unlikely to be sustainable (Diao, Xinshen, Breisinger & Thurlow, 2009).

Nigeria's agriculture remains largely subsistence based, with about 80% of agricultural output coming from the rural poor (Gain Report, 2011). Agriculture has, however, suffered from years of mismanagement, inconsistent and poorly conceived government policies, and lack of basic infrastructure. Continued reduction in production and productivity has continued to characterize the Nigerian agricultural sector, thereby limiting the ability of the sector to perform its traditional role in economic development. In an attempt to break this cycle and improve the performance of the agricultural sector, the Nigerian government over the years introduced and implemented several policies and programmes aimed at revamping the sector (Uniamikogbo & Enoma 2001; Ajibefun & Aderinola, 2003; Sanyal & Babu, 2010; Izuchukwu, 2011). The programmes were meant to improve resource use, farmers' income productivity, food security, and to accelerate rural development. The expected effectiveness of the programmes was substantially curtailed by lack of consistency and continuity in the policies adopted by successive administrations in the country and the lack of understanding of the actual farm-level situation. These efforts can only yield a sustainable result if farm-level planning, the type of cropping system practiced by the farmers, and the characteristics of farm households are given the desired attention.

The two main cropping systems practised in Nigeria are mono and intercropping systems. The cropping systems considered in this study are practised under rain-fed conditions. Generally, intercropping involves the growing of rain-fed crops in mixtures, using available resources which permit farmers to maintain low, but often adequate and relatively steady production. Monocropping generates vast amounts of corporate wealth, gives higher yields, is more efficient than intercropping, provides jobs, and gives higher economic returns (Nelson, 2006; Mmom 2009). The question is, can this type of system provide sufficient food to the ever-increasing population in Nigeria and other parts of sub-Saharan Africa? Farmers in northern Nigeria practice both monocropping and intercropping. Intercropping is practiced as a means of diversification to safeguard against risk associated with agricultural production. The question of which cropping system is better in terms of technical and cost efficiency in the context of monocropping and intercropping systems in Nigeria has not yet been answered. Should farmers continue with the monocropping system, which gives high production yield in the short term, or continue with intercropping which gives low but often adequate and relatively steady production over the longer term? The increase in productivity in any of the systems will depend on how efficient resources are utilised by the farmers.

1.2 Problem statement

Despite the various programmes launched and established by the government, returns from the agricultural sector have been much below the potential (Izuchukwu, 2011). Crop yields continue to decline and are substantially lower than potential yields (Nwafor, 2011). For the past 15 years, food crop production growth in Nigeria has been driven entirely by expansion in area planted, rather than by increasing productivity per hectare through improved technology and development of high yielding varieties of arable crops (Report of the Vision 2020, 2009). The gap between potential and actual crop yields obtained by farmers suggests abundant scope for improvement in productivity. Growth targets thus should be productivity driven (Diao *et al*., 2009) instead of measuring productivity by acreage expansion, as is the current practice in Nigeria. The FAO (2002), too, argues that much of the future food production growth will have to come from higher productivity.

Another problem is that most government programmes are designed without giving consideration to farmers' characteristics, for example, the risk preference of the farmers (Olarinde, Manyong & Okoruwa, 2007). Agricultural production is highly characterized by risks which range from adverse weather, pests to diseases, which in turn lead to price uncertainty (Musser & Patrick, 2002; Glauber & Collins, 2002; Ayinde, Omotesho & Adewumi, 2008). For these reasons, farmers' attitudes towards risk is imperative in understanding their behaviour towards the adoption of new technology and managerial decisions (Ayinde *et al*., 2008; Binici, Koc, Zulauf & Bayaner, 2003; Knight, Weir & Woldehanna, 2003; Liu, 2008; Alpizar, Carlsson & Naranjo, 2010). For example, the more risk-averse a farmer is, the more likely the farmer is to make managerial decisions that emphasize the goal of reducing variation in income, rather than the goal of maximising income; the converse is also true (Binici *et al*., 2003).

Depending on their ability to absorb risk and their psychological attitudes or preferences towards risk, the risk inherent in a new technology or input choice will affect farmers differently (Binswanger & Sillers 1983; Knight *et al*., 2003). Risk is a characteristic of agricultural production. Several factors influencing production are not dependent upon the actions of a producer. Hardaker, Huirne and Anderson (1997) define production risk as the risk that comes from the unpredictable nature of weather and uncertainty about the performance of crops or livestock.

Bamire and Oludimu (2001) and Ojo (2005) argue that the limited success of Nigeria in rural development programmes is a result of the absence of a prior analysis of attitudes towards risk inherent in new technologies and the failure to ascertain the farmers' trade-offs between risk and return in traditional agriculture. A lack of clear understanding of farmers' attitudes towards risks remains an important factor inhibiting increased agricultural productivity. It is not in any way difficult to point out that the observed resource use of farmers reveals the underlying degrees of risk preferences (Olarinde *et al*., 2008). Although some researchers have quantified risk attitudes of farmers in Nigeria, it is evident that most of the studies applied the Safety First Behaviour and Portfolio model to measure risk attitude of farmers (Alimi & Ayanwale, 2005; Ajetumobi & Binuomote, 2006; Ogunniyi & Ojedokun, 2012). The Safety First Behaviour model is criticised owing to the fact that it is difficult to determine the relative influence of risk and other factors on the decisions of the individuals, while the Portfolio behaviour is criticised because it does not produce very detailed information (Binswanger, 1981). No reliable knowledge is available on these issues.

Research on the sources of risk and management strategies in the Kebbi State of Nigeria is scanty. Alimi and Ayanwale (2005) have investigated the risk management strategies among onion farmers in Kebbi State. The researchers did not consider the factors that influence risk aversion, and besides this, there is little or no research that has investigated the relationships between the risk sources, risk management strategies, risk attitude and farmers' characteristics in the study area. There is a general belief that a positive relationship exists between risk perception and the farmers' use of risk management strategies, and that risk attitude is also an important driving force for the adoption of management strategies by farmers (Pennings and Leuthold, 2000; Mishra and El-Osta, 2002). However, there is no real evidence to prove the expectations of the behaviour of farmers in the production environment. There is need to have a better understanding of the risk and the coping strategies of monocroppers and intercroppers in Kebbi State in order to ascertain the decision-making behaviours of the farmers, to develop appropriate risk-coping strategies for the farmers, and to add to the existing knowledge in the field of agricultural risk.

Productivity can be enhanced if there is reliable empirical knowledge available on technical and allocative efficiency of resource allocation and the factors that determine such efficiencies. Most of the farm efficiency studies carried out in the northern parts of Nigeria have shown that resources are inefficiently utilised (Hamidu, 2000; Amaza, 2000; Jirgi, 2002; Baiyegunhi, Chikwendu & Fraser, 2010). The basic approach to estimate allocative efficiency of farmers from Nigerian studies is through the marginal value product which is calculated from econometrically estimated production functions (Hamidu, 2000; Amaza, 2000; Jirgi, 2002; Baiyegunhi *et al*., 2010). Allocative efficiency is determined by the ratio of the marginal value product to the marginal factor cost. Most of the studies on efficiency focus on socio-economic variables, such as age, farming experience, extension, education and gender, as explanatory variables. The researchers have not investigated the influence of risk attitude on efficiency. The fact that risk aversion is associated with the decision-making behaviour of an individual means that it should be incorporated in the determination of factors that influence efficiency. Information on risk attitude as a determinant of allocative efficiency is lacking in the study area.

Some researchers have explored technical efficiency and its determinants in Nigeria. Empirical studies on the use of the Stochastic Frontier (SF) Model to estimate technical and cost efficiency and their determinants are scanty in the study area (Tanko & Jirgi, 2008; Tanko, 2004). Few researchers have used the two-stage Data Envelopment Analysis (DEA) approach to investigate the determinants of efficiency of farmers (Yusuf & Malomo, 2007; Ajibefun, 2008). In the two-stage DEA approach, efficiency scores are estimated in the first stage using DEA, and in the second stage, Tobit regression is used to investigate the determinants of efficiency. Tobit regression is used in the second stage owing to the belief that the dependent variable is censored. However, Simar and Wilson (2007) have questioned the appropriateness of the two-stage approach. The researchers argued that DEA efficiency scores are serially correlated and biased when used in the two-stage DEA approach and that efficiency scores are not censored. By applying an incorrect approach, the information that was generated by the researchers may not be reliable. Research on the comparison of efficiencies in agriculture is scanty. The research that has compared the efficiency of technologies used the highest average DEA score to indicate the decision making units (DMU) that are more efficient (Binici, Zoulauf, Kacira, & Karli, 2006; Alene, Manyong & Gockowski, 2006). Frey, Fassola, Pachas, Colcombet, Lacorte, Pérez, Renkow,Warren, Cubbage. (2012) argued that such comparison is inappropriate because high efficiency scores among a group of DMUs only gives a measure of relative homogeneity among the efficiency of the DMUs. Battese (2004) introduced the use of a Metatechnology ratio (MTR) to compare efficiencies between different groups. The MTR is a more reliable approach for comparing efficiencies of different groups of enterprises.

Thus, although the topic of efficiency and risk has received attention by researchers in recent times, there is a lack of reliable information on the determinants of efficiency, comparison of efficiencies among different farm cropping systems, sources of risk and management strategies, risk attitudes and also the influence of risk attitudes on the decision-making behaviour of the farmers.

1.3 Objectives of the Study

The broad objective of the study is to examine attitude towards risk, risk sources and management strategies and technical and cost efficiency of farmers in Kebbi State, in order to generate reliable knowledge on the influence of risk attitudes on the decision-making behaviour of farmers and determinants of efficiency.

The specific objectives of the study are to:

1. Explore the risk attitudes of the farmers. Risk aversion coefficients will be quantified and regressed on characteristics of the farmers in order to ascertain the factors that influence risk attitudes of the farmers.

   Objective 1 will be achieved by using the experimental approach within the subjective expected utility framework, owing to the fact that the usual interview technique of eliciting certainty equivalents and the safety-based approach are not reliable (Binswanger, 1981). The experimental approach that will be applied in the study will provide more reliable information on the decision-making behaviour of the farmers. This information is important in designing strategies for agricultural development. Although the subjective expected utility theory has been criticised, it has remained the most appropriate theory for prescriptive assessment of risk choices (Hardaker, James, Lien & Schumann, 2004; Meyer, 2001). The risk aversion coefficients obtained from objective 1 will be used in objectives 2, 3 and 4.

2. Explore the sources of risk and coping strategies that farmers use to manage their exposure to risk and also determine their dimensions in terms of the underlying latent factor. The relationships between sources of risk and coping strategies, risk attitudes and farmers' characteristics will also be investigated.

The dimensions of the perceived risk sources and management strategies will be determined using factor analysis in order to ascertain the most important factor of risk sources and management strategies. Factor analysis describes the variance in the observed variables in terms of the underlying latent factor (Habing, 2003). Following Meuwissen, Huirne and Hardaker (2001), the relationships between sources of risk and coping strategies, risk attitudes and farmers' characteristics will be explored using multiple regression in order to identify the most important risk source and management factors and the variables that influence each other in the regression. Understanding the relationships between farmers' characteristics, risk attitude, risk sources and management strategies is important in determining the best coping strategies for farmers. Such information will help policy makers in designing the right risk coping strategies to enhance farmers' productivity.

3. Determine whether farmers' attitudes towards risk and their characteristics influence their choice of cropping system, in order to make recommendations on the programmes that will improve monocropping or intercropping.

   Logit regression is used to achieve objective 3. The results from objective 3 will serve as a basis for policy makers to consider the factors influencing choice of cropping systems when designing programmes to improve monocropping or intercropping.

4. Investigate the levels of efficiency which farmers use with their production inputs to produce their crops. The levels of technical and cost efficiency will be quantified in order to determine how efficient the farmers are. The relationship between the efficiency scores and characteristics of the farmers will be explored so as to have a better understanding of the characteristics associated with higher levels of efficiency. In addition, the efficiencies of the monocrop and intercropping systems will be compared in order to determine which technology is better and to ascertain whether the technologies have equal efficiency.

   Objective 4 is achieved by estimating technical and cost efficiency for each decision-making unit (DMU) using the Data Envelopment Analysis (DEA) approach. To determine the explanatory variables that influence technical efficiency of the farmers, the Double Bootstrapping procedure of Simar and Wilson (2007) will be used. The use of Double Bootstrapping ensures that the limitations of using Tobit in the second stage to explore the determinants of efficiency are overcome. Following Jordaan (2012), the Double Bootstrap procedure will be used within the framework of the Principal Component Regression (PCR) in order to reduce the dimensionality of the data in which there are a large number of correlated variables, while retaining the variation present in the data set (Jolliffe, 2002). The technical efficiency results that will emanate from this study will add to the existing knowledge of efficiency in the study area and will also provide more reliable information on the determinants of technical efficiency. The procedure will further serve as bases on which other research can be based to provide more reliable information on efficiency.

Despite the fact that cost efficiency has the same challenges as technical efficiency, following the recommendation of McDonald (2009), Ordinary Least Squares (OLS) will be used since there is no Double Bootstrapping procedure for cost efficiency. The problem of serial correlation is reduced when the logarithms of the dependent variable is used as the regressand. The identification of sources of cost inefficiency is important for the policy makers to design policies to improve performance.

Following O'Donnell, Rao & Battese (2008), the metafrontier approach will be used to compare the efficiencies of the different groups of mono and intercrop farmers. This will give an insight into the gap between the group frontier and the metafrontier. This information will help policy makers to design programmes improving the performance of farms by making changes to the production environment. The Rank-Sum-Test (Wilcoxon-Mann-Whitney) will be used to test if there are significant differences between the efficiency scores of monocroppers and intercroppers. The results from this study will provide more reliable information about comparisons of efficiencies between different groups.

1.4 Organization of the study

The remainder of the thesis is organised in six further chapters.

Chapter 2. Literature review: Chapter 2 provides literature on the conceptual framework and a review of related literature on the concept of risk, the types and sources of risk, and the responses to risk in agriculture. Efficiency and the factors influencing farm efficiency are also discussed.

Chapter 3. Study area, data collection and characteristics of the respondents: The main objective of this chapter is to provide an overview description of the study area, resources available to the farmers and the institutional support services. Data collection, sampling technique, and the characteristics of the households in terms of demographics based on the data collected are highlighted.

Chapter 4. Procedures: This chapter gives the description of the procedures applied in order to achieve the objectives of the study.

Chapter 5. Results and discussion: Risk attitude, risk sources and management strategies of the monocrop and intercrop farmers: The risk preferences, sources of risk and risk management strategies are presented in this chapter. The explanatory variables that influence the choice of monocropping or intercropping systems are also discussed.

Chapter 6. Results and discussion: Technical and cost efficiency of monocrop and intercrop farmers in Kebbi State: Analyses of the technical and cost efficiency of monocropping and intercropping systems and the environmental variables affecting efficiency are presented and discussed. The comparisons of efficiencies for the different cropping systems are also highlighted.

Chapter 7. Summary, achievement of objectives and recommendations: The last chapter of the study provides a summary and the conclusion with regard to achievement of the objectives, together with recommendations arising from the findings of the study.

CHAPTER 2
LITERATURE REVIEW

Introduction

Chapter 2 reviews relevant literature on monocropping and intercropping, and the attributes of small-scale farmers, while some of the constraints faced by small-scale farmers in Nigeria are highlighted. The risk preferences and efficiency of farmers are also discussed, as well as the approaches used in risk and efficiency studies. The purpose of the literature review is to acquire knowledge of what other researchers have done on the subject of risk, risk sources and copping strategies and efficiencies in order to ascertain the gaps that exist in these areas and to find a way of filling the gaps in knowledge.

2.1 Cropping systems

For the purpose of this study, 'cropping system' refers to monocropping and intercropping. Intercropping is a multiple cropping system where two or more crops are grown concurrently on the same field. The different crops can be planted in alternating rows or sections (Blanco-Canqui & Lal, 2010). "Intercropping is a form of multiple cropping, which generally involves the growing of rain-fed crops in mixtures, uses available resources and permits farmers to maintain low but often adequate and relatively steady production" (Wood, 1985). For the purpose of this study, intercropping is defined as the cultivation of two crops simultaneously on the same area of land. Cropping pattern is defined as the yearly sequence and spatial arrangement of crops and fallow on a given area.

2.2 Small-scale farms in Nigeria

2.2.1 Definition and attributes of small-scale farmers

In developing countries, as is the case of Nigeria, small-scale farmers dominate the agricultural economy. Over 80% of the farming population in Nigeria are small holders, residing mostly in rural areas. Agriculture in the country, however, is characterised by a large number of these small-scale farmers, scattered over wide expanses of land, with holdings ranging from 0.05-3.0 hectares per farmer, low capitalization and a low yield per hectare (Olayide, 1980).

The small-scale farmers are very significant in world development, with 50% of world's population depending on them. Olayide (1980) has stated, based on a survey conducted by the Federal Office of Statistics in 1973/74, that the small-scale farms were classified in a range between 0.1 ha and 5.99 ha and that they constitute about 81% of all farm holdings; the medium-scale farms range from 6.0 to 9.99 ha and constituted about 14% of all farm holdings; while large farms range from 10.0 ha and above and constituted about 6% of all farm holdings. According to Adubi (2000), small-scale farmers are a category of farmers that exist at the margins of the modern market, neither fully integrated into that economy nor wholly insulated from its pressures, i.e. they have one foot in the market economy and the other in subsistence economy. They are more exposed to risk than other segments of the farming population.

Hence, there is a need to study the risk attitudes of the farmers in order to establish their decision-making behaviour, the various sources of risk that the farmers are exposed to and the most important coping strategies the farmers have devised to mitigate the sources of risk.

2.2.2 Major problems faced by farmers in Nigeria

Farmers have been faced with problems which have affected their productivity and contribution to national aggregate output. These problems can be grouped into infrastructural facilities, skills development, land tenure system, economic factors, government/regulatory policies and environmental factors.

Infrastructural facilities

Okuneye (Undated) observed that there are poor feeder roads and inadequate road networks between the rural areas and urban areas in Nigeria. Most of the agricultural production takes place in the rural areas where unfortunately most of the feeder roads are unsurfaced, narrow, poorly drained and winding (Famoroti, 1998). IFAD (2001) has reported that about 70% of the rural road network is in poor or very poor condition and that Nigeria's rural road density is one of the lowest in sub-Saharan Africa. This affects the prices that farmers receive for their produce. Heavy losses of agricultural produce result from inadequate on-farm and off-farm storage facilities. Olukosi, Isitor, and Ode, (2008) have reported that the problem of inappropriate on-farm storage facilities leads to wastage of farm produce. Health care facilities are few or absent in the rural areas, hence many man-days are lost owing to ill health which could have been easily treated (Okuneye, Undated). This is worse for HIV/AIDS patients, as observed by IFAD (2001), which indicated that more than 5% of the rural population is affected by HIV/AIDS. In addition, the lack of adequate formal institutions in the rural areas has led to the migration of youths to the urban areas for various reasons and the consequent effect of this is the reduction of labour supply in the rural areas (Okuneye, Undated). The author added that irrigation facilities are still very poor, despite the existence of River Basin Development Authorities (RBDA), and as a result, farmers depend solely on rain-fed agriculture.

Skills development

The extension service delivery system still suffers from an inadequate number of extension personnel. In Kebbi state, for example the extension–agent farmer ratio was 1:1000 in 2009 (KARDA, 2009). Koyenikan (2008) reported that the extension agent–farmer ratio in some states of the south-east and south-west in Nigeria is as high as 1:1590-7000 and 1:1275-5600, respectively. NARP (1994) also observed a ratio of 1:1700 in the north-east zone of the country. The few delivery systems that are in place lack mobility to improve on extension–farmer contact, while women extension personnel are too few to handle gender issues. The frequency of extension message discovery is limited by poor research situations in Universities and Research Institutes, thus farmers continue to practice the same type of cropping systems continually (Okuneye, Undated). This wide gap in the extension worker–farmer ratio affects the quality and frequency of visits.

Land tenure system

The key factor that limits farmers from gaining access to land is the land-tenure system prevailing in different parts of the country. The land-tenure system comprises the body of laws, contracts, and arrangements by which people gain access to land for agriculture and non-agricultural uses (Phillip, Nkonya, Pender, & Oni, 2009). In Nigeria, the land-tenure system varies from one place to another. In the southern parts of the country, the communal system of land ownership, in which individual ownership of land is embedded in group or kinship ownership, prevails among most ethnic groups (Onyebinama, 2004). Arua and Okorji (1997) have stated that individual land ownership and communal tenure systems of land prevail in the eastern parts of Nigeria. Land tenure systems have been bedevilled by problems of population explosion, high food demand, rising inflation and unemployment which leads to rising rural–urban migration of youth (Famoriyo, 1980). There are a growing number of landless households in the rural communities (IFAD, 2001). This has led to small and uneconomic holdings. Because of religious beliefs, the roles of women in agricultural production are limited to few activities and hence provide low returns and low family income.

Economic factors

Ogunfowora (1993) reported that between the late 1980s and mid-1990s, domestic fertiliser production as a percentage of the total supply varied between 46 % and 60 %. Virtually all of the fertiliser used in Nigeria has been imported since the early 2000s. Some of the issues that relate to the domestic supply of fertilisers include high transport costs from port to inland destinations, poor distribution infrastructure, absence of capital for private–sector participation in distribution, significant business risks facing fertiliser importers and inconsistencies in government policies (Phillip *et al.*, 2009). Unavailability of improved inputs is one of the major constraints faced by farmers in Nigeria and this obliges them to rely heavily on seed stored at harvest, which loses its viability over time, thus producing low yields (Jirgi, 2002).

Inadequate loan amounts, collateral requirements by the banks, and high interest rates charged by the banks are some of the major constraints on farm credit in Nigeria (Phillip and Adetimirin, 2001). Some of the problems associated with credit acquisition by farmers from commercial banks are that farmers have to travel long distances to reach the nearest bank, illiteracy, fear of excessive debts, as well as the banks' 'stringent' loan requirements. Famoriyo (1980) observed that lack of information and uncertainty in the supervision and repayment of loans are the major constraints faced by financial institutions with respect to giving loans to the farmers. Another economic factor that constrains agricultural production in the country is the problem of institutional ineptitude found in such institutions as farmers unions, partnerships, cooperatives, marketing concerns and government agricultural institutions, among others (Olayide, 1980). Another problem is the lack of good linkages between the farm sector and the manufacturing sector to generate a demand–pull situation, which would propel high prices for industrial raw materials (Okuneye, Undated).

Government/Regulatory policies

Policies, such as reflected in the Land Use Act, the importation tariff and other unprotective policies, among others, are not supportive enough to agricultural change. Besides, instability in non-agricultural policies affects agricultural production negatively (Okuneye, Undated). Furthermore, low research funding from government and the low participation of the private sector in agricultural research are factors limiting agricultural productivity in the country (Phillip *et al*., 2009).

Environmental factors

These include high incidence of pests and diseases (Adeniji, 2007) and drought in some areas. For instance, Olayide (1980) has reported on a severe drought in the northern part of Nigeria which affected the yield of crops grown in the area. Also, Ekpoh and Nsa (2011) stated that drought was experienced in northern Nigeria in the 1990s. In addition, Okuneye (Undated) has mentioned erosion, desert encroachment and pollution by industrial activities, especially by oil companies and some manufacturers, as some of the environmental factors affecting agricultural productivity.

It is evident from the foregoing literature review that the Nigerian farmers are faced with various problems. These problems directly or indirectly influence farm efficiency. Providing solutions to these problems will, no doubt, help to improve the efficiency of farmers and agricultural productivity in Nigeria.

2.3 Risk and risk aversion

Measuring risk preferences is important because it forms the basis for exploring farmers' decision-making in agricultural production and marketing decisions. According to Just and Pope (2002), since farming practices are similar among farmers in the same environment, farmers tend to compare their risk, based on how their peers perceive them: this is termed social risk. Besides, farming is associated with financial risk, and the risk-averse farmer will prefer to accept lower returns in exchange for a lower uncertainty level, hence the need to measure risk preferences of farmers.

The classical expected utility model and the non-expected utility model (prospect theory), among others, are the theories used in analysing and measuring the "riskiness" of a decision in the farm enterprise. The expected utility model (EUM) is primarily a prescriptive tool. It infers that decision makers who obey certain axioms should choose actions that maximize their expected utility (Robison, Barry, Kliebenstein & Patrick, 1984; Meyer, 2001). Risk attitudes can be described by using the EUM, and its predictive power is tested through experiments or inferences based on observed economic behaviour (Robison *et al*., 1984). The non-expected utility model (prospect theory) assumes that individuals do not maximize expected utility. Other models include the lexicographic utility (Safety-First Model) (Robison *et al*., 1984) and the attitudinal scale approach as applied by Bard and Berry (2000).

2.3.1 The expected utility model

The work of Von Neumann and Morgenstern (1947), "Theory of games and economic behaviour", forms the basis of modern utility theory. The term expected utility (EU) now refers to the analysis of an economic model under the assumption that expected utility is maximized. By 1971, EU was clearly regarded as a decision model rather than just a ranking criterion (Meyer, 2001). The EU model views decision making under risk as a choice between alternatives. The EUM provides a single-valued index that orders action choices according to the preferences or attitudes of the decision maker (Robison *et al*., 1984).

Robison *et al*. (1984) have summarized the components of a decision problem by assuming a set of action choices $A_1, A_2, ..., A_n$, a set of monetary outcomes X_{ij} associated with the j th action choice in the i th state of nature, and probability density functions $P(s_i)$ indicating the likelihood of outcomes in the respective states, for an action choice. To order these action choices, each monetary outcome, X_{ij}, is assigned a utility value according to a personalized, randomly-scaled utility function. The utility value for each possible outcome of an action choice is weighted by its probability and summed. The resulting expected utility is a preference index for the action choices. Action choices are ranked according to their level of expected utility, with the highest value being most preferred.

The goal function is specified as:

$$\max_{j} \; EU(x) = \sum_{i} U(x_{ij}) P(s_i), \qquad j = 1,2,...,n \qquad ..2.1$$

where the probability function is a distinct distribution and the notation is defined above.

The expected utility model clearly explains a decision maker's perception of the amount of uncertainty involved and his or her attitude toward additional income. The amount of uncertainty is reflected by the decision maker's expectations, which are expressed as probability density functions based on the subjective or objective concepts of probability. The amount of uncertainty and other characteristics associated with the action choices are valued by the decision makers according to their unique attitudes, as they are encapsulated in the utility function (Robison *et al.*, 1984).

Axioms of the expected utility theory

The EUM is based on a theorem derived from a set of axioms about individual behaviour. Details of this can be found in the works of Von Neumann and Morgenstern (1947). The axioms are considered conditions or assumptions of how people behave: they amount to a general assumption that people are rational and consistent in choosing among risky alternatives. If the axioms hold, the theorem follows that an optimal risky choice is based on the maximization of EU. The axioms are necessary and sufficient for the EU representation $U(.)$ over the preferences. The set axioms are as follows:

1. Ordering of choices: For any two actions choices, D_1 and D_2, the decision maker either prefers D_1 to D_2, or prefers D_2 to D_1. However, there is a possibility that neither D_1 nor D_2 is preferred (i.e. the decision maker is indifferent between D_1 to D_2.

2. Transitivity among choices: If D_1 is preferred to D_2, and D_2 is preferred to D_3, then D_1 must be preferred to D_3.

3. Continuity: If D_1 is preferred to D_2, and D_2 is preferred to D_3, then some probability P exists that the decision is indifferent to having D_2 for certain or receiving D_1 with probability P and D_3 with probability $(1-P)$. Thus D_2 is the certainty equivalent of $PA_1+(1-P)A_3$. Continuity means that small changes in probabilities do not change the nature of ordering between two lotteries (Mas-Colell, Whinston & Green, 1995).

4. Independence: If D_1 is preferred to D_2 and D_3 is some other risky choice, then the decision maker will prefer D_1 and D_3 as outcomes to D_2 and D_3 when $P(A_1)=P(A_2)$. It is the independence axiom that gives the theory its empirical content and power in determining rational behaviour (Robison *et al*., 1984).

According to Hey (1979), if a decision maker obeys these axioms (and several others that can be more technical), a utility function can be formulated that reflects the decision maker's preferences.

Theoretical measures of risk preference

Pratt (1964) and Arrow (1965) independently suggested measuring an individual's risk aversion by dividing the second derivative of the utility function by the first derivative. Two measures have resulted. One is a measure of absolute risk aversion:

$$R_a(x) = {-U^{''}(x)} \big/ {U^{'}(x)} \qquad \text{...2.2}$$

The other is a measure of relative risk aversion:

$$R_r(x) = -\mathrm{x}\, {U^{''}(x)} \big/ {U^{'}(x)} \qquad \text{...2.3}$$

Where $U(x)$ is the expected utility function with properties $U^{'}>0$ and $U^{''}<0$, and $U^{'}$ and $U^{''}$ are the first and second order derivative of the expected utility function, and x is the wealth or income position, $R_a(x)$ is the change in marginal utility per unit of outcome space

(Raskin & Cochran, 1986). If $R_a(x) < 0$, = 0 or > 0, then the individual is risk-seeking, risk-neutral and risk-averse respectively.

A risk-averse decision maker would display decreasing (non-increasing) absolute risk aversion for increases in x (Pratt, 1964; Arrow, 1971). Mas-Colell *et al*. (1995) stated that a risk-averse individual with decreasing relative risk aversion will exhibit decreasing absolute risk aversion, but the converse does not necessarily hold. Menezes and Hanson (1970) proposed a related measure of risk aversion referred to as partial relative risk aversion based on the work of Pratt (1964) and Arrow (1971). It is defined as:

$$P(x,t) = \frac{-tU''(x+t)}{U'(x+t)} \qquad \text{... 2.4}$$

Where $U(x)$ and x are as defined above and t is income associated with a new prospect that is increasingly risky for increases in its payoff. Menezes and Hanson (1970) and Binswanger (1980) hypothesized that a risk-averse decision-maker would display increasing (non-decreasing) partial relative risk aversion for increases in the prospect t.

To this end, the axioms are assumptions in choosing risk alternatives and describe how a rational individual should behave. If an individual obeys the expected utility axioms, then a utility function can be formulated that reflects the individual preferences (Robison *et al*., 1984). In addition, an individual's risk attitude can be inferred from the shape of the individual's utility function. The predictive power of expected utility theory is tested through experiments or inferences made from actual observed economic behaviour. Since the work of Von Neumann and Morgenstern (1947), the expected utility model has been the dominant model in predicting choice behaviour under risk. Nevertheless, expected utility theory has come under criticism (Rabin and Thaler, 2001; Allais, 1984; Rabin, 2000). The subjected expected utility (SEU) hypothesis, however, remains the most appropriate theory for prescriptive assessment of risky choices (Hardaker *et al*, 2004; Meyer, 2001).

2.4 Certainty equivalent and risk premium

According to Hardaker *et al*. (2004), the partial ordering of alternatives by utility values is the same as partial ordering them by certainty equivalent (CE). Hoag (2009) defined CE "as the ‘certain’ amount that a person would have to be paid to give up the potential payoff from a risky activity”. The CE of a risky prospect is the sure sum with the same utility as the expected utility of the prospect (Hardaker *et al*., 2004). That is to say, for a given utility function, it is the point mass at which the individual is indifferent between the value and the risky outcome: the estimated CE is classically less than the expected money value (EMV) and greater than or equal to the minimum value for a risk-averse individual which is usually the normal case. The risk premium (RP) is equal to the EMV of the risky event minus its CE (Hoag, 2009). Solá (2010) also defined risk premium as the amount of money that an individual is willing to pay to avoid a risky outcome. As mentioned earlier, partial ordering of alternatives by utility values is the same as partial ordering them by (CE): it is more convenient to convert the utilities to CE values by taking the inverse of the function:

$$CE(x, r(x)) = U^{-1}(x, r(x)) \qquad ...2.5$$

Given an exponential utility function, CE is defined by Hardaker *et al*. (2004) and Grové (2007) as:

$$CE(x, r_a(x)) = \ln\left[\left(\frac{1}{n}\sum_{i}^{n}\exp(-r_a(x)x_i)\right)^{\frac{-1}{r_{a(x)}}}\right] \qquad ... 2.6$$

Where $r_a(x)$ is a specific absolute risk aversion coefficient, n is a random sample size from a risky alternative x.

The alternatives which have the highest or equal highest CE values for some value in the range of $r_a(x)$ are utility efficient.

2.5 Sources of risk and responses to risk in agriculture

The sources of risk vary from one region to another, so also the responses to risk are unique to a particular region.

2.5.1 Types and sources of risk in agriculture

According to Boehlje (2002), risk sources can be classified as tactical or operational, which comprise business, financial and strategic risks. The focus of strategic risk is the sensitivity of the strategic direction and the ultimate susceptibility of a firm to uncertainties in the business climate. The uncertainties include political, government policy, macro-economic, social and natural contingencies, industry dynamics involving input markets, and competitive and technological uncertainties.

This study uses the classification of Musser and Patrick (2002), Hardaker *et al*. (2004), and Drollete (2009) who classified the types and sources of risk into five types, namely production, price, institutional, personal and financial risk.

Production risk is a random variability inherent in a farm's production process. The major sources of production risk are weather, diseases and pest infestations, which cause variation in crop yields and in livestock and poultry production (Hardaker *et al.*, 2004; LeBel, 2003; Musser & Patrick, 2002; Drollete, 2009). Sonka and Patrick (1984) have opined that fire, wind, theft and casualties are other sources of production risk.

Price or market risk is related to the variations in commodity prices and quantities that can be marketed (OECD, 2009). Price or market risk can occur owing to imperfect knowledge about input and output prices (LeBel, 2003; Drollete, 2009). Prices of farm outputs are rarely known for certain at the time that a farmer must make decisions about how much of which inputs to use or what and how much of different products to produce (Hardaker *et al.*, 1997). Short-run fluctuations in input prices can cause considerable income losses and cash shortfalls (Sonka & Patrick, 1984).

Institutional risk is concerned with changes in the rules that affect farm production which can have far-reaching implications for profitability (Hardaker *et al*., 2004). The major source of institutional risk emanates from the government (LaBel, 2003). For example, while legislation on price control can lower farmers' income in the face of increasing demand for their products, price support on the other hand could help stabilize their income in the face of low prices owing to a decline in demand. Furthermore, while legislation on production control may help in regulating production and supply in the market leading to stable income, an abrogation of such a law could result in opposite implications.

Human resource risk is the threat that owners, family, and/or employees will not be available for farm labour and management (Musser & Patrick, 2002). Hardaker *et al*. (2004)

have stated that farm business operators may be a source of risk for the profitability of the farm business. Major life predicaments, such as death of the owner, prolonged illness of one of the principals, and carelessness by the farmer or farm workers in handling livestock or using machinery may lead to significant losses in the farm business (Drollete, 2009). The aggregate effect of production, market, institutional and personal risk is called *business risk*. It occurs when there is variation in income levels (Hardaker *et al.,* 2004).

Financial risk results from the method of financing the farm business. Financial risk is unexpected risk in interest rate changes on borrowed funds or unavailability of loans from financial institutions (Drollete, 2009). The uses of outside finance in financing farm enterprises expose farmers to financial risk. Financial risk is concretely manifested when enterprise profitability (rate of return) is less than the cost of capital. It multiplies with financial leverage ratio (debt/equity ratio) and it is inversely related to profitability (Hardaker *et al.*, 2004). They added that the use of credit in farm business is associated with financial risk. The most significant of these are unexpected increases in interest rates on borrowed funds, the unanticipated calling-in of a loan by the lender and the possible unavailability of loan finance when needed.

Various factors contribute to the risk, for example gestation lag, biological nature of farming and the farming firm. Research has shown that harvest failures of rural households, policy shocks, death and illness of livestock, high yearly yield fluctuations (in monetary term) per unit of land/crop, yield variability, output prices and input cost, diseases, and insect infestations have been experienced by farmers (Dercon, 2002; Patrick, Peiter, Knight, Coble, & Baquet 2007).

2.5.2 Responses to risk in agriculture

The choice of risk management strategies is a difficult decision which a farmer must make in order to alleviate or ease risk (Cobble, Heifner & Zuniga, 2000). Several authors have identified a variety of risk management strategies. Some of the following, among others, are used by the farmers: enterprise diversification; crop insurance; *Esusu* (Yoruba language) or *Adashe* (Hausa language), which means revolving contributed cash; forward marketing techniques, such as future options and cash forward contracts; sequential marketing, i.e. marketing several times per year; direct sales to consumers; controlling and limiting debt;

off-farm work and investments; controlling family consumptions; strategic business planning; keeping cash at hand; and the use of extension services and farmers' cooperatives (Meuwissen *et al*., 2001; Musser & Patrick, 2002; Alimi & Ayanwale, 2005; Salimonu & Falusi, 2009). For example, diversification and strategic planning are used to combat production risk. Crop insurance, *Esusu* (Yoruba language), controlling and limiting debt, off-farm work and investments, and cash at hand are used to mitigate financial risk. Price/market risk is combated with sequential, forward marketing and direct sales to consumers. Cooperatives and extension services are associated with mitigation of institutional risk.

2.6 Applied research on risk attitudes, risk sources and management strategies

Several researchers (Binswanger, 1980; Anderson, Dillon & Hardaker, 1977; Roumassett, 1973; Shahabuddin, Mestelman & Feeny, 1986) have applied different methods to measure risk of individual farmers. These researchers typically used the utility-based and security-based models. The expected utility is the standard model for analysing decision making under uncertainty (Tuthil & Frechette, 2002). Rabin and Thaler (2001) argued that the manner in which risk is characterized in the expected utility model leads to illogical conclusions. This is the major criticism of the utility theory. Despite its limitations, the utility theory has remained the most suitable theory for prescriptive assessment of risky choices (Hardaker *et al*., 2004; Meyer, 2001).

Tuthil and Frechette (2002) have presented three alternatives to overcome the problems of the expected utility model. The alternatives are weighted expected utility, rank dependent utility and cumulative prospect theory. The three alternatives are capable of accommodating the common consequence effect and are thus able to explain the so-called Allias paradox. The utility theory has, *inter alia*, been used by Ferrer, Hoag and Nieuwoudt (1997), Holt and Laury (2002), Yesuf and Bluffstone (2009), and Kouamé (2010).

The safety-based utility rules can be defined in terms of gains and losses arising from a simple prospect, or in terms of final income. A limitation of the safety-based utility method is that very rarely do the proponents consider the information required of the analysts who attempt to make predictions for an individual or a group of individuals (Binswanger, 1980).

According to Binswanger (1980), the safety-based rules are safety-fix, safety principle and lexicographic rules (LSF). For details of the explanations, see Binswanger (1980).

Demiryurürek, Ceyhan, and Bozoğlu (2012) classified the methods of eliciting risk attitudes of farmers into two categories, namely the experimental gambling method and the indirect approach. According to Dillon and Scandizzo (1978) and Binswanger (1980, 1981), the experimental gambling method is based on alternative choices between certain and risky alternatives which can be either hypothetical or real. The experimental approach gives more reliable estimates of risk aversion than the indirect approach (Binswanger, 1980). The indirect approach is based on deducing attitudes to risk by comparing observed economic behaviour to predicted behaviour under a theoretical model of profit maximisation (Binswanger 1978; Knight *et al*., 2003; Demiryurürek *et al.*, 2012). In this literature review, most of the international studies used the experimental gambling method (Ferrer *et al*., 1997; Gunjal & Legault, 1995; Binici *et al*., 2003).

Based on previous outline, some of the literature on risk is discussed next.

2.6.1 International studies

Binswanger (1980) examined the attitude toward risk in rural India. The researcher used two methods: an interview method, eliciting certainty equivalents and an experimental gambling approach with real payoffs. Two hundred and forty subjects were involved in the risk attitude experiment. The result interpreted from the utility framework showed that all but one of 118 individuals had non-linear, risk-averse utility functions, which exhibit increasing partial risk aversion. At high payoff levels, almost all the subjects are moderately risk-averse with slight variation based on personal characteristics. Risk aversion reduces slightly as wealth level increases but its effect is not statistically significant. The interview method results were completely different with the experimental measures of risk aversion owing to interviewer bias.

Brüntrup (2000) measured the risk aversion of farmers in northern Benin, western Africa, using an experimental gambling approach. Farmers of all included regions and ethnic groups were found to be severely risk averse: if measured as Z-score (level of trade-off between expected gain and its standard deviation) the average risk aversion was 0.5-1. Regional origin, ethnic group and household internal factors were of low importance for the degree of risk aversion. Such strong risk aversion has to be taken into account in any economic assessment if useful predictions of innovation adoption or policy response are to be expected.

Holt and Laury (2002) examined risk aversion and incentive effects. Using a simple lottery choice experiment, the researchers measured the degree of risk aversion over a wide range of payoffs. They also compared behaviours under hypothetical and real incentives. The results reveal that "with normal" laboratory payoffs of several dollars, most of the respondents are risk averse and few are risk loving. Two-thirds of the subjects exhibited risk aversion at the low payoff level. When payoffs are actually paid in cash, risk aversion increases sharply when payoffs are scaled up by factors of 20, 50 and 90. The behaviour of the subject is not affected when hypothetical payoffs are scaled up.

Yesuf and Bluffstone (2009) investigated poverty, risk aversion, and path dependence in low-income countries using an experimental method. The study was conducted in Ethiopia. The results depict that subjects become more risk averse as payoffs increase which imply increasing partial risk aversion. Twenty-eight per cent of the respondents were severely to extremely risk averse, which implies extremely high-risk aversion at relatively larger stakes. A comparison of risk aversion by oxen holdings show that there is a statistically significant difference in risk behaviour depending on oxen ownership, with wealthier households having lower levels of risk aversion. The results from the probit model estimates revealed that the estimated coefficients for a number of wealth categories in the form of oxen, total domestic animals, cash or land tended to reduce severe and extreme risk aversion and moved respondents into less risk-averse categories.

Kouamé (2010) investigated the risk, risk aversion and choice of risk management strategies by cocoa farmers in western Cote D'Ivoire. Experimental gambling and a probit model were used to achieve the objectives of the study. The results show that the farmers exhibit moderate risk aversion. The subjects were more risk averse as the size of the payoff increases, which depicts increasing partial risk aversion. The most important risk sources were output (cocoa) price fluctuation, pests/diseases and input access risk. About 60% of the producers utilised precautionary savings, 43% were members of social networks while 33% used crop diversification as risk management strategies. The results from the multivariate probit model showed that farm size, literacy, off-farm employment, cocoa price risk and risk aversion were the factors that significantly affected adoption of crop diversification in the study area. For the precautionary savings, the most significant variables were farm size, land ownership, farming experience, household size, off-farm employment, pests/diseases of cocoa plant, input access, and illness/death of a member of the house, risk aversion and farmer's access to information. Farm size, literacy, experience, household size, off-farm employment, input access, illness/death and risk aversion were the variables that were significant in the social network participation.

Risk preferences of Kwazulu-Natal commercial sugar cane farmers were examined by Ferrer *et al.* (1997). The researchers used a direct elicitation of utility approach. The result revealed that of the 53 farmers surveyed, 2 refused to participate in lottery games for religious or moral reasons. Of the remaining respondents, 57%, 30% and 13% were risk averse, risk neutral and risk preferring, respectively. Even though risk preferences vary significantly among individual farmers, on average they were risk averse. With increasing gamble payoff range, the farmers exhibit increasing absolute risk aversion at a decreasing rate.

Risk Preferences of Dairy and Hog Producers in Quebec were examined by Gunjal and Legault (1995). The direct elicitation of utility method was employed to determine producers' degrees of risk aversion. The Delphi process was used to obtain more refined and realistic responses. The findings suggested that the risk preferences of the farmers were highly diverse. The percentage of risk-taking farmers ranged from 8% to 23%, depending upon the level of investment and the nature of the enterprise. On average, the majority of farmers in both groups were found to be risk averse. Hog producers were found to be consistently more risk averse than dairy producers, based on the differences between the means, as well as frequency distributions, although not all cases were significant. Moreover, the gap between the two groups widened as the level of investment increased. The implications of this result are that the stability of farm income owing to supply management in dairy sector might facilitate investments of a given risk (for example, adoption of a new technology) more so than it would in the hog sector.

Binici *et al.* (2003) investigated the risk attitudes of farmers in terms of risk aversion for the lower Seyhan plain farmers in Adana province, Turkey. The equally likely certainty equivalent (ELCE) model was used to determine the farmers' risk preferences. The parameters estimated from the cubic, negative exponential, power and expo-power utility functions were used to determine the Arrow-Pratt coefficient of absolute risk aversion. The results indicated that 91% of the farmers were risk averse.

Ceyhan and Demiryürek (2009) compared the attitudes to risk of organic and non-organic hazelnut producers in the Samsun province of Turkey. The ELCE model was used to elicit utility from 64 randomly selected non-organic producers and all organic hazelnut producers (39). The Arrow-Pratt risk aversion coefficient ($(r_a(w))$ was used to measure the degree of risk aversion. It was found that organic hazelnut producers were more risk-taking compared to non-organic producers. The mean absolute risk-aversion coefficients were 3.03 and 2.38 for non-organic and organic producers respectively. The factors that influenced farmers' conversion from non-organic to organic hazelnut production in the study area were the educational level of the farmers, farm income, total capital, time allocated outside the farm, farm land, hazelnut orchard size, plot number of hazelnut orchard, and total information.

Shahabuddin *et al*. (1986) investigated peasant behaviour toward risk and socio-economic and structural characteristics of farm households in Bangladesh. They used an expression capturing peasant behaviour towards risk in a Safety-First model. The risk coefficients for the majority of the farmers were negative, which implied that they should have "risk-averse" behaviour, although many households displayed positive risk coefficients. In this situation, it was rational for the farmers to "gamble" on riskier crops. The risk coefficients were significantly related to a set of important socio-economic and structural variables of the farmers in Bangladesh. Particularly the coefficients of the major explanatory variables, family size, farm size and off-farm income had the expected signs and were statistically significant for one of the regions (i.e. Sylhet region) considered. There were mixed relationships between the socio-economic variables and structural variables in the other regions.

The risk and risk management strategies of Dutch livestock farmers were investigated by Meuwissen *et al*. (2001). Factor analysis and multiple regression were used to analyse the data. The results revealed that the farmers perceived price and production risk as the important sources of risk. The relevant strategy to manage risk was insurance. The multiple regression result by Meuwissen *et al*. (2001) showed that gross income, solvency, farm size and farmers' education significantly related to the farmers' relative risk attitudes. For the factor analysis results, the researchers found that family health, finances, legislation, production and change were the risk factors. The management strategies factors were price risk reduction, insurance, diversification and certain income. The authors concluded that although risk perceptions were very personal, the results provided insight for policy makers, advisers, developers and sellers of new risk management strategies.

Lien, Flaten, Ebbesvik, Koesling and Valle (2003) studied the goals, relative risk attitudes, sources of risk and risk management responses among organic and conventional dairy farmers. The sample size constituted 370 conventional and 160 organic dairy farmers in Norway. The results showed that the average organic farmer was less risk averse. The most important source of risk for both organic and conventional production system was institutional risk. Forage yield risk was experienced more among organic farmers. The most important risk management strategy in the two groups of farmers was diversification and different kinds of flexibility.

Perceptions of key business and financial risks by large-scale sugarcane farmers in KwaZulu-Natal were investigated by MacNicol, Ortman and Ferrer (2007). The researchers used factor analysis to identify the dimensions of risk sources of the large-scale sugarcane farmers. The farmers ranked land reform, labour legislation (specifically minimum wages), crop price variability, changes in input costs and crop yield variability as the five most important sources of risk. The important risk source factors were macroeconomic and political index, legislation index, labour and inputs index, human capital and credit access index, management index and water rights index. The researchers recommended that transparency should be maintained in dealing with land reform issues and also the creation of an enabling business environment that would reduce risk and uncertainty for production.

Le and Cheong (2009) measured risk levels and efficacy of risk management strategies in Vietnamese catfish farming. Farmers' perceptions of risk and risk management were analysed using descriptive statistics. The results revealed that the most important sources of risk were price variability, cost of operating inputs, high fish death rates owing to diseases and low quality of fingerlings. The most important risk management strategies that the farmers perceived were farm management, disease prevention, and selecting good quality inputs (water source, feed and fingerlings). Application of price risk reduction strategies were not perceived as relevant strategies to the farmers.

2.6.2 Nigerian studies

Risk aversion among poultry egg producers in south western Nigeria, using a safety-first behaviour model, was examined by Ajetumobi and Binuomote (2006). The results showed that 69% of the poultry farmers had a medium level of aversion to risk, while about 7% had high level of risk aversion. The risk premiums were low, encouraging the use of the feeds under safety-first behaviour. The regression result revealed that family size of the farmers, capacity of deep litter, cost of veterinary services, cost of construction of deep litter and cost of land were significant in explaining the risk bearing capacity of the poultry farmers.

Ogunniyi and Ojedokun (2012) investigated the production risk of rice farmers in Kwara State, Nigeria. A Safety First model was used to assess the risk attitudes of the farmers. The results revealed that 76% of the farmers were intermediate risk averse and that 13% were low risk averse. Eight per cent and two per cent were risk preferring and high risk averse, respectively. The household size, education, experience and farm size had a statistically significant influence on risk attitudes of the farmers. The coefficients for education and experience were negative, implying that more educated and experienced farmers would be less willing to bear risk than less educated and experienced ones. Household size had a positive and statistically significant influence on risk attitude of the farmers, meaning that larger households had a higher potential for dealing with risk than smaller households did. Farm size had a positive and statistically significant influence on risk attitude of the farmers, implying that attitude to risk increased with increases in farm size. The researchers also examined the sources of risk and risk coping strategies of the rice farmers. The results showed that the most severe sources of risk were flood (natural risk), bush fire and civil disorder (social risk), price fluctuation (economic risk), inadequate fertiliser, poor soil condition and lack of improved seed (technical risk). The coping strategies that farmers used to combat the risk sources were education, mixed farming, special diversification, cultivation flexibilities, price support system, cooperative society and extension services, in order of importance.

Attitudes towards risk among maize farmers in the dry savannah zone of Nigeria were analysed by Olarinde *et al*. (2007). The researchers applied econometric analysis to quantitatively determine the individual risk attitudes of the sampled maize farmers. The extent of the risk attitudes were then made the basis for categorizing the farmers into three groups of low, intermediate and high risk averse maize farmers. This categorisation formed a necessary condition for improving the typology of the farmers, which was hypothesised to be influenced by socio-economic, demographic and other extrinsic “risk factor”. The typology was essentially made possible by discriminant analyses, which re-categorised the farmers into their appropriate risk groups. The findings revealed that about 8%, 42% and 50% of the farmers were low, intermediately and highly averse to maize risk, respectively. About 72% of the hypothesised variables were found to be responsible for the risk aversion among the sampled farmers. These variables were the basis of a policy recommendation to address issues generated by the four types of risks identified in maize production, namely natural, social, economic and technical risks. These are important for harnessing crop technology and to alleviate hunger and poverty in Africa.

Alimi and Ayanwale (2005) studied the risk and risk management strategies in onion production in Kebbi State of Nigeria. Frequency distributions, importance indices and a portfolio model were used to analyse the data. The results showed that drought, pest/diseases, input price, output price, theft and lack of capital were the most important risk sources in the study area. Ranking of risk sources of the respondents using importance indices revealed that output price was the most important risk source. The farmers used native safeguards, such as fencing, guards (watchmen) and native medicine (juju), as a means of reducing social risk by scaring off thieves and preventing theft. Diversification was used as a means of stabilizing farm household income, which involved deriving income from two or more activities or enterprises. Forty-six per cent of the respondents engaged in non-farm activities apart from farming where they earned non-farm income. All the onion farmers practiced enterprise diversification by combining onion production with other vegetable crops, such as tomatoes, peppers, potatoes and maize. Strategic means of reducing market risk were not available. The portfolio model analysis of the diversification strategy indicated that the farmers were not efficient in their enterprise combination.

From these reviews, it is evident that the use of the experimental approach to estimate the risk attitude of farmers in Nigeria has not yet been done. Hence, there is a need to fill this knowledge gap. Research, however, has been done internationally using the experimental approach. The Safety First Behaviour model has been criticised because of the fact that it is difficult to determine the relative influence of risk and other factors on the decisions of the individual (Binswanger, 1980). The econometric studies of portfolio behaviour have the advantage of being more realistic, but the approach has been questioned because it does not produce very detailed information (Bardsely & Harris, 1987). The experimental approach is a more reliable method of estimating risk aversion (Binswanger, 1980). Accordingly there is need to investigate the risk attitudes of the farmers in Nigeria using the experimental method, which is a more reliable approach. The knowledge generated should be suitable for guiding policy makers, advisers and extension agents in the formulation of programmes that will improve farmers' productivity.

2.7 Farm efficiency

2.7.1 Definition and types of efficiency

Fried, Lovel and Schmidt (2008) have defined efficiency as a comparison between observed and optimal value of output and input. Efficiency is improved if more outputs are generated without changing inputs, or if the same outputs are generated with fewer inputs. According to Bravo-Ureta and Rieger (1991), substantial resources can be saved through efficiency measurement. The importance of efficiency was highlighted by Ajibefun (2008) and Freid *et al*. (2008): "Firstly, it is a success indicator and performance measure by which production units are evaluated. Secondly, the exploring of hypothesis relating to the sources of efficiency differential can only be possible by measuring efficiency and separating its effects from the effects of the production environment. Thirdly, identification of sources of inefficiency is important to the public and private organisation policies designed to enhance performance" (Ajibefun, 2008: 96). In general, efficiency indicates the inputs – output relationship of the production function which defines the possible combinations of inputs and the resulting outputs (Hollingsworth & Peacock, 2008). The subject of efficiency measurement started with Farrell (1957) who proposed a measure of the efficiency of a farm that consists of two components: technical and allocative efficiency.

Allocative efficiency in input selection involves selecting that mix of inputs (such as land, labour and capital) which produce a given quantity of output at minimum cost (given the input prices which prevail) (Coelli, Prasada Roa, O'Donnell & Battese, 2005). Technical efficiency is defined as the ability of a firm to obtain maximum output from a given set of inputs (Farrell, 1957). Economic efficiency or total efficiency is the product of technical and allocative efficiencies (Coelli *et al.,* 2005; Coelli, 1996). Economic efficiency can also be defined as the ability of a farm to achieve the highest possible profit, given the prices and levels of output prices of that farm (Bagi, 1982).

2.7.2 Measuring farm efficiency

As an introduction, some items in the literature on approaches to measuring farm efficiency are briefly presented here. Farm efficiency can be measured using Data Envelopment Analyses (DEA) or Stochastic Frontier (SF) methods, which involve mathematical programming and econometric methods respectively (Coelli *et al.,* 2005). These techniques are broadly categorized into two approaches: parametric and non-parametric. The parametric SF approach and the non-parametric DEA approach (Sarafidis, 2002) are the most popular techniques used in efficiency analysis. Alene *et al.* (2006) stated that additional alternatives, such as Parametric Distance Functions (PDF), have also been available since their development by Shephard (1953, 1970), although they are not as popular as the former methods.

The three methods have their advantages and disadvantages. The advantages of the SF approach are that it takes into account random errors and random variables and permits statistical tests of hypotheses pertaining to production structure and degree of inefficiency (Coelli, Prasada Rao & Battese, 1998). The SF approach is also appropriate for agricultural application, especially in developing countries where the data are heavily influenced by measurement errors and the effects of weather (Bekele, 2003). The main criticism of the SF model, as pointed out by Coelli *et al.* (1998), is the absence of general *a priori* justification for the selection of any particular distributional form for the random variables.

The main advantage of the PDF method is that multi-input, multi-output technology can be specified when price information is not available but cost, profit or revenue function representations are precluded because of violations of the required behavioural assumptions (Alene *et al.*, 2006).

Assumptions regarding the functional form of the production function or distribution of error term are not needed in DEA (Coelli, 1996; Sarafidis, 2002; Andreu & Grunnewald, 2006; Cooper, Seiford & Tone, 2007). Thus, the question of mis-specifying the frontier does not arise, which is one of the advantages of DEA when compared to SFA. DEA can be applied for multi-output and multi-input data. Another advantage of DEA is that it works well with small samples (Pasiouras, Sifodaskalakis & Zopounidis, 2011). A disadvantage of the DEA approach is that it does not take into account the possible influence of measurement errors and other noise upon the frontier; all deviations from the frontier are assumed to be the result of technical inefficiency (Coelli *et al.*, 1998; Sarafidis, 2002). This limitation can be overcome by applying the bootstrap procedure to correct the bias in DEA estimators of technical efficiency and establish their confidence interval (Simar and Wilson, 1998, 2000). DEA is also sensitive to outliers. Outliers can cause problems in both DEA and SFA, but for different reasons: while with DEA it is probable to find too much inefficiency in the sample, SFA can fail to discover any inefficiency at all. The solution to this limitation in both approaches is to remove the outliers from the analysis and proceed without them. In this study, DEA will be used in order to obtain more reliable estimates of the efficiency levels of the farmers. DEA will also be used because of its applicability in multi-output and multi-input data as it relates to the monocropping and intercropping systems of this study.

Coelli *et al*. (2005) explained two types of orientation measures: input-orientated measures and output-orientated measures. The input-orientated technical efficiency measures indicate the amount by which input quantities can be proportionally reduced without changing the output quantities produced. The output-orientated measure answers the question of the amount of output quantities to be proportionally expanded, using the same quantities of input. In the current study on the efficiency of farmers in Kebbi State, the input orientated measure will be used, since farmers do not have control over the output. The concern in this study is to improve the efficiency level of farmers, given the existing technology set.

The absence of an error or stochastic disturbance term in DEA means that standard errors (and therefore, confidence intervals) cannot be estimated, which is a serious econometric problem. Advances in DEA literature include using bootstrap to establish the confidence interval of technical efficiency (Simar & Wilson, 2000). Bootstrap will be used to construct confidence intervals for this study. Unlike the stochastic frontier model, DEA does not give an estimate of a farmer's specific variables that affect efficiency. This, however, can be estimated using the Tobit model or ordinary least square regression (Ajibefun, 2008; Gul, Koc, Dagistan, Akpinar & Parlakay, 2009; Binam, Sylla, Diarra & Nyambi, 2003; Hoff, 2007).

2.7.3 The metafrontier model

Metafrontier production function was first proposed by Hayami (1969), followed by Hayami and Ruttan, (1970, 1971), with the aim of examining the causes of agricultural productivity differences among developed countries. The researchers assumed that the technological possibilities available to all agricultural producers in different countries could be characterised by the same production function, that is, the meta-production function. It is important to note that the framework of the meta-production function does not necessarily imply that all producers operate on a universal production function.

Meta-production function approach is used to compare agricultural productivity across countries (Hayami & Ruttan 1970, 1971). The concept arises from the fact that the efficiency levels measured relative to one frontier cannot be compared with efficiency levels measured relative to another frontier (O'Donnell *et al*., 2008; Huang, Chiang, Chen & Chiu, 2010).

The meta-production function approach has an advantage in that the data collected from different countries have the capacity of variations in the dependent and independent variables and the number of observations can be dramatically increased. However, the major limitations of this approach are the incomparability of data, specification of production function and the differences in the basic economic environment (Huang *et al*., 2010).

Metafrontier technique was recently proposed by Battese, Rao and O'Donnell (2004). This approach allows for the calculation of technical efficiencies for farms operating under different technologies, as well as the metatechnology gap ratio, which measures the extent to which the technology frontier of individual groups deviate from the metafrontier.

The concept of metatechnology is based on the simple hypothesis that all countries have potential access to the same technology and it allows for the comparisons of production efficiencies among producers operating under different technologies (Huang *et al*., 2010).

Recently, O'Donnel *et al*. (2008) developed a framework for making efficiency comparisons across groups of firms. In this framework, efficiency is measured relative to a common metafrontier, which is defined as the boundary of an unrestricted technology set. The *group* frontiers are defined as the boundaries of a restricted technology set. The restrictions arise owing to the differences in human and financial capital (e.g. quality of labour force, access to income, savings), economic infrastructure (e.g. access to markets), resource endowments (e.g. soil quality, climate of the region) and other physical, social and economic environment factors in the production environment (O'Donnell *et al*., 2008; Heshmati, Lee & Hwang, 2012). It is worth noting that the metafrontier envelops the group frontier such that the group frontier lies below the metafrontier (O'Donnell *et al*., 2008; Huang *et al*., 2010)

O'Donnell *et al*. (2008) have mentioned that efficiencies measured relative to the metafrontier can be decomposed into two components that measure the distance from an input-output point to the group frontier. This is described as the common measure of technical efficiency and a component that measures the distance between the group frontier and the metafrontier, which represent the restrictive nature of the production environment.

Programmes for performance improvement are designed when information on technical efficiency estimates are known. Estimates from the metatechnology ratio can be used by policy makers to design policies/programmes that could improve the performance of the farm enterprise. Such programmes, according to O'Donnell *et al*. (2008), will involve changes in the production environment.

2.8 Review of efficiency studies

2.8.1 Factors affecting farm efficiency

Some of the factors influencing technical inefficiency include age of the farmer, years of experience, education of household head, risk aversion, farm size, land fragmentation, extension services, access to credit, ownership of oxen, labour, household size, gender and seed. These factors are discussed next.

Age of the farmer

Increasing age is expected to lead to a reduction in the level of technical efficiency. Older farmers will have less physical efforts to put into their farming. Ajibefun and Abdulkari (2004), Ajibefun (2006), Ogundele (2003), and Otitoju and Arene (2010) have stated that age of farming household heads have an inverse relationship with productivity of farmers in Nigeria. They argued that this was understandable since it was expected that as a farming household head becomes older, the farmer's productivity would decline. Similar results were obtained by Gul *et al*. (2009) for Turkey and Dhehibi, Lachaal, Elloumil and Messaoudi (2007) for Tunisia. Younger farmers are more knowledgeable about new practices and may be more willing to bear risk owing to longer planning horizons (Polson & Spencer, 1991). Other researchers have found that age increases technical efficiency (Msuya, Hisano & Nariu, 2008); Amos, 2007). It is believed that experience increases with age and resource endowment, hence giving an increase in efficiency.

Years of farming experience

Experience is the first determinant of profitability because it can inform farmers to adjust to changing economic conditions and adopt the most efficient cultural practice (Yusuf, 2007). Years of farming experience increase as the age of the farmer increases. Studies conducted in the humid forest and moist savannah agro-ecological zones of Nigeria showed that productivity was positively associated with more experience in farming (Ajibefun & Abdulkadri 2004; Ajibefun, 2006; Idjesa, 2007; Ogunniyi & Ojedokun, 2012). Farming experience has positive effect on the farmer's efficiency (Yusuf & Malomo, 2007; Abdulai & Eberlin, 2001). Gul *et al*. (2009) and Ogisi O'raye, Chukwuji, Christopher & Daniel (2012) also found that farming experience has a positive effect on technical efficiency among cotton farmers in Cukurova region, Turkey and rice farmers in Nigeria, respectively.

Education of household head

The education of the household head has a positive effect on farm efficiency (Abdulai & Eberlin, 2001; Dhehibi *et al*., 2007; Gul *et al*., 2009; Solís *et al.*, 2009; Kyei, Foli & Ankoh, 2011; Ogisi *et al*., 2012). Education enhances the adoption of innovations and thus increases efficiency. In the same vein, Amaza (2000), Ajani (2000), Adeoti (2002), Ajibefun and Abdulkadri (2004), Ajibefun (2006), Yusuf and Malomo (2007), Akinbode, Dipeolu and Ayinde (2011) and Ogunniyi and Ojedokun (2012) have all pointed out that education was key to enhancing productivity among farming households in the humid forest, dry savannah, moist savannah and guinea savannah agro-ecological zones of Nigeria. Similar results were reported by Khai and Yabe (2011), Kamruzzaman and Hedayetul Islam (2008) and Jordaan (2012). A negative relationship exists between education and technical inefficiency (Ogundari & Ojo, 2007; Koc, Gul & Parlakay, 2011). The importance of a farmer's education cannot be overemphasized.

Risk aversion

Dhungana, Nuthall and Nartea (2004) measured the economic inefficiency of Nepalese rice farms using DEA. The researchers found that risk aversion coefficient had a positive significant relationship with technical efficiency. The researchers argued that the more risk averse the farmers were, the more likely they were to allocate farm resources under their discretion more optimally, hence they were more technically efficient. This is because risk-averse farmers try to avoid wastage of resources by carefully allocating their limited resources.

Farm size

Ajibefun, Battese & Daramola (2002) studied the determinants of technical efficiency in small-holder food crop farming. They applied a stochastic frontier production function and their results show that large farm size enhanced productivity among farmers in the dry savannah and humid forest agro-ecological zones of Nigeria. Tanko and Jirgi (2008) examined the economic efficiency among small-holder arable farmers in Kebbi State, Nigeria. The stochastic frontier results suggested that farm size had a significant influence on farmers' efficiency. Similar results were reported by Binam *et al*. (2007), Gul *et al*. (2009) and Chirwa (2007). On the contrary, Haji (2007) found that farm size had a negative influence on technical efficiency. Jordaan (2012) found that area harvested for raisin farmers had a positive relationship with technical efficiency.

Land fragmentation

There are two typical cases where fragmentation of landholding is likely to occur. When communal property land is divided among commoners, and when private property land is inherited jointly by co-heirs (Bentley, 1987). Gul *et al*. (2009) found that an increase in the number of land parcels had a negative effect on technical efficiency. In areas where land is fragmented, farmers walk long distances to the farms and hence labour input on the farm is reduced because of the time wasted in walking to the farms, resulting in inefficient input application (especially farmyard manure) and farm work supervision. Wadud and White (2000) studied the farm household efficiency of rice farmers in Bangladesh and the results showed that land fragmentation had a negative impact on technical efficiency. Msuya *et al*.

(2008) also found similar results for farmers in Tanzania. Land fragmentation thus impairs agricultural efficiency.

Extension services

Extension services, if properly implemented, should increase the efficiency of farmers, since farmers would obtain the knowledge of using innovations that will improve their productivity. One of the important factors in the establishment of profitable agricultural enterprises is the availability of appropriate technology and extension services. Bekele (2003) stated that most extension services in Africa are oriented toward solving technical problems and are ill equipped to address farm management or social issues that are necessary for technology transfer and adoption. Studies have shown that increase in extension contact has a positive influence on technical efficiency (Akinbode *et al*., 2011, Kamruzzaman & Hedayetul Islam, 2008; Ogisi *et al*., 2012). A contrary result was obtained by Haji (2007).

Access to credit

Access to credit will increase the farmer's ability to purchase improved inputs, farm implements and adopt innovations. Findings from Venter *et al*. (1993) suggested that credit was much more important to emerging commercial farmers who have adopted modern technologies than to subsistence and sub-subsistence farmers in South Africa. Tanko and Jirgi (2008) investigated the effects of agricultural credit on the output and profitability of egg farms in Abia state, Nigeria: the results revealed that agricultural credit had a positive and significant effect on profit. Agricultural credit and production efficiency in sorghum-based cropping enterprises in Kebbi state, Nigeria was also examined by Tanko and Jirgi (2008). The findings showed that farmers that produced with credit were technically more efficient. A similar result was reported by Abdulai and Eberlin (2001) and Maseatile (2011) for small-scale farmers in Lesotho. Jordaan, (2012) found that formal and informal credit has a positive relationship with technical efficiency among raisin producers in Eksteenskuil, South Africa.

Ownership of oxen

The ownership of oxen is important to the livelihood of rural people in Nigeria and in most developing countries (Sanni, Kuswaha, Jirgi & Bala 2003). The use of oxen as draught animals is becoming popular in the northern parts of Nigeria. Camels are also used for ploughing and transport of products from the farm to the storehouse and to the market. Both oxen and camels are used for weeding operations. Economic differentiation among rural households is a function of differential access to draught oxen, land, and available active family labour (Bekele, 2003). Bekele reported that the number of oxen owned has positive influence on technical efficiency.

Labour

Roche (1988) found that the most important success-determining factors for adopting new technology are those relating to human capital endowments (family labour, level of education, experience, knowledge and farming efficiency) and economic status (income, farm size, credit use, etc.) of the farming household. Farmers in northern Nigeria utilise both family and non-family labour (Jirgi & Baba, 2000; Dikwal & Jirgi, 2000). Labour is an important factor in explaining output (Sani *et al*., 2003). Khai and Yabe (2011) found that intensive labour use in rice cultivation has a positive impact on technical efficiency. A similar result was reported by Chirwa (2007). Jordaan (2012) stated that a negative relationship exist between family labour and technical efficiency for raisin farmers in Eksteenskuil, South Africa. The researcher explained that family labour lowers technical efficiency scores of the farmers, especially in vineyards that are older than 25 years of age.

Household size

Yusuf and Malomo (2007) and Binam *et al*. (2003) reported that household size has a negative influence on technical efficiency. According to the researchers, in a situation where the family size is large with only a small fraction of the family members contributing to farm labour, inefficiency in labour use can be expected. Abdulai and Eberlin (2001) reported that large families have a positive influence on technical efficiency, when a large proportion of family members contribute to farm work.

Membership of cooperative society

Membership of a cooperative society has a positive influence on technical efficiency of farmers. Membership of cooperative societies gives members of the cooperative more access to inputs and information on how to improve farm management practices (Obare *et al*., 2010; Nyagaka *et al*., 2010).

Gender

Gender has a negative influence on efficiency (Yusuf & Malomo, 2007; Binam *et al*., 2003; Otitoju & Arena, 2010). Gender was represented by a dummy variable 1 if farmer is male and 0 if otherwise. More men were found to be technically efficient than their female counterparts: the reason is that farming is labour intensive and is highly gender biased.

Seed

Seed has a positive relationship with technical efficiency (Chirwa, 2007). Maseatile (2011) reported that seed quality has a positive influence on technical efficiency of maize farmers in Lesotho. The quality of seed when complemented with other inputs increased crop yields, hence improving efficiency.

Fertiliser

The use of fertiliser has a positive and significant relationship with technical efficiency (Chirwa, 2007). Jordaan (2012) reported that sufficient fertiliser has a negative relationship with technical efficiency, while timely fertiliser application has a positive relationship with technical efficiency. According to the researcher, the negative influence of sufficient quantity of fertiliser applied shows that improved performance does not merely depend on fertiliser application by the farmers in Eksteenskuil, South Africa. The application of the right quantities of fertiliser occurs in combination with other management decisions.

Assets

Assets have a positive impact on technical efficiency of farmers (Haji, 2007). Farmers with higher asset values are likely to purchase and use farm inputs adequately, hence improving their efficiency.

2.8.2 Factors affecting cost and economic efficiency

Age

Age has a positive and significant relationship with a farmer's economic efficiency (Mbanasor & Kalu, 2008). Khan and Saeed (2011) found that age has a positive and significant relationship with the economic efficiency of tomato farmers in Northern Pakistan. The older the farmer, the more experienced he is expected to be, which aids in decision-making. On the contrary, other researchers have reported a negative relationship between age and allocative efficiency (Okoye *et al*., 2006; Akinbode *et al*., 2011).

Years of farming experience

The number of years of farming experience has a positive and significant relationship with a farmer's economic efficiency (Mbanasor & Kalu, 2008; Obare *et al*., 2010). Okoye *et al*. (2006) reported that farming experience has a positive relationship with the allocative efficiency of small-holder cocoyam farmers in Anambra State, Nigeria. Similarly, Jordaan (2012) reported that experience has a positive influence on cost efficiency among raisin producers in Eksteenskuil, South Africa. This implies that the higher the level of experience of the farmer, the higher his cost efficiency level will be.

Education of household head

The education of the household head has a positive and significant relationship with economic efficiency (Hassan, 2008; Khan & Saeed, 2011). According to Akinbode *et al*. (2011), education contributes to effective management of resources by farmers, which, in turn, influences the farmers' efficiency. Okoye *et al*. (2006), however, reported a negative relationship between education and allocative efficiency. Mbanasor and Kalu (2008) have also found a negative relationship between education and economic efficiency. The explanation for the negative relationship between education and economic efficiency could be because of the fact that most farmers rely on their years of experience to attain economic efficiency rather than education (Mbanasor & Kalu, 2008). According to Ojo and Ajibefun (2000), education is expected to have a positive correlation with the adoption of innovation and hence increase in efficiency.

Farm size

Ogunniyi and Ojedokun (2012) found that farm size has a positive significant relationship with economic and allocative efficiency among rice farmers in Kwara State, Nigeria. Farmers with larger farm sizes are expected to be more cost efficient owing to the advantage of economies of scale, as the unit cost of output decreases with increased production. A contrary result was obtained by Mbanasor and Kalu (2008) who found that farm size has no significant positive relationship with the economic efficiency of commercial vegetable farmers in Akwa Ibom State, Nigeria. Okoye *et al*. (2006) and Jordaan (2012) found a negative relationship between size of farm and cost efficiency. Larger farm sizes are associated with lower levels of cost efficiency. The negative relationship may be the result of the characteristics of small-scale farmers who have little experience of operating on large pieces of land.

Land fragmentation

Msuya *et al*. (2008) examined the productivity variation among smallholder maize farmers in Tanzania. The researchers found that land fragmentation has a negative influence on the cost efficiency of the farmers. Fragmentation of farm lands leads to an increase in transport cost for farm inputs and it also leads to inefficient utilisation of labour and other farm inputs and ultimately allocative inefficiency (Hamidu, 2000)

Extension services

Mbanasor and Kalu (2008) found that the number of extension visits had a significant positive relationship with economic efficiency of commercial vegetable farmers in Akwa Ibom State, Nigeria. Similar results were obtained by Obare *et al*. (2010) and Khan and Saeed (2011). Through extension visits, farmers become better informed about farm management, planning and new technologies, hence improving their efficiency.

Access to credit

Access to credit has a positive and significant relationship with a farmer’s allocative and economic efficiency (Okoye *et al*., 2006; Mbanasor & Kalu, 2008; Obare *et al*., 2010; Khan

& Saeed, 2011). Credit access enables farmers to purchase farm inputs adequately and in good time, hence credit improves allocative and economic efficiency.

Membership of cooperatives

Membership of cooperative organisations is expected to have a positive influence on allocative efficiency (Obare *et al.*, 2010). Farmers who belong to cooperatives are better informed on resources use and farm planning which enables them to utilise resources more efficiently.

Ownership of oxen

The ownership of oxen is an important livelihood source to rural people in Nigeria and in most developing countries. The use of oxen as draught animals is becoming popular in the northern parts of Nigeria. Camels are also used for ploughing and transport of products from the farm to the store house and to the market. Both oxen and camels are used for land preparation and weeding (Kubkomawa *et al.*, 2011, Mohammed & Hoffmann, 2006).

Labour

Farmers in northern Nigeria utilise both family and non-family labour (Jirgi & Baba, 2000; Dikwal & Jirgi, 2000). Labour is an important factor in explaining output (Sani *et al.*, 2003). Khai and Yabe (2011) found that intensive labour in rice cultivation has a positive impact on cost efficiency.

Seed

Seed and planting materials have a significant influence on cost of production. Increases in prices of planting materials will increase the total cost of production (Ogundare & Ojo, 2007; Mbanasor & Kalu, 2008).

Fertiliser

The use of fertiliser has a positive and significant relationship with economic and allocative efficiency (Okoye *et al.*, 2006; Ogunniyi & Ojedokun 2012). This emphasises the importance of fertiliser in crop production, as pointed out by Okoye *et al.* (2006): if a farmer fails to buy fertiliser for his or her crops, output loss may be severe. Van der Merwe (2012) found that farmers in Eksteenskuil, South Africa, who use a combination of fertiliser types have the highest probability of being cost efficient.

Assets

Assets have a positive impact on the allocative and economic efficiency of farmers (Haji, 2007). Assets give farmers the ability to purchase farm resources and use them adequately, hence, improving their allocative and economic efficiency.

Risk aversion

Dhungana *et al*. (2004) measured the economic inefficiency of Nepalese rice farms using DEA. The researcher found that risk aversion is negatively related to economic and allocative efficiency. The results imply that the higher the risk aversion, the greater the likelihood of being cost and price inefficient: because of production uncertainties, farmers tend to underutilise purchased farm inputs (Williams *et al*., 1992).

2.8.3 International studies on efficiency measurement approaches and efficiency levels

Farm efficiency can be measured using Data Envelopment Analyses (DEA) (non-parametric) or Stochastic Frontier (SF) (parametric) methods, which involve mathematical programming and econometric methods, respectively (Coelli *et al.*, 2005; Sarafidis, 2002; Alene *et al*. 2006). The advantages and disadvantages of the two approaches are mentioned in section 2.7.2. Particularly, Simar and Wilson (1998, 2000, 2007) have mentioned that DEA efficiency scores are serially correlated and biased when used in the two-stage DEA approach. Simar and Wilson (2007) recommend the use of double bootstrapping procedure in the two-stage DEA in order to obtain unbiased and consistently reliable estimates. Several researchers have applied the DEA and SF approaches to estimate efficiency. Some of the studies are reviewed next.

Wadud and White (2000) studied the farm household efficiency of rice farmers in Bangladesh. They compared the SF and DEA methods. The results from the DEA revealed that the mean technical efficiencies estimated for the Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) assumptions are 0.79 and 0.86, which indicate that there was some inefficiency among rice farmers in the study area. The scale efficiency index of the sampled farmers ranged from 0.62 to 1.00. The mean scale efficiency was 0.92. Most of the farms exhibited mildly decreasing returns to scale under the SF, but increasing and dominantly decreasing returns to scale under the DEA approach. A comparison of the efficiency scores between the SF and DEA models show that the VRS DEA is greater than that obtained from the SF and that estimated from CRS DEA approach. Greater variability exists from the CRS DEA, VRS DEA efficiency scores than the SF model. The researchers concluded that there was considerable inefficiency among the farmers and that agricultural output could be enhanced through the improvement of technical efficiency without resorting to technical improvements.

The production efficiency of the smallholders' vegetable-dominated mixed farming system in eastern Ethiopia was evaluated by Haji (2007). He used a non-parametric DEA approach and Tobit regression to determine the variables influencing efficiency. The results obtained from the DEA model showed that TE indices ranged from 34% to 100% for the farmers in the sample with an average of 91%. The TE scores for each Decision Making Unit (DMU) were the same under the CRS and VRS DEA model. The mean scale efficiency is nearly 1 for each DMU, implying the absence of scale inefficiency.

Stokes *et al*. (2007), using DEA, investigated the efficiency of a group of Pennsylvanian dairy farms to determine factors that contributed to efficiency in production and business management. The results indicated that out of the 34 DMU examined, 6 were DEA-efficient while 28 were not efficient. The 6 efficient DMUs have efficiency scores equal to 1.

Factors affecting TE among coffee farmers in Cote d'Ivoire was investigated by Binam *et al*. (2003). A DEA model was used to compute the farm-level technical efficiency measures of 81 peasant farmers. The results revealed that the TE scores ranged from 2 to 100% with an average of 36% when using CRS, while TE scores using VRS ranged from 5 to 100% with an average of 47% for the farms in the sample. This implies that, if a farmer in the sample were to achieve the TE level of his or her most efficient counterpart, then the average farmer could realize a 64 and 53% cost saving under CRS and VRS assumptions, respectively.

Bayda (2003) evaluated North Dakotan farm production efficiency and financial performance over time. Farm-level efficiency and productivity measures were derived using DEA and

Malmquist Total Factor Productivity (TFP) indices for panel data of 130 North Dakotan farms over 7 years. The researcher considered farm technical efficiency (TE) scores under the assumption of CRS, VRS and scale efficiency (SE) using a DEA multiple-input, multiple-output model. His results showed that the TE score under the assumption of CRS ranged from 0.05 to 1.00, with an average of 0.75. Under the VRS, the TE scores also ranged from 0.05 to 1.00, however, the TE scores under this assumption were slightly higher than the TE scores under CRS with an average of 0.79. The average SE was 0.96. The results indicated that most farms operated at an efficient scale and, therefore, no significant improvements in SE could be achieved by most of the farms in the sample by changing the scale of their operation. Results from the Malmquist TFP indicated a 1.7% productivity growth per year, which is moderately attributed to technical change.

Dhungana *et al*. (2004) measured the economic inefficiency of Nepalese rice farms using DEA. The researcher found that the average relative economic, allocative and technical efficiencies were 34%, 13% and 24%, respectively. Seed, labour, fertiliser and mechanical power explained the output of rice. Risk aversion had a positive significant relationship with technical efficiency but was negatively related to economic and allocative efficiency. The researcher argued that the more risk averse the farmers were, the more likely they were to allocate farm resources under their discretion more optimally. Because of production uncertainties, farmers tend to underutilise purchased farm inputs (Williams *et al*., 1992).

The technical and scale efficiency of rice farms in West Java was investigated by Brázdik (2006) who identified determinants affecting farms' efficiency. The researcher used a DEA (input-oriented) model to estimate the technical efficiency scores; the results showed that the TE ranged from 0.60 to 0.77 (under the assumption of the time varying production possibility frontier). The average scale efficiency was 0.90. Farmers could reduce their inputs from 23% to 42% while maintaining the same output. Decreasing returns to scale existed among 77% of the farms. Size-efficiency relation analysis showed an inverse relationship between farm size and productivity. Technical inefficiency is caused by the employment of technically inefficient production mixes and not because of size of farming operations.

Gul *et al.* (2009) analysed the technical efficiency of cotton farms in Çukurova region in Turkey. The researchers used an input-oriented DEA approach to generate technical efficiency estimates. The results showed a mean TE of 0.72 and 0.89 under the CRS and

VRS, respectively. The mean scale efficiency was 0.79 and the TE ranged between 0.23 and 1. Sixteen farms under CRS and 26 farms under VRS had efficiency scores of 1, implying that the farms were fully efficient.

Olson and Vu (2007) applied DEA to investigate the economic efficiency and factors explaining differences between Minnesotan farm households using DEA. The results revealed that the initial estimates of average technical efficiency were 0.87 and 0.90 when assuming CRS and VRS, respectively. The bias-corrected point estimate assuming VRS was 0.77. The average allocative efficiency was 0.77 over the long-term, with 31% of the farms having a score of 1.

Koc *et al*. (2011) analysed the technical efficiency of second crop maize growing farms in the East Mediterranean region of Turkey using Data Envelopment Analysis (DEA). It was found that maize growers had mean TEs of 0.72 and 0.88 under the assumption of CRS and VRS assumptions, respectively. The maximum TE was 1 for both CRS and VRS, respectively, while the minimum was 0.31 and 0.68 for CRS and VRS, respectively. The mean scale efficiency was 0.81, implying that there were some opportunities for improving resource-use efficiency.

Van der Merwe (2012) used a DEA approach to examine the cost efficiency of raisin producers in Eksteenskuil, South Africa. The result showed that the mean cost efficiency of raisin producers was 0.35. The minimum and maximum cost efficiency was 0.04 and 1, respectively. Jordaan (2012) also investigated the technical and cost efficiency of raisin producers in Eksteenskuil, South Africa. The researcher applied DEA using the Double Bootstrapping approach to examine the TE of the farmers. The result showed that the bias-corrected technical efficiency scores of the raisin farmers ranged from 0.21 to 1. The average bias-corrected technical efficiency score was 0.78. Thirty per cent of the farmers achieved cost efficiency scores between 0.3 and 1. About 62% of the raisin producers achieved cost efficiency scores of less than 0.3.

Technical efficiency during the economic reform in Nicaragua was investigated by Abdulai and Eberlin (2001). The researchers used the translog SF model to examine the TE of maize and bean farmers. The results showed that the average efficiency levels were 69.8% and

74% for maize and beans, respectively. Farmers in the different regions under the study area exhibited different efficiency levels.

Wilson *et al*. (2001) studied the influence of management characteristics on the TE of wheat farmers in eastern England. Using panel data for the 1993-1997 crop years, the researchers utilised the SF production function to achieve the objective of the study. The results indicated a minimum and maximum TE of 50% and 98%, respectively. The mean value was 87%.

Bekele (2003) analysed the effect of farm size on technical efficiency of the Moretna-Jirru District in central Ethiopia. Using the SF approach, the researcher found that among the 8 inefficiency factors postulated to influence technical efficiency of wheat and tef, 5 of them were found to be statistical significant at 1% and 5% test level. These were land parcels, distance between parcels, number of oxen owned, family size and income per household.

Chirwa (2007) examined the sources of technical efficiency among smallholder maize farmers in southern Malawi. The researcher employed the SF model to achieve the objectives of his study. The results depicted that the coefficients of land, capital, labour, fertiliser, seed, seed fair-quality and seed quality-good included in the production function were positive, but only labour was statistically significant. The mean TE level among the respondents was 46.23%. Measurement and sources of technical inefficiency in the Tunisian citrus growing sector was investigated by Dhehibi *et al.* (2007) using the SF model. The findings showed that the average TE is 86.23% with a minimum of 27% and a maximum of 98%.

Hassan (2007) estimated the cost efficiency of wheat farmers in Bangladesh using an SF analysis. The results showed an average economic efficiency of 76% among the farmers. This implies that wheat output could be increased by 24% with the existing technology and levels of inputs.

Kamruzzaman and Hedayetul Islam (2008) applied SFA to investigate the TE of wheat growers in some selected sites of Dinajpur district of Bangladesh. The findings indicated that the TE ranged from 40% to 90% with a mean of 70%. Educational level and frequent contact with extension workers had a positive influence on TE of wheat practicing farmers.

Obare *et al*. (2010) studied the allocative efficiency of Irish potato producers in Nyandarua north district, Kenya, using SFA. The researcher found a mean allocative efficiency of 0.57 among the farmers, and that the potato production in the study area was characterised by decreasing returns to scale.

Khan and Saeed (2011) measured the technical, allocative and economic efficiency of tomato farms in northern Pakistan. The study revealed technical and allocative efficiency indices of 65 and 56% respectively. The mean economic efficiency was 35%.

Khai and Yabe (2011) investigated the technical efficiency of rice production in Vietnam using SFA. The results showed that farmers were relatively efficient, which was depicted by a technical efficiency score of 82%.

Nyagaka *et al*. (2010) studied the technical efficiency in resource use of smallholder Irish potato farmers in Nyandarua north, Kenya. The researchers applied a dual Stochastic Parametric Decomposition Technique to derive the technical efficiency indices, and a two-limit Tobit model to examine the influence of socio-economic characteristics and institutional factors on the technical indices. The researchers found that the average technical efficiency was 67%. Education, access to extension, access to credit, membership of farmers' associations and innovations had positive significant effects on technical efficiency. Labour, seed, fertiliser and pesticides had positive influences on the output of the Irish potatoes. According to the researchers, the positive influence of education on technical efficiency implied that more educated farmers were able to perceive, interpret and adopt improved technology. The positive relationship between extension and technical efficiency indicated how important extension was in motivating and educating farmers about existing technology, thereby enhancing efficiency. The researchers added that access to credit enabled farmers to overcome liquidity constraints which enhanced their ability to purchase farm inputs, hence improving efficiency.

From the literature review, it should be noted that various approaches have been applied to estimate efficiencies and their determinants in different countries. The two major approaches used are SFA and DEA. Although DEA has limitations when applied on its own, namely giving biased and inconsistent efficiency estimates, researchers have continued to apply the approach. These shortcomings of DEA, however, can be overcome when applied in conjunction with Double Bootsrapping. When applied together with Double Bootstrapping in the first stage, it gives unbiased and consistent estimates, and in the second stage DEA, the limitations of using Tobit to explore the determinants of efficiency are overcome. From the literature reviewed, only Olson and Vu (2007) and Jordaan (2012) applied DEA using the Double Bootstrapping approach to obtain reliable estimates of efficiency levels of the farmers they studied. Accordingly, the application of the DEA Double Bootstrapping approach in this study will fill in the existing knowledge gap in the subject matter.

2.8.4 Nigerian studies on efficiency measurement approaches and efficiency levels

Yusuf and Malomo (2007) examined the technical efficiency of poultry egg production in Ogun state Nigeria using DEA and OLS regression. The researchers found that 45% of the respondents had efficiency scores of between 0.80 and 0.90. The mean TE was 0.87, which suggested that on average for poultry farms, the observed output was 13% less than the optimum output. This accounted for the level of inefficiency for an average farm. Farmers with larger farm sizes were more efficient than those with medium and small farm sizes. Yusuf and Malomo (2007) argued that this is probably because farmers with larger farm sizes have more capital which may enable them to purchase the prescribed quantities of inputs, thus utilizing resources more efficiently.

Ogunyinka *et al*. (2004) examined efficiency under multi-cropping systems in Ekiti state, Nigeria. A non-parametric DEA approach was used to analyse inter-farm efficiency differences. Tobit regression was used to examine the determinants of efficiency. The results revealed that, on average, pure technical efficiency, scale efficiency and overall technical efficiency were 0.84, 0.88, and 0.74, respectively. Consideration of individual farmers in the entire sample showed that 30 and 34 farmers had pure technical efficiency equal to, and less than 1, respectively.

Ogisi *et al*. (2012) studied the efficiency of resource use by rice farmers in Ebonyi State, south east Nigeria using the DEA approach. The results revealed that about 6% of the farmers attained technical efficiency of 100%. The technical efficiency ranged from 20% to 100%.

Ajibefun (2008), in his study of small-scale food crop production in Nigeria, compared the results of Stochastic Frontier Production Function (SFPF) analysis, a parametric technique, with those of a DEA non-parametric technique. Results of analysis indicated that the sample farmers had varying levels of technical efficiency, ranging from 0.22 to 0.87 for both techniques. The estimated mean technical efficiency did not vary widely with the method used, though some differences in magnitude of individual technical efficiencies were noted. Finally, a combination of the technical efficiency scores obtained from the two different methods was proposed as the efficiency indicator to use.

Okoye *et al*. (2006) investigated the allocative efficiency of small-holder cocoyam farmers in Anambra State, Nigeria. The researchers applied the SF method. The results showed that the average allocative efficiency was 0.65, and the allocative efficiency ranged from 0.10 to 0.97.

Goni *et al*. (2007) analysed the resource use efficiency in rice production in the Lake Chad area of Borno State, Nigeria. Production function analyses which incorporated the conventional neoclassical test of economic and technical efficiencies were used as the analytical technique. Findings depicted that the farmers were relatively inefficient in the use of all the resources. Generally, however, inputs such as seed, land and fertiliser were under-utilised.

Mbanasor and Kalu (2008) analysed the economic efficiency of the commercial vegetable production system in Akwa Ibom State, Nigeria, using the SF cost function approach. The results revealed a mean economic efficiency of about 61%.

Otitoju and Arene (2010) studied the constraints and determinants of technical efficiency in medium-scale soybean production in Benue State, Nigeria, using the Stochastic Frontier approach. The findings showed that the average technical efficiency was about 73%.

Akinbode *et al*. (2011) applied the SFA to examine the technical, allocative and economic efficiencies of *ofada* rice farming in Ogun State, Nigeria. The results revealed mean technical, allocative and economic efficiencies of 0.73, 0.93 and 0.67, respectively. This showed that there was inefficiency in the technical, allocative and economic areas.

Ogunniyi and Ojedokun (2012) investigated the production risk and economic efficiency of rice farmers in Kwara State, Nigeria, using an SFA approach. The average technical efficiency score was 0.87, the mean allocative and economic efficiencies were 0.42 and 0.37, respectively. The results showed that there were significant allocative and economic inefficiencies among rice farmers in Kwara State.

The review of the efficiency studies in Nigeria also shows that researchers who have applied the DEA did not apply the Double Bootstrapping procedure. Most of the researchers continue to use the Tobit or OLS in the two-stage DEA, which gives unreliable estimates of the determinants of efficiency (Simar & Wilson, 2007).

There is thus a need for researchers to apply the Double Bootstrapping DEA procedure in order to obtain more valid information on the determinants of efficiency. It is also clear from the literature review that information on the inclusion of risk aversion as a determinant of efficiency is scanty. Such information is important in order to generate reliable knowledge on the influence of risk attitudes on the decision-making behaviour of farmers and on the determinants of efficiency. In the current study, the Double Bootstrap DEA approach will be used to determine the explanatory variables that influence the technical efficiency of the farmers. The influence of risk attitude on the efficiency of farmers will also be explored.

2.8.5 Review of literature on metafrontier

The metafrontier approach was used by Villano *et al.* (2010) to examine the varietal differences in Pistachio production in Iran, using SFA. The results showed that on average, little difference existed in the technical efficiency between farms growing the different tree varieties. The Technology Gap Ratio (TGR) revealed that farmers growing the three varieties differed in the use of inputs.

Dadzie and Dasmani (2010) investigated the differences in farm level efficiency in Ghana. Their estimation was based on the SFA metafrontier approach. The researchers found that the farms under female management were more efficient and also near to the potential output, defined by the metafrontier production function, compared to the farms managed by males.

Moreira and Bravo-Ureta (2010) studied the technical efficiency and metatechnology ratios for dairy farms in Southern Cone countries using the SFA metafrontier approach. The results showed that the production frontiers for Argentina and Uruguay were relatively close to the metafrontier (MF). Chile was further away from the MF, suggesting that Chile could benefit from adaptive research, designed to make "borrowed" technology from Argentina and/or Uruguay applicable to local conditions, which could be a cost-effective way to improve dairy farm performance.

The literature reviewed on the metafrontier reveals that only a few researchers have applied this methodology to compare efficiency of different groups at the farm level. Accordingly, the application of the metafrontier approach to compare the efficiencies of the different groups of mono and intercrop farmers in this study will add to the existing knowledge on the comparison of efficiencies.

2.9 Conclusions

Theoretical and practical issues relating to efficiency, factors affecting efficiency, and risk preferences were discussed in this Chapter. Information was sought from journals, books and other materials that were relevant to the study. Risk preference studies applied the experimental gambling or indirect method to measure risk aversion of farmers. The results from the reviewed literature revealed that the subjects exhibited risk aversion in most cases and that socio-economic variables also have significant influence on risk preference of farmers. Most of the studies reviewed applied either the DEA, SF model or both to determine technical and cost efficiencies, and the Tobit or OLS model to explain the influence of socio-economic variables on technical and cost efficiency. Research on the use of metafrontier in agricultural production shows that this approach is not popular. The few studies that have applied the MF approach used the SFA. The application of DEA in the MF approach is scanty. There is a gap in knowledge in the application of the MF approach to the efficiencies of farms to the MF in Nigeria. The current study is intended to apply the Double Bootstrapping approach in a two-stage DEA to determine the explanatory variables that influence the technical efficiency of farmers. The study will also use the DEA approach to estimate the cost efficiency and the metatechnology ratio of the monocroppers and intercroppers.

Although the topic of efficiency and risk has received attention from researchers in recent times, there is a lack of reliable information on the determinants of efficiency, sources of risk and management strategies, risk attitudes and also the influence of risk attitudes on the decision-making behaviour of the farmers. The empirical review from the efficiency studies, both in Nigeria and at an international level, suggests that farmers have varying levels of technical and cost efficiency and that meaningful inefficiencies in input utilisation exists among many farmers. Various socio-economic variables, such as age, educational level, extension services, access to credit, farm size, off/non-farm income, assets, crop diversification, among others, have significant influences on technical and cost efficiency. The inclusion of risk aversion of farmers in efficiency studies has been scanty.

There is a need to conduct more research on farming efficiency using the Double Bootstrapping procedure in the two-stage DEA in order to obtain unbiased and consistent estimates. Also, since farmers' risk attitudes affect their behaviour in decision-making, the influence of the risk attitudes of farmers on efficiency should be given due attention.

CHAPTER 3
STUDY AREA, DATA COLLECTION AND CHARACTERISTICS OF THE RESPONDENTS

Introduction

The purpose of this chapter is three fold. First, the study area is described as to its location and population. Next, an overview is given of the data collection methodology. The data collection methodology involves questionnaire development, sampling and the survey. This is followed by an outline of the relevant characteristics of the respondents, such as gender, age, education and farming experience. The agricultural facilities available to the farmers are also discussed.

3.1 Description of the study area

3.1.1 Location and population

The study was carried out in Kebbi State, located in the north-western part of Nigeria. Kebbi State is situated between latitudes 10° 8′ N – 13° 15′ N, and longitudes 3° 30′ E – 6° 02′ E. The State is bordered by Sokoto and Zamfara States to the east, Niger State to the south, Benin Republic to the west and the Niger Republic to the north. The population of the State was 3 238 628 in 2006 (NPC, 2006), and projected to be 3 952 766 in 2012 (UNFPA, 2012). The State occupies an area of about 36 229 square kilometres. The major cities in the State include Birnin Kebbi (State capital), Argungu Yauri, Koko, Zuru, Jega. A map of Nigeria showing the location of the study area is presented in Figure 3.1 below.

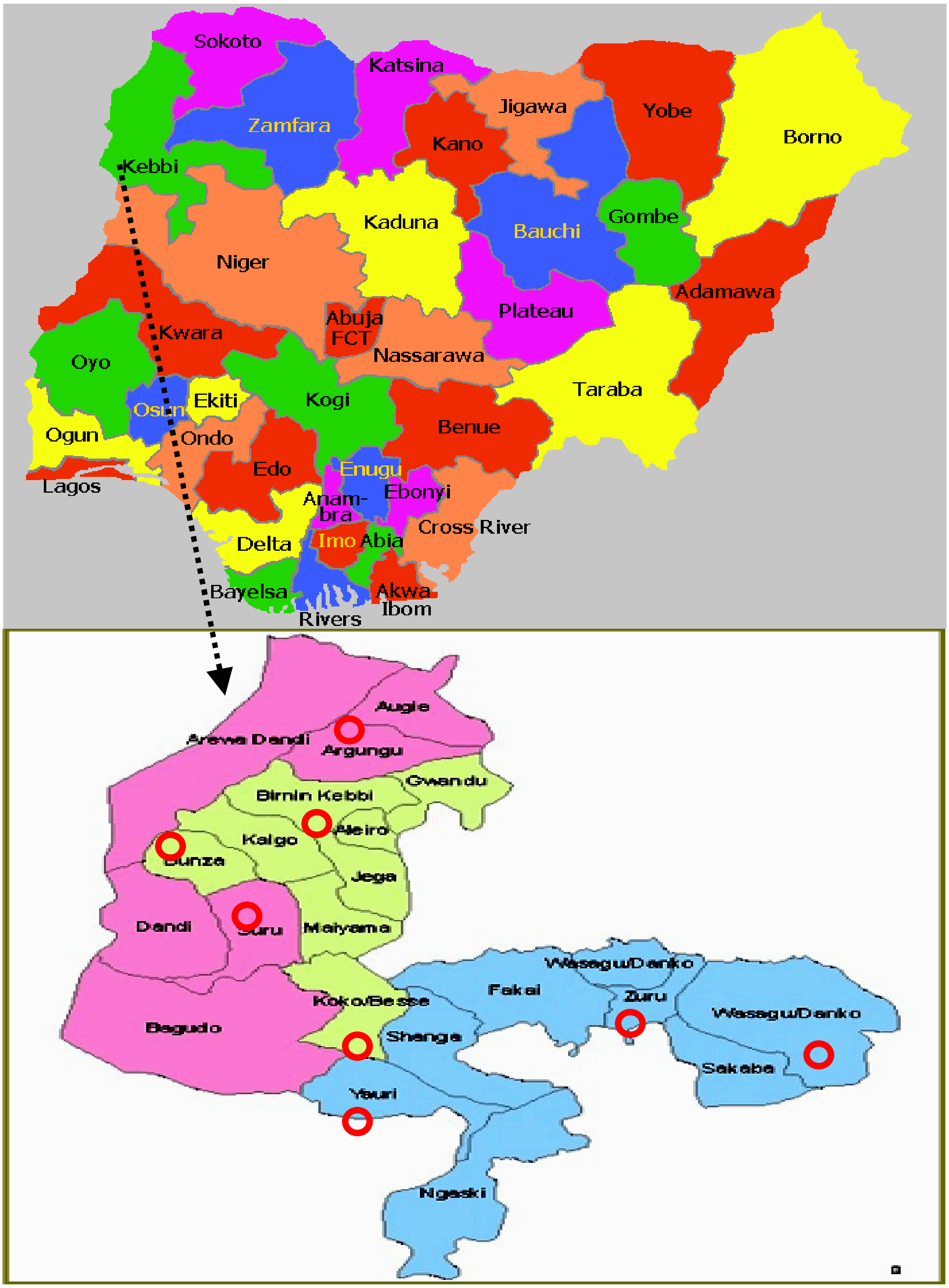

Figure 3.1 Map of Nigeria and Kebbi State.

Represent the selected local government areas for the study.

Source: http://www.nigeriahc.org.uk/images/nigeria_map_m.gif

3.1.2 Climate and vegetation

Kebbi State falls within the dry savannah agro-ecological zone of Nigeria (Tanko and Jirgi, 2008). The average annual rainfall is 1 020 mm (CBN, 2009). Kebbi State experiences peak rainfall between July and August while harmattan (cold season) is usually from November to February and is characterised with strong winds. The mean annual temperature of about 27°C is recorded in all locations, but temperature is generally high. However, during the harmattan season, the lowest temperature is 21°C. Temperatures can go up to 40°C during the months of April to June (Onlinenigeria, 2012). The average relative humidity during the wet season is 80 %, but it is generally low (40 %) for most of the year. The variation in relative humidity explains the hot, dry environment which is in sharp contrast to a hot, humid environment in the southern parts of Nigeria.

The climate favours both crop and livestock production. Agriculture is the major source of revenue and the backbone of the economy of the State. Over two-thirds of the population are engaged in agricultural production with about 80 – 90 % of the population living in the rural areas (Tanko, 2004). The natural vegetation of Kebbi State consists of northern guinea savannah in the south and southeast, and Sudan savannah in the northern part (Onlinenigeria, 2012). The natural vegetation, however, has been altered in many areas owing to intensive cultivation, grazing, fuel wood harvesting and bush burning. The soils in the area range between sandy, loamy and clayey. The sandy soils are well drained and erodible. The clayey soils are common in the *fadama* areas. *Fadama* are flood plains and low-lying areas underlined by shallow aquifers and are found along Nigeria's river systems, which are used for small scale irrigation (Ingawa *et al*, 2004; Ayanwale and Alimi, 2004).

3.1.3 Ecological problems

One of the major problems associated with the physical environment in the State is desertification. Desertification refers to a phenomenon of impoverishment of the terrestrial environment under the impact of unfavourable weather and human activities (Odiogor, 2010). About 35 million people are located in the 11 States in northern Nigeria where desertification is evident and are facing threats of hunger and extreme weather conditions as a result of desert encroachment on arable lands (Danjuma, 2012). The evidence of desertification is seen through the incidence of wind erosion, dune accumulation and exposure of lateritic ironstone on the landscape. The main causes of desertification are: too much demand for fuel wood, bush burning, unreliable rainfall patterns and grazing (Danjuma, 2012). The establishment of shelter belts, woodlots, roadside plantations and forest reserves are some of the measures taken by the government to mitigate the menace. Other ecological problems affecting the State, *inter alia*, are flooding, pest infestation and erosion. Since 1988, flooding has become an annual event. The 2010 flood was devastating for the State, causing destruction of croplands and livestock within the flood plains, settlements bordering them and loss of lives (Babajide and Aderemi, 2012). The common pests in the study area are grasshoppers, caterpillars and quella birds.

3.1.4 Farming system

3.1.4.1 Cropping system

Intercropping is the predominant type of farming system, especially rain fed, with the use of traditional inefficient hand tools (KARDA, 2009). Monocropping is also practised by the farmers. Millet, sorghum, maize, rice, groundnuts and cowpeas are the dominant rain fed crops in the State. Other crops grown under rain fed conditions include wheat and soya beans. Onions and peppers, which have some ecological limitations, are the dominant irrigated crops. Several crop mixtures are practiced by the farmers. These typically include, sorghum/cowpeas, millet/sorghum, sorghum/groundnuts, millet/cowpeas, sorghum/cowpeas/rice (KARDA, 2009). The dominant *fadama* crops in the State, which include peppers, onions, ginger, tomatoes, lettuce, okra and sugarcane, are planted usually as sole crops. Tree crops, such as mango, guava, pawpaw and cashew, are cultivated by farmers in the State.

3.1.4.2 Livestock production

Animal husbandry is also practised by farmers in the State (Tanko, 2004). Livestock, such as cattle, sheep, goats and poultry (mostly local breeds), are raised on a small scale on free range systems. Complementary relationships exist with livestock fed on crop-residues, which contributes to draught power, manure, source of protein, income, savings and reserve against risk (Upton, 2004). Livestock also provide different products and services to people, including socio-cultural roles (ILRI, 2002).

3.1.5 Resource utilisation

3.1.5.1 Labour

Three types of labour sources are used by the smallholder farmers, namely, hired, family and cooperative or communal labour. In Nigerian agriculture, hired labour is mostly used. In fact, this makes up 88% of the total labour use on farms (Okuneye, 2000). The availability of labour has been found to have an impact on planting precision, weed control, timely harvesting and crop processing (Oluyole *et al.,* 2007). Gocowski and Oduwole (2003) have stated that labour is a major constraint in peasant production, especially during planting, weeding and harvesting. During the season of crop production, there is always a continual high demand for labour for most farm activities and this leads to shortage of labour during the on-season.

Within the slack labour demand periods, the youths in the study area migrate to other areas within the state or to the southern parts of the country in search for off-farm work. During peak periods when labour is in short supply, they return. Prior to harvest, some farm households suffer hunger. During the periods of hunger, the households either use off-farm income or collect grains from relatives, friends or neighbours with the informal agreement of paying back double quantity or the money equivalent after harvest. This shows that off-farm income is important for the household.

The role of women in agricultural production varies in Nigeria. Among the Muslims in the north, married women mostly live in seclusion (*purdah)* and are not expected to leave home. The exceptions are the cattle-owning Fulani households, where married women work outside the home, primarily to milk the cows and sell the milk, butter or cheese (NARP, 1994). According to Phillip *et al.* (2009), processing and selling activities, as well as direct on-farm roles, are very limited for married Muslim women in the northern part of Nigeria. However, in some parts of the north where Christianity and traditional religion are dominant, women are substantially involved in on-farm production activities, in addition to their exclusive contributions to marketing, water and firewood fetching, cooking and caring for the children. Children also assist their parents with some of the farm activities. Small children who cannot do farm work help their mothers by carrying the younger ones. Both young boys and girls are often involved in taking care of the animals.

3.1.5.2 Fertiliser

Fertiliser cost and its availability is a serious problem in Nigeria. Currently, the supply of fertiliser by the government (at subsidised rates) is always untimely and inadequate (Phillip *et al*., 2009, Banful *et al*., 2010). Thus, farmers are forced to buy fertiliser from the markets, which is very expensive. In view of this, the majority of the farmers cannot afford to apply the recommended rates for fertiliser. For example, the recommended rates of fertiliser for the dry savannah agro-ecological zone of Nigeria are: 64 kgN/ha, 16 kgP/ha and 30 kgK/ha (Adeoye, 2006). The consequent effect of this is low crop yields and hence low income. The few farmers that rear livestock in the study area apply farm yard manure, either as supplements or substitutes for fertiliser.

Fertiliser use is prompted primarily by the fertiliser subsidy policy in Nigeria. The World Development Report (2008) stated that the main challenge with regard to fertiliser subsidy policy is that the fertiliser subsidy has not been pro-poor, nor has it increased market participation of the rural poor.

In spite of the economic reforms in Nigeria, fertilizer subsidies have remained. The federal government subsidy rate for fertiliser has remained stable at 25 % from 2001 to 2008 (Nagy and Edun, 2002). The majority of the farmers in Kebbi State have poor access to agro inputs (improved seed, herbicides and pesticides). Where such inputs are available, the prices are not affordable for the farmers.

3.1.5.3 Nature of land ownership

Land allocations and transfers among households in a community and within households are based on inheritance laws and practices. Family structure and inheritance practices are most influential, thus, most land transfers are effected by inheritance (Jerome, 2002). Customary land is not supposed to be sold or allocated permanently to someone outside the community without the consent of the community or family concerned. Jirgi (2002) has reported that, in Kebbi State, 100 % of the sampled farmers acquired their farm land through inheritance. Subdivision of holdings among household members prevails as a consequence of the inheritance system. Inheritance leads to land fragmentation among future heirs, and subsequent uneconomic farm sizes per member (Phillip *et al*., 2009).

Women's ability to gain access to land is often restricted by inheritance law. However, women's access to land is regulated through male relations. Women, in most cases, have only cultivation rights. Restrictions on land sales deter the use of land as collateral, thereby hindering development of the rural credit market. Communal land ownership is a deterrent to the improvement of land quality and long-term investment in land.

3.1.6 Access to agricultural finance

Phillip *et al.* (2009) and Gana *et al*. (2009) reported that cooperatives, contributions, friends and family members predominate as the sources of farm credit among the rural farmers surveyed in Nigeria. However, the total amount of farm credit available from these sources is very limited in relation to the amounts that formal sources like banks would have offered. Issues of collateral and high interest rates appear to screen out most of the potential rural smallholder lenders (Freeman *et al.,* 1998; Phillip *et al.,* 2009).

3.1.7 Markets and produce prices

The majority of the farmers in Kebbi State sell their farm produce in the nearest village market, either directly to consumers, retailers or to wholesalers who buy the produce and sell it in other cities within the country, or to neighbouring countries like the Republic of Niger. Grain prices are associated with seasonal variations. Low prices are obtained at harvest time, usually in December, and higher prices are obtained between August and October, which is before the harvest.

3.2 Data collection

The study is based on primary data gathered through a questionnaire survey of the sampled farmers in the study area. A formal survey was conducted using a structured questionnaire through personal interviews by the researcher and trained enumerators. The questionnaire was administered using a single visit approach.

3.2.1 Questionnaire development

The questionnaire used for the study was developed by the researcher. Relevant literature (Binswanger 1980, 1981; Meuwissen *et al*., 2001; Bekele, 2003; Tanko, 2004; Dhungana *et al.,* 2004; Alimi and Ayanwale, 2005; Drollete 2009, Salimonu and Falusi, 2009) was consulted in order to identify the variables to include in the survey. Some of the questions asked in the questionnaire covered: personal characteristics of the respondents, farm inputs, outputs and their prices, the experimental gambling game, risk sources and management strategies. The questions were designed to answer the objectives of the study. The questionnaire was developed in English and interpreted to the sampled farmers in *Hausa* (the common local language in Kebbi State) by the researcher and trained enumerators.

A pilot study was conducted to test the validity of the questionnaire. Ten farmers were randomly selected from each of the four agricultural zones in Kebbi and the questionnaire was administered to them. The responses from the respondents were checked to see if the replies were as required in the questions. The questions that seemed not to be clear to the farmers were reconstructed.

3.2.2 Sampling technique

A multi-stage sampling technique was used to select 256 farmers comprising 98 monocrop farmers and 158 intercrop farmers. The reason for the sample size chosen is that there are more intercrop farmers than monocrop farmers in the State. In the first stage, the four agricultural zones were purposively selected in order to have a good representation of all the agro-ecological zones in the State. The second stage involved a random selection of two Local Government Areas (LGAs) from each of the four agricultural zones. In the third stage, four villages were randomly selected from each of the two LGAs. The fourth stage involved the random selection of the 98 monocrop farmers and the 158 intercrop farmers. Since the population of the LGAs is not homogeneous, the number of farmers selected from each of the selected LGAs was calculated using the formula:

$$P = \frac{S}{N} \times n$$

Where P = Proportion, S = Desired sample size, N = Total population, n = Population of LGA in question. The LGAs and the number of respondents are shown in Table 3.1 below.

Table 3.1 Number of respondents selected, Kebbi State, January 2012

Zone	Local Government Area (n =8)	Number of respondents
Zone I	Argungu	37
	Birnin Kebbi	45
Zone II	Bunza	22
	Suru	27
Zone III	Zuru	29
	Danko/ Wasagu	51
Zone IV	Koko Besse	28
	Yauri	17

3.2.3 The survey and data collected

The survey was carried out in January to February, 2012 and data were collected on production practices for the 2011 cropping season. The household heads were interviewed by the researcher and the trained enumerators. Data were collected on farmers' characteristics, including the age of the farmer, educational level of household head, years of farming experience, household size, extension contacts, access to credit, land fragmentation, land degradation, type of house, asset value, walking distance to the farm, risk preference of the farmer, ownership of oxen, ploughs, gender of household head, membership of farmers' organizations and *fadama* cultivation.

The data on inputs used by the farmers include: farm size (ha), labour, both family and hired (man-days), fertiliser (Kg), seed (Kg), farm equipment (₦). The yields obtained of sorghum (Kg), millet (Kg), cowpeas (Kg), groundnuts (Kg) was also asked in the questionnaire. Data were also collected on risk sources and risk management strategies. Besides data obtained from questions asked in the questionnaire, other information was also obtained during the survey through personal discussions with the farmers, farmers groups and the staff of the agricultural development project.

The data collected on the socio-economic characteristics will be used to describe the characteristics of the respondents in the study area. The variables will be used in the subsequent chapters as independent variables in order to determine the relationships between risk attitudes, sources of risk and management strategies and to explore the determinants of technical and cost efficiency. The efficiency levels of the farmers will be estimated using the input and output data. The Likert-scale type responses will be used in the factor analysis. Details of the questionnaire are presented in Appendix A.

3.3 Characteristics of the farmers in the study area

Beside the socio-economic characteristics of the farmers, other explanatory variables that are thought to affect crop production, as well as farm specific characteristics, are presented next.

3.3.1 Gender of the farmers

All respondents interviewed were male and they were the household heads of their families. The males are the bread winners of their families and they are actively involved in farming activities, such as land clearing, planting, weeding and harvesting. The women were mostly involved in processing and marketing activities.

This is not surprising as women in the study area do not have land ownership. Customary rules recognise only male ownership. In most cases, women have only rights to cultivate the land.

3.3.2 Age distribution of the respondents

The age distribution of the farmers is shown in Figure 3.2 below. The largest proportion of the monocroppers and intercroppers (48% and 43% respectively) are within the age group 30 to 39. It can also be seen from the age distribution that most of the farmers in Kebbi State are in the economically active age. From the sampled monocrop farmers, 12% are between 20 and 29 years old. The minimum and the maximum age of the respondents are 20 years and 65 years respectively.

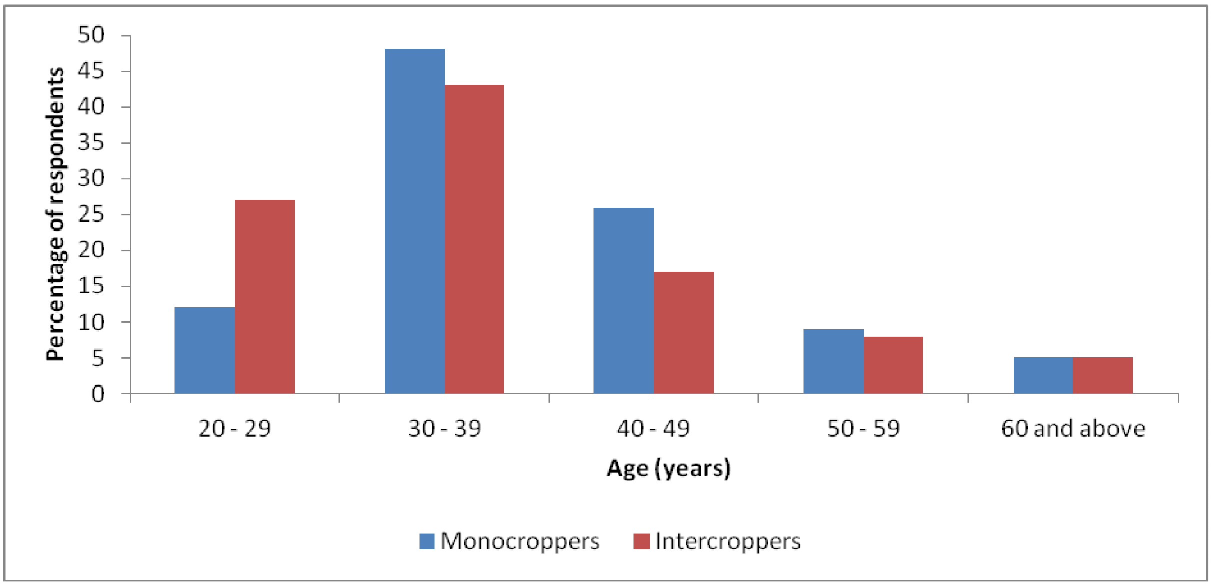

Figure 3.2 Age distribution of farmers, Kebbi State, January 2012

3.3.3 Years of education of the farmers

The distribution of years of education of the respondents in Figure 3.3 below reveals that 58% of the monocroppers and 59% of the intercroppers have not attended school. About 5% of monocroppers and 8% of intercroppers have spent between 11 and 15 years in school, meaning that they have a secondary school certificates and/or tertiary institution certificates, such as the National Diploma (ND) or the National Certificate of Education (NCE).

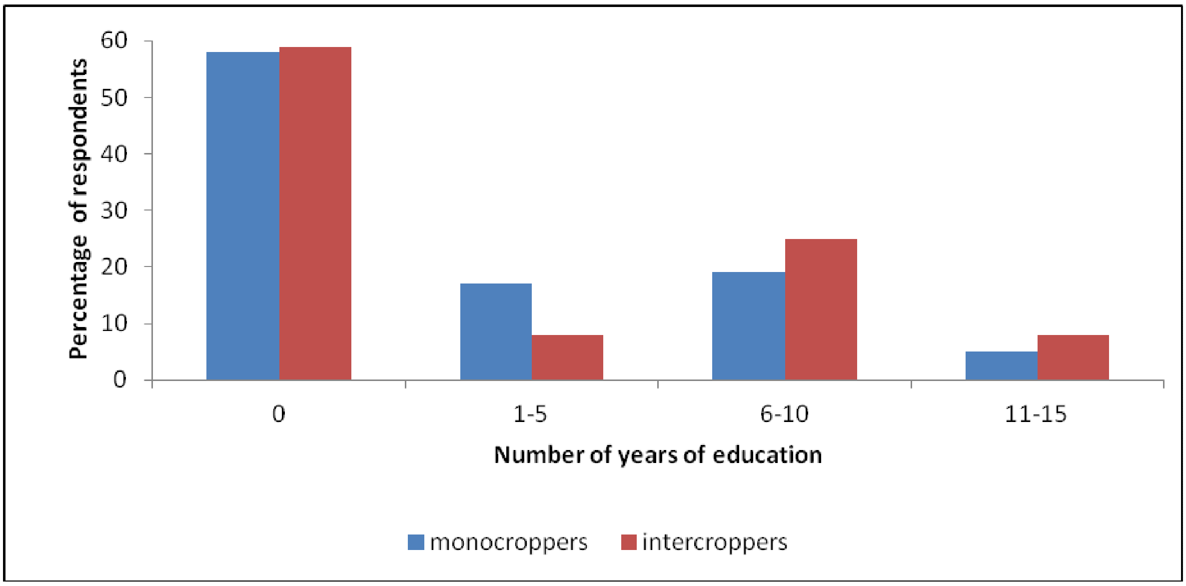

Figure 3.3 Number of years of education of respondents, Kebbi State, January 2012

3.3.4 Farming experience of the respondents

Table 3.2 below shows that 44% of the monocroppers have farming experience between 11 and 20 years. For the intercrop farmers, 35% have experience between six and 10 years. On average, the monocrop farmers and intercrop farmers have 15 and 12 years of farming experience. The distribution shows that both monocroppers and intercroppers have less than 16 years of farming experience, on average. This implies that the farmers in the study area have relatively little experience in farming.

Table 3.2 Distribution of respondents according to farming experience, Kebbi State, January 2012

	Monocroppers (n=98)		Intercroppers (n=158)	
Farming experience in years	Number of	%	Number of	%
1-5	11	11	39	25
6-10	23	24	56	35
11-15	20	20	15	9
16-20	23	24	23	15
21-25	9	9	3	2
26-30	2	2	11	7
31-35	5	5	4	3
36-40	5	5	7	4
Average farming experience (years)	15		12	
Minimum farming experience (years)	4		1	
Maximum farming experience (years)	39		40	
Standard deviation	8.88		9.58	

3.3.5 Household size of the farmers

The distribution of household sizes of the respondents is shown in Figure 3.4 below. Forty-eight per cent of monocroppers and forty-five per cent of intercroppers have a household size of between six and 10. Three per cent of monocrop farmers have household sizes between 21 and 25. The relatively large size of the households is attributable to the dominance in some parts of the State of the Islamic religion which permits marriage with four wives.

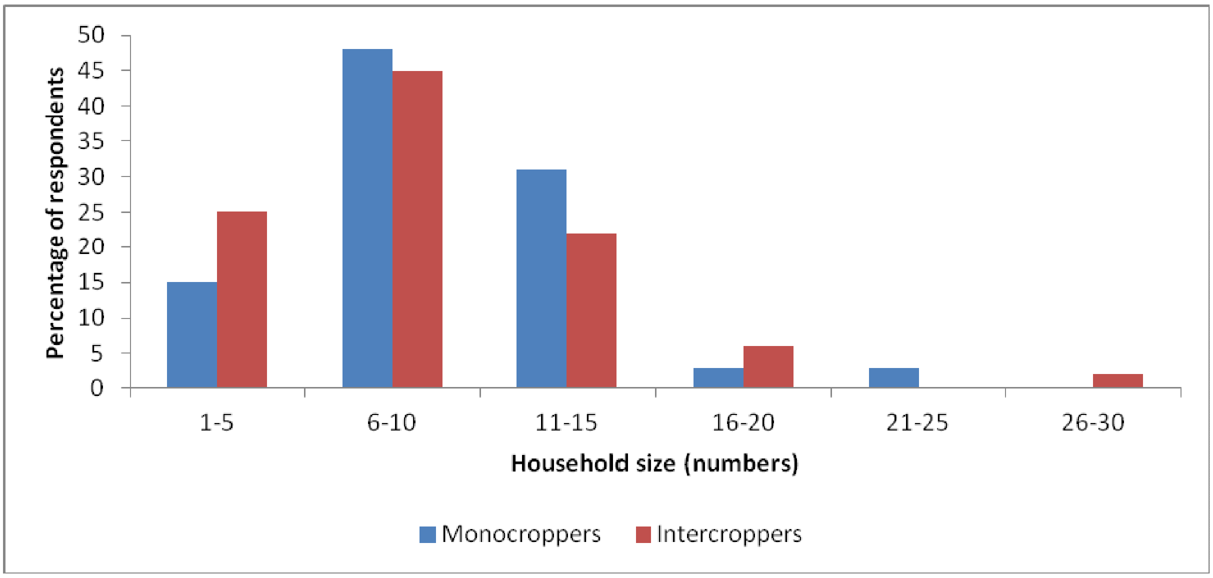

Figure 3.4 Household sizes of respondents, Kebbi State, January 2012

3.3.6 Access to institutional support services

The distribution in Table 3.3 below shows that 70% and more of both monocrop and intercrop respondents do not have access to agricultural extension services, formal financial institutions or cooperatives. Around 85% of both monocrop and intercrop respondents have access to formal markets. The high percentage of inaccessibility to extension services is not unconnected to the fact that the farmer extension ratio in the State is 1:1000 (KARDA, 2009). The few extension agents that are available lack the basic incentives to effectively deliver extension services to the farmers.

Farmers have inadequate access to financial organisations. Thus, farmers are not able to purchase the recommended farm inputs, such as fertiliser, herbicides, insecticides, seed and farm implements. This, no doubt, results in low productivity. In the absence of formal financial institutions, farmers resort to borrowing from village money lenders, friends and relatives or engaging in *adashe* (which is rotation savings).

Table 3.3 Distribution of respondents according to access to institutional support services, Kebbi State, January 2012

	Monocroppers (n=98)		Intercroppers (n=158)	
	Access (%)	No access (%)	Access (%)	No access (%)
Agricultural extension services	29	71	28	72
Formal financial organisation	16	84	18	82
Cooperatives	12	88	30	70
Formal markets	86	14	85	15

Where credit institutions are available, the cost of borrowing money is relatively high. The current interest rate charged by the financial institutions is 14%. High interest rate charges will, no doubt, have a negative effect on the cost of production.

Farmers' cooperatives are not common in the study area. There are, however, a few cooperatives that are coming up, such as the *fadama* users' cooperative, and some farmers' associations. The benefit of forming a cooperative is that it gives members easy access to obtain loans from financial institutions, since the institutions deal with the cooperatives and not directly with individual members (Iheduru, 2002), and accordingly the rate of loan defaults by individuals is reduced to a minimum. The cooperatives can improve farm productivity and access to obtain fertiliser and improved seed from the agricultural-related institutions. Farmers in the cooperatives can also contribute money to buy farm implements and use these as a group. The majority of the respondents have access to formal markets which are situated in the rural areas, although some of the rural market roads are in poor state. Thus, the farmers transport their farm produce to the rural markets using draught animals, such as donkeys and camels.

3.3.7 Asset value of the farmers

The distribution of the respondents, according to asset value, in Figure 3.5 below reveals that 25% of the monocrop farmers have assets valued between ₦90 000 and ₦130 000, and that almost 70% have assets valued more than ₦130 000. About 33% of the intercrop farmers have assets valued between ₦50 000 and ₦90 000 and 32% have assets valued between ₦90 000 and ₦130 000, with only about 28% holding assets valued at more than ₦130 000.

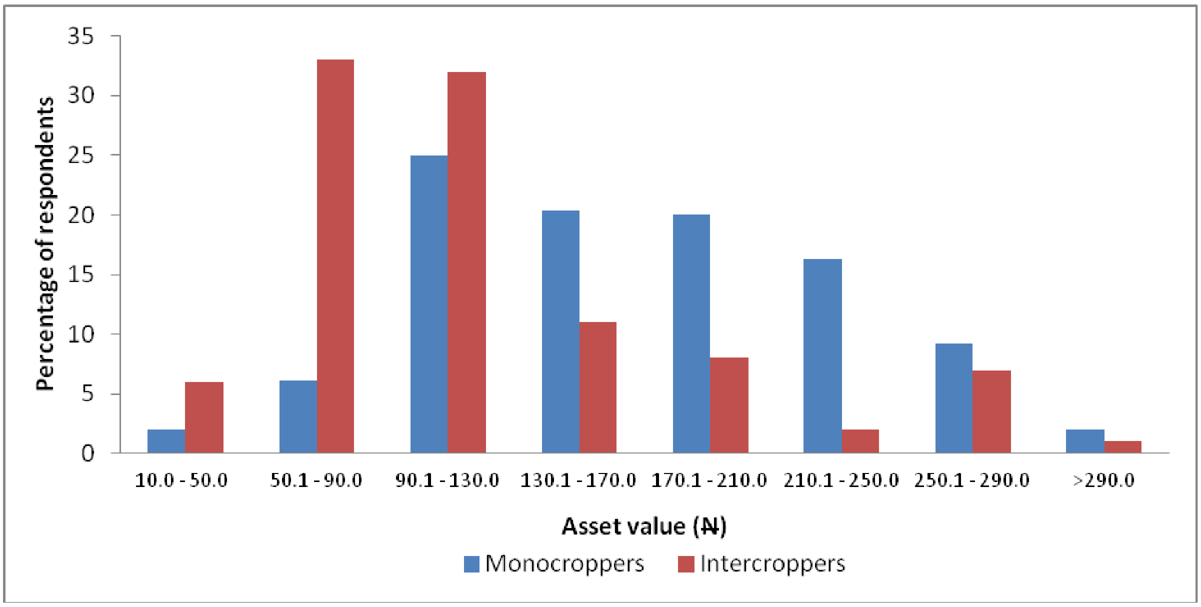

Figure 3.5 Distribution of respondents according to asset value (₦), Kebbi State, January 2012

Note: The asset value figures are in thousands (1 US$ = ₦162).

Farmers' asset value can have an effect on purchasing power and hence productivity. Farmers with high asset values are likely to purchase more farm inputs and afford more labour than farmers with less asset value.

3.3.8 Land acquisition in the study area

The distribution of sources of farm land of the respondents is presented in Table 3.4 below. The results show that on average, 71% of monocrop respondents and intercrop respondents acquired their farm land through inheritance. Agahiu, Udensi, Tarawali, Okoye, Ogbuji and Baiyeri. (2011) reported that 100% of cassava farmers in Kogi State acquired farm land through inheritance.

Table 3.4 Distribution of respondents according to source of farm land, Kebbi State January 2012

Source of farm land	Monocroppers (%)	Intercroppers (%)	Average (%)
Purchased	14	17	16
Rented	7	12	10
Inherited	75	69	71
Allocated by village head	4	2	3

About 16% of the farmers purchased land for farming. The implication of acquiring land by inheritance is that as the population increases, new households emerge and land is further subdivided (Binns, 2012). The subdivision of land discourages agricultural mechanisation and impairs productivity.

3.3.9 Access to *fadama* land

As shown in Table 3.5 below, the distribution of farmers according to access to *fadama* depicts that, on average, 67% of the monocrop farmers and intercrop farmers do not have access to *fadama*. A greater percentage (37%) of the monocrop farmers than intercrop farmers has access to *fadama* land. Perhaps this may explain why they practice monocropping, because they can always fall back on the *fadama* crops in case of crop failure.

Table 3.5 Distribution of respondents by access to *fadama* land, Kebbi State, January 2012

	Access (%)	No access (%)
Monocroppers	37	63
Intercroppers	30	70
Aggregate	33	67

3.3.10 Land fragmentation and degradation

Land fragmentation refers to distinct land parcels that are owned and tilled as a sole enterprise (Kakwagh, Aderonmu & Ikwuba, 2011). Land degradation results in loss of land productivity, and is evident through wind erosion, sand dune accumulation, depletion of soil nutrients and gully erosion owing to unreliable or torrential rainfall patterns.

Table 3.6 below reveals that land fragmentation has been experienced by 40% and 69% of monocrop and intercrop respondents, respectively. Land fragmentation is a result of the nature of the land tenure system, which is predominantly by inheritance (Kakwagh *et al*, 2011). Fragmentation of land is associated with increased cost of production owing to inefficient allocation of resources (Shuhao, 2005). Land fragmentation also has a negative impact on agricultural mechanisation and farm productivity.

Table 3.6 Land fragmentation and degradation distribution of the respondents, Kebbi State, January 2012

	Monocroppers (%)	Intercroppers (%)	Average (%)
Land fragmentation			
Yes	40	69	58
No	60	31	42
Land degradation			
Yes	62	73	69
No	38	27	31

As regards land degradation, it can be seen from Table 3.6 above that 62% and 73% of the monocrop and intercrop respondents have experienced land degradation. The land degradation menace is connected with the desertification and desert encroachment experienced in the study area (Danjuma, 2012). The consequent effect of land degradation on arable land is that it reduces soil fertility and agricultural productivity.

3.3.11 Farm distance from residence

The distance travelled by the respondents from house to farm is reported in Figure 3.6 below. Sixty-one per cent of the monocrop farmers and sixty-five per cent of intercrop farmers travelled less than 6 kilometres from their house to the farm.

Less than 15% of both monocrop farmers and intercrop farmers travelled more than 10 kilometres. The distance travelled by the farmers who do not have means of transportation is likely to have a negative influence on labour hours spent by the farmers on their farms.

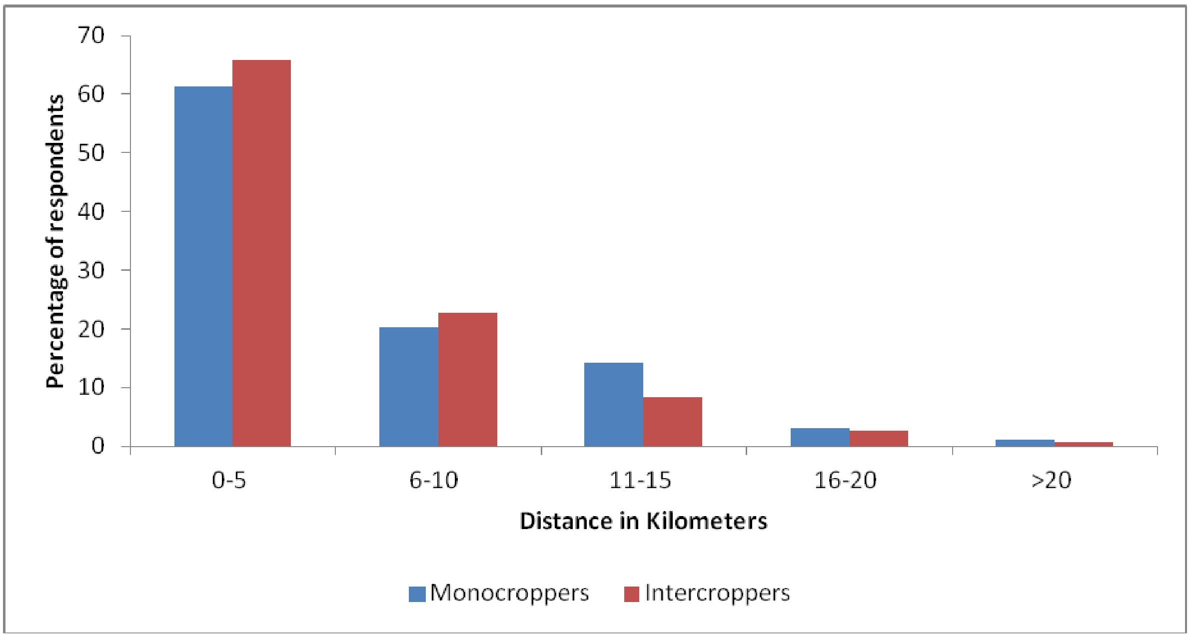

Figure 3.6 Distance travelled by the respondents from house to the farm, Kebbi State, January 2012

3.3.12 Type of house owned by the respondents

Figure 3.7 below reveals that 68% of the intercrop farmers have local, while 52% of the monocrop farmers have modern houses. This is not surprising, considering the fact that the majority of the monocrop farmers have higher asset values compared to the intercrop farmers. Only 32% of the intercrop farmers have modern houses.

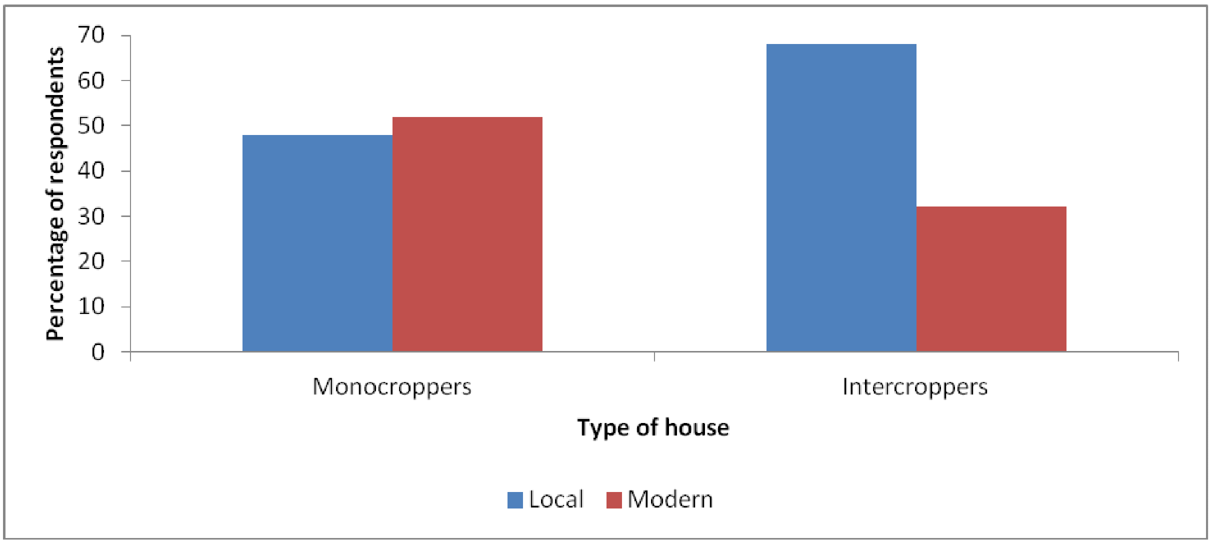

Figure 3.7 Distribution of respondents by the type of house they own, Kebbi State, January 2012

3.3.13 Ownership of animal traction

On average, 64% of the monocrop and intercrop farmers do not own animal traction, as depicted from Table 3.7 below. Farmers who own animal traction carry out their farm operations (e.g. ploughing, planting and weeding) timely. The planting data for planting sorghum and millet in the State is from the end of June to beginning of July, while cowpea is planted in August (Ajeigbe *et al*, 2008).

Table 3.7 Distribution of respondents by ownership of animal traction, Kebbi State, January 2012

	Monocroppers		Intercroppers		Aggregate	
	n = 98	%	n = 158	%	n = 256	%
Yes	39	40	54	34	93	36
No	59	60	104	66	168	64

Farmers who do not own animal traction and who have to hire from those who do stand at a disadvantage. Such farmers may have their farm operations delayed, thus their yields may be affected negatively. The use of animal traction is becoming popular in the study area. The common animals used for traction are oxen and camels. The use of tractors is gradually phasing out because tractors are beyond the reach of small-scale farmers and, besides, the farm sizes of the farmers are too small to support mechanised farming.

The test for the significant differences of some of the numeric explanatory variables is shown in Table 3.8 below. Age, years of farming experience, household size, asset value, kilometres travelled and size of farm land of the monocroppers were statistically significantly different from intercroppers, at one per cent level of probability. Monocrop farmers were statistically significantly more experienced than the intercroppers. Education levels of the monocrop farmers and intercrop farmers was not statistically significantly different.

Table 3.8 T-test result of some of the numeric characteristics variables, Kebbi State, January, 2012

Variable	Overall n = 256 Mean	Monocroppers n = 98 Mean	Intercroppers n = 158 Mean	Mean comparison t (assume ≠ variances)
Age	37.26	38.84	36.28	2.78***
Education	2.89	2.69	3.02	1.18
Experience	13.20	15.37	11.86	3.83***
Household size	9.07	9.73	8.66	3.99***
Asset value	137115.27	166895.37	118644.08	5.96***
Kilometre	5.33	5.85	5.01	2.91***
Size of farm land	2.01	2.08	1.97	9.42***
Risk aversion	1.14	0.58	1.48	0.01

*** represent statistically significance at 1%.

The Chi-square analysis was used to test whether there were significant differences between the monocroppers' and intercroppers' responses to the categorical variable. The results in Table 3.9 below show that there are statistically significance differences between the categorical variables of the cropping systems.

Table 3.9 Chi-square result of the categorical variables, Kebbi State, January 2012

	Monocroppers n = 98		Intercroppers n = 158	
Variables	**Frequency**		**Frequency**	
	Yes	**No**	**Yes**	**No**
Access to agricultural extension	30	68	44	114
Access to credit	16	82	28	130
Land fragmentation	39	59	72	86
Land degradation	60	38	115	43
House type	52	46	50	108
Ownership of animal traction	39	59	54	104
Membership of cooperative	27	71	39	119
Fadama land	35	63	48	110
Access to market	84	14	135	23
Agricultural zone	21	77	61	97
χ^2	26.73**			
χ^2 critical value	16.92			
Degrees of freedom (n-1)	9			

3.3.14 Farm specific characteristics

3.3.14.1 Farm inputs and outputs

The mean size of land for each of the enterprises is less than or equal to 2.56 hectares, the minimum size of land is 0.40 and the maximum size of land is 4.00, as revealed in Table 3.10 below. This is in agreement with the findings of Jirgi (2002) and Jirgi, Ibrahim, Tanko, and Lawal, (2007). The output and profitability of a farm is, *inter alia*, determined by the farm size (Ojo and Imoudu, 2000).

Table 3.10 Allocation of land to the various enterprises, Kebbi State, January 2012

	Size of land (Hectares)			
Enterprise	Mean	Standard deviation	Minimum	Maximum
Sorghum	2.24	0.95	0.50	4.00
Cowpea	1.78	0.72	1.00	3.50
Groundnut	2.56	1.02	1.30	4.00
Millet	2.00	0.72	0.50	3.50
Sorghum/cowpea	2.08	0.89	0.40	3.80
Sorghum/groundnut	2.13	0.66	1.20	3.20
Millet/cowpea	1.79	0.67	0.50	3.00

The results from Table 3.11 below reveal a mean labour use of about 115 man-days for sorghum enterprises, and 89 man-days for millet enterprises.

Table 3.11 Labour use per hectare for the various enterprises, Kebbi State, January 2012

	Labour (man-day) per hectare			
Enterprise	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Sorghum	115	30	67	220
Cowpea	106	26	59	165
Groundnut	82	27	50	96
Millet	89	30	51	181
Sorghum/cowpea	110	29	35	200
Sorghum/groundnut	98	14	67	119
Millet/cowpea	130	29	74	224

The results from Table 3.12 below show that the mean quantities of nitrogen, phosphorus and potassium fertilizer applied by the farmers for all the enterprises are less than or equal to 11.74 Kg/ha, less than or equal to 7.93 Kg/ha, and less than or equal to 6.79 Kg/ha, respectively. This is far below the recommended rates of 64 kgN/ha, 16 kgP/ha and 30 kgK/ha for the dry savannah agro-ecological zone of Nigeria (Adeoye, 2006).

Table 3.12 Fertiliser use per hectare for the various enterprises, Kebbi State, January 2012

	Fertilizer (Kg per hectare)											
	N				P				K			
Enterprise	Mean	Stdev	Min	Max	Mean	Stdev	Min	Max	Mean	Stdev	Min	Max
Sorghum	6.36	2.91	1.80	16.50	4.77	2.15	1.80	11.00	4.92	2.19	1.80	11.50
Cowpea	0.00	1.36	0.00	3.50	5.49	2.49	1.30	10.99	0.43	0.46	0.00	1.17
Groundnut	0.83	1.19	0.00	2.63	2.95	0.45	2.52	3.46	0.28	0.39	0.00	0.88
Millet	8.05	4.39	2.78	24.17	6.11	3.64	1.99	18.67	6.29	3.69	2.09	19.17
Sorghum/cowpea	11.74	6.53	1.17	32.10	7.93	4.22	1.71	26.60	6.79	4.53	1.71	27.10
Sorghum/g/nut	7.16	2.59	2.52	11.57	4.93	1.42	2.52	8.43	5.14	1.49	2.52	8.71
Millet/cowpea	6.98	3.69	2.39	27.00	5.04	2.57	2.39	20.84	5.22	2.65	2.39	21.40

Table 3.13 below shows the quantity of seed utilised by the various enterprises of the farmers.

Table 3.13 Seed quantity use per hectare for the various enterprises, Kebbi State, January 2012

	Seed (Kg/ha)							
	Seed 1				Seed 2			
Enterprise	Mean	Stdev	Min	Max	Mean	Stdev	Min	Max
Monocrop								
Sorghum	10.49	3.48	4.38	22.00				
Cowpea	18.52	3.29	11.58	26.00				
Groundnut	11.52	4.23	7.25	16.15				
Millet	11.08	2.78	7.31	20.00				
Intercrop								
Sorghum/cowpea	13.01	2.89	5.33	44.00	7.53	2.89	3.50	19.17
Sorghum/ground-nut	8.32	0.97	6.32	11.33	4.27	0.97	2.96	6.54
Millet/cowpea	7.28	2.59	4.00	22.00	11.58	3.37	6.00	28.00

The distribution reveals that all the monocroppers used about 11 Kg of seed per hectare on average, the mean seed used by the sorghum/cowpea farmers was about 13 Kg/ha of sorghum and about 8 Kg/ha of cowpea. The result shows that, on average, sorghum, cowpea and groundnut seeds were used below the recommended rates of 13 kg/ha, 20 kg/ha and 50 kg/ha (KNARDA, 2008). The use of quality seed at recommended rates has an influence on the yield of crops (Ajeigbe *et al.*, 2008).

Table 3.14 below shows the descriptive statistics of the depreciation of farm implements for the various enterprises of the farmers. The various farm implements which the farmers use include hoes, cutlasses, axes, sickles, knapsack sprayers, and animal drawn ploughs. The straight line depreciation method was used to calculate the depreciation. Sorghum farmers had the highest mean of about ₦834 for the depreciation cost on farm implements. Groundnut farmers had the lowest mean of ₦374 depreciation costs per hectare.

Table 3.14 Depreciation cost on farm implements per hectare for the various enterprises, Kebbi State, January 2012

	Depreciation cost on farm implements (₦) per hectare			
Enterprise	**Mean**	**Stdev**	**Min**	**Max**
Monocrop				
Sorghum	834.24	1018.97	200.00	4800.00
Cowpea	486.46	192.14	222.22	843.00
Groundnut	373.99	68.49	295.83	458.40
Millet	482.58	186.08	222.22	900.00
Intercrop				
Sorghum/cowpea	478.81	423.28	66.80	3575.00
Sorghum/groundnut	408.77	135.97	269.42	852.30
Millet/cowpea	352.81	143.32	149.50	1037.04

As shown in Table 3.15 below, sorghum is the highest yielding monocrop (1 847 Kg/ha), on average. Millet gave the lowest yield (1 389 Kg/ha), on average. For the intercrops, sorghum/groundnut enterprise gave the highest yield (2 141 Kg/ha). The results show that the average outputs are below the potential yields of sorghum (3 000kg/ha), cowpea (2 300 kg/ha), millet (2 400 kg/ha) and groundnuts (2 000 kg/ha) (Nwafor, 2011).

Table 3.15 Descriptive statistics of output per hectare for the various enterprises, Kebbi State, January 2012

	Output (Kg) per hectare							
	Output 1				Output 2			
Enterprise	**Mean**	**Stdev**	**Min**	**Max**	**Mean**	**Stdev**	**Min**	**Max**
Monocroppers								
Sorghum	1847	425	1143	3000				
Cowpea	1816	356	1192	2440				
Groundnut	1527	360	1224	2092				
Millet	1389	386	833	2450				
Intercroppers								
Sorghum/cowpea	1468	184	500	2750	321	184	88	962
Sorghum/groundnut	1119	385	867	1636	1022	385	455	1867
Millet/cowpea	1477	362	667	2333	313	362	74	1067

Table 3.16 below shows the result of the t-test for output, input quantities and input cost of the farmers. All the means of the variables, except gross margin and phosphorus, were statistically different, either at 1%, 5% or 10% levels of probability. This implies that the output, input quantities and input cost used by the monocroppers are statically significantly different from those used by intercroppers.

Table 3.16 Result of t-test for output, input quantities and input costs of the farmers, Kebbi State, January 2012

Item	Overall mean n = 256 Mean	Monocroppers n = 98 Mean	Intercroppers n = 158 Mean	Mean comparison t(assume ≠ variances)
Output	1776.55	1683.77	1834.11	-2.63***
Gross margin	53954.49	56545.24	52347.57	1.13
Labour	111.66	103.42	116.77	-3.16***
Nitrogen	7.00	5.51	7.93	-2.57***
Phosphorus	5.55	5.24	5.73	1.04
Potassium	5.25	4.14	5.93	-1.99**
Seed	16.38	12.45	18.82	-7.59***
Labour cost	38171.78	33073.93	41333.74	-5.24***
Nitrogen cost	917.77	681.51	1064.31	-2.31**
Phosphorus cost	737.98	837.49	676.25	1.90*
Potassium cost	611.91	453.78	709.99	-2.29**
Seed cost	1284.32	954.56	1488.85	-8.09***

***, ** and * represent statistically significant at 1%, 5% and 10% respectively.

3.4 Conclusions

The aim of chapter 3 was to describe the study area, the method of data collection and the relevant characteristics of the respondents in Kebbi State. The main conclusion from chapter 3 is that there is a low level of education in Kebbi State. The majority of the farmers have relatively few years of farming experience. Among the socio-economic variables, age, years of farming experience, household size, asset values, kilometre travelled and size of farm land of the monocroppers differ significantly from those of intercroppers. Land acquisition is mainly by inheritance. It is also evident that the farmers have experienced land fragmentation and degradation. The use of farm inputs is below recommended rates and the yields are below the potential levels.

From the foregoing, it is evident that farmers in Kebbi State are faced with the challenge of inadequate inputs and low yields. The provision of adequate inputs through cooperatives, government and non-governmental organisations will help in improving the yields of farmers in order to safeguard against food insecurity.

Since land acquisition is mainly through inheritance, land fragmentation is inevitable, which poses a challenge to the agricultural sector. Increases in productivity can no longer be sustained through land expansion, hence the need to utilise the limited land efficiently, and this can only be achieved if the farmers are technically and allocatively efficient in resource utilisation. Accordingly, there is a need for more research on efficiency in order to ascertain the levels of efficiency of the farmers and the factors influencing efficiency.

Developing programmes and policies that will enhance the socio-economic status of the farmers will help in improving productivity in Kebbi State. The relatively low level of farming experience calls for the need to enhance farmers' experience through training and education on agriculture by the Ministry of Agriculture, Agricultural Development Projects (ADP), research institutes, and through the extension agents and the mass media.

CHAPTER 4
PROCEDURES

Introduction

Chapter 4 gives the description of the procedures used to achieve the objectives of the study. In order to achieve objective 1, the risk preference of the farmers is described using Binswanger's experimental approach.

Objective 2 of the study is to determine the most important risk sources and management strategies, and to determine their dimensions in terms of the underlying latent factor.

- The average scores and ranking of means was used to determine the most important sources of risk and risk management strategies from the Likert-type scale responses.

- Factor analysis was used to determine the dimensions of the perceived risk sources and management strategies.

- Factor scores for sources of risk and risk management strategies obtained from the factor analysis was used in the multiple regressions as variables.

- Multiple regressions were used to investigate the relationship between risk attitudes and risk sources, risk management strategies and explanatory variables.

The purpose of Objective 3 is to determine the factors that influence the choice of cropping system by the farmers.

- A Logit regression model was used to determine the influence of risk attitudes and respondents' characteristics on the choice of cropping system of the households.

Objective 4 of the study is to explore the levels of efficiency with which farmers use production inputs to produce their crops and also to investigate the determinants of efficiency. The efficiencies of the monocroppers and intercroppers were compared.

- The Data Envelopment Analysis model was used to determine the technical and cost efficiencies in the use of resources by the intercropping and monocropping farmers in the study area.

- The metafrontier approach was used to compare the efficiencies of the monocroppers and intercroppers.

- To test for the significant differences between the efficiencies of the mono and intercrop farms, the Wilcoxon Rank-Sum Test was used.

4.1 Determining risk preferences of farmers in the study area

This section describes the procedure used in order to achieve the first objective of the study, which is to explore the risk attitudes of the farmers. "Risk attitude means there is a fear trade-off/greed between making money and avoiding potential unfavourable consequences as a result of taking risks" (FinaMetrica, 2008).

Hardaker *et al*. (2004) have described three main attitudes towards risk, namely risk averse, risk neutral, and risk seeking or risk loving. The risk-averse individual is one who is wary of taking risks. The risk-neutral is a person who only cares about the expected pay off of an investment and not the risk that must be taken to achieve the investment objective. A risk-seeking individual is one who actively engages in risky investments. The measure of the amount of risk an individual is willing to take in order to achieve an investment goal is referred to as risk preference (Hoag, 2009).

The principal theory that is used to guide decision-making under risk is subjective expected utility theory (SEU). Chances of bad versus good outcomes can only be evaluated and compared knowing the decision maker's relative preferences for such outcomes. According to the subjective expected utility (SEU) hypothesis, the decision maker's utility function reflects his or her attitude towards risk (Anderson *et al*. 1977). Although expected utility theory has come under criticism (Rabin and Thaler, 2001; Allais, 1984; Rabin, 2000), the SEU hypothesis nevertheless remains the most appropriate theory for prescriptive assessment of risky choices (Hardaker *et al*, 2004; Meyer, 2001). The SEU was selected for this study based on the fact that the theory is more appropriate for perspective assessment of risk choices.

- **Measuring of risk aversion**

In terms of utility framework, risk aversion can be measured by partial risk aversion, which is fixed regardless of the level of payoff (Menezes and Hanson, 1970; Zeckhauser and Keeler, 1970).

Let W stand for final wealth which consist of an initial wealth (φ), and the certainty equivalent of the prospect of new wealth M, by definition,

$$W = \varphi + M \qquad \text{...4.1}$$

An individual's utility function is given by, $U(W) = U(\varphi + M)$.

From the utility function, relative risk aversion (RRA) can be defined. Relative risk aversion traces the behaviour of an individual as both wealth φ and the size of the prospect M rise (Binswanger, 1981). The measure of relative risk aversion is expressed as:

$$RRA = -W\frac{U^{''}}{U^{'}} = WQ \qquad \text{...4.2}$$

Where Q represents absolute risk aversion (Pratt, 1964).

$U^{'}$ and $U^{''}$ are the first and second derivatives of the utility function.

Evaluating RRA at point ($\varphi + M$), this becomes:

$$RRA = (\varphi + M)Q \qquad \text{...4.3}$$

The partial relative risk aversion (PRRA) was proposed by Menezes and Hanson (1970) and Zeckhauser and Keeler (1970) following RRA. PRA is abbreviated as partial risk aversion. Partial risk aversion traces the behaviour of an individual when the scale of the prospects M changes by a certain factor but wealth φ remains the same (Binswanger, 1981). Partial risk aversion, S, is given by:

$$S(W + M) = -M\frac{U^{''}(W + M)}{U^{'}(W + M)} \qquad \text{...4.4}$$

Where W is certain wealth and M is the certainty equivalent of a new prospect.

A risk-averse individual would have increasing partial risk aversion for increases in the prospects M (Menezes and Hanson, 1970; Miyata, 2003). For the game used in this study, each risk aversion category corresponds to an interval of partial risk aversion (S)[1]. Wealth W and the certainty equivalent of a new prospect M were provided.

4.1.1 Elicitation of risk attitudes: the experiment

A simple lottery-choice experiment approach that allows the measurement of the degree of risk aversion over a wide range of payoffs was used in this study. The approach is similar to the lottery-choice data from a field experiment by Binswanger (1980). The lottery-choice procedure was recently used by Yesuf (2007), Kouamé (2010) and Miyata (2011). In the experiment, respondents were presented with a set of alternative prospects involving hypothetical money payments.

The payoffs were varied from very low levels (slightly above the daily wage of an unskilled rural labourer) to high levels (slightly above the minimum monthly wage rate of a civil servant). It is, however, believed that the payoffs provided the incentive for respondents to reveal their true preferences. The respondents' choices between the given alternative prospects is taken as an indication or sign of the degree of the individuals' degrees of risk aversion. The experiment was administered as part of the questionnaire undertaken by the sampled farmers in Kebbi State, Nigeria.

In this experiment, each subject was offered a series of choices from sets of alternative risky prospects, such as the set presented in Table 4.1 below. The game lists six prospects, each with 50% probability of winning. Each respondent was asked to choose his or her preferred alternative from the six prospects: O, A, B, C, D, or E. The risk aversion coefficients of the respondents were calculated using a constant partial risk aversion (CPR) utility function of the form $U = (S-1)M^{1-S}$, where S is the coefficient of risk aversion, and M is the certainty equivalent of a prospect. The partial risk aversion coefficients were computed for each

1 A constant risk aversion function (CRA) was used in order to obtain a unique measure of partial risk aversion associated with the indifference points between two alternatives (Binswanger, 1981). CRA is expressed as: $U = (1-S)M^{1-S}$

indifference point (CE) at each game scale. The upper and lower limits of the CPR coefficients for each prospect are presented in Table 4.1 below.

Table 4.1 Classification of risk aversion coefficients of the respondents, Kebbi State, January 2012

Choices	Bad outcome "Heads"	Good outcome "Tails"	Expected gain	Standard deviation or spread	*S* Approximate partial risk aversion coefficient	Risk classification
O	₦5000	₦5000	5000	0	∞ to7.51	Extreme
A	₦4500	₦9500	7000	3535.534	7.51 to 1.77	Severe
B	₦4000	₦12000	8000	5656.854	1.77 to 0.84	Intermediate
C	₦3000	₦15000	9000	8485.281	0.84 to 0	Moderate
D	₦1000	₦19000	10000	12727.92		Inefficient
E	₦0	₦20000	10000	14142.14	0 to - ∞	Neutral to preferring

Source: Adapted from Binswanger (1980). Note that 1$ US = ₦160

From Table 4.1 above, it will be seen that alternative O is the safest alternative in this game. An individual who chose alternative O would simply get ₦5000, whether he got heads or tails with the flip of a coin, i.e. participation in the game would result in an automatic and sure increase in wealth by ₦5000. If the individual chose alternative A instead of O, his or her expected gain would increase by ₦2000, but a bad luck alternative (heads) would give him or her ₦500 less in return than the person would have received with the safe alternative O. It means that, if the respondent chose A instead of O, the standard deviation in gain increased from O to ₦3535.534. The same explanation holds for the successive alternatives, A to B, B to C, and C to D: the expected gain increases, and so does the spread between the two outcomes. Alternative D and E have the same expected gain, but alternative E has a larger spread. According to Kouamé (2010), when risk is viewed in terms of uncertainty in gains, income or wealth, as in utility based choice theories, the alternatives involve more risk the further down you get in Table 4.1 above. The degree of concavity of an individual's utility function determines the choice the individual will make. The classification of the different prospects from extreme risk aversion (alternative O) to neutral to preferring (alternative E) is the same as the one used by Binswanger (1980), Miyata (2011) and Kouamé (2010). The inefficient choice D was treated as its neighbouring choice E and was considered as risk neutral in the subsequent analysis Binswanger (1980). The intervals of the partial risk aversion (S) presented in Table 4.1 above correspond to the risk aversion class. The values of S are used as one of the explanatory variables in multiple regressions, technical efficiency and cost efficiency models.

4.2 Determining the sources of risk and risk management strategies as perceived by the respondents and the dimensions of the sources of risk and risk management strategies

Twenty-one risk sources variables and twenty risk management strategies variables identified from the literature review were used in the study. In the questionnaire, survey farmers were presented a Likert-type scale range from one (not at all) to five (very important). (The Likert-type scale was used by Meuwissen *et al*. (2001), Akcaoz and Ozkan (2005).) Farmers were asked to rank the risk source and management strategies that were important to them. The means of the responses obtained were then ranked in order of importance to identify the most important risk sources and management strategies.

To examine the dimensions of the perceived risk sources and management strategies for the monocroppers and intercroppers, factor analysis was used. For the factor analysis, it is believed that standard parametric statistical measures are appropriate for ordinal variables in the form of Likert-type scale (Patrick and Musser, 1997; Meuwissen *et al*., 2001). Habing (2003) has stated that factor analysis describes the variance in the observed variables in terms of underlying latent factor. Factor analysis reduces attribute space from a larger number of variables to a smaller number of factors and as such is a "non-dependent" procedure (that is, it does not assume that a dependent variable is specified). The data should be screened to check for outliers that might attenuate the result (Barnett and Lewis, 1994). The factor analysis was carried out using SPSS version 20.

The data were screened for outliers and the result shows that there were no outliers in the monocroppers data. One outlier was removed for intercroppers (risk source) and seven outliers were removed from the intercroppers (risk management). Ninety-eight monocroppers were maintained for both risk source and risk management data. One hundred and fifty-seven (157) intercrop farmers (risk source) were maintained and used for the factor analysis. For the intercrop farmers (risk management), 151 farmers were maintained for the factor analysis.

To determine whether it is necessary to perform the factor analysis, the measure of sampling adequacy (MSA) is used. A sample size is adequate for factor analysis if the ratio of cases to variables in a principal component analysis is at least 5 to 1. The result from the analysis shows a ratio of 5 to 1 for risk source and management strategy (monocroppers), while the ratio for the risk source and risk management (intercroppers) was 8 to 1 (see appendix B3 and B4). Factor analysis can only be carried out if there is correlation between the variables (Habing, 2003), therefore the data were subjected to correlation analysis. The result for the correlation analysis shows that the variables were correlated for both risk sources and management strategies for the intercroppers and monocroppers. The highest correlation value is 1.000 (see appendix B3 and B4).

It is also necessary to consider Bartlett's sphericity test which is used to test for the null hypothesis that the correlation matrix is an identity matrix (Bartlett, 1950). The probability value for Bartlett's test should not exceed 0.05. The results from the analysis reveal that the probability value for Bartlette's test for all the groups of farmers considered was P = 0.00 (see appendix B3 and B4).

The Kaiser-Meyer-Olkin (KMO-test) gives a measure of sampling adequacy; it determines the suitability of individual variables for use in factor analysis. Kaiser and Rice, as cited by Berghaus, Lombard, Gardner & Farver (2005), expressed the Kaiser-Meyer-Olkin (KMO) measure as:

$$MSA(J) = \frac{\sum_{k \neq j} r^2_{jk}}{\sum_{k \neq j} r^2_{jk} + \sum_{k \neq j} q^2_{jk}} \qquad ...4.5$$

Where, MSA(J) is the measure of sampling adequacy for the j^{th} variable, r_{jk} represents an element of the correlation matrix **R**, and q_{jk} represents an element of the anti-image correlation matrix **Q**, which is in turn defined by the equation $\mathbf{Q}=\mathbf{S}\mathbf{R}^{-1}\mathbf{S}$, where **S**= (diag **R**-1)$^{1/2}$. The MSA must lie between 0 and 1, and is described by Kaiser as a measure of the extent to which a variable "belongs to the family" of the larger group of variables. The minimum acceptable KMO-value should exceed 0.50 (Kaiser and Rice, as cited by Berghaus *et al*., 2005).

The overall Kaiser-Meyer-Olkin (KMO) test for sources of risk for monocrop farmers and intercrop farmers was 0.69 and 0.63, respectively (B1, B1a). The KMO-test for risk management strategies of monocroppers and intercroppers was 0.56 and 0.74, respectively (see appendix B2, B2a). The result indicates that all the KMOs are within the acceptable value range (Kaiser and Rice, as cited by Berghaus *et al*., 2005).

In order to determine the number of factors (initial) to be specified in the factor analysis, principal component analysis was done (Afifi *et al*., 2004). Habing (2003) and Stevens, as cited by Berghaus *et al.* (2005), have outlined rules which can be used to determine the number of factors that have to be specified in the factor analysis. The rules are: scree plot, fixed % of variance explained, a priori expectation and Kaiser's criterion/Eigen value. For this study Kaiser's criterion/Eigen value greater than 1 was used. The rule states to take as many factors as there are Eigen values >1 for the correlation matrix.

For the current study, principal component analysis was used to determine the number of factors to be specified in the factor analysis. Only principal factors or components with Eigen values greater than 1 were considered (Habing, 2003) (see appendix B). For the risk source (monocroppers), 3 factors have Eigen values greater than 1, and they explain 61.49% of the total variation in the original variables. Risk source (intercroppers) have 5 factors with Eigen values greater than 1, which explain 69.79% of the total variation in the original variables. Risk management (monocroppers) have 3 factors with Eigen values greater than 1, and they explain 62.68% of the total variation in the original variables. While for risk management (intercroppers), 3 factors have Eigen values greater than 1, which explain 71.25% of the total variation in the original variables.

Factor rotation

According to Kleinbaum *et al*., (1988), factor rotation is necessary to simplify the factor structure and enhance interpretability. There are two types of rotation, orthogonal and oblique rotation. In orthogonal rotation, there is no correlation between the extracted factors, while there is in oblique rotation. Habing (2003) stated that it is best to use an orthogonal rotation which can be varimax or quartimax. The former maximises the sum of the squared factor loadings across the columns which tends to force each variable to load highly on as few factors as possible. Whereas the later does the same, but focuses on the rows. For this study the varimax rotation was used. The next step is to find the proportion of variables that is explained by the common factors.

Communality

Communality is the proportion of variance in a variable that is explained by factors that are retained (Pohlmann, 2004). If these variables were to be regressed on the retained factors, communality represents the R-squared value that would be achieved (NCSS, 2007). Low communality is evidence that the variables analysed have little in common with one another. The results from the analysis show that all the variables retained for the factor analysis have communality values greater than 0.50 (see appendix B3 and B4). After determining the communalities, the next step was to conduct a reliability test.

Reliability analysis scale alpha

According to Vogt (1999) and Miller *et al*. (2003), the overall reliability of internal consistency can be tested using Cronbach's alpha. It gives an indication of the extent to which each item is measuring the same concept as the overall section in the questionnaire covers the sources and risk management strategies. Cronbach's alpha value ranges from 0 to 1.0 (Vogt, 1999). A value greater than 0.7 indicates the acceptable level of reliability (Lazenbatt *et al*., 2005). Seung *et al* (2006), however, state that Cronbach's alpha values greater than or equal to 0.50 are considered acceptable, which suggests that the instrument is reliable.

Cronbach's alpha is given by:

$$a = \frac{K}{K-1}\left[1 - \frac{\sum_{i=1}^{k}\sigma_{ii}}{\sum_{i=1}^{k}\sum_{j=1}^{k}\sigma_{ij}}\right] \qquad ...4.6$$

Where K is the number of items (questions) and σ_{ij} is the estimate covariance between items *i* and *j*. Note that the σ_{ij} is the variance, not the standard deviation of item *i*.

The results from the factor analysis reveal that, overall, Cronbach's alpha values are greater than 0.50 for both monocroppers' and intercroppers' sources of risk and risk management strategies (see appendix B3 and B4). This implies that the variables explain the underlying construct and they are intercorrelated.

The variables (var) retained in the factor analysis for the risk sources and risk management strategies for the monocrop and intercrop farmers are:

Monocrop- risk sources

var2 (pests), var5 (excessive rainfall), var6 (insufficient rainfall), var7 (drought), var9 (change in government and agricultural policy), var10 (illness of household member), var12 (insufficient family labour), var13 (loss of land/ethnic clash), var14 (theft) and var18 (insufficient work animals).

Intercrop-risk sources

var2 (pests), var5 (excessive rainfall), var6 (insufficient rainfall), var10 (illness of household member), var11 (difficulties in finding labour) var13 (loss of land/ethnic clash), var14 (theft) var16 (price fluctuation, of input and output) var17 (family relationships), var18 (insufficient work animals) and var21 (changes in climatic conditions).

Monocrop-risk management strategies

var6 (intercropping), var9 (storage programme), var10 (gathering market information), var12 (price support), var15 (household head working off-farm), var18 (faith in God), var19 (planning and expenditures) and var20 (spraying for diseases and pests).

Intercrop- risk management strategies

var3 (training and education) var4 (investing off-farm), var7 (Adashe, i.e. cash rotation contribution), var10 (gathering market information) var11 (having crop insurance), var12 (price support), var15 (household head working off-farm), var16 (reduced consumption) var18 (faith in God) and var19 (planning and expenditures).

Factor scores are composite variables which provide information about an individual's placement on the factors or components (DiStefano *et al.*, 2009). Factor scores were computed and then used in multiple regressions. The remaining variables that were excluded from the factor analysis were also included in the regressions. The multiple regressions investigated the relationships between risk attitudes, socio-economic factors, sources of risk and risk management strategies.

4.3 Investigating the relationship between risk attitude, respondents characteristics, risk sources and management strategies

Part of objective 2 is to investigate the relationships between sources of risk and management strategies and respondents characteristics. Factor analysis was conducted on the data obtained in relation to risk sources and strategies in order to obtain factor scores.

Multiple regression was used to investigate the relationship between risk attitudes and explanatory variables, sources of risk and risk management strategies. In order to test for multicollinearity and (degrees of freedom) problems which result from high correlation of independent variables and small number of sample size compared to the large number of independent variables, multicollinearity tests were done.

4.3.1 Testing for Multicollinearity

Matignon (2005) and Anderson *et al*. (2008) described the correlation between the independent variables as multicollinearity. The presence of multicollinearity among independent variables makes it difficult to interpret the individual effect on the response variable (Matignon, 2005). There are several methods/indicators that can be used for examination of the presence of multicollinearity between variables. Some of the methods/indicators include correlation matrix, tolerance (TOL), variance inflation factor (VIF), Eigen values and condition index (CI) (Gujarati, 2009; Walker and Maddan, 2008).

Correlation matrix

Walker and Maddan, (2008) stated that multicollinearity can be detected with the correlation matrix. The rule of thumb test is that multicollinearity becomes a problem if the correlation coefficient exceeds 0.7 for any two of the independent variables (Anderson *et al.*, 2008; Walker and Maddan, 2008).

Tolerance (TOL)

TOL tells how much of the variance of an independent variable does not depend on other independent variables. The closer the Tolerance value to 1, the smaller the multicollinearity problem (Walker and Maddan, 2008, Gujarati, 2003).

Variance inflation factor (VIF)

VIF reveals how the variance of an estimator is *inflated* by the presence of multicollinearity (Gujarati, 2003). The VIF indicates whether there is multicollinearity in a model and it shows which variable is problematical. According to Walker and Maddan (2008), a VIF of less than 4 indicates that there is no multicollinearity. A VIF of 5 is also acceptable. However, O'Brien (2007) stated that any VIF greater than 10 indicates the presence of multicollinearity.

Eigen values and condition index (CI)

The condition number is defined as the ratio of the maximum Eigen value to the minimum Eigen value. The condition index is the square root of the condition number (Gujarati, 2003).

The rule of thumb for condition number is that if it ranges between 100 and 1000, then the variables are collinear. A value greater than 1000 shows serious multicollinearity (Gujarati, 2003).

For the current study, the correlation matrix, VIF, and the Eigen values and condition index were used to test for the presence of multicollinearity. The respondents' characteristics used for the regressions were subjected to multicollinearity tests. The tests were done using NCSS (Number Cruncher Statistical System), 2007.

- The tests for multicollinearity between the independent variables (explanatory variables) reveals that the correlations were low (see appendix C).

- The variance inflation factor (VIF) for risk attitude as the dependent variable for monocroppers and intercroppers was less than 5, which indicates that multicollinearity among the variables is unimportant.

- The condition number was less than 50 and the condition index number was less than 10, which also shows that multicollinearity is not a serious problem (see appendix C).

- The VIF for sources of risk as dependent variable for monocroppers and intercroppers was less than 3. The condition number for monocroppers was less than 20 and less than 17 for intercroppers. The condition index for both monocroppers and intercroppers was less than 5. For the monocroppers' management strategy as the dependent variable, the VIF was less than 3.

- The condition number and condition index were less than 14 and 4 respectively. For the intercroppers' management strategy as the dependent variable, the VIF was less than 3. The condition number and condition index were less than 16 and 5, respectively.

Since multicollinearity was not a serious problem, the regressions were done without adjusting the model.

4.3.2 Specification of regression model to investigate the relationship between risk attitude and respondents characteristics (variables), sources of risk and management strategies

Multiple regression was used to investigate the relationship between risk attitudes and respondents' characteristics, sources of risk, risk management strategies for the monocroppers and intercroppers. The dependent variable is the risk attitude (indicated by risk aversion coefficients) of the farmers, while the independent variables are farmers' characteristics, sources of risk (as factor scores) and other variables excluded from the factor analysis, and risk management strategies (as factor scores) and other variables excluded from the factor analysis. The implicit regression model is given by:

$$Y = \alpha_0 + \beta X_i .... + X_n + e_i \qquad ...4.7$$

Where Y = risk aversion coefficients (standardised), X = respondents' characteristics, sources of risk (as factor scores), other variables excluded from the factor analysis and risk management strategies (as factor scores), and other variables excluded from the factor analysis.

4.3.2.1 Variables that are hypothesised to influence monocrop and intercrop farmers' attitude towards risk

Farmers' risk attitudes depend on their socio-economic and other characteristics. Some of the respondents' characteristics that are hypothesised to influence farmers' attitude towards risk are shown in Table 4.2 below.

Cooperative: Farmers who belong to a cooperative are hypothesised to be less risk averse because they can get financial support from the cooperative in case of any misfortune.

Education: It is hypothesised that the more educated an individual is, the less risk averse the individual will be (Binswanger, 1980), probably because they have other sources of income, more access to agricultural institutions, and other skills.

Table 4.2 Variables and expected signs for risk attitude of monocrop and intercrop farmers, Kebbi State, January 2012

Variables	**Variable description**	**Mono and intercrop farmers**
Cooperative	Dummy 1 if the household head belong to a cooperative or 0 if otherwise	–
Education	Education of the household head in years spent in school	–
Farming experience	Farming experience of household head in years	–
Fadama	Dummy 1 if the household head is involved in *fadama* cultivation or 0 if otherwise	–
Size of farm	Number of hectares cultivated by the household head	+/-
Household size	Number of individuals living under the same roof and eating from the same pot with the household head	–
House type	Dummy 1 if the household head has a modern house or 0 if otherwise	–
Kilometre	Distance travelled by the farmer from house to the farm	+

Positive sign implies that the variable has a direct influence on risk attitude of the farmer meaning that increase in the variable leads to increase in risk aversion of the farmer the converse is true for negative signs.

Farming experience: Farmers who have more years of farming experience are expected to be less risk averse (Binswanger, 1980). This is because they are more knowledgeable concerning environmental factors and seasonal price variations of various agricultural products.

Fadama: Farmers who have *fadama* land may likely be less risk averse, because *fadama* cultivation serves as a source of extra income, and the lands can be used as collateral to obtain loans from the financial institutions.

Farm size: Under unfavourable conditions, farmers with larger farm sizes are hypothesised to be more risk averse for the fear of uncertainties. The converse is true under favourable conditions.

Household size: The larger the household size, the less risk averse the farmer is expected to be (Miyata, 2003). A large number of household members provide family labour to the farmer and some extra income from off-farm activities

House type: Farmers who own modern houses are likely to be less risk averse, because they are thought to be relatively wealthy and probably have some assets that they can fall back on in the case of any unforeseen events.

Kilometre: The further the farm is located from the house, the more likely the farmer will be risk averse through the fear of theft, especially during harvest, and outbreaks of fire, and also because of higher costs in terms of time and transport.

4.3.3 Specification of regression model to investigate the relationship between sources of risk and respondents characteristics (variables), risk attitude and management strategies

Multiple regression was used to investigate the relationships between sources of risk and respondents' characteristics variables, risk attitudes and risk management strategies. The dependent variable is the sources of risk (indicated by factor scores), other variables excluded from the factor analysis, while the independent variables will be the respondents' characteristics, risk attitudes (risk aversion coefficients) and risk management strategies (as factor scores) and other variables excluded from the factor analysis. The implicit Ordinary Least Squares (OLS) regression model is given by:

$$Y = \alpha_0 + \beta X_i .... + X_n + e_i \qquad ...4.8$$

Where Y = sources of risk (as factor scores), other variables excluded from the factor analysis, X = farmers' characteristics, variables of the farmers, risk aversion coefficients and risk management strategies (as factor scores) and other variables excluded from the factor analysis.

4.3.3.1 Variables and expected signs for sources of risk for monocrop and intercrop farmers

The variables and expected signs for sources of risk for monocrop and intercrop farmers are presented in Table 4.3 below.

Table 4.3 Variables and the expected signs of sources of risk of monocrop and intercrop farmers, Kebbi State, January 2012

	Variables												
Sources of risk	**Age**	**cooperative**	**Education**	**Farming experience**	***Fadama***	**Farm type**	**Size of farm**	**Household size**	**House type**	**Kilometre**	**Risk attitude**	**Gross margin**	**Asset value**
Flood/storm	+	+	+	+	+	+	+	+	+	+	+	+	+
Pests	-/+	+	+	-/+	+	+	+	+	+	+	+	-	-
Diseases	-/+	+	+	-/+	+	+	+	+	+	+	+	-	-
Erratic rainfall	+	+	+	+	+	+	+	+	+	+	+	+	+
Excessive rainfall	+	+	+	+	+	+	+	+	+	+	+	+	+
Insufficient rainfall	+	+	+	+	+	+	+	+	+	+	+	+	+
Drought	+	+	+	+	+	+	+	+	+	+	+	+	+
Fire outbreak	+	+	+	+	+	+	+	+	+	+	+	+	+
Change in government	+	+	+	+	+	+	+	+	+	+	+	+	+
Illness of household	+	+	+	+	+	+	+	+	+	+	+	+	+
Difficulties for finding	+	+	+	+	+	+	+	-	+	+	+	+	+
Insufficient family	+	+	+	-	+	+	+	-	-	+	+	+	+
Loss of land/ethnic	+	+	+	+	-	+	+	+	+	+	+	+	+
Theft	+	+	+	+	+	+	+	+	+	+	+	+	+
Market failure	+	+	+	+	+	+	+	+	+	+	+	+	+
Price fluctuation (of	+	+	-	-	-	+	+	+	+	+	+	+	+
Family relationships	-	-	-	-	+	+	+	+	+	+	+	+	-
Insufficient work	+	-	+	+	-	+	+	-	-	+	+	+	-
Lack of work animals	+	-	+	+	-	+	+	-	-	+	+	+	-
Fertilizer	+	-	+	+	+	+	+	+	-	-	+	+	+
Change in climatic	-	+	+	+	+	+	+	+	+	+	+	+	+

Positive values mean that the variable has a direct influence on the sources of risk. Increase in the variable implies that the monocrop and intercrop farmer sees the risk item as a source of risk. The reverse is true for the negative values. -/+ means that the variable has negative influence for monocroppers and positive influence for intercroppers.

4.3.4 Specification of regression model to investigate the relationship between risk management strategies and respondents characteristics (variables), risk attitude and sources of risk

Multiple regression was used to investigate the relationships between risk management strategies and farmers' characteristics, risk attitudes and sources of risk for the mono and intercroppers. The dependent variable is the risk management strategies (indicated by factor scores), other management variables excluded from the factor analysis, while the independent variables will be the characteristics (variables) of the farmers, risk attitude (as risk aversion coefficients) of the farmers and sources of risk (indicated by factor scores) and other management variables excluded from the factor analysis. The implicit OLS regression model is expressed as:

$$Y = \alpha_0 + \beta X_i........+ X_n + e_i \quad 4.9$$

Where Y = risk management strategies (as factor scores), X = Farmers' characteristics variables, risk aversion coefficients and sources of risk (indicated by factor scores) and other management variables excluded for the factor analysis.

4.3.4.1 Variables and expected signs for risk management for monocrop and intercrop farmers

The variables and the expected signs for risk management for monocrop and intercrop farmers are shown in Table 4.4 below.

Table 4.4 Variables and the expected signs of risk management strategies of monocrop and intercrop farmers, Kebbi State, January 2012

	Variables												
Risk management strategies	**Age**	**cooperative**	**Education**	**Farming experienc**	***Fadama***	**Farm type**	**Size of farm**	**Household size**	**House type**	**Kilometre**	**Risk attitude**	**Gross margin**	**Asset value**
Spreading sales	+	+	+	+	_	+	+	+	+	+	+	+	+
Fertilizer provision by government/self	+	+	+	+	+	+	+	+	+	+	+	+	+
Training and education	-	+	+	-	+	+	+	+	+	+	+	+	+
Investing off- farm	+	+	+	+	+	+	+	+	+	+	+	+	+
Fadama cultivation	+	+	+	+	+	+	+	+	+	+	+	+	+
Intercropping	-/+	-	-	-/+	-	-	-	-	-	-	+	+	+
Adashe (rotation savings)	+	+	+	+	+	+	+	+	+	+	+	+	+
Cooperatives	+	+	+	+	+	+	+	+	+	+	+	+	+
Storage programme	+	+	+	+	+	+	+	+	+	+	+	+	+

Gathering market information	+	+	+	+	+	+	+	+	+	+	+	+	+
Having crop insurance	-	+	+	+	+	+	+	+	+	+	+	+	+
Price support	+	+	+	+	+	+	+	+	+	+	+	+	+
Borrowing (cash or grains)	+	+	+	+	+	+	+	+	-	+	+	-	-
Family members working off-farm	+	+	+	+	+	+	+	+	+	+	+	+/-	+/-
Household head work off-farm	-	-	-	-	-	+	+	+	-	+	+	-	-
Reduced consumption	+	+	-	+	+	+	+	+	-	+	+	-	-
Selling of assets	+	-	-	+	-	+	+	+	-	+	+	+	+
Faith in God	+	+	+	+	+	+	+	+	+	+	+	+	+
Planning expenditures	+	+	+	+	+	+	+	+	+	+	+	+	+
Spraying for diseases and pests	+	+	+	+	+	+	+	+	+	+	+	+	+

Positive signs mean that the variable has a direct influence on risk management strategies which implies that the higher the explanatory variable, the more the monocrop and intercrop farmer sees the variable as a risk management strategy. Converse is true for negative signs. -/+ means that the variable has negative influence for monocroppers and positive influence for intercroppers. The +/- sign for family members working off-farm means that the variable is ambiguous for both the monocroppers and intercroppers.

4.4 Determining the factors that influence the choice of cropping system

The third objective of the study is to determine whether respondents' attitudes toward risk and characteristics influence their choice of cropping system. Logit regression was used in order to achieve objective 3.

4.4.1 Specification of the regression model to determine the factors that influence the choice of cropping system

The Logit model was used to ascertain the influence of household characteristics on the choice of the cropping system practised. The Logit model arises from assuming a logistic distribution. Greene (2000) has stated that under the standard assumptions about the error term, there is no *a priori* reason to prefer Probit to Logit estimation. In most applications, it seems not to make much difference. Logit model is estimated by maximum likelihood. Consequently, goodness of fit and inferential statistics is based on the log likelihood and Chi-square test statistics. The general form of the Logistic regression model is given by:

$$L_i = Ln\left(\frac{\phi_i}{1-\phi_i}\right) = \beta_0 + \beta_i X_i + e_i \qquad \text{... 4.10}$$

L_i is referred to as the logit, hence the term "logit model", and ϕ_i is the probability of a farmer practicing intercropping, X_i represents the set of explanatory variables that influence the farmer practicing intercropping, β_i is the parameter to be estimated and e_i represents the error term.

In general, the formulation of the model can be written as:

$$CHO_{im} = \beta_o + \beta_1 EXP + \beta_2 ASV + \beta_3 RA + \beta_4 FS + \beta_5 LD + e_i$$

Where *CHO* is the choice of cropping system (intercropping or monocropping).

EXP = Years of farming experience, *ASV* = Asset value, *RA* = Risk aversion coefficients, *FS* = Size of farm land, *LD* = Land degradation.

4.4.1.1 The variables that influence the choice of cropping system and the expected signs

The variables that influence the choice of cropping system and the expected signs are presented in Table 4.5 below.

Table 4.5 Variables that influence the choice of cropping system and the expected signs

Variables	Variable description	Expected sign
Farming experience (EXP)	Farming experience of household head in years	-
Asset value (ASV)	The amount of assets (e.g house, oxen, bicycle, etc) valued in naira	-
Risk aversion: (RA)	Risk aversion coefficients	+
Size of farm land(FS)	Farm size (ha)	-
Land degradation (LD)	Dummy: 1 if the farmer perceives his soil fertility is low and eroded; 0 if otherwise	+

Farming experience

Farming experience reduces the probability of farmers' practicing intercropping. The farmers with only few years of farming experience are likely to be more risk averse and may tend to practise intercropping as a means of diversification, so that they can harvest at least one crop in a bad year.

Asset value

Asset value is expected to reduce the probability of farmers' practicing intercropping. For good yields, farm inputs such as fertilizer, agrochemicals and seed must be applied at the right time and at recommended rates. Only farmers with high asset value can afford inputs at the right time and at recommended rates.

Risk aversion

Risk aversion enhances the probability of farmers' practicing intercropping. The risk averse farmers are more likely to practise intercropping as a means of diversification so as to avoid total crop and market failure in a bad year.

Size of farm land

Farm size is hypothesised to decrease the probability of farmers' practicing intercropping. Farmers with larger farm sizes are likely to practise monocropping because of its advantage of giving higher yields and more economic returns (Nelson, 2006; Mmom, 2009).

Land degradation

Land degradation is expected to enhance the probability of farmers' practicing intercropping. One of the advantages of intercropping is that it serves as a means of replenishing the soil nutrients, and farmers whose farm lands are degraded are likely to practise intercropping as a means of combating the menace.

4.5 Estimation procedure of technical and cost efficiency

The fourth objective of this study is to investigate the levels of efficiency with which the farmers use their production inputs to produce their crops. This section describes the procedure for the estimation of farm efficiencies, in order to achieve objective 4.

4.5.1 Variables used in the estimation of efficiency

The production process involves the utilisation of inputs to produce outputs. Data for the input variables and outputs obtained from the questionnaire in appendix A were used to estimate the technical and cost efficiencies. Additional information on environmental variables was also obtained from the questionnaire.

The inputs used to analyse the technical efficiency of the monocrop and intercrop farmers are labour, nitrogen phosphorus, potassium and seed. Most of the labour utilised by the farmers in the study area is manual, using simple farm implements, such as hoes, cutlasses, sickles and rakes. Animal traction is mostly used for land preparation. Labour can be measured in man-hours or man-days. In this study, labour was measured in man-days because it is believed that farmers can recall the number of man-days used for each operation more easily than the man-hours used. Researchers, such as Ogundari and Ojo, 2007; Ajibefun, 2008; Ogundari *et al*., 2010; Begum *et al*., 2011, have used man-days to measure labour.

Nitrogen (N), phosphorus (P) and potassium (K) were identified as the sources of plant nutrients that enhance the vegetative growth of sorghum, cowpea, groundnuts and millet as monocrops and as intercrops. N also suppresses *striga hermonthica* (Del.) Benth which is the witchweed that parasitizes sorghum and causes about 80% of the loss in production (Mumera and Below, 1993, Sinebo and Drennan, 2001). The use of fertilisers (NPK) has been reported to increase sorghum yield up to 122% in India (Abida, Mussarrat, Safdar, Ghulam, & Rehana 2007). One of the important factors limiting higher crop yields is the low application of P in relation to N (Abida *et al*., 2007). Combination of NPK fertilizers gives better sorghum yield (Tanchev, 1995).

The effect of NPK on cowpea production is improvement in yield components and grain yield (Abayomi *et al*., 2008). N plays an important role for growth and development of pearl millet (Khairwal *et al*., 2007). P availability helps in increased efficiency of nitrogen use by plants, as plants cannot grow without P (Khairwal *et al*., 2007). Potassium plays a vital role in the improvement of quality of crop produce. Seed is the key to overall economic growth for increased agricultural productivity. For this study, seed was included as an important variable in the estimation of efficiency. Research has shown that the quality of seed alone accounts for an increase in productivity of at least 10-15% (Ousmane and Ajeigbe, 2008).

4.5.2 Variables hypothesised to influence technical efficiency

The explanatory variables associated with technical efficiencies are: age, educational level of household head, years of farming experience, household size, access to extension, access to credit, land fragmentation, land degradation, type of house, asset value, walking distance to the farm, risk attitude of the farmer, animal traction, membership of farmers' organization, *fadama* cultivation, and access to market. A positive sign means a positive influence on efficiency.

Table 4.6 below shows the hypothesised variables, description and their expected signs. **Age** is hypothesised to have a positive influence on technical efficiency (Msuya *et al*, 2008; Amos, 2007). A farmer's experience increases with age and resource empowerment, thus leading to increase in efficiency.

Education is hypothesised to have a positive relationship with technical efficiency (Gul *et al*., 2009; Amaza 2000; Ajani 2000; Adeoti 2002; Ajibefun and Abdulkadri 2004; Ajibefun *et al*., 2006; Yusuf and Malomo 2007; Solís *et al*., 2009; Kyei *et al*., 2011; Ogunniyi and Ojedokun 2012; Jordaan, 2012). Educated farmers have a better understanding of new technologies and can more easily adopt the technologies, they often also have better managerial skills, and hence they are likely to be more efficient than farmers who are not educated.

Farming experience is expected to have a positive influence on technical efficiency, because farmers with more years of farming experience tend to have a better understanding of farming practices (Ajibefun and Abdulkadri 2004; Ajibefun *et al.*, 2006; Idjesa, 2007; Ogunniyi and Ojedokun, 2012; Yusuf and Malomo 2007; Gul *et al*., 2009; Kyei *et al*., 2011).

The household size of the farmer is expected to have a positive or negative influence on technical efficiency. Yusuf and Malomo (2007) and Binam *et al*. (2003), reported that household size has negative influence on technical efficiency. Ebong, (2005) and Onyenweaku *et al*. (2005) however, stated that household size has a positive association with technical efficiency.

Table 4.6 Variable definition and expected signs for factors hypothesised to influence technical efficiency for monocrop and intercrop farmers in Kebbi State, Nigeria.

Variable	**Description**	**Expected sign**
Age (AGE)	Age of household head, years	+
Education (EDU)	Education of the household head in years of schooling	+
Farming experience (EXP)	Farming experience of household head in years	+
Household size (HHS)	Number of individuals living under the same roof and eating from the same pot with the household	+/-
Access to extension (AGX)	Dummy: 1 if the farmer had a contact with an extension agent, 0 if otherwise	+
Access to credit (CRT)	Dummy: 1 if the household head benefitted from financial institution or 0 if otherwise	+
Land fragmentation (LF)	Dummy: 1 if the farmers land is fragmented into more than two plots or 0 if otherwise	-
Land degradation (LD)	Dummy: 1 if the farmer perceives his soil fertility is low and eroded or 0 if otherwise	-
Type of house (HT)	Dummy: 1 if the farmer has a modern house and 0 if otherwise	+
Asset value (ASV)	The amount of assets (e.g house, oxen, bicycle etc) valued in naira	+
Kilometre (KM)	Average walking distance to farm	-
Risk attitude (RA)	Risk aversion coefficients	+
Traction (TR)	Dummy 1 if the household head use animal traction or 0 if otherwise	+
Membership of organisation (COOP)	Dummy 1 if the household head belong to any farmers organisation or 0 if otherwise	+
Access to *fadama* (FDM)	Dummy 1 if the household head is involved in *fadama* cultivation or 0 if otherwise	+
Access to market	Dummy 1 if the farmer has access to market or 0 if otherwise	+

Positive sign imply that the variable has a positive influence on technical efficiency; converse is true for negative signs.

Access to extension is expected to have a positive influence on technical efficiency (Tchale and Sauer, 2007; Kamruzzaman and Hedayetul Islam, 2008; Solís *et al*., 2009; Nyagaka *et al*., 2010; Akinbode *et al*., 2011). Farmers who have access to extension services become better informed on farm management practices that can enhance farm productivity.

Access to credit is hypothesised to influence technical efficiency positively (Abdulai and Eberlin, 2001; Tchale and Sauer, 2007; Tanko and Jirgi, 2008; Nyagaka *et al*., 2010; Maseatile, 2011). Jordaan (2012) reported a positive relationship between formal and informal credit and technical efficiency. Access to credit enables farmers to purchase adequate farm inputs, and in good time, thus improving efficiency.

Land fragmentation is hypothesised to have a negative influence on technical efficiency (Gul *et al*., 2009; Wadud and White, 2000). The negative association of land fragmentation on technical efficiency is caused by the fact that fragmentation increases transportation costs of the farmer and his or her farm implements. Also, resources are diverted away from what would have otherwise been productively applied to production (Monchuk *et al.*, 2010).

Land degradation (soils that are eroded and low in soil fertility) is expected to have a negative influence on technical efficiency (Wadud and White, 2000). Land degradation leads to depletion of the soil nutrients essential for plant growth, hence decreasing efficiency. Msuya *et al*. (2008) reported that land fragmentation has a negative effect on technical efficiency.

Type of house is hypothesised to influence technical efficiency. Farmers with modern houses are considered to be wealthy and can afford to purchase adequate farm inputs which enhance better crop yield.

Asset value is hypothesised to have positive influence on technical efficiency (Haji, 2007). Farmers with high asset value are more likely to have higher incomes which enable them to purchase adequate farm inputs.

Kilometre, which is the average walking distance from the house to the farm, is hypothesised to have a negative relationship with technical efficiency (Msuya *et al*., 2008). This is because of the fact that more time, that is supposed to be utilised for labour on farms, is used to walk long distances to the farms.

Risk attitude is hypothesised to have positive influence on technical efficiency. Risk-averse farmers are more likely to be technically efficient, and this could be attributed to their tendency to allocate resources under their discretion more optimally (Dhungana *et al*., 2004). There is also a possibility that risk-averse farmers may allocate their resources more conservatively. Technical efficiency may be related to farmers' perceptions of production uncertainty (Dhungana *et al*., 2004).

The use of **animal traction** is hypothesised to have a positive influence on technical efficiency (Douglas, 2008). Animal traction tends to enhance labour utilisation, especially during land preparation and weeding.

Membership of farmer's organisation is hypothesised to influence technical efficiency positively (Nyagaka *et al*., 2010). Farmers who belong to cooperatives pool their resources to purchase farm implements and inputs, which are shared among members of the cooperative, thus improving the resource utilisation of the farmers. The cooperatives can improve farmers' access to obtaining fertiliser and improved seed from the agricultural-related institutions.

Access to *fadama* is hypothesised to have a positive influence on technical efficiency of the farmers. As mentioned above, *fadama* are flood plains and low-lying areas underlined by shallow aquifers found along Nigeria's river systems which are used for small-scale irrigation. *Fadama* cultivation is a form of enterprise diversification which allows farmers to generate extra income that can be used to finance other farm enterprises, thus improving farm efficiency.

Access to market is expected to have a positive influence on efficiency (Msuya *et al*., 2008; Desilva 2011). Tchale and Sauer (2007) stated that access to output markets reduce transaction cost and encourage farmers to grow 'best-bet' crops. Douglas (2008) stated that lack of access to markets is a disincentive to farmers, which discourages them from increasing future production.

4.5.3 Data envelopment analysis

DEA method is aimed at constructing a non-parametric, piece-wise surface or frontier over the data. Efficiency measures are then calculated relative to this surface (Coelli *et al.*, 2005). The decision making units (DMUs) are the farmers who are either monocroppers or intercroppers. A DMU is said to be fully efficient if it lies on the frontier, and inefficient if otherwise.

To measure technical efficiency, the output orientated efficiency estimator, $\hat{\delta}_i$, can be derived by solving the following linear programming problem for each DMU, thus obtaining a value of technical efficiency score for each DMU (Coelli *et al.*, 2005; Simar and Wilson, 2007).

$$\hat{\delta}_i = max\{\delta > 0 | \hat{\delta}_i y_i \leq \sum_{i=1}^{n} y_i\lambda; x_i \geq \sum_{i=1}^{n} x_i\lambda; \lambda \geq 0\} \quad \text{...4.11}$$

$$\hat{\delta}_{i,}\lambda$$

$i = 1....n$ DMU's

Where y_i is a vector of outputs, x_i is a vector of inputs and λ is a I×1 vector of constants.

The value obtained for $\hat{\delta}$ is the technical efficiency score for the i[th] DMU. It satisfies: $\hat{\delta} \leq 1$, with a value of $\hat{\delta} = 1$, indicating that the DMU is technically efficient. This linear programming problem must be solved I times, once for each DMU. A value of $\hat{\delta}$ is thus obtained for each DMU.

The DEA model described above is a constant return to scale (CRS) model. Variable return to scale (VRS) can be imposed on the model in equation 4.11 **Error! Reference source not found.** by introducing the constraint $\sum_{i=1}^{n} \lambda = 1$. In this study the CRS assumption was used.

Russell (1990) stated that the use of CRS assumptions has some mathematical properties which are desirable.

4.5.3.1 Bootstrapping procedure

The Double Bootstrapping procedure is applied to a truncated regression of non-parametric DEA efficiency estimates on explanatory variables in a two-stage procedure explaining the sources of efficiency variations among monocrop and intercrop farmers. The double bootstrap procedure was recently used by Olson and Vu (2009) and Jordaan (2012). Bootstrapping allows the computation of the estimated standard errors, confidence intervals and hypothesis testing. Algorithm two was used in the study, following Jordaan (2012).

[1] Calculate the DEA output-orientated efficiency score $\hat{\delta}_i$ for each DMU, using the linear programming problem in equation 4.11 **Error! Reference source not found.**.

[2] Use the maximum likelihood method to estimate the truncated regression of $\hat{\delta}_i$ on z_i, to provide an estimate $\hat{\beta}_i$ of β, as well as an estimate $\hat{\sigma}_\varepsilon$ of σ_ε.

The principal components extracted from the original variables that were hypothesised to influence technical efficiency were used as the explanatory or environmental variables (z_i). Following Jordaan (2012), the explanatory variables were standardized in order to extract the principal components. For the standardised variables, a mean of zero and standard deviation of one was obtained. The Eigen vectors that are used to construct the principal component were calculated using the standardized explanatory variables. Principal components with an Eigen vector greater than 1 were included in the regression analysis (Kaiser, 1960). The Eigen values of the principal components of the variables that were initially hypothesised to influence the technical efficiency of the monocrop and intercrop farmers are presented in Chapter 6. The summary of the factor loadings for the different sample groups is shown in Appendix E.

[3] For each DMU $i = 1,...n,$ repeat the next four steps (i - iv) L_1 times to obtain n set of bootstrap estimates $B_i = \{\hat{\delta}_{i,b}^{*}\}_{b=1}^{L1}$:

[i] Draw ε_i from the $N(0, \hat{\sigma}_{\varepsilon}^{2})$ distribution with left truncation at $1 - \hat{\beta} z_i$.

[ii] Compute $\delta_i^* = \hat{\beta} z_i + \varepsilon_i$.

[iii] Construct a pseudo data set (x_i^*, y_i^*), where $x_i^* = x_i$ and $y_i^* = y_i \hat{\delta}_i / \delta_i^*$.

[iv] Compute a new DEA estimate δ_i^* on the set of pseudo data (x_i^*, y_i^*), i.e.

[4] For each DMU, compute the bias corrected estimate $\hat{\hat{\delta}}_i = \hat{\delta}_i - \hat{bias}$, where $\hat{bias}_i$ is the bootstrap estimator of bias obtained as: $\hat{bias}_i = \frac{1}{B}\sum_{b=1}^{B} \hat{\delta}_{i,b} - \hat{\delta}_i$.

[5] Use the Maximum likelihood method to estimate the truncated regression of $\hat{\hat{\delta}}_i$ on z_i, providing estimates $\left(\hat{\hat{\beta}}, \hat{\hat{\sigma}} \right)$ of $(\beta, \sigma_{\varepsilon})$.

In the truncated regression, the principal components of the explanatory variables were used as z_i.

[6] Repeat the next three steps (i – iii) B_2 times to obtain a set of bootstrap estimates

$$\left\{ \left(\hat{\hat{\beta}}_b^*, \hat{\hat{\sigma}}_b^*, b = 1,..., B_2 \right) \right\}.$$

[i] For $i = 1,...n, \varepsilon_i$ is drawn from $N\left(0, \hat{\hat{\sigma}}\right)$ with left truncation at $\left(1 - \hat{\hat{\beta}} z_i\right)$.

[ii] For $i = 1,...,n,$ compute $\delta_i^{**} = \hat{\hat{\beta}} z_i + \varepsilon_i$.

[iv] The Maximum likelihood method is again used to estimate the truncated regression of δ_i^{**} on z_i, providing estimates $\left(\hat{\hat{\beta}}^*, \hat{\hat{\sigma}}^*\right)$.

[7] Use the bootstrap results to construct confidence intervals (Simar and Wilson, 2007).

4.5.4 Determination of allocative efficiency of monocrop and intercrop farmers in Kebbi State

Part of objective 4 is to investigate the levels of allocative efficiency of the farmers in Kebbi State and to explore the determinants of cost efficiency. The procedures followed to achieve objective 4 are discussed in this section.

4.5.4.1 Definition of allocative efficiency

Allocative efficiency is defined as the ability of a decision maker to utilise the inputs in optimal proportions, given their respective prices and the production technology (Coelli *et al*., 2005). Coelli *et al*. (2005) mentioned that there are three measures of allocative efficiency. They are cost, revenue and profit efficiency. The three efficiency measures can be determined if price data are available. In this study, cost efficiency is used as a measure of allocative efficiency of the monocrop and intercrop farmers. Cost efficiency is the ability of a farm to produce the current output levels at minimum cost (Coelli *et al*., 2005). Cost efficiency is given by the ratio of minimum feasible cost to actual cost (Coelli *et al*., 2005). It is possible to estimate cost efficiency when the DMUs pay different prices for their inputs and obtain the same prices for their produce (Coelli *et al*., 2005). In this study it is assumed that, on average, farmers receive the same prices for their produce and pay different prices for their inputs. For details of revenue and profit efficiency, see Coelli *et al*. (2005) and Jordaan (2012).

4.5.4.2 Specification of the DEA model to estimate cost efficiency

The cost minimising DEA for the case of variable returns to scale (VRS) using an input-orientated DEA model, according to Coelli *et al*. (2005), is given by:

$$\min_{\lambda, x_i^*} \; W_i^{'} X_i^{*}, \qquad \text{...4.12}$$

$$\text{Subject to} \qquad -q_i + Q\lambda \geq 0,$$

$$x_i^* - X\lambda \geq 0,$$

$$I1^{'}\lambda = 1$$

$$\lambda \geq 0,$$

Where W_i is a $N \times 1$ vector of input prices for the $i-th$ farm and x_i^* (which is calculated by the linear programming) is the cost minimising vector of input quantities for the $i-th$ farm, given the input prices W_i and the output levels q_i. λ is a $I \times 1$vector of weights, $M \times I$ is output matrix Q,

The total cost efficiency (CE) of the farm is expressed as:

$$\text{CE} = W_i^{'} x_i^{*} \big/ W_i^{'} x_i \qquad \text{...4.13}$$

Thus, the CE is the ratio of minimum cost calculated from equation 4.12 above to the observed or actual cost for the $i-th$ farm. The value of CE score lies between zero and one. A value of one indicates that the farm lies on the frontier and is efficient (Begum *et al*., 2011; Jordaan, 2012).

4.5.5 Estimating the determinants of cost efficiency of the respondents

Recent studies on the determinants of efficiency using DEA approach have applied Tobit regression in the second stage (Begum, 2011; Aman and Haji, 2011). It has been argued that the efficiency scores obtained from DEA are not generated by a censoring process but are fractional data (McDonald, 2009; Simar and Wilson 2007). Therefore, the use of Tobit to estimate the determinants of DEA efficiency scores is not reliable. Since the double bootstrapping procedure for cost efficiency has not yet been developed (Olson and Vu, 2009), the linear unit interval model is an appropriate data generating process (DGP) for efficiency scores. According to McDonald (2009), ordinary least squares (OLS) is an unbiased and consistent estimator. The linear unit interval model is given by:

$$y_i = x_i \beta + u_i \qquad ...4.14$$

Where u_i / x_i are normally, identically and independently distributed with zero means, $0 \leq y_i \leq 1$, with the limit point $y_i = 1$ possessing positive probability.

Generally, OLS estimates of β is consistent and asymptotically normal (McDonald, 2009). From the foregoing, the current study uses the DGP in equation 4.14 above to examine the determinants of cost efficiency among monocrop and intercrop farmers in Kebbi State. The efficiency scores (y_i) which is the dependent variable obtained from equation 4.13 above, is logged (McDonald, 2009; Jordaan, 2012). The explanatory variables are the independent variables in the regression. Table 4.7 presents the factors hypothesised to influence cost efficiency.

Table 4.7 Variables hypothesised to influence cost efficiency of monocrop and intercrop farmers in Kebbi State, January, 2012

Variable	**Description**	**Expected sign**
Education (EDU)	Education of the household head in years of schooling	+
Farming experience (EXP)	Farming experience of household head in years	+
Access to extension (AGX)	Dummy 1: if the farmer had a contact with an extension agent, 0 if otherwise	+
Access to Credit (CRT)	Dummy 1: if the household head benefitted from financial institution or 0 if otherwise	+
Asset value (ASV)	The amount of assets (e.g. house, oxen, bicycle etc) valued in naira	+
Risk attitude (RASTD)	Risk aversion coefficients	-
Membership of organisation (COOP)	Dummy 1 if: the household head belong to any farmers organisation or 0 if otherwise	+
Access to *fadama* (FDM)	Dummy 1 if: the household head is involved in *fadama* cultivation or 0 if otherwise	+
Age (AGE)	Age of household head, years	+
Land fragmentation (LF)	Dummy: 1 if the farmers land is fragmented into more than two plots or 0 if otherwise	-

Positive values indicate that the variable has a positive relationship with cost efficiency

Education

Education is hypothesised to have positive influence on cost efficiency. Farmers who are educated are likely to have better managerial ability, understanding of resource allocation, farm planning and access to information which influences cost efficiency (Dhungana *et al*., 2004; Hassan, 2007; Khan and Saeed, 2011).

Farming experience

Over the years, farmers gain better understanding of farm management practices and attain better managerial skills which influence allocative efficiency positively (Okoye *et al*., 2006; Bozoglu and Ceyhan, 2007; Obare *et al*., 2010; Jordaan, 2012). In this study the variable farming experience is hypothesised to have a positive effect on cost efficiency. Farmers with higher farming experience have good knowledge of seasonal price variations of inputs and thus purchase input at minimum cost, which in turn results in allocative efficiency.

Access to extension

Access to extension is hypothesised to have positive influence on allocative efficiency. Farmers who are trained on the adoption of improved agronomic practices, produce marketing, and seasonal price variations have a higher ability to use resources efficiently (Mbanasor and Kalu, 2008; Obare et al., 2010; Khan and Saeed 2011).

Access to Credit

Access to credit is expected to have positive effect on allocative efficiency. Farmers who have access to credit are likely to purchase farm inputs, farm implements and also pay for labour, all in good time, hence increasing allocative efficiency (Okoye *et al*., 2006; Obare *et al*., 2010;).

Asset value

A higher asset value of a farmer is hypothesised to have a positive relationship with allocative efficiency (Haji, 2007). Farmers with high asset values are able to purchase adequate farm inputs and implements, and in good time, thus improving allocative efficiency.

Risk attitude

Risk attitude is hypothesised to have a negative influence on allocative efficiency. The more risk averse a farmer is, the more likely the farmer is to be cost inefficient (Dhungana *et al*., 2004). This is because production uncertainties tend to make farmers underutilise purchased farm inputs (Williams *et al*., 1992).

Membership of agricultural organizations

Membership of agricultural organizations is expected to have a positive influence on allocative efficiency. According to Obare *et al*. (2010), farmers who belong to cooperatives are better informed about production practices and have better access to inputs, thus enhancing their allocative efficiency.

Access to fadama

Access to *fadama* is hypothesised to have a positive relationship with allocative efficiency. It is believed that farmers who cultivate *fadama* lands have more experience in terms of resource utilisation and are able to get extra income from *fadama* crops, which can be used to enhance the cultivation of arable or upland crops.

Age

A positive relationship is expected between age and cost efficiency of farmers (Mbanasor and Kalu, 2008). Older farmers are more experienced in farming and are expected to make more rational decisions on resource allocation, hence they are likely to be more cost efficient.

Land fragmentation

Land fragmentation is hypothesised to have a negative association with cost efficiency. Land fragmentation leads to small and uneconomic sizes of operational holdings and this is considered to be an impediment to efficiency, thus resulting to cost inefficiency (Kawasaki, 2010). The number of arable plots cultivated is negatively correlated with the net farm income per hectare (Bizimana, Nieuwoudt & Ferrer, 2004).

4.6 Estimation procedure for the technical and cost efficiency metafrontier

Part of Objective 4 is to compare the technical and cost efficiencies of the mono and intercrop farms in order to ascertain the differences between metafrontier and the group frontier. Following O'Donnell *et al*. (2008), the metafrontier production function was used to achieve this objective.

The basic analytical framework

The production theory and the concept of distance function form the basis of the efficiency measurement. O'Donnell *et al*. (2008) have defined the metafrontier and group frontiers in terms of output sets and output distance functions.

4.6.1.1 The metafrontier

Let y and x be non-negative real output and input vectors of dimensions M x1 and N x1, respectively. The *metatechnology set* contains all input-output combinations that are technologically feasible. Then,

$$T = \{(x, y) : x \geq 0; y \geq 0; \ x \text{ can produce } y\}. \qquad ...4.15$$

The *metatechnology set* is associated with input and output sets. The output set is defined for any input vector, x, given by:

$$P(x) = \{y : (x, y) \in T\}. \qquad ...4.16$$

The boundary of this output set is referred to as the output *metafrontier*. The output set is assumed to satisfy the standard regularity properties described by Färe and Primont (1995). When measuring efficiency, the technology using the output *metadistance* function, is defined as:

$$D(x, y) = \inf_{\theta}\{\theta > 0 : (y/\theta) \in P(x)\}. \qquad ...4.17$$

Given an input vector, this function gives the maximum amount by which a farm can radially expand its output vector. The distance function inherits its regularity properties from the regularity properties of the output set. An observation (x, y) can be considered technically efficient with respect to the metafrontier if, and only if, $D(x, y) = 1$.

4.6.1.2 Group frontier

Consider the case where the universe of the farms can be divided into $h(>1)$ groups, and suppose that a certain group is constrained by resources, regulatory and other environmental factors which may prevent the farms from choosing the full range of technologically feasible input-output combinations in the metatechnology set, T. Rather, the input-output combinations available to farms in the h^{th} group are contained in the group-specific technology set:

$$T^h = \{(x, y) : x \geq 0; y \geq 0; x \text{ can be used by farms in group } h \text{ to produce, } y\}. \qquad ...4.18$$

The H group-specific technologies can also be represented by the following group-specific output sets and output distance functions:

$$P^h(x) = \{y : (x, y) \in T^h\}, \quad h = 1,2,...,H; \text{ and} \qquad ...4.19$$

$$D^k(x, y) = \inf_\theta \{\theta > 0 : (y/\theta) \in P^h(x)\}, \quad h = 1,2,...,H \qquad ...4.20$$

The boundaries of the group-specific output sets are referred to as *group frontiers*. If the output sets, $P^h(x), h = 1,2,...,H$, satisfy standard regularity properties, then the distance functions, $D^h(x, y), h = 1,2,...,H$, also satisfy standard regularity properties. For details of the standard regularity properties, refer to O'Donnell *et al*. (2008 pp233) and Färe and Primont (1995).

4.6.1.3 Technical efficiencies and metatechnology ratios

An observation (x, y) is technically efficient with respect to the metafrontier if, and only if, $D(x, y) = 1$. Generally, an output orientated measure of technical efficiency of an observed pair (x, y) with respect to the metatechnology is represented by:

$$TE(x, y) = D(x, y). \qquad ...4.21$$

Since the group-h output distance function, $D^h(x, y)$, can take a value no less than the output metadistance function, $D(x, y)$. In another way, the metafrontier envelops the group-h frontier. Whenever a strict inequality is observed between the group-h distance function and the metadistance function, we can obtain a measure of how close the group-h frontier is to the metafrontier. Specifically, the output-orientated *metatechnology ratio*[2] (MTR) for group-h farm is defined as:

$$MTR^h(x, y) = \frac{D(x, y)}{D^h(x, y)} = \frac{TE(x, y)}{TE^h(x, y)} \qquad ...4.22$$

In this study the groups comprise the sorghum farms (monocrop), sorghum/cowpea and millet/cowpea (intercrops).

The decomposition of the technical efficiency of a particular input-output combination is provided by equation 4.23 below:

$$TE(x, y) = TE^k(x, y) \times MTR^h(x, y). \qquad ...4.23$$

Equation 4.23 above shows that technical efficiency measured with reference to the metafrontier (representing the existing state of knowledge) can be decomposed into the product of technical efficiency measured with reference to the group-h frontier (representing the existing state of knowledge and the physical, social and economic environment that characterise group-h (which measures how close the group-h frontier is to the metafrontier).

4.6.2 Data Envelopment Analysis for the technical efficiency

For the DEA technical efficiency metatechnology frontier comparison, the estimates were done normally without using the bootstrapping approach. The DEA is a linear programming methodology that uses data on output and inputs of groups.

Using the input orientated approach and assuming constant returns to scale, the DEA problem is given by:

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2 Battese *et al*. (2004: 94) refer to this measure as the "technology gap ratio". However, increases in the (technology gap) ratio imply decreases in the gap between the group frontier and the metafrontier. In this study the "metatechnology ratio" is used.

$$\min_{\lambda x_i} \quad \theta$$

$$\text{Subject to } -q_i + Q\lambda \geq 0,$$

$$\theta_{X_i} - X\lambda \geq 0,$$

$$\lambda \geq 0, \qquad \text{...4.24}$$

Where θ is a scalar and λ is a $I \times 1$vector of constants. $N \times 1$ input matrix X , $M \times 1$ output matrix, Q, q_i and x_i are the column vectors of output and input respectively. The value of θobtained is the efficiency score for the i*th* farm. The value satisfies $\theta \leq 1$, with a value of 1 indicating a point on the frontier and hence a technically efficient farm (Coelli *et al*., 2005). Note that the linear programming problem must be solved I times, once for each farm in the sample. A value of θ is then obtained for each farm.

For each group-*h* the above linear programming is solved L_h times for each DMU. The metafrontier is constructed using DEA model, based on the pooled data for all the cropping systems in the study area. Since there are a total of $L = \sum_h L_h$ cropping systems, equation 4.23 above will be re-run with the inputs and outputs matrices with data for all the cropping systems in the Kebbi State. The outputs for the intercroppers were converted to their monetary value, i.e. the farm income. The inputs used were labour, nitrogen, phosphorus and potassium, as indicated above. The variable, seed, was omitted because the conversion of seed to its monetary values will not be appropriate for use in the cost function (Data Envelopment Programme (DEAP), since the programme will not run when the input value is also the same as the input price. The 1 = cost DEA in DEAP 2.1 was used to obtain both the technical and cost efficiency scores.

4.7 Metafrontier cost function

Following Huang *et al*. (2010), the metafrontier cost function was used, which is based on the metafrontier production function proposed by Battese *et al*. (2004). The CRS and input orientated DEA model defined in a linear programming (LP) is:

Cost minimisation

$$\min_{\lambda, x_i^*} \quad W_i' x_i^* \qquad 4.25$$

$$\text{Subject to} \quad -q_i + Q\lambda \geq 0,$$

$$x_i^* - X\lambda \geq 0,$$

$$\lambda \geq 0,$$

Where, λ is a $I \times 1$ vector of constants, W_i' is a $N \times I$ input matrix, X, $M \times I$ output matrix, Q, W_i is a $N \times I$ vector of input prices for the i*th* farm, x_i^* (which is calculated by the LP) is the cost minimising vector of inputs quantities for the i*th* farm, given the input prices W_i and the output levels q_i.

For CRS, the cost efficiency (CE) scores are less than or equal to one. The total cost efficiency (CE) of the i*th* farm is given by:

$$CE = W_i' x_i^* \big/ W_i' x_i \qquad ...4.26$$

That is, CE is the ratio of minimum cost to observed cost, for the i*th* farm.

4.7.1 Cost efficiency and metafrontier ratio

The metafrontier cost efficiency (i.e. efficiency for all groups or pooled efficiency) is given by equation 4.27 below.

The cost frontier for group-*h* is expressed as:

$$CE^h = W_{ih}' x_{ih}^* \big/ W_{ih}' x_{ih} \qquad ...4.27$$

All variables are as defined in equation 4.24 above.

The metafrontier cost ratio for group-*h* is defined as:

$$MTR^h = CE \Big/ CE^h \qquad ...4.28$$

MTR is defined between 0 and 1, where a value of one means that the group frontier is the same as the metafrontier. The higher the average value of the MTR is for a group, the closer it is to the metafrontier.

Summarising equations (4.24) – (4.28), the relationships among the technical efficiency and MTR relative to the metafrontier can be expressed as:

$$CE = CE^h \times MTR^K \qquad ...4.29$$

4.8 Wilcoxon Rank-Sum Test

In order to test for the differences in the technical efficiency and cost efficiency of the monocroppers and intercroppers, the Wilcoxon Rank-Sum Tests was used. The Mann-Whitney test is essentially identical to the Wilcoxon test, even though it uses a different test statistic. The Wilcoxon Rank-Sum test is a nonparametric statistical test, based on the ranking of data. Wilcoxon tries to detect whether there are local shifts in the distribution of the population of sample A to B. For small samples, independent groups, Wilcoxon for $n_1 \geq 10$ and $n_2 \geq 10$ is given by:

Test statistic:

$$Z = \frac{T_A - n_1(n_1 + n_2 + 1)/2}{\sqrt{n_1 n_2 (n_1 + n_2 + 1)/12}} \qquad 4.30$$

Where, T_A is sum ranking.

The rejection region: one-tailed $Z > Z_\alpha$, two-tailed $|Z| > Z_{\alpha/2}$. Comparing the $Z-$ statistic to $Z-$ value is equivalent to comparing the $P-$ value to α.

4.9 Conclusions

The purpose of chapter 4 was to describe the procedures that were used to achieve the objectives of the study. Following Binswanger (1980), the experimental gambling approach within the expected utility framework was used to estimate the risk aversion coefficients of the farmers. The experimental approach gives more reliable estimates of risk aversion. Factor analysis was used to examine the dimensions of the perceived risk sources and management strategies. The relationships between risk attitude, farmers' characteristics, risk sources and management strategies was explored using multiple regression. In order to determine the factors that influence the choice of cropping systems in Kebbi State, the logit model was used.

Lastly, the DEA model was used to explore the levels of efficiency with which farmers used their production inputs to produce their crops. The determinants of efficiencies were also determined. Taking into account the criticisms of using Tobit in the two-stage DEA (Simar and Wilson, 2000, 2007), the Double Bootstrapping procedure was applied in order to overcome the limitations of using Tobit in the two-stage DEA. Following Jordaan (2012), the double bootstrap procedure was used within the framework of the Principal Component Regression (PCR) in order to reduce the dimensionality of the data in which there are a large number of correlated variables, while retaining the variation present in the data set (Jolliffe, 2002).

The results that have emanated from the procedures described in Chapter 4 should be reliable and will add to the existing knowledge on risk attitudes, risk sources and management strategies and efficiencies of the farmers in the study area.

CHAPTER 5

RESULTS AND DISCUSSION OF RISK ATTITUDE, RISK SOURCES AND MANAGEMENT STRATEGIES OF THE MONOCROP AND INTERCROP FARMERS

Introduction

This chapter presents the results and discussion of the risk attitudes of the respondents, the sources of risk and risk management strategies, as well as the multiple regression results for the relationship between risk attitudes, farmers' socio-economic variables, sources of risk and risk management strategies. The chapter then discusses the factors that influence the choice of cropping system.

5.1 Risk attitude of the respondents

The first objective of this study was to determine the risk attitudes of the farmers in Kebbi State. The risk classification of the farmers, based on the risk aversion coefficients, are presented in Table 5.1 below.

Table 5.1 Risk classification of the farmers, Kebbi State, January 2012

Risk classification	Monocroppers		Intercroppers		Aggregate	
	n = 98	%	n = 158	%	n = 256	%
Extreme risk averse	2	2	5	3	7	3
Severe risk averse	4	4	37	23	41	16
Intermediate risk averse	17	17	37	23	54	21
Moderate risk averse	49	50	67	43	116	45
Total risk averse	**72**	**73**	**146**	**92**	**218**	**85**
Neutral to preferring risk	26	27	12	8	38	15
Total neutral to preferring	**26**	**27**	**12**	**8**	**38**	**15**
χ^2	8.52**					
χ^2 critical value	3.84					
Degrees of freedom (n-1)	1					

Table 5.1 above shows that 50% of the monocrop farmers are in the moderate risk averse class and about 27% in the neutral to preferring risk class. The table also shows that a greater percentage of the intercroppers are either in the severe (23%) or intermediate (23%) classes, compared to severe (4%) and intermediate (17%) risk averse classes for monocroppers. This supports the assumption that farmers practising intercropping do so

because they are more risk averse. The risk-averse farmers are apprehensive about taking risk. Risk-averse farmers would tend to safeguard against crop failure by diversification in cropping system. This result is in line with the findings of Olarinde *et al*. (2007) who reported that maize farmers in the dry savannah zone of Nigeria are lowly (8 %), intermediately (42 %), and highly risk averse (50 %). Binici *et al*. (2003) found that not all, but the majority, of the farmers were risk averse.

The chi-square test was used to ascertain whether there were significant differences between the risk averse and neutral to preferring risk averse classes for the monocrop and intercrop farmers. The results show that there were statistically significant differences between the risk averse and neutral to preferring class of the monocroppers and intercroppers. The intercroppers are statistically significantly more risk averse than the monocroppers.

5.2 Sources of risk and risk management strategies as perceived by the survey respondents

A Likert-type scale of 1 (not at all) to 5 (very important) was presented to the respondents in order to establish the important sources of risk and risk management strategies of the monocrop and intercrop farmers. The respondents were asked to score a list of 21 and 20 potential risk sources and risk management strategies respectively, according to their importance. The most important risk sources and management strategies were ranked based on the mean scores of the variables on the lists.

5.2.1 Average scores and ranking of the sources of risk as perceived by the respondents

Table 5.2 below shows the average scores and ranking of the sources of risk of the monocroppers and intercroppers.

Table 5.2 Average scores and ranking of important sources of risk by the monocrop and intercrop farmers, Kebbi State, January 2012.

	Monocroppers n = 98		Intercroppers n = 157		Overall n = 255		Mean comparison t (assume ≠variances)
Sources of risk	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	
Diseases	3.26	2	3.13	1	3.18	1	0.985
Erratic rainfall	3.28	1	2.87	2	3.02	2	7.804***
Change in government and agricultural policy	2.76	5	2.82	3	2.79	3	-0.352
Changes in climatic conditions	2.83	4	2.66	5	2.72	4	1.2
Price fluctuation (of input and output)	2.89	3	2.56	6	2.69	5	2.426**
Flood/storm	2.6	10	2.71	4	2.67	6	-0.675
Pests	2.19	13	2.1	16	2.67	6	0.703
Lack of work animals	2.61	9	2.55	7	2.58	7	0.441
Fertiliser (unavailability)	2.67	8	2.48	10	2.56	8	1.396
Drought	2.5	11	2.53	8	2.52	9	-0.141
Difficulties of finding labour	2.71	6	2.37	11	2.5	10	2.655***
Insufficient work animals	2.47	12	2.49	9	2.49	11	-0.141
Market failure	2.69	7	2.32	12	2.47	12	86.118***
Illness of household member	2.13	15	2.31	13	2.24	13	-1.412
Insufficient family labour	2.18	14	2.19	15	2.19	14	-0.078
Family relationships	1.83	21	2.22	14	2.07	15	-2.800***
Insufficient rainfall	1.92	20	2.05	17	2	16	-1.222
Loss of land/ethnic clash	2.02	16	1.96	19	1.98	17	0.526
Fire outbreak	1.92	19	2	18	1.97	18	-0.664
Excessive rainfall	1.94	18	1.9	20	1.91	19	0.188
Theft	1.95	17	1.64	21	1.76	20	2.474***

The asterisks (***and **) represents statistical significance at 1% and 5% probability levels, respectively.

Monocrop farmers and intercrop farmers rated diseases, erratic rainfall and changes in government policy as the three most important sources of risk. These variables have a mean rating of 3.18, 3.02 and 2.79, respectively. Other risk sources perceived to be important to the monocroppers and intercroppers were changes in climatic conditions (2.72), price fluctuation, of input and output, (2.69), flood/storm (2.67), lack of work animals (2.58) and fertiliser unavailability (2.56). The monocrop farmers perceived erratic rainfall (3.28), diseases (3.26) and price fluctuation, of input and output (2.89) as the three most important sources of risk, while the intercroppers rated diseases (3.13), erratic rainfall (2.87) and changes in government and agricultural policy (2.82) as the three most important sources of risk. The results further reveal that there was a statistically significant difference at one per cent level ($P<0.01$) between the means of erratic rainfall for the monocrop and intercrop farmers. Also, the mean for price fluctuation was statistically significantly different at five per cent level ($P<0.05$) between the monocrop and intercrop farmers.

The monocroppers perceived changes in climatic conditions (2.83), changes in government and agricultural policy (2.76) and difficulty in finding labour (2.71) as other important sources of risk. There was a statistically significant difference at one per cent level ($P<0.01$) between the means for difficulty in finding labour for the monocroppers and intercroppers. Flood/storm (2.71), changes in climatic conditions (2.66), price fluctuation (of input and output) (2.56) and lack of work animals (2.55) were rated as other important sources of risk by the intercrop farmers. For monocroppers, excessive rainfall, insufficient rainfall, fire outbreak, theft and family relationships scored less than two, implying that most of the monocroppers did not perceive them as important. The result further shows that the mean for family relationships and theft were both statistically significantly different $P<0.01$ between the monocrop and intercrop farmers. The intercroppers perceived excessive rainfall, loss of land/ethnic clash and theft as relatively less important sources of risk. According to Hardaker *et al*. (1997), farmers are faced with five major classes of risk, namely institutional, production, price, human/personal and financial risk. This study has revealed that most of the farmers in the study area are faced with production, institutional, human/personal and price risk.

Disease was rated as one of the most important risk source by both monocroppers and intercroppers: intercrop farmers rated disease as the most important source of risk, and the monocroppers rated disease as the second most important factor. Sorghum downy mildew, induced by *Peronosclerospora sorghi*, and *stem* borer limit sorghum and millet production in northern Nigeria (USAID, 2008; Kutama, Aliyu, Nuraddin & Kiyawa, 2008). Virus diseases constitute a serious threat that affects cowpea production in Nigeria and yields can as a result be reduced by 80-100% (Mohammed *et al*. 2012). Some of the common diseases that infest cowpea are: aphid-borne mosaic virus *potyvirus*, cowpea mild mottle virus *carlavirus*, cowpea mosaic virus *comovirus*, bacterial blight induced by *Xanthomonas* axono-podis pv vignicola, and cowpea leaf smut (*Entyloma vignae*), among others (Alegbejo and Kashina, 2001; Ajeigbe *et al*, 2008). Groundnut production is affected by *groundnut rosette* which is a virus disease common in northern Nigeria (Country Report, 2008). The use of agrochemicals has a positive, significant influence on crop yield (Abdullahi, 2012). Farmers rate diseases as an important source of risk owing to the fact that disease control through the use of agrochemicals increases the cost of crop production. Erratic rainfall is rated as an important source of risk by both the monocroppers and intercroppers. While monocroppers rated erratic rainfall as the most important factor, it was rated as the second most important source of risk by the intercroppers. In recent times, irregular rainfall has been experienced by farmers in Nigeria, especially in the northern parts of the country (Hassan, 2010). The consequent effect of erratic rainfall is delay in planting dates and death of plants when dry spells periods are prolonged.

On aggregate, changes in government and agricultural policy is scored as the third important source of risk for both monocrop and intercrop farmers. While monocroppers rated price fluctuation (of input and output) as the third important source of risk, the intercroppers scored changes in government and agricultural policy as the third important risk source. Intercroppers perceive uncertainty about changes in government and agricultural policy as a more important source of risk. Government policies on agriculture have been inconsistent and poorly implemented: these policies relate to fertiliser subsidy, agricultural pricing, pesticide regulation and crop insurance. The instability and poor implementation of government policies on agriculture are the major constraints to agricultural productivity in Nigeria (Atser, 2007; Philip *et al*., 2009), which pose a source of risk to the farmers. Philip *et al*, (2009) reported that although the fertiliser subsidy has persisted in Nigeria, its execution is still unclear. Government policy on pesticide regulation is generally unsatisfactory (Asogwa and Dongo, 2009). Government policy on land reform was rated as the foremost important source of risk by large-scale sugarcane farmers in KwaZulu Natal (MacNicol *et al*., 2007).

Price fluctuation is an important source of risk to the farmers, which is more pronounced for monocrop farmers. This is so probably because they have only one type of crop to sell and if the price is low this affects the profit of the enterprise. This is unlike the case of intercroppers who have different crops to sell and if the price of one crop is low, profit can be gained from the high price obtained from the sale of the other crop. Low prices are unfavourable to farmers because they have a negative effect on their profit. The price support policy does not seem to be stable, thus farmers rated price fluctuation as an important source of risk. Output and input prices have been ranked the highest source of risk by onion farmers in Kebbi State, Nigeria (Alimi and Ayanwale, 2005). Crop price and changes in input costs have been rated high as sources of risk, as noted by MacNicol *et al*. (2007).

Other important sources of risk perceived by the farmers are, market failure, flood/storm, fertiliser unavailability, changes in climatic conditions and difficulties in finding labour. Market failure is perceived as a more important source of risk by the monocrop farmers. There is a statistically significant difference at one per cent level ($P<0.01$) between the means of market failure for the monocrop and intercrop farmers. This is not surprising because monocroppers produce only one type of crop and in the event of market failure, they will make little or no profits. Uncertainty about flood/storm was rated as an important source of risk by the farmers, and this is probably because of the flood incidence experienced by farmers in the State in the 2010 cropping season which devastated many farms, lives and properties. The effect of floods on crop production is poor harvests, or in severe cases total loss of crops, with a resultant effect of increased food crop prices in the affected areas, as has been experienced in Kebbi State and other northern states of Nigeria (Hassan, 2010). The absence of capital for private-sector participation in the supply and distribution of fertiliser in Nigeria poses a serious challenge to the use of fertiliser by the small-scale farmers (Philip *et al*., 2009). The federal government and the various state governments have subsidised fertiliser for farmers, which is distributed to farmers through the Agricultural Development Projects (ADPs), although the supply of fertiliser by the government is inadequate and untimely (Hassan, 2010). Farmers purchase fertiliser in the market at high prices and that is why they rated fertiliser unavailability as a source of risk to farming. Amanze, Eze and Eze

(2010) reported that, among other factors, the price of fertiliser is an important factor that influences farmers' use of fertiliser in arable crop production in Imo State Nigeria.

Changes in climatic conditions were perceived as another important source of risk by the farmers. According to Hassan (2010), rural farmers are experiencing the effects of climate change which is manifested in the form of delayed rainfall, floods and disease outbreaks. The consequent effect of climate change is hunger among the rural dwellers who depend solely on agriculture as a source of livelihood. Farmers also perceived difficulties in finding labour as another important source of risk. Farmers in the study area face labour constraints, especially during peak labour demand periods, because some youths migrate from the State to the southern part of the country in search of employment.

5.2.2 Average and ranking of risk management strategies by the monocrop and intercrop farmers

Risk sources have adverse effects on farm productivity and this reduces farm income. Farmers have over the years, however, devised different risk management strategies to combat the risk sources. Table 5.3 below shows the average and ranking of risk management strategies by the monocrop and intercrop farmers in the study area.

Overall, monocroppers and intercroppers scored spreading sales (3.20), family members working off-farm (3.15) and borrowing (cash or grains) (2.96) as the three most important risk management strategies. Other management strategies perceived to be important by both monocroppers and intercroppers were spraying for diseases and pests (2.94), intercropping (2.90) and storage programmes (2.73).

Monocrop farmers rated spraying for diseases and pests (3.23), spreading sales (3.06) and borrowing (cash or grain) (2.96) as the three most important risk management strategies. Intercroppers scored family members working off-farm (3.36), spreading sales (3.29) and intercropping (3.23) as the three most important management strategies.

Table 5.3 Average score and ranking of important risk management strategies by monocrop and intercrop farmers, Kebbi State, January 2012

Risk management strategies	Monocroppers n = 98		Intercroppers n = 151		Overall n = 249		Mean comparison t (assume ≠variances)
	Mean	Rank	Mean	Rank	Mean	Rank	
Spreading sales	3.06	2	3.29	2	3.20	1	-1.53
Family members working off-farm	2.83	6	3.36	1	3.15	2	-3.533***
Borrowing (cash or grains)	2.96	3	2.95	4	2.96	3	0.00
Spraying for diseases and pests	3.23	1	2.75	7	2.94	4	3.447***
Intercropping	2.41	12	3.23	3	2.90	5	-6.095***
Selling of assets	2.84	5	2.85	5	2.84	6	-0.07
Fadama cultivation	2.92	4	2.68	8	2.77	7	1.885*
Storage programme	2.57	8	2.83	6	2.73	8	-1.899*
Cooperative societies	2.61	7	2.62	9	2.62	9	-0.07
Fertiliser provision by government/self	2.50	9	2.39	11	2.44	10	0.86
Planning expenditure	2.50	9	2.28	13	2.37	11	1.54
Having crop insurance	2.31	15	2.40	10	2.37	12	-0.70
Gathering market information	2.46	11	2.27	14	2.35	13	1.46
Price support	2.32	14	2.34	12	2.33	14	-0.16
Training and education	2.49	10	2.17	15	2.29	15	2.806***
Investing off-farm	2.33	13	2.14	16	2.21	16	1.66
Household head working off-farm	2.18	17	2.13	17	2.15	17	0.44
Faith in God	2.23	16	2.05	20	2.12	18	1.48
Adashe (Rotation contribution)	2.15	18	2.08	18	2.11	19	0.75
Reduced consumption	2.12	19	2.07	19	2.09	20	0.38

The asterisks (*** and *) represents statistical significance at 1% and 10% probability levels, respectively.

The mean for family members working off-farm for the two groups of farmers were statistically significantly different at one per cent level (P<0.01). Monocroppers and intercroppers rated spreading sales as the second most important management strategy. Other management strategies perceived by the monocroppers were *fadama* cultivation (2.92), selling of assets (2.83), family members working off-farm (2.83), and membership of cooperative societies (2.62). Intercroppers perceived borrowing (cash or grains) (2.95), selling of assets (2.85), storage programmes (2.84) and spraying for diseases and pests (2.75) as other important risk management strategies. Both monocrop and intercrop farmers rated household head working off-farm, *adashe* (rotation contribution) and reduced consumption as relatively the least important management strategies. Reduced consumption was seen as relatively the least important management strategy, probably because farmers can borrow grains or cash from their relatives, which is evident from the high rating of borrowing.

From the scores obtained for the management strategies, it can be deduced that farmers in the study are combating price, financial and production risk. As mentioned above, spreading sales is the second most important strategy noted by the monocrop and intercrop farmers. Farmers in the study area did not sell all the farm produce at the same time because farm produce is associated with seasonal price variation. Farmers try to take advantage of periods when supply is low and the demand is high so as to get good prices, thereby maximizing profit. Alimi and Ayanwale (2005) found that 4% of the onion farmers in Kebbi State carried out sequential marketing, although the percentage is low, probably because onions are a perishable commodity.

Family members working off-farm is seen as an important management strategy by the farmers because working off-farm boosts household income. This result is consistent with the findings of Beyena (2008) for Ethiopian farmers, and of Babatunde and Qaim (2009) and Salimonu and Falusi (2009) for Nigerian farmers. Borrowing (cash or grains) was perceived as an important risk management strategy by the farmers, though it was ranked higher by the monocroppers. Borrowing has a cushion effect on farmers' finances during periods of scarcity and borrowing of grains helps to reduce hunger, especially towards the period of harvest. Intercropping was the third most important management strategy for the intercrop farmers. This is not surprising because intercropping is practised in order to guard against the risk of crop failure and so intercropping is a form of diversification. Selling of assets was seen as another important management strategy by monocrop and intercrop farmers. Most farmers in the study area have livestock enterprises which serve as liquid assets: livestock and livestock products are sold when there is food shortage or when there are other needs to be met by the household. The result is comparable with those of Salimonu and Falusi (2009) and Korir (2011) who reported that farmers sell liquid assets as a means of managing risk.

Fadama cultivation is more pronounced as an important management strategy by the monocroppers probably because monocroppers are more at risk in the event of any uncertainty occurrence. *Fadama* cultivation involves the cultivation of vegetable crops (such as onions, cabbages, tomatoes, peppers (hot and mild), ginger, cucumbers, Irish and sweet potatoes), maize and wheat. *Fadama* cultivation is carried out to safeguard against crop failure, thereby reducing risk and it is also seen as an important enterprise diversification by the farmers. *Fadama* cultivation serves as a means of getting some income for the farmers. Korir (2011) reported that farmers in Kenya see enterprise diversification as an important risk management strategy that reduces risk to the farmers. The use of storage programmes is perceived as an important risk management strategy by the farmers, especially the intercroppers. Farmers store their farm produce until the prices are high so as to get higher prices, thus more farm income. The means for training and education for the two groups of farmers were statistically significantly different at one per cent level ($P<0.01$). Training and education helps farmers to know the best management practices to adopt in order to enhance productivity.

In order to examine the factors or the dimensions of the perceived risk sources and management strategies of the farmers, factor analysis was carried out and the results are shown in the next section.

5.3 Factor analysis results for sources of risk and risk management strategies for monocrop and intercrop farmers

Factor analysis was conducted on the risk sources and risk management strategies of the monocroppers and intercroppers in order to determine the variance in the observed variables in terms of the underlying latent factor (Habing, 2003).

5.3.1 Factors for sources of risk for monocrop and intercrop farmers

Table 5.4 below shows the rotated factor loadings of risk sources for monocrop and intercrop farmers. Details of the variables used, KMO-values and Eigen values used for the factor analysis are presented in Appendix (B).

Risk source factors for monocrop farmers

The factors obtained from the factor analysis were named based on the variables that have high loadings (Table 5.4 below). Factor 1 "social" comprises the variables insufficient labour, loss of land/ethnic clash, and theft. This indicates that the variables were positively correlated (MacNicol *et al*., 2007). The Cronbach's alpha for "social" factor is 0.714 (Table 5.5 below). This implies that the group of variables measure the same underlying construct. The high positive loading of loss of land/ethnic clash could be caused by the recent flood disaster which occurred in the State in 2010. Many farmers lost their farm lands (Babajide and Aderemi, 2012). Farm lands are also lost owing to desertification (Danjuma, 2012). The high loading of insufficient labour could be caused by the rural–urban drift of youths in search of better economic opportunities. Another possible reason for insufficient labour could be the Universal Basic Education (UBE) Act, established in 2004, which has reduced the availability of school children for labour.

Table 5.4 Rotated factor loadings of risk sources for monocrop and intercrop farmers, Kebbi State, January 2012

		Monocroppers				Intercroppers				
Factors		**1**	**2**	**3**		**1**	**2**	**3**	**4**	**5**
Initial Eigen value		2.633	2.039	1.478		2.68	1.515	1.309	1.14	1.033
%variance explained(cumulative)		26.33	46.72	61.49		24.358	38.13	50.033	60.399	69.793
Sources of risk	**Communality**				**Communality**					
Insufficient labour	0.674	**0.801**	0.159	-0.081						
Loss of land/ethnic clash	0.625	**0.786**	-0.017	0.082	0.566	0.149	**0.731**	0.177	-0.051	-0.035
Theft	0.593	**0.703**	-0.023	0.314	0.545	0.034	**0.888**	0.037	0.047	0.036
Pest	0.673	-0.223	**0.788**	0.056	0.696	**0.741**	-0.106	0.291	-0.061	0.09
Excessive rainfall	0.752	0.3	**0.812**	0.056	0.627	**0.784**	0.181	-0.103	0.176	-0.015
Insufficient rainfall	0.693	0.134	**0.809**	-0.141	0.71	**0.827**	0.155	0.11	0.054	0.022
Drought	0.534	-0.254	0.368	**0.578**						
Change in government policy	0.544	0.042	-0.077	**0.732**						
Illness of household member	0.544	0.457	0.099	**0.579**	0.635	0.149	0.155	**0.744**	0.08	-0.047
Insufficient work animals	0.503	0.197	-0.122	**0.674**	0.607	-0.016	-0.094	0.308	**0.729**	0.032
Difficulty in finding labour					0.612	0.117	-0.002	**0.846**	0.084	0.19
Price fluctuation(of input and output)					0.517	-0.101	-0.204	0.154	-0.035	**0.814**
Family relationships					0.614	0.146	0.081	-0.089	**0.827**	0.087
Changes in climatic conditions					0.711	0.205	0.237	-0.018	0.186	**0.742**

Factors 1 to 3 are social, rainfall and uncertainty, respectively, for monocroppers. Factors 1 to 5 are rainfall, social, difficulties, inadequate labour and uncertainty, respectively, for intercroppers. Loadings of greater than 0.5 are in bold.

Factor 2 has a high positive loading for pests, excessive rainfall and insufficient rainfall. Factor 2 was named "rainfall". The Cronbach's alpha for "rainfall" factor is 0.737 (Table 5.5 below). This implies that the group of variables measure the same underlying construct and are interrelated. The high loadings of the rainfall-related variables are probably caused by change in rainfall patterns in recent years, and the occasional infestation of pests in the study area. The common pests are Quelea birds (Quelea quelea), grasshoppers (*Hieroglypus daganensis; Aiolopus similatrix; Oedaleus senegalensis)*, aphids (*Rhoplasosiphum maidis*) and stem borer (*Sesamia calamistis*) (PMP for NFDP-II Report, undated).

Drought, change in government and agricultural policy, and illness of household member scored the highest factor loading in factor 3 and hence were named "uncertainty". The Cronbach's alpha for "uncertainty" factor is 0.568 (Table 5.5 below). This means that the group of variables measure the same underlying construct. Factor 3 can be explained, based on the fact that the farmer is uncertain about the occurrence of drought, changes in government and agricultural policies, and illness of household members. The occurrence of drought has an adverse effect on farming as this can lead to devastation of the whole farm in severe cases. Changes in government and agricultural policy affect farm planning and expenditure in a negative way. Illness of a household member affects farmers' budgets since most farmers in the rural areas do not plan for medical bills and a health insurance policy has yet to be established for farmers in the rural areas. Illness of a household member also has a negative effect on labour supply to the farmer.

Risk source factors for intercrop farmers

Five factors were identified for the intercrop farmers. The results from Table 5.4 above shows that the factor "rainfall" has a high positive loading for pests, excessive rainfall and insufficient rainfall. The Cronbach's alpha for "rainfall" factor is 0.711 (Table 5.5 below). This implies that the group of variables measure the same underlying construct. The factor "rainfall" was also identified for monocroppers. Factor 2, which is called "social factor", is associated with loss of land/ethnic clash and theft. The Cronbach's alpha for "social" factor is 0.636 (Table 5.5 below) which indicates sufficient reliability within a single construct. This implies that the group of variables measured are interrelated. These variables have high positive loadings. The high loading for loss of land/ethnic clash was also high for the monocroppers. This implies that the factor is important to both groups of farmers. Floods and desertification are the possible reason for this, as mentioned above. Factor 3 has high positive loadings for illness of household members and difficulties for finding labour. The factor was named "difficulties". The Cronbach's alpha for the "difficulties" factor is 0.652 (Table 5.5 below). This means that the group of variables measure the same underlying construct. Difficulties for finding labour is more peculiar to intercroppers, probably because weeding intercrops is more labour-intensive than for monocrops (Lithourgidis *et al*., 2011; Kahn *et al*., 2012).

Factor 4 was named "inadequate labour". The Cronbach's alpha for the "inadequate labour" factor is 0.449 (Table 5.5 below). This implies that the group of variables measured do not significantly measure the same underlying construct. This means that the variables are not highly intercorrelated. Factor 4 has a high positive loading with family relationships and insufficient work animals. Family relationships affect the supply of labour, especially where communal labour is practised. Divorce could also affect a farmer's income, especially in a situation where one of the partners is the main contributor to the finances for the farming enterprise. Insufficient work animals also have a high positive loading under the uncertainty factor for monocroppers. The implication of insufficient work animals for the monocroppers and intercroppers is delay in planting and weeding, which has an adverse effect on crop yield. Factor 5 was named "uncertainty". The Cronbach's alpha for "uncertainty" factor is 0.402 (Table 5.5 below). This means that the group of variables measured are not interrelated. Factor 5 has a high positive loading for price fluctuation (of input and output) and changes in climatic conditions. This factor was more pronounced for the intercroppers. Change in climatic conditions is seen as an important factor for the intercroppers and perhaps this might be the main reason why they practice intercropping in order to combat the negative effects of climate change to avoid total loss of crops in a bad year.

The communalities are also presented in Table 5.4 above. All the variables have communalities greater than 0.5, which implies that the factors explained more than 50% of the variation in the variables for both monocrop and intercrop farmers.

Reliability analysis for monocrop and intercrop farmers

The reliability results for the sources of risk for the monocroppers and intercroppers are presented in Table 5.5 below.

Table 5.5 Result for the reliability analysis scale alpha for the sources of risk of the monocroppers and intercroppers, Kebbi State, January 2012

Factor	Monocroppers Cronbach's alpha	Intercroppers Cronbach's alpha
Social	0.714	0.636
Rainfall	0.737	0.711
Uncertainty	0.568	0.402
Difficulties		0.652
Inadequate labour		0.449
Overall	**0.653**	**0.648**

Table 5.5 above depicts that the Cronbach's alpha for factors 1, 2 and 3 was 0.71, 0.74 and 0.57, respectively, for the monocrop farmers, while the Cronbach's alpha value for factor 1, 2, 3, 4 and 5 for intercroppers has a maximum value of 0.71 and a minimum of 0.40. The alpha values suggest that there is an internal consistency in all the factors for monocrop and intercrop farmers, which means that each item is measuring the same concept as the overall factor.

5.3.2 Factors for risk management strategies of monocrop and intercrop farmers

Table 5.6 below shows the rotated factor loadings of the risk management strategies for monocrop and intercrop farmers. Details of the variables used, KMO-values and Eigen values used for the factor analysis are presented in Appendix B.

Risk management strategy factors for monocrop farmers

The factor analysis reveals three factors with Eigen values greater than 1 for the monocroppers (Table 5.6 below). Factor 1 is associated with faith in God, planning expenditures and spraying for diseases, which variables have high positive loadings. The factor was named "production strategy". The Cronbach's alpha value for "production strategy" factor is 0.732 (Table 5.7 below). This means that the variables explain the underlying construct and they are intercorrelated. The high loading of faith in God implies that the farmers in the study area are religious and they trust in God for protection against theft and other natural disasters. Planning expenditure is seen as an important management strategy by the monocrppers because planning is one of the tools for the success of any business.

Table 5.6 Rotated factor loadings of risk management strategy for monocrop and intercrop farmers, Kebbi State, January 2012

		Monocroppers				Intercroppers		
Factors		**1**	**2**	**3**		**1**	**2**	**3**
Initial Eigen value		2.322	1.629	1.064		4.424	1.398	1.303
Percentage variance explained		29.02	49.38	62.68		44.24	58.22	71.25
Risk management strategy	**Communality**				**Communality**			
Faith	0.640	**0.750**	0.152	0.233	0.760	0.067	0.155	**0.855**
Planning expenditures	0.777	**0.868**	0.125	0.084	0.752	0.070	0.441	**0.743**
Spraying for diseases and pests	0.622	**0.727**	-0.285	0.112				
Storage programme	0.538	-0.158	**0.714**	0.049				
Gathering market information	0.558	0.022	**0.731**	0.149	0.741	**0.739**	0.439	0.047
Price support	0.631	0.313	**0.681**	-0.264	0.671	**0.782**	0.002	0.245
Intercropping	0.527	0.302	-0.076	**0.656**				
Household head working off-farm	0.722	0.058	0.115	**0.840**	0.482	**0.615**	0.115	0.301
Training and education					0.889	0.274	**0.898**	0.088
Investing off-farm					0.841	0.266	**0.852**	0.212
Adashe (rotation savings)					0.562	**0.683**	0.308	0.005
Having crop insurance					0.806	**0.853**	0.277	0.031
Reduced consumption					0.621	0.428	-0.249	**0.613**

Factors 1 to 3 are production strategies, marketing plan and extra income, respectively, for monocroppers. Factors 1 to 3 are personal and government policy, capacity building and planning respectively for intercroppers. Loadings of greater than 0.5 are in bold.

Farmers plan to buy farm inputs when the prices are low or when the demand is low and sell output when the prices are high. Planning helps the farmers to minimise production cost and maximise profit in the farm enterprise. Spraying for disease as a management strategy is more pronounced for the monocroppers, probably because the effect of pests and disease infestation is more destructive for monocrops than intercrops.

Factor 2 was named "marketing plan" and has high positive loadings for storage programme, gathering market information and price support. The Cronbach's alpha value for "marketing plan" factor is 0.54, which indicates sufficient reliability within a single construct (Table 5.7 below). The high loading for storage programme arises because farmers store the farm produce and sell the produce when the demand and the prices are high. Gathering information has a high loading, probably because farmers gather information about the prices of farm produce from the markets in the surrounding local government areas and the farmers sell the produce in the markets that offers better prices. Price support by the state and federal government serves as an incentive for farmers to produce more. Farmers see price support as an important risk management strategy because price support gives the farmers an assurance of market readiness for the farm produce.

Factor 3 has positive loadings for intercropping and household head working off-farm. The factor was named "extra income". The Cronbach's alpha value for "extra income" factor is 0.423 (Table 5.7 below). This means that the variables do not significantly explain the underlying construct and they are not highly related. The high loading of intercropping for monocroppers as a risk management strategy is contrary to expectation. The probable reason for monocroppers perceiving intercropping as a management strategy is because they practice intercropping with other crops not covered in this study. When resources are limited, the household head works off-farm in order to get extra income to meet various family obligations.

Risk management strategy factors for intercrop farmers

For the intercroppers, 3 factors were identified as revealed by the factor analysis (Table 5.6 above). Factor 1, "Personal and government policy", includes variables such as *adashe* (rotation savings), gathering market information, having crop insurance, price support and household head working off-farm, which variables have high positive loadings. The

Cronbach's alpha for "Personal and government policy" factor is 0.848, which indicates sufficient reliability within a single construct. This implies that the group of variables measured are intercorrelated (Table 5.7 below). *Adashe* (rotation savings), having crop insurance and reduced consumption are more pronounced as management strategies by the intercroppers, probably because greater percentages of the intercroppers are risk averse and so they see issues of personal and government policy as important management strategies. *Adashe* helps farmers to save some cash, which can be used for the farm enterprise. The availability of insurance can lead a farmer to take on more risk than he would if insurance were not available (Hoag, 2009).

Factor 2, named "capacity building", has high positive loadings for training and education and investing off-farm. The Cronbach's alpha for the "capacity building" factor is 0.800, which indicates that the variables measure the same underlying construct. This implies that the group of variables measured are interrelated (Table 5.7 below). Factor 2 is peculiar to the intercroppers as a risk management factor. The high loading of training and education by the intercrop farmers is probably because of the training the farmers have received from the Agricultural Development Project (ADP) on how to improve the cultural practices of intercropping. Farmers are taught the crop combination to use, plant spacing, time of weeding, spraying of pests and diseases, among other agricultural practices. Farmers in the study invest in other enterprises, *inter alia*, trading, tailoring, hording of grains, craft work and blacksmithing work. Investing off-farm by the farmers reduces the total dependence on farming for household needs.

Factor 3 has high positive loadings for reduced consumption, faith and planning expenditures, and was therefore named "planning". The Cronbach's alpha for "planning" factor is 0.423, which indicates that the variables do not measure the same underlying construct. Reduced consumption is more pronounced for the intercroppers (Table 5.6 above).

The communalities are presented in Table 5.6 above. All the variables, except household head working off-farm, have communalities greater than 0.5, which implies that the factors explained more than 50% of the variation in the variables for both monocrop and intercrop farmers. Household head working off-farm has a communality of 0.482, which indicates that the variable only explain 48% of the variation in the variables for intercrop farmers.

Reliability analysis for monocrop and intercrop farmers

The reliability results for the risk management strategies of the monocroppers and intercroppers are presented in Table 5.7 below.

Table 5.7 Result for the reliability analysis scale alpha for the risk management strategy of monocroppers and intercroppers, Kebbi State, January 2012

Factor	Monocroppers Cronbach's alpha	Intercroppers Cronbach's alpha
Production strategies	0.732	
Marketing plan	0.547	
Income	0.423	
Personal and government policy		0.848
Capacity building		0.800
Planning		0.512
Overall	**0.590**	**0.853**

Table 5.7 above reveals that the overall Cronbach's alpha for the monocrop and intercrop farmers was 0.59 and 0.85, respectively. As mentioned above, the alpha values suggest that there is an internal consistency in all the factors for the risk management strategies for the monocrop and intercrop farmers, which mean that each variable has a high correlation with the overall factor.

The next section presents the regression results to show the relationship between risk attitude, farmers' characteristics variables, sources of risk and risk management strategies of the farmers.

5.4 Multiple regression of respondents risk attitude, on their characteristics, sources of risk and risk management strategies.

The relationship between risk attitude, respondents' characteristics, sources of risk and risk management strategies was examined using multiple regression analysis. Multicollinearity tests were done to determine whether the variables were correlated. Multicollinearity was not a serious problem (as indicated in Chapter 4); the regressions were carried out and the results are presented in the next section, 5.4.1, multiple regression of monocroppers risk attitude and on their characteristics, risk sources and risk management strategies.

The results of the regression of monocrop farmers' risk attitude, on their characteristics, risk sources and risk management strategies are shown in Table 5.8 below. The value of the coefficient of determination (R^2) is 0.49.

This implies that the variables included in the model explain 49% of the variation in the risk aversion of the respondents (Table 5.8). The results reveals that flood/storm, extra income factor, *fadama* cultivation and *adashe* (rotation savings) significantly relate to farmers' risk attitudes at 10% ($P<0.1$) and 5% ($P<0.05$) levels, respectively. All these variables have a direct relationship with risk attitude. The result implies that the more risk averse the farmer is, the more the monocropper perceives flood/storm as a source of risk. The more risk averse the farmer is, the more the monocropper perceives extra income factor, *fadama* cultivation and *adashe* (rotation savings) as risk management strategies. Fertiliser provision by government/self and training and education were statistically significant at 10% ($P<0.1$) and 5% ($P<0.05$) levels of probability. Fertiliser provisions by government/self and training and education have an inverse relationship with risk attitude. This implies that the less risk averse the farmer is, the more the farmer perceives fertiliser provision by government/self and training and education as risk management strategies. A possible reason for this is that training and education expose the farmer to innovations that help in improving crop production.

Table 5.8 Multiple regression results of monocroppers risk attitude, on their characteristics, risk sources and risk management strategies, Kebbi State, January 2012

Explanatory variables	Regression	T-values
Characteristics of respondents		
Cooperative[b]	-0.022	-0.086
Education of household head	-0.016	-0.479
Farming experience	-0.012	-0.733
Fadama[c]	-0.095	-0.340
Farm size	0.208	1.314
Household size	0.038	1.034
House type[d]	-0.045	-0.156
Kilometre	0.000	0.028
Gross margin	0.000	0.000
Asset value	0.000	0.000
Sources of risk		
Social factor	-0.044	-0.297
Rainfall factor	0.031	0.227
Uncertainty factor	-0.217	-1.593
Flood/storm	0.172	1.770*
Diseases	-0.074	-0.818
Erratic rainfall	-0.118	-1.233
Fire outbreak	-0.186	-1.097
Difficulties for finding labour	0.026	0.234
Market failure	-0.016	-0.117
Price fluctuation	0.039	0.359
Family relationships	0.206	0.992
Lack of work animals	0.037	0.320
Fertiliser	0.135	0.911
Change in climatic conditions	0.101	0.915
Risk management strategies		
Production strategy factor	-0.042	-0.263
Marketing plan factor	0.010	0.052
Extra income factor	0.287	1.952**
Spreading sales	0.086	0.880
Fertiliser provision by government /self	-0.276	-1.781*
Training and education	-0.369	-2.067**
Investing off-farm	-0.024	-0.149
Fadama cultivation	0.246	2.240**
Adashe rotation savings	0.377	2.158**
Cooperatives	-0.022	-0.086
Having crop insurance	0.103	0.601
Borrowing	-0.010	-0.085
Family members working off-farm	0.028	0.292
Reduced consumption	-0.003	-0.019
Selling of assets	0.127	1.150
R^2	0.49	

[a]The asterisks (***, ** and *) represents statistical significance at 1%, 5% and 10% probability level respectively.
[b]Measured as dummy variable with 1 if a farmer has access to cooperative and 0 if otherwise.
[c]Measured as a dummy variable with 1 if a farmer has access to *fadama* land and 0 if otherwise.
[d]Measured as a dummy variable with 1 if a farmer has a modern house and 0 if otherwise.

The use of fertiliser in the study area cannot be overemphasised because the soils are low in plant nutrients and that is the probable reason why farmers see fertiliser provision by government/self as a risk management strategy.

5.4.1 Multiple regression of intercroppers risk attitude on their characteristics, risk sources and risk management strategies

The results of the intercrop farmers' risk attitudes on their characteristics, risk sources and risk management strategies are presented in Table 5.9 below. The R^2 for the regression is 0.29. "Rainfall" factor and "difficulties" factor were statistically significant at 10% (P<0.1) level. "Rainfall" factor and "difficulties" factors have a positive relationship with risk attitude of the intercrop farmers. This implies that the more risk averse the farmer is, the more the farmer perceives rainfall factor and difficulties factor as source of risk. Fire outbreak, market failure and spraying for diseases and pests have negative statistically significant relationships with risk attitude at 5% (P<0.05), 10% (P<0.1) and 5% (P<0.05) levels, respectively.

Table 5.9 Multiple regression results of intercroppers risk attitude their characteristics, risk sources and risk management strategies, Kebbi State, January 2012

Explanatory variables	Regression	T-values
Characteristics of the respondents		
Cooperative[b]	0.026	0.219
Education	-0.033	-0.902
Experience	0.000	0.036
Fadama[c]	-0.155	-0.495
Farm size	0.053	0.240
Household size	-0.087	-1.611
House type[d]	-0.407	-1.001
Kilometre	-0.011	-0.331
Gross margin	0.000	0.000
Asset value	0.000	0.000
Sources of risk		
Rainfall factor	0.553	2.639***
Social factor	0.039	0.215
Difficulties factor	0.656	3.363***
Inadequate labour factor	0.099	0.611
Uncertainty factor	0.006	0.042
Flood/storm	-0.067	-0.573
Diseases	0.077	0.627
Erratic rainfall	-0.078	-0.616
Drought	0.023	0.147
Fire outbreak	-0.496	-2.232**
Change in government and agricultural policy	-0.008	-0.070
Insufficient labour	0.044	0.223
Market failure	-0.266	-1.723*
Lack of work animals	-0.113	-0.698
Fertiliser	-0.153	-0.835
Risk management strategies		
Personal and government policy	-0.044	-0.191
Capacity building	0.008	0.034
Planning	-0.177	-0.909
Spreading sales	0.168	1.323
Fertiliser provision by government/self	-0.056	-0.227
Fadama cultivation	-0.061	-0.342
Intercropping	-0.195	-1.566
Cooperative	0.026	0.219
Storage programme	0.108	0.784
Borrowing	-0.031	-0.243
Family members working off-farm	-0.032	-0.236
Selling of assets	0.025	0.205
Spraying for diseases and pests	-0.405	-2.429**
R^2	0.29	

[a]The asterisks (***, ** and *) represents statistical significance at 1%, 5% and 10% probability levels, respectively.
[b]Measured as dummy variable with 1 if a farmer has access to cooperative and 0 if otherwise.
[c]Measured as a dummy variable with 1 if a farmer has access to *fadama* land and 0 if otherwise.
[d]Measured as a dummy variable with 1 if a farmer has a modern house and 0 if otherwise.

5.4.2 Multiple regression of monocroppers risk sources their characteristics, risk attitude and risk management strategies

The purpose of this regression analysis was to explore the relationship between risk sources on their characteristics, risk attitude and risk management strategies which are part of objective 2. Exploring these relationships will provide insight on how risk sources are related to management strategies used by farmers.

Table 5.10 below shows the results of multiple regression of monocroppers risk sources on their characteristics variables, risk attitude and risk management strategies. The R^2 for FAC1 "Social factor", FAC2 "rainfall factor" and FAC 3 "uncertainty" are greater than or equal to 0.34. Fertiliser unavailability (FER) and family relationships (FRSP) have R^2 values of 0.60 and 0.55 respectively. As predicted, education (EDU) has a statistically significant positive relationship with lack of work animals (LCKWA), at 10% ($P<0.1$) level, and with changes in climatic conditions (CHCLIM) at 5% ($P<0.05$) level. This implies that the more educated the monocropper is, the more the farmer perceived CHCLIM and LCKWA as risk sources. Contrary to expectation, farming experience (EXP) has a statistically significant positive relationship with FRSP at 5% ($P<0.05$) level, which implies that the more experienced a farmer is, the more the farmer perceives family relationships as a source of risk.

A direct relationship exists between EXP and FER. The variable is statistically significant at 5% ($P<0.05$) level. As expected, the more experienced the monocropper is, the more the farmer perceives unavailability of fertiliser as a source of risk. This is because farmers with experience have over the years learnt/known the contribution of fertiliser to crop yield. Risk attitude (RA) has a positive statistically significant relationship with flood/storm (FLST) at ($P<0.05$) level.

Table 5.10 Multiple regression results of monocroppers risk sources on their characteristics, risk attitude and risk management strategies, Kebbi State, January 2012

Variables	Sources of risk													
	FAC1	FAC2	FAC3	FLST	DIS	ERRN	FROBK	DFLAB	MKFL	PCFLUC	FRSP	LCKWA	FER	CHCLIM
(COOP=1)	0.039	0.241	0.160	0.284	-0.053	0.198	0.104	0.180	-0.280	-0.065	-0.045	-0.005	0.273	0.071
	(0.155)	(0.993)	(0.642)	(0.931)	(-0.161)	(0.600)	(0.504)	(0.593)	(-1.087)	(-0.219)	(-0.241)	(-0.019)	(1.290)	(0.253)
EDU	0.020	0.013	-0.046	-0.018	-0.006	-0.009	-0.037	0.054	0.045	-0.050	-0.005	0.062	-0.001	0.066
	(0.683)	(0.467)	(-1.530)	(-0.493)	(-0.151)	(-0.232)	(-1.502)	(1.494)	(1.461)	(-1.396)	(-0.257)	(1.697)*	(-0.038)	(1.958)**
EXP	-0.003	0.008	-0.015	-0.029	0.001	0.012	0.001	-0.011	0.011	-0.016	0.023	-0.022	0.031	-0.005
	(-0.195)	(0.579)	(-1.007)	(-1.558)	(0.093)	(0.603)	(0.105)	(-0.629)	(0.740)	(-0.870)	(2.065)**	-1.211	(2.389)**	-0.308
(FDM=1)	0.248	0.579	-0.072	-0.392	0.311	-0.534	0.171	-0.020	0.011	-0.611	0.200	0.044	0.382	-0.352
	(0.986)	(0.553)	(-0.289)	(-1.278)	(0.936)	(-1.613)	(0.818)	(-0.067)	(0.043)	(-2.021)**	(1.062)	(0.147)	(1.795)*	(-1.247)
FS	-0.100	-0.081	-0.132	0.084	-0.087	0.064	0.164	0.160	-0.139	-0.069	-0.147	-0.230	-0.003	0.041
	(-0.654)	(-0.549)	(-0.869)	(0.453)	(-0.435)	(0.323)	(1.295)	(0.867)	(-0.888)	(-0.378)	(-1.286)	(-1.244)	(-0.028)	(0.244)
HHS	-0.001	-0.011	0.058	0.042	-0.053	0.014	0.034	0.020	-0.021	0.004	-0.010		-0.047	0.030
	(-0.035)	(-0.348)	(1.680)*	(0.997)	(-1.156)	(0.308)	(1.187)	(0.484)	(-0.588)	(0.093)	(-0.392)		(-1.581)	(0.773)
(HT=1)	0.020	0.327	0.162	0.206	-0.185	-0.250	0.114	-0.182	-0.372	-0.631	0.023		0.012	-0.475
	(0.074)	(1.201)	(0.581)	(0.602)	(-0.500)	(-0.675)	(0.488)	(-0.533)	(-1.283)	(-1.866)*	(0.111)		(0.052)	(-1.504)
KM	0.016	0.0120	0.010	0.053	0.012	-0.037	-0.008	-0.014	-0.028	-0.035	-0.006		-0.034	-0.033
	(0.760)	(0.563)	(0.489)	(1.991)**	(0.414)	(-1.279)	(-0.441)	(-0.543)	(-1.252)	(-1.337)	(-0.392)		(-1.872)*	(-1.352)
GM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)
ASV	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
RA	-0.047	0.069	-0.167	0.361	-0.199	-0.286	-0.1370	0.021	0.038	0.173	0.027		0.146	0.176
	(-0.401)	(0.600)	(-1.421)	(2.496)**	(-1.271)*	(-1.829)*	(-1.389)	(0.147)	(0.312)	(1.213)	(0.310)		(1.452)	(1.325)

Variables	Sources of risk													
	FAC1	**FAC2**	**FAC3**	**FLST**	**DIS**	**ERRN**	**FROBK**	**DFLAB**	**MKFL**	**PCFLUC**	**FRSP**	**LCKWA**	**FER**	**CHCLIM**
FA1_1	0.430	0.124	0.273	0.109	-0.059	0.177	0.235	0.170	-0.019	-0.151	0.204	0.226	0.572	0.301
	(3.465)***	(1.035)	(2.213)**	(0.723)	(-0.362)	(1.085)	(2.288)**	(1.135)	(-0.154)	(-1.017)	(2.195)**	(1.506)	(5.450***	(2.162)**
FA2_1	0.407	0.107	0.218	0.249	-0.040	0.307	0.417	-0.097	-0.344	-0.078	0.478	-0.049	0.232	0.103
	(2.668)***	(0.726)	(1.443)	(1.339)	(-0.202)	(1.530)	(3.302)***	(-0.525)	(-2.193)**	(-0.428)	(4.180)***	(-0.270)	(1.800)*	(0.605)
FA3_1	0.043	-0.097	0.001	-0.075	0.129	0.438	0.095	-0.225	-0.280	-0.093	0.002	0.173	0.078	0.139
	(0.312)	(-0.729)	(0.005)	(-0.446)	(0.712)	(2.409)**	(0.829)	(-1.346)	(-1.966)**	(-0.561)	(0.027)	(1.033)	(0.673)	(0.896)
SPDSL	-0.049	-0.052	0.114	-0.446	-0.034	0.002	0.069	0.037	0.082	-0.068	0.045		0.026	0.055
	(-0.507)	(-0.553)	(1.166)	(0.385)	(-0.264)	(0.018)	(0.854)	(0.316)	(0.806)	(-0.576)	(0.608)		(0.310)	(0.501)
FERGOV	-0.208	0.068	0.058	0.362	-0.264	-0.331	-0.181	0.061	0.051	0.232	-0.113	-0.005	0.263	0.336
	(-1.425)	(0.488)	(0.400)	(2.040)**	(0.439)	(-1.727)*	(-1.495)	(0.347)	(0.341)	(1.328)	(-1.030)	(-0.030)	(2.130)*	(2.054)**
TRED	0.022	0.176	-0.078	0.021	-0.067	-0.564	-0.109	0.062	0.284	-0.112	0.145		0.064	-0.168
	(0.136)	(1.104)	(-0.480)	(0.107)	(0.354)**	(-2.604)**	(-0.798)	(0.311)	(1.672)*	(-0.565)	(1.172)		(0.458)	(-0.911)
INVOFF	0.104	-0.030	-0.171	-0.235	0.063	0.128	-0.136	-0.033	-0.049	0.063	0.004		-0.058	0.143
	(0.635)	(-0.192)	(-1.049)	(-1.176)	(0.291)	(0.593)	(-0.994)	(-0.167)	(-0.288)	(0.320)	(0.029)		(-0.419)	(0.774)
FDMCUL	0.025	-0.079	0.259	-0.091	-0.044	0.087	0.129	0.117	-0.063	0.107	-0.065	0.025	-0.078	0.104
	(0.242)	-0.795	(2.511)**	(-0.723)	(-0.321)	(0.638)	(1.501)	(0.932)	(-0.590)	(0.858)	(-0.830)	(0.196)	(-0.891)	(0.892)
ADSH	0.059	-0.028	0.225	0.056	0.022	-0.195	0.091	0.109	-0.017	0.058	0.25	0.046	-0.277	-0.334
	(0.361)	(-0.177)	(1.369)	(0.275)	(0.102)	(-0.897)	(0.663)	(0.546)	(-0.097)	(0.292)	(2.014)**	(0.231)	(-1.979)**	(-1.802)
COOPx	0.039	-0.040	0.059	0.070	-0.020	0.182	-0.213	-0.177	0.056	-0.094	-0.058	0.096	-0.195	-0.064
	(0.155)	(-0.392)	(0.555)	(0.536)	(-0.142)	(1.288)	(-2.386)**	(-1.357)	(0.510)	(-0.732)	(-0.719)	(0.738)	(-2.145)**	(-0.529)

Variables	Sources of risk													
	FAC1	**FAC2**	**FAC3**	**FLST**	**DIS**	**ERRN**	**FROBK**	**DFLAB**	**MKFL**	**PCFLUC**	**FRSP**	**LCKWA**	**FER**	**CHCLIM**
HAVINS	-0.293	0.268	-0.205	-0.074	0.018	0.065	-0.143	0.339	0.261	-0.278	-0.064		-0.015	-0.374
	(-2.116)**	(1.999)**	(-1.489)	(-0.441)	(0.101)	(0.354)	(-1.240)	(2.024)**	(1.827)*	(-1.673)*	(-0.619)		(-0.131)	(-2.408)**
BRW	0.032	-0.065	0.108	-0.203	0.334	0.014	-0.041	0.008	0.073	0.222	0.087	0.148	-0.036	0.077
	(0.265)	(-0.565)	(0.906)	(-1.389)	(2.113)**	(0.085)	(-0.411)	(0.046)	(0.590)	(0.221)	(0.963)	(1.015)	(-0.354)	(0.570)
FMOFF	-0.043	-0.048	0.023	-0.036	-0.114	0.111	0.074	-0.077	-0.0287	0.044	0.123	-0.116	0.024	-0.089
	(-0.478)	(-0.552)	(0.256)	(-0.323)	(-0.943)	(0.923)	(0.980)	(-0.691)	(-0.305)	(0.403)	(1.790)*	(-1.050)	(0.311)	(-0.873)
RDCON	0.478	-0.053	0.0545	-0.207	-0.008	-0.458	0.175	0.235	0.178	-0.471	0.257		-0.016	-0.173
	(-0.116)	(-0.433)	(0.434)	(-1.347)	(-0.049)***	(-2.759)***	(1.675)*	(1.534)	(1.368)	(-3.103)***	(2.713)***		(-0.152)	(-1.223)
SELAST	-0.158	0.064	0.093	-0.001	0.023	0.245	0.044	-0.020	0.055	0.053	-0.032		0.117	-0.219
	(-1.522)	(0.64)	(0.902)	(-0.012)	(0.173)*	(1.795)*	(0.518)	(-0.159)	(0.513)	(0.429)	(-0.416)		(1.331)	(-1.880)*
R^2	**0.34**	**0.38**	**0.34**	**0.34**	**0.16**	**0.34**	**0.39**	**0.30**	**0.28**	**0.32**	**0.55**	**0.30**	**0.60**	**0.38**

The asterisks (***, ** and *) represents statistical significance at 1%, 5% and 10% probability levels, respectively.

Figures in parenthesis are the t-values

As expected, the more risk averse a farmer is, the more the individual perceives flood/storm as a source of risk. Risk aversion has a negative statistically significant relationship with diseases (DIS) and erratic rainfall (ERRN) both at 10% ($P<0.1$) significant level. This is contrary to expectation, one would expect risk aversion to have a positive relationship with diseases and erratic rainfall as sources of risk.

FA1_1 “production strategies” factor has a positive statistically significant relationship with FAC1 “social” factor ($P<0.01$), FAC3 “uncertainty” factor ($P<0.05$), fire outbreak (FROBK) ($P<0.05$), family relationships ($P<0.05$), fertiliser unavailability ($P<0.01$) and changes in climatic conditions ($P<0.05$). This means that the more the monocropper perceives “production strategies” as a risk management strategy, the more the farmer perceives “social” factor, “uncertainty” factor, fire outbreak, family relationships, fertiliser unavailability and changes in climatic conditions as sources of risk. It is not surprising that FA2_1 “marketing plan” has a positive statistically significant relationship with FAC1 “social” factor ($P<0.01$), fire outbreak ($P<0.01$), family relationships ($P<0.01$) and unavailability of fertiliser ($P<0.1$). This implies that the more the monocropper perceives “marketing plan” factor as a management strategy, the more the farmer perceives “social” factor, fire outbreak, family relationships and unavailability of fertiliser as sources of risk. There is an inverse relationship between “marketing plan” factor and market failure (MKFL) at 5% ($P<0.05$) level. The more the monocrop farmer perceives “marketing plan” as a management strategy, the less the farmer perceives market failure as a source of risk. There is a positive statistically significant relationship between FA3_1 “extra income” factor and erratic rainfall at 5% ($P<0.05$) level and a negative statistically significant relationship with market failure at 5% ($P<0.05$) level. This means that the more the monocropper perceives the “extra income” factor as a risk management strategy, the less the farmer sees market failure as a source of risk.

Fertiliser provision by government/self (FERGOV) has a positive statistically significant relationship with FLST, FER and CHCLIM at 5% ($P<0.05$), 10% ($P<0.1$) and 5% ($P<0.05$) levels, respectively. This signifies that the more the monocropper perceives fertiliser provision by government/self, the more the farmer sees flood/storm, fertiliser unavailability and changes in climatic conditions as sources of risk. Provision of fertiliser by the government is inadequate and untimely and self-provision of fertiliser is associated with high cost and unavailability, and perhaps that is why it is not surprising that fertiliser provision by government/self has a direct relationship with fertiliser unavailability as a source of risk. FERGOV has a negative statistically significant relationship with ERRN at 10% ($P<0.1$) level.

The risk management strategy variable, training and education (TRED), has an inverse statistically significant relationship with DIS and a direct relationship with MKFL at 5% ($P<0.05$) and 10% ($P<0.1$) levels, respectively. The inverse relationship between TRED and DIS is as expected: the training and education that farmers receive for the agricultural development project (ADP), through the ministry of agriculture and mass media, is an important strategy used to combat diseases. The direct relationship between training and education with market failure as sources of risk is contrary to expectation. TRED has a negative statistically significant relationship with ERRN at 5% ($P<0.05$) level. This means that the more the monocropper perceives training and education as a management strategy, the less the farmer perceives erratic rainfall as a source of risk. Training and education from the Nigerian Meteorological Agency (NIMET) through the media, seminars and workshops expose farmers to knowledge of rainfall patterns and weather forecasts that help the farmers to adjust planting dates of crops. The training received from the agricultural development project (ADP), ministry of agriculture and mass media educates farmers on the cropping patterns that will help to protect the soils from the effect of erratic rainfall, especially those associated with soil erosion.

Membership of cooperative societies (COOPx) as a management strategy has an inverse statistically significant relationship with fire outbreak (FROBK) and fertiliser unavailability (FER) at 5% ($P<0.05$) level of significance. This implies that the more the farmer perceives membership of cooperative societies as a management strategy, the less the farmer sees fire outbreak and fertiliser unavailability as sources of risk. A possible reason could be that membership of cooperative societies enable farmers to obtain loans to purchase farm inputs.

Having crop insurance (HAVINS) has a negative statistically significant relationship with FAC1 “social factor”, price fluctuation (PCFLUC) and changes in climatic conditions (CHCLIM) at 5% ($P<0.05$), 10% ($P<0.1$) and 5% ($P<0.05$) levels, respectively. This means that the more the monocropper is insured, the less the farmer sees “social” factor, price fluctuation and changes in climatic conditions as risk sources. Crop insurance (HAVINS) has a positive statistically significant relationship with FAC2 “rainfall” factor, difficulties for finding labour (DFLAB) and market failure (MKFL) at 5% ($P<0.05$), 5% ($P<0.05$) and 10% ($P<0.1$) levels, respectively. This is contrary to expectation: the findings reveal that even with crop insurance, monocropppers still have fears for the “rainfall” factor, difficulties for finding labour and market failure. This could be because of the fact that the crop insurance is not very effective against these factors.

Selling of assets (SELAST) has a positive statistically significant influence on DIS and ERRN, both at 10% ($P<0.1$) level. This implies that a monocrop farmer who perceives selling of assets as a management strategy sees diseases and erratic rainfall as important sources of risk. Selling of assets (SELAST) has a negative statistically significant relationship with changes in climatic conditions (CHCLIM) at 10% ($P<0.1$) level. This means that the more the monocropper perceives selling of assets as a risk management strategy, the less the farmer perceives changes in climatic conditions as a risk source. A possible reason for this is that farmers who have assets can afford to sell the assets to purchase grains and other commodities in the event of crop failure owing to changes in climatic conditions.

5.4.3 Multiple regression for intercroppers risk sources on their characteristics, risk attitude and risk management strategies

The results of the multiple regression of intercroppers risk sources on their characteristics, risk attitude and risk management strategies are presented in Table 5.11 below. The results reveal that the R^2 ranges from 0.13 to 0.39. Membership of cooperative society (COOP=1) for the intercroppers has a positive statistically significant relationship with FAC2 “social” factor and drought (DRT), both at 5% ($P<0.05$) level. This means that farmers who belong to cooperative societies perceive “social” factor and drought as most relevant source of risk. The likely reason for this is that the amounts for loans farmers receive from cooperative societies are meagre and cannot cover for loss of land and drought effects. Intercrop farmers’ education (EDU) has a direct statistically significant relationship with FAC4 “inadequate labour” and lack of work animals (LCKWA) at 10% ($P<0.1$) and 5% ($P<0.05$), respectively. There is an inverse statistically significant relationship between education (EDU) and diseases (DIS) at 10% ($P<0.1$). This implies that more educated intercropper farmers perceive diseases as less relevant sources of risk.

Table 5.11 Multiple regression results of intercroppers risk sources on their characteristics, risk attitude and risk management strategies, Kebbi State, January 2012

Sources of risk

Variable Variablese	FAC1	FAC2	FAC3	FAC4	FAC5	FLST	DIS	ERRN	DRT	FROBK	CGPOL	INSLAB	MKFL	LCKWA	FER
(COOP=1)	-0.192	0.391	0.144	-0.009	-0.231	0.101	-0.231	0.209	-0.586	-0.008	0.178	0.192	-0.194	-0.112	-0.267
	(-0.952)	(1.96)**	-0.791	(-0.05)	(-1.066)	-0.355	(-0.884)	-0.814	(0.23)**	(-0.039)	-0.672	-1.047	(-0.889)	(-0.501)	(-1.333)
EDU	0.022	0.012	0.022	0.035	0.014	-0.018	-0.049	-0.003	0.008	-0.008	0.025	0.028	-0.003	0.055	-0.01
	(-1.102)	-0.577	-1.166	(1.669)*	-0.634	(-0.604)	(-1.87)*	(-0.114)	-0.023	(-0.436)	-0.912	-1.552	(-0.139)	(2.414)**	(-0.508)
EXP	-0.002	0.005	0.013	0.004	-0.014	-0.014	0.01	-0.017	-0.015	-0.006	-0.007	0.013	0.022	0.006	0.002
	(-0.267)	-0.482	-1.401	-0.408	(-1.292)	(-0.95)	-0.754	(-1.291)	-0.012	(-0.542)	(-0.541)	-1.343	(1.954)**	-0.505	-0.225
(FDM=1)	-0.049	-0.073	0.039	-0.242	-0.255	-0.173	-0.025	0.199	0.065	-0.126	-0.516	-0.065	0.037	-0.355	-0.118
	(-0.282)	(-0.418)	-0.248	(-1.326)	(-1.349)	(-0.696)	(-0.11)	-0.886	-0.201	(-0.735)	(-2.23)**	(-0.405)	-0.196	(-1.82)*	(-0.674)
FS	-0.278	-0.253	-0.114	-0.132	0.294	-0.071	0.048	0.117	0.112	-0.225	0.127	-0.243	0.032	0.001	-0.305
	(-2.381)**	(-2.192)*	(-1.085)	(-1.095)	(2.341)**	(-0.429)	-0.32	-0.785	-0.133	(-1.97)**	-0.833	(-2.29)**	-0.252	-0.011	(-2.63)***
HHS	0.007	-0.043	0.044	-0.012	-0.003	0.0254	-0.09	-0.02	0.062	0.0206	-0.015	-0.014	0.012	-0.005	-0.012
	-0.239	(-1.426)	-1.614	(-0.364)	(-0.116)	-0.592	(-2.284)	(-0.52)**	(0.035)*	-0.694	(-0.384)	(-0.495)	-0.367	(-0.126)	(-0.391)
(HT=1)	-0.19	0.179	-0.345	0.014	-0.224	0.02	-0.292	0.337	-0.341	-0.059	-0.046	-0.162	-0.072	-0.091	-0.109
	-0.239	-0.781	(-1.644)*	-0.06	(-0.896)	-0.061	(-0.97)	-1.137	-0.265	(-0.258)	(-0.152)	(-0.769)	(-0.285)	(-0.352)	(-0.474)
KM	-0.006	0.035	0.01	0	-0.009	-0.016	-0.025	0.002	0.013	0.011	0.005	-0.012	0.007	-0.013	-0.023
	(-0.31)	(1.797)*	-0.585	(-0.022)	(-0.459)	(-0.562)	(-0.985)	-0.079	-0.023	-0.577	-0.209	(-0.661)	-0.306	(-0.598)	(-1.175)
GM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RA	0.058	-0.051	0.115	-0.017	0.009	-0.037	0.077	-0.048	0.038	-0.039	-0.023	0.019	-0.044	0.011	0.023
	-1.139	(-1.003)	(2.469)**	(-0.31)	-0.162	(-0.504)	-1.16	(-0.724)	-0.059	(-0.778)	(-0.344)	-0.4	(-0.783)	-0.199	-0.452

FA1_1	0.155	0.14	0.042	0.1	-0.178	-0.19	-0.369	-0.353	-0.008	0.26	0.075	0.122	-0.325	-0.056	0.182
	-1.296	-1.181	-0.391	-0.808	(-1.382)	(-1.125)	(-2.37)**	(-2.31)**	-0.137	(2.221)**	-0.474	-1.12	(-2.51)**	(-0.424)	-1.524
FA2_1	-0.017	-0.014	-0.175	0.456	-0.042	-0.519	-0.437	-0.308	0.037	-0.113	-0.119	-0.24	-0.067	-0.123	0.066
	(-0.14)	(-0.117)	(-1.537)	(3.5)***	(-0.313)	(-2.92)***	(-2.67)***	(-1.915)*	-0.144	(-0.92)	(-0.713)	(-2.09)**	(-0.488)	(-0.877)	-0.53
FA3_1	0.091	-0.005	0.292	0.071	-0.039	-0.121	0.047	0.222	0.087	0.062	0.011	0.098	0.244	0.195	-0.031
	-0.874	(-0.045)	(3.093)***	-0.653	(-0.349)	(-0.819)	-0.346	(1.663)*	-0.119	-0.606	-0.083	-1.036	(2.155)**	(1.681)*	(-0.295)
SPDSL	-0.147	-0.032	-0.032	0.007	0.031	0.017	-0.019	0.165	-0.039	-0.096	-0.012	-0.015	0	0.11	-0.099
	(-2.053)**	(-0.45)	(-0.497)	-0.092	-0.394	-0.169	(-0.214)	(1.805)*	-0.082	(-1.376)	(-0.132)	(-0.229)	(-0.002)	-1.384	(-1.398)
FERGOV	0.157	0.191	0.222	-0.202	0.047	0.474	0.324	0.441	0.07	0.176	0.011	0.44	0.372	0.227	0.361
	-1.345	(1.654)*	(2.11)**	(-1.68)*	-0.363	(2.883)***	(2.144)**	(2.96)***	-0.133	-1.546	-0.072	(4.16)***	(2.95)***	(1.756)*	(3.11)***
STRPR	0.045	0.003	0.096	-0.063	0.061	0.051	0.115	0.021	0.017	0.15	0.175	-0.025	0.103	-0.02	0.067
	-0.599	-0.034	-1.41	(-0.808)	-0.757	-0.475	-1.173	-0.217	-0.086	(2.034)**	(1.763)*	(-0.361)	-1.258	(-0.238)	-0.885
FDMCUL	0.084	-0.16	0.117	0.045	0.033	0.066	0.131	0.236	0.078	-0.001	0.0785	-0.012	0.207	0.059	-0.103
	-0.853	(-1.639)*	-1.314	-0.44	-0.311	-0.475	-1.019	(1.87)*	-0.113	(-0.009)	-0.606	(-0.133)	(1.939)**	-0.543	(-1.048)
SPDISPT	0.078	-0.072	0.253	-0.156	-0.05	0.299	0.139	-0.003	0.104	0.039	0.188	0.232	-0.108	-0.069	0.07
	-0.894	(-0.832)	(3.20)***	(-1.73)*	(-0.536)	(2.424)**	-1.225	(-0.022)	-0.099	-0.459	(1.636)*	(2.93)***	(-1.145)	(-0.708)	-0.807
COOPx	0.024	-0.165	-0.055	-0.065	0.023	-0.047	-0.079	-0.083	0.006	-0.082	-0.069	-0.066	-0.08	-0.013	-0.005
	-0.362	(-2.46)**	(-0.903)	(-0.928)	-0.312	(-0.491)	(-0.906)	(-0.964)	-0.077	(-1.244)	(-0.772)	(-1.079)	(-1.092)	(-0.178)	(-0.077)
INTC	0.079	0.095	0.048	0.067	-0.011	0.026	0.016	0.152	-0.033	0.042	-0.014	0.039	0.012	0.146	0.12
	-1.137	-1.388	-0.763	-0.911	(-0.146)	-0.268	-0.179	(1.705)*	-0.079	-0.618	(-0.158)	-0.627	-0.164	(1.894)*	(1.735)*
BRW	0.019	0.072	-0.005	-0.001	0.04	-0.058	0.126	0.012	-0.013	0.004	-0.032	0.015	0.12	-0.005	-0.053
	-0.267	-0.993	(-0.076)	(-0.014)	-0.501	(-0.558)	-1.306	-0.129	-0.085	-0.06	(-0.33)	-0.219	-1.499	(-0.063)	(-0.721)
FMOFF	0.005	-0.106	-0.057	0.012	-0.029	-0.007	-0.096	0.065	0.044	-0.157	-0.018	-0.147	0.008	-0.025	-0.12
	-0.067	(-1.393)	(-0.816)	-0.161	(-0.351)	(-0.062)	(-0.955)	-0.654	-0.088	(-2.08)**	(-0.18)	(-2.09)**	-0.09	(-0.29)	(-1.56)
SELAST	0.095	-0.135	-0.122	-0.009	0.054	0.068	0.008	0.107	0.012	0.013	0.155	-0.014	-0.059	-0.051	0.039
	-1.365	(-1.95)**	(-1.941)*	(-0.135)	-0.72	-0.687	-0.089	-1.194	-0.079	-0.194	(1.69)*	(-0.216)	(-0.778)	(-0.656)	-0.56
R 2	**0.26**	**0.24**	**0.38**	**0.2**	**0.13**	**0.16**	**0.18**	**0.25**	**0.15**	**0.25**	**0.15**	**0.39**	**0.24**	**0.18**	**0.37**

The asterisks (***, ** and *) represents statistical significance at 1%, 5% and 10% probability level respectively. Figures in parenthesis are the t-values.

A possible reason could arise from the fact that most educated farmers are civil servants who earn extra income from their extracurricular jobs and so they can afford to purchase disease control chemicals.

Fadama cultivation (FDM=1) has a negative statistically significant influence on changes in government policy (CGPOL) and lack of work animals (LCKWA) at 5% ($P<0.05$) and 10% ($P<0.1$), respectively. This implies that the more the intercropper cultivates *fadama*, the less the farmer sees changes in government policy and lack of work animals as important sources of risk. A possible reason why the farmers perceive changes in government policy as less important is probably because most government policies focus more on arable crops than vegetable crops which are mostly grown as *fadama* crops. Intercroppers who cultivate *fadama* see lack of work animals as a less important source of risk because most *fadama* users do not use work animals owing to the clayey and marshy nature of *fadama* soils. The negative relationship between *fadama* cultivation and lack of work animals is as predicted.

Farm size (FS) has a negative statistically significant relationship with FAC1 "rainfall' factor ($P<0.05$), FAC2 "social" factor ($P<0.1$), fire outbreak (FROBK) ($P<0.05$), insufficient labour (INSLAB) ($P<0.05$) and fertiliser unavailability (FER) ($P<0.01$) level. This means that the larger the farm size, the less the intercropper perceives "rainfall' factor, "social" factor, fire outbreak, insufficient labour and fertiliser unavailability as relevant sources of risk. The possible explanation for this is that farmers who have larger farm sizes are likely to have more farm income which they can use to purchase fertiliser, and since intercropping helps in improving the fertility of the soils, the intercroppers may not perceive unavailability of fertiliser as a most important source of risk. A positive relationship is expected between farm size and insufficient labour because intercropping is associated with intensive labour use, accordingly the result is contrary to expectation. Farm size (FS) has a positive statistically significant relationship with FAC5 "uncertainty" factor at 5% ($P<0.05$) level. This is as expected; the larger the farm size, the more the intercropper perceives changes in climatic conditions ("uncertainty" factor) as most important sources of risk.

House type (HT=1) has a negative statistically significant effect on FAC3 (illness of household member and difficulties in finding labour) "difficulties" factor at 10% ($P<0.1$) level. This means that farmers with modern houses perceive "difficulties" as less important risk source. This is probably because the farmers are thought to be wealthy and can afford to pay hospital bills and they might also afford to pay labour more and so the farmers may not perceive difficulties in finding labour as most relevant source of risk. Risk attitude (RA) has a positive statistically significant relationship with FAC3 "difficulties" factor at 5% (P<0.05) level. The more risk averse the intercropper is, the more the farmer perceives the "difficulties" factor as an important risk source.

FA1_1 "personal and government policy" factor has a negative statistically significant effect on diseases (DIS), erratic rainfall (ERRN) and market failure (MKFL), all at 5% (P<0.05) level. This is not surprising because farmers who perceive personal and government policy factor as a risk management strategy are likely to perceive diseases, erratic rainfall and market failure as less important source of risk. The farmers use gathering of market information, price support policy, household head working off-farm, *adashe* and having crop insurance management strategies to combat the risk sources (diseases, erratic rainfall and market failure).

FA2_1 "capacity building" factor has a positive statistically significant relationship with FAC4 "inadequate labour" at 10% (P<0.1) level. FA2_1 "capacity building" factor has a negative statistically significant relationship with flood/storm (FLST) (P<0.01), diseases (DIS) (P<0.01), erratic rainfall (ERRN) (P<0.1), and insufficient labour (INSLAB) (P<0.05) level. The result implies that the intercroppers who perceived capacity building as a risk management strategy see flood/storm, diseases, erratic rainfall and insufficient labour as less important sources of risk. Capacity building comprises training and education and investing off-farm. Training and education helps farmers to know better methods of disease control. Investing off-farm gives the intercropper the ability to cope with the negative effects of flood/storm, diseases, erratic rainfall and insufficient labour by finding alternative means of getting income rather than depending on farming alone.

FA3_1 "planning" factor has a positive statistically significant relationship with FAC3 "difficulties" (P<0.01), erratic rainfall (P<0.05), market failure (P<0.05) and lack of work animals (P<0.1) level. This implies that the farmer perceives the "difficulties" factor, erratic rainfall, market failure and lack of work animals as most important risk sources. Fertiliser provision by government/self has a positive statistically significant influence on FAC2 "social" factor (P<0.1), FAC3 "difficulties" factor (P<0.05), flood/storm (P<0.01), diseases (P<0.05), erratic rainfall (P<0.01), insufficient labour (P<0.01), market failure (P<0.01), lack of work animals (P<0.1) and fertiliser unavailability (P<0.01) level. This means that the more the intercropper perceives fertiliser provision by government/self as a management strategy, the more the farmer sees “social” factor, “difficulties” factor, flood/storm, diseases, erratic rainfall, insufficient labour, market failure, lack of work animals and fertiliser unavailability as most relevant sources of risk. Fertiliser is one of the most important inputs in crop production in Kebbi State since it determines the crop output, and probably that is why it has a positive relationship with “social” factor, “difficulties” factor, fertiliser unavailability, etc.

Storage programme (STRPR) has a positive statistically significant relationship with fire outbreak (FROBK) and changes in government and agricultural policy (CGPOL) at 5% (P<0.05) and 10% (P<0.1) level respectively. The intercropper who perceives storage programme as a management strategy sees fire outbreak and changes in government and agricultural policy as most important sources of risk. The possible reason is that the intercrop farmers are apprehensive of fire accidents that might consume the stored farm produce and are fearful of changes in government and agricultural policy, especially those related to importation, removal of custom duty and tariffs, that might have negative effect on domestic product prices.

Spraying for diseases and pests (SPDISPT) has a positive statistically significant relationship with FAC3 “difficulties” factor (P<0.01), flood/storm (FLST) (P<0.05), changes in government and agricultural policy (CGPOL) (P<0.1) and insufficient labour (INSLAB) (P<0.01) level. This means that the more the intercropper perceive spraying for diseases and pests as a management strategy, the more the farmer sees “difficulties” factor, flood/storm, changes in government and agricultural policy and insufficient labour as important sources of risk.

Spraying for diseases and pests (SPDISPT) has a negative statistically significant relationship with FAC4 “inadequate labour” factor. This is probably because of the fact that most farmers use knapsack sprayers which are less time consuming for spraying the farms. Selling of assets (SELAST) has a negative statistically significant relationship with FAC2 “social” factor, FAC3 “difficulties” factor at 5% percent (P<0.05) and 10% (P<0.1) levels, respectively. This implies that intercroppers perceive “social” factor and “difficulties” factor as less relevant sources of risk. The relationship between selling of assets and changes in government policy was positive and statistically significant at 10% ($P<0.1$) level. The possible reason for this is that the prices the farmers receive for the assets they have are likely to be determined by government policy.

When comparing the analysis of the mono and intercroppers, the following should *inter alia* be pointed out. There is a positive statistically significant relationship between FERGOV (fertiliser provision by government/self) and FER (fertiliser unavailability) for both the monocroppers and intercroppers. This shows how important fertiliser is to both groups of farmers. FA_1 1 “production strategies” has a positive significant relationship with FROBK (fire outbreak) for both monocrop and intercrop farmers. This means that “production strategies” are important in combating fire outbreak as a source of risk. Also, FA3_1 “extra income” has a positive statistically significant relationship with ERRN (erratic rainfall) for both groups of farmers. This implies that the farmers perceive “extra income” as a means of dealing with the risk source erratic rainfall which might cause crop failure. For the monocrop farmers, crop insurance (HAVINGS) has a positive statistically significant relationship with FAC2 “rainfall” factor, difficulties for finding labour (DFLAB) and market failure (MKFL). The result is contrary to expectation. The probable reason for the direct relationship could be because of the fact that crop insurance is not very effective in the study area. This again stresses the fact that monocropping is associated with more risk than the intercropping.

5.4.4 Multiple regression of monocroppers risk management strategies on their characteristics, risk attitude and risk sources

Part of objective 2 is to determine the relationship between farmers’ risk management strategies and their characteristics, risk attitudes and risk sources. Exploring this relationship will help in designing policies that will enhance coping strategies.

Table 5.12 below presents the multiple regression results of monocroppers risk management strategies on their characteristics, risk attitudes and risk sources. Table 5.12 indicates that the maximum and minimum R^2 were 0.52 and 0.18, respectively. Education (EDU) has a negative statistically significant relationship with reduced consumption (RDCON) at 10% ($P<0.1$) which means that the more educated a monocropper is, the less the farmer perceives reduced consumption as an important risk management strategy. This is not surprising because most of the educated farmers are civil servants who have other sources of income to take care of family needs other than farm income.

Experience (EXP) has a negative statistically significant influence on FA1_1 "production strategies" factor ($P<0.1$), training and education (TRED) ($P<0.1$), borrowing (BRW) ($P<0.1$), family members working off-farm (FMOFF) ($P<0.1$) and selling of assets (SELAST) ($P<0.05$) level.

Table 5.12 Multiple regression results of monocroppers risk management strategies on their characteristics, risk attitude and risk sources, Kebbi State, January 2012

Variables	Risk management strategies														
	FA1_1	**FA2_1**	**FA3_1**	**SPDSL**	**FERGOV**	**TRED**	**INVOFF**	**FDMCUL**	**ADSH**	**COOP**	**HAVINS**	**BRW**	**FMOFF**	**RDCON**	**SELAST**
(COOP=1)	-0.248	-0.213	0.047	0.319	0.269	0.153	0.237	-0.162	0.112	-0.224	-0.103	0.479	-0.003	0.091	-0.182
	(-1.281)	(-1.086)	(0.228)	(1.092)	(1.304)	(0.756)	(0.207)	(-0.561)	(0.622)	(0.260)	(-0.464)	(2.179)**	(-0.009)	(0.429)	(-1.503)
EDU	0.003	0.005	0.005	0.058	0.011	0.007	-0.003	-0.008	0.037	-0.018	-0.020	0.036	0.012	-0.053	0.004
	(0.094)	(0.160)	(0.033)	(1.371)	(0.372)	(0.220)	(0.030)	(-0.008)	(1.425)	(0.038)	(-0.602)	(1.119)	(0.266)	(-1.703)*	(0.104)
EXP	-0.021	-0.016	-0.008	-0.020	0.004	-0.024	-0.023	0.028	0.016	0.008	-0.012	-0.024	-0.034	-0.007	-0.042
	(-1.674)*	(-1.277)	(0.014)	(-1.072)	0.293)	(-1.904)*	(0.013)*	(1.546)	(1.413)	(0.016)	(-0.834)	(-1.724)*	(-1.759)*	(-0.505)	(-2.435)**
(FDM=1)	-0.136	-0.131	0.021	-0.585	-0.064	-0.066	0.055	0.516	-0.130	0.676	-0.191	0.146	0.288	-0.464	0.100
	(-0.695)	(-0.660)	(0.230)	(-1.98)*	(-0.304)	(-0.323)	(0.209)	(1.765)*	(-0.717)	(0.2628)*	(-0.850)	(0.658)	(0.924)	(-2.161)**	(0.363)
FS	0.026	0.150	-0.293	-0.214	0.099	0.032	-0.052	-0.235	-0.057	0.244	-0.022	0.411	-0.122	0.043	0.087
	(0.225)	(1.305)	(0.134)**	(-1.250)	(0.819)	(0.268)	(0.121)	(-1.386)	(-0.539)	(0.152)	(-0.169)	(3.19)***	(-0.677)	(0.348)	(0.543)
HHS	0.067	-0.016	-0.016	-0.027	0.021	0.036	0.057	-0.064	-0.029	0.018	0.028	0.092	0.051	-0.016	0.055
	(2.561)**	(-0.613)	(0.031)	(-0.695)	(0.752)	(1.326)	(0.0278)**	(-1.639)	(-1.192)	(0.035)	(0.926)	(3.1)***	(1.221)	(-0.548)	(1.500)
(HT=1)	-0.033	-0.466	0.431	-0.299	-0.085	0.028	0.299	0.029	-0.123	-0.081	-0.465	0.089	0.081	0.198	0.586
	(-0.145)	(-2.038)**	(0.265)	(-0.879)	(-0.352)	(0.120)	(0.241)	(0.087)	(-0.590)	(0.303)	(-1.796)*	(0.348)	(0.225)	(0.802)	(1.845)*
KM	-0.014	-0.009	0.008	-0.019	-0.033	-0.022	-0.004	0.014	-0.039	-0.024	0.009	0.034	0.034	0.023	0.024
	(-0.697)	(-0.434)	(0.023)	(-0.656)	(-1.567)	(-1.076)	(0.021)	(0.497)	(-2.171)**	(0.026)	(0.407)	(1.549)	(1.088)	(1.097)	(0.887)
GM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ASV	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.0000	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
RA	0.016	-0.028	0.242	0.089	-0.086	-0.103	-0.068	0.302	0.134	0.225	0.055	0.140	-0.055	0.152	0.186
	(0.173)	(-0.295)	(0.109)**	(0.638)	(-0.873)	(-1.062)	(0.099)	(2.186)**	(1.560)	(0.124)*	(0.516)	(1.331)	(-0.373)	(1.500)	(1.431)
FAC1_1	0.338	-0.068	-0.220	-0.110	-0.118	0.146	0.114	0.019	0.042	0.001	-0.184	-0.196	-0.117	-0.236	-0.147
	(3.07)***	(-0.614)	(0.129)*	(-0.665)	(-1.011)	(1.271)	(0.117)	(0.117)	(0.410)	(0.148)	(-1.462)	(-1.568)	(-0.667)	(-1.955)*	(-0.953)
FAC2_1	0.094	0.126	-0.185	-0.135	0.108	0.187	0.180	0.088	-0.079	0.175	0.331	-0.110	-0.045	-0.349	0.087
	(0.907)	(1.200)	(0.121)	(-0.869)	(0.979)	(1.738)*	(0.110)	(0.569)	(-0.830)	(0.139)	(2.792)***	(-0.940)	(-0.275)	(-3.082)***	(0.596)
FAC3_1	0.198	-0.029	-0.093	0.073	0.047	0.140	0.017	0.392	0.062	0.299	-0.162	0.103	0.026	-0.062	0.263
	(1.885)*	(-0.271)	(0.123)	(0.460)	(0.417)	(1.280)	(0.112)	(2.506)**	(0.637)	(0.141)**	(-1.348)	(0.863)	(0.154)	(-0.535)	(1.783)*
ERRN	0.012	0.149	0.019	0.021	-0.078	-0.042	0.038	0.056	-0.119	0.142	0.203	0.055	0.157	-0.216	0.142
	(0.184)	(2.213)**	(0.078)	(0.206)	(-1.095)	(-0.605)	(0.071)	(0.559)	(-1.935)*	(0.089)	(2.655)***	(0.734)	(1.481)	(-2.961)***	(1.519)

Variables	Risk management strategies														
	FA1_1	**FA2_1**	**FA3_1**	**SPDSL**	**FERGOV**	**TRED**	**INVOFF**	**FDMCUL**	**ADSH**	**COOP**	**HAVINS**	**BRW**	**FMOFF**	**RDCON**	**SELAST**
DIS	-0.056	-0.004	0.119	-0.004	0.043	-0.051	-0.021	-0.045	0.053	-0.027	-0.019	0.190	-0.132	0.096	0.082
	(-0.755)	(-0.046)	(0.087)	(-0.036)	(0.545)	(-0.659)	(0.079)	(-0.404)	(0.771)	(0.099)	(-0.225)	(2.273)**	(-1.126)	(1.186)	(0.794)
FLST	-0.034	0.194	-0.088	0.111	0.141	-0.022	-0.002	-0.140	0.103	0.022	0.092	-0.145	-0.078	-0.091	-0.068
	(-0.426)	(2.449)**	(0.092)	(0.939)	(1.685)*	(-0.268)	(0.084)	(-1.199)	(1.414)	(0.105)	(1.021)	(-1.625)	(-0.626)	(-1.059)	(-0.618)
FER	0.476	0.100	0.154	0.078	0.296	0.301	0.272	0.005	-0.052	-0.177	0.260	-0.097	0.197	-0.080	0.320
	(5.12)***	(1.068)	(0.109)	(0.556)	(2.993)***	(3.11)***	(0.099)***	(0.038)	(-0.601)	(0.124)	(2.438)*	(-0.917)	(1.337)	(-0.791)	(2.453)*
FROBK	-0.110	-0.173	0.116	0.153	-0.259	-0.329	-0.428	0.046	0.002	-0.531	-0.299	0.002	-0.129	0.286	-0.005
	(-0.901)	(-1.400)	(0.144)	(0.832)	(-1.986)*	(-2.58)**	(0.130)***	(0.252)	(0.013)	(0.16)***	(-2.129)	(0.015)	(-0.663)	(2.133)**	(-0.029)
FRSP	-0.093	0.598	0.314	0.239	0.252	0.147	0.387	-0.402	0.385	0.015	0.256	0.257	0.384	0.250	-0.152
	(-0.698)	(4.45)***	(0.156)**	(1.194)	(1.779)*	(1.063)	(0.141)***	(-2.027)**	(3.13)***	(0.178)	(1.681)*	(1.702)*	(1.815)*	(1.714)***	(-0.814)
LCKWA	-0.106	-0.101	0.109	-0.132	-0.029	-0.232	-0.127	-0.083	0.006	0.007	-0.003	0.126	-0.226	0.216	-0.030
	(-1.179)	(-1.117)	(0.105)	(-0.976)	(-0.305)	(-2.478)**	(0.096)	(-0.617)	(0.069)	(0.120)	(-0.029)	(1.241)	(-1.585)	(2.196)**	(-0.240)
DFLAB	-0.001	0.029	0.015	0.015	0.071	-0.105	-0.045	0.068	0.023	-0.175	0.186	-0.051	-0.093	0.158	-0.082
	(-0.010)	(0.334)	(0.101)	(0.118)	(0.768)	(-1.161)	(0.092)	(0.530)	(0.286)	(0.116)	(1.883)*	(-0.516)	(-0.679)	(1.675)*	(-0.679)
MKFL	0.094	-0.240	-0.168	0.065	0.008	0.202	-0.022	0.166	-0.125	0.131	-0.017	-0.093	-0.028	0.026	0.190
	(0.923)	(-2.337)	(0.119)**	(0.424)	(0.075)	(1.908)*	(0.109)	(1.092)	(-1.330)	(0.136)	(-0.142)	(-0.804)	(-0.172)	(0.237)	(1.329)
PCFLUC	-0.112	-0.064	-0.085	-0.035	-0.065	-0.107	-0.089	-0.009	0.046	-0.099	-0.175	0.136	0.083	-0.217	-0.035
	(-1.388)	(-0.786)	(0.095)	(-0.285)	(-0.757)	(-1.271)	(0.086)	(-0.073)	(0.620)	(0.108)	(-1.892)*	(1.491)	(0.649)	(-2.453)**	(-0.308)
CHCLIM	0.049	-0.105	0.034	-0.070	0.064	-0.081	0.010	0.071	-0.035	-0.046	-0.182	0.028	-0.034	0.036	-0.182
	(0.574)	(-1.209)	(0.101)	(-0.542)	(0.703)	(-0.901)	(0.092)	(0.550)	(-0.442)	(0.115)	(-1.846)*	(0.286)	(-0.247)	(0.386)	(-1.503)
R^2	**0.52**	**0.51**	**0.35**	**0.28**	**0.46**	**0.38**	**0.43**	**0.29**	**0.39**	**0.38**	**0.46**	**0.45**	**0.18**	**0.50**	**0.32**

The asterisks (***, ** and *) represents statistical significance at 1%, 5% and 10% probability levels, respectively.

Figures in parenthesis are the t-values

The implication of this is that over the years monocroppers have learnt to combat risk sources using "production strategies" factor, training and education, borrowing, family members working off-farm and selling of assets, and so the farmers perceive these as less important over time. There is a positive statistically significant relationship between experience (EXP) and investing off-farm (INVOFF) at 10% (P<0.1) level. The possible reason could be that experienced farmers have over the years experienced the challenges associated with the farming enterprise and so they have learnt certain investment strategies that they might fall back on in the event of crop failure.

Fadama cultivation (FDM=1) has a positive statistically significant relationship with *fadama* cultivation (FDMCUL) as a risk management strategy and with cooperative (COOP), both at 10% (P<0.1) level. This means that a monocrop farmer perceives *fadama* cultivation as a relevant management strategy. This could arise from the fact that *fadama* cultivation serves as a means of producing different crops using simple irrigation techniques to produce vegetable crops and cereals, such as maize and wheat. Farmers can always fall back on *fadama* crops when arable crops fail. F*adama* cultivation has a negative statistically significant relationship with reduced consumption at 5% (P<0.05) level. This is as expected because *fadama* cultivation combined with rain fed agriculture allows the farmer to produce crops throughout the year.

There was a positive statistically significant relationship between farm size (FS) and FA3_1 "extra income" factor and borrowing (BRW) at 5% (P<0.05) and 1% (P<0.01) levels, respectively. The relationship between farm size and "extra income" factor and borrowing is as predicted. The larger the farm size, the more the monocropper perceives borrowing to be a risk management strategy. Small-scale farmers have limited resources and borrowing enables the farmers to purchase farm inputs and pay for labour. A positive statistically significant relationship exists between household size (HHS) and FA1_1 "production strategies" factor, investing off-farm (INVOFF) and borrowing (BRW) at 5% (P<0.05), 5% (P<0.05) and 1% (P<0.01) levels, respectively. As predicted, the larger the household size, the more the farmer perceives "production strategies", investing off-farm and borrowing as important management strategies. House type (HT) has a negative statistically significant influence on FA2_1 "marketing plan" factor and having crop insurance (HAVINS) at 5% (P<0.05) and 1% (P<0.01) levels, respectively. A positive statistically significant relationship exists between house type (HT) and selling of assets (SELAST) at 10% ($P<0.1$) level. This is as predicted, probably because farmers with modern houses are thought to be relatively wealthy and they have assets that they could sell in order to meet other family needs.

There is a positive statistically significant relationship between risk aversion (RA) and FA3_1 "extra income", *fadama* cultivation (FDMCUL) and membership of cooperative society (COOP) at 5% ($P<0.05$), 5% ($P<0.05$) and 10% ($P<0.1$) levels, respectively. This is as expected; the more risk averse the monocropper is, the more the farmer perceives extra income, *fadama* cultivation and membership of cooperative society as important management strategies. Extra income, *fadama* cultivation and membership of cooperative society are ways by which monocrop farmers can cope with risk. FAC1_1 "social" factor has a positive statistically significant relationship with FA1_1 "production strategies" factor and FA2_1 "marketing plan" at 1% ($P<0.01$) and 10% ($P<0.1$) levels, respectively. This is because of the fact that risk source related to "social" factor (loss of land/ethnic clash and theft) can lead to devastation of a farm, thus the farmer needs to apply production strategies in order to combat such sources of risk.

FAC2_1 "rainfall" factor has a positive statistically significant relationship with training and education (TRED) and having crop insurance (HAVINS) at 10% ($P<0.1$) and 1% ($P<0.01$) levels respectively. FAC2_1 "rainfall" factor has a negative statistically significant relationship with reduced consumption (RDCON) at 1% ($P<0.01$) level. Rainfall as a source of risk has a negative effect on farm output: the use of management strategies, such as training and education and having crop insurance, are perceived as the most important ways of combating rainfall as a source of risk. FAC3_1 "uncertainty" factor has a positive statistically significant influence on FA1_1 "production strategies" at 10 % ($P<0.1$), *fadama* cultivation (FDMCUL) at 5 % ($P<0.05$), membership of cooperative society (COOP) at 5 % ($P<0.05$) and selling of assets (SELAST) at 10 % ($P<0.1$) level. Production strategies", *fadama* cultivation, membership of cooperative society and selling of assets are perceived as important management strategies to combat the "uncertainty" factor. The variables associated with "uncertainty" factor are drought, changes in government policy, illness of a household member and insufficient work animals. In the event of uncertainties farmers can fall back on their assets, income from *fadama* cultivation and a cooperative society.

A positive statistically significant relationship exists between fertiliser unavailability (FER) and FA1_1 "production strategy" factor (P<0.01), fertiliser provision by government/self (FERGOV) (P<0.01), training and education (TRED) (P<0.01), investing off-farm (INVOFF) (P<0.01), having crop insurance (HAVINS) (P<0.1) and selling of assets (SELAST) (P<0.1) level. The monocropper who perceives fertiliser unavailability as a source of risk sees fertiliser provision by government/self as a more relevant management strategy. This is as expected because fertiliser is used to improve the fertility of the soil and hence improve output; unavailability of fertiliser is an important source of risk to the farmers in the study area. Training and education is perceived as a management strategy to combat unavailability of fertiliser. Farmers are trained and educated on the type of fertilisers to apply and effective methods of fertiliser application in order to obtain maximum yields. Fertiliser prices are high and thus investing off-farm (which allows farmers to earn higher incomes) and selling of assets enable farmers to purchase fertiliser.

Family relationships (FRSP) have a positive statistically significant relationship with FA2_1 "marketing plan" factor (P<0.01), FA3_1 "extra income" factor (P<0.05), fertiliser provision by government/self (FERGOV) (P<0.1), investing off-farm (INVOFF) (P<0.01), *adashe* (rotation savings) (ADSH) (P<0.01), having crop insurance (HAVINS) (P<0.1), borrowing (P<0.1), family member working off-farm (FMOFF) (P<0.1) and reduced consumption (RDCON) (P<0.01) levels. The more a farmer perceives family relationships as a risk source, the more the farmer perceives *adashe* (rotation savings) and borrowing as management strategies; this is probably because *adashe* (rotation savings) is handled between the farmer and family relatives/ friends. Farmers usually borrow from their relatives. There was a negative statistically significant relationship between family relationships (FRSP) and *fadama* cultivation (FDMCUL) at 5% (P<0.05) level. A possible reason for the negative relationship could be that farmers depend on family relatives for help in times of need.

A positive statistically significant relationship exists between market failure (MKFL) and FA3_1 "extra income" factor, and training and education (TRED) at 5% (P<0.05) and 10% (P<0.1) level respectively. This means that monocroppers perceived "extra income" factor and training and education as measures for combating market failure as a source of risk.

5.4.5 Multiple regression of intercroppers risk management strategies on their characteristics, risk attitude and risk sources

Table 5.13 below shows the multiple regression results for intercroppers' risk management strategies on their characteristics, risk attitude and risk sources. The R^2 for the multiple regression for intercroppers' risk management strategies and farmers' characteristics variables, risk attitude and risk sources range between 0.47 and 0.10. A negative statistically significant relationship exists between membership of cooperative society (COOP=1) and spreading sales (SPDSL) and fertiliser provision by government/self (FERGOV) at 5% (P<0.05) and 10% (P<0.1) level respectively. Intercroppers who belong to a cooperative society perceive spreading sales and fertiliser provision by government/self as less important risk management strategies. A possible reason why the farmers perceive fertiliser provision by government/self as less important risk management strategy is because members of the cooperative societies are given priority when fertiliser is supplied by the government through the Agricultural Development Projects. The fertiliser is given to farmers at subsidised rates.

Education (EDU) has a negative statistically significant relationship with FA1_1 "personal and government policy" factor and borrowing (BRW) at 5% (P<0.05) and 10% (P<0.1) levels, respectively. This implies that more educated intercroppers perceive "personal and government policy" factor and borrowing as less important management strategies. The "Personal and government policy" factor comprises storage programme, *adashe* (rotation savings), having crop insurance and planning expenditure. Educated farmers are likely to be more knowledgeable in planning expenditures and crop insurance.

Farming experience (EXP) has a positive statistically significant relationship with *fadama* cultivation (FDMCUL) and family member working off-farm (FMOFF) at 10% (P<0.1) and 5% (P<0.05) levels, respectively. Intercroppers have over the years perceived *fadama* cultivation and family member working off-farm as important risk management strategies. There is a positive statistically significant relationship between household size (HHS) and family member working off-farm (FMOFF). The larger the household size, the more the intercropper perceives family member working off-farm as a management strategy. This is probably because farm income alone is too small to sustain the needs of the large family size, and accordingly extra income is needed to complement farm income.

Table 5.13 Multiple regression results of intercroppers risk management strategies on their characteristics, risk attitude and risk sources, Kebbi State, January 2012

Variables	Risk Management strategies												
	FA1_1	FA2_1	FA3_1	SPDSL	FERGOV	FDMCUL	INTC	COOP	STRPR	BRW	FMOFF	SELAST	SPDISPT
(COOP=1)	0.092	-0.003	-0.039	-0.169	-0.053	0.375	-0.630	0.417	0.074	-0.085	-0.373	-0.031	-0.391
	(0.482)	(-0.015)	(-0.180)	(-	(-0.285)*	(1.443)	(-2.372)	(1.545)	(0.299)	(-0.322)	(-1.404)	(-0.114)	(-1.754)
EDU	-0.022	0.009	-0.036	-0.021	0.001	0.038	-0.036	-0.008	0.048	-0.016	-0.025	-0.008	0.009
	(-	(0.414)	(-1.653)	(-0.800)	(0.033)	(1.437)	(-1.323)	(-0.274)	(1.910)	(-	(-0.912)	(-0.274)	(0.403)
EXP	0.008	-0.006	-0.002	0.006	-0.002	0.007	-0.001	-0.005	0.011	-0.001	0.003	0.013	-0.007
	(0.802)	(-0.531)	(-0.203)	(0.470)	(-0.222)	(0.539)*	(-0.049)	(-0.353)	(0.879)	(-0.074)	(0.218)**	(0.926)	(-0.600)
(FDM=1)	0.025	-0.008	-0.179	-0.019	0.087	-0.189	0.042	0.083	0.072	-0.123	0.080	0.093	-0.034
	(0.148)	(-0.044)	(-0.932)	(-0.085)	(0.525)	(-0.818)	(0.178)	(0.348)	(0.327)	(-0.527)	(0.340)	(0.385)	(-0.171)
FS	0.247	0.260	0.006	0.093	0.333	-0.170	0.142	0.135	-0.053	0.039	-0.207	-0.048	0.323
	(2.348)	(2.314)	(0.049)	(0.654)	(3.217)	(-1.180)	(0.965)	(0.907)	(-0.390)	(0.269)	(-1.408)	(-0.318)	(2.627)
HHS	-0.016	-0.023	-0.036	-0.035	-0.004	0.032	-0.030	-0.012	0.004	0.054	0.012	-0.014	-0.044
	(-0.559)	(-0.737)	(-1.100)	(-0.881)	(-0.149)	(0.795)	(-0.729)	(-0.299)	(0.100)	(1.340)	(0.304)*	(-0.340)	(-1.288)
(HT=1)	0.297	0.047	-0.162	-0.160	-0.085	0.763	0.116	0.444	0.089	-0.159	-0.020	-0.333	-0.031
	(1.404)	(0.210)	(-0.673)	(-0.561)	(-0.409)	(2.645)	(0.392)	(1.484)**	(0.327)	(-	(-0.068)	(-1.106)	(-0.125)
KM	-0.009	-0.016	-0.028	-0.022	0.012	0.004	-0.028	0.012	-0.028	-0.030	-0.009	-0.001	-0.024
	(-0.505)	(-0.802)	(-1.340)	(-0.901)	(0.676)	(0.142)	(-1.093)	(0.448)	(-1.179)	(-1.180)	(-0.356)	(-0.027)	(-1.108)
GM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ASV	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
RA	-0.009	-0.073	-0.045	0.049	-0.036	-0.024	-0.108	-0.012	0.043	0.004	-0.059	-0.012	-0.187
	(-0.189)	(-1.406)	(-0.806)	(0.752)	(-0.752)	(-0.357)	(-1.591)	(-0.172)	(0.686)	(0.059)	(-0.867)	(-0.174)	(-3.292)
FAC1_1	0.186	0.128	0.145	-0.132	0.076	0.158	0.181	0.073	-0.086	0.112	0.296	0.088	0.395
	(1.721)*	(1.103)	(1.175)	(-0.901)	(0.710)	(1.068)	(1.198)	(0.473)	(-0.615)	(0.751)	(1.96)**	(0.570)	(3.114)*
FAC2_1	0.003	0.021	0.123	0.009	-0.020	-0.128	0.122	-0.270	-0.022	0.100	0.075	-0.131	-0.064
	(0.027)	(0.205)	(1.125)	(0.068)	(-0.208)	(-0.976)	(0.911)	(-1.990)	(-0.177)	(0.755)	(0.557)	(-0.962)	(-0.573)
FAC3_1	0.143	0.125	0.255	-0.021	0.067	0.109	0.126	0.013	0.038	0.036	0.146	-0.163	0.458
	(1.430)	(1.167)	(2.242)**	(-0.157)	(0.675)	(0.798)	(0.903)	(0.091)	(0.293)	(0.261)	(1.044)	(-1.143)	(3.908)**
FAC4_1	-0.099	0.250	0.031	0.000	-0.075	0.092	0.087	-0.143	-0.121	-0.055	0.004	0.039	0.102
	(-1.213)*	(2.86)***	(0.331)	(-0.003)	(-0.928)	(0.828)	(0.765)	(-1.237)	(-1.147)	(-0.487)	(0.037)	(0.337)	(1.065)
FAC5_1	-0.158	0.030	-0.084	-0.012	-0.071	-0.052	0.017	0.025	0.118	0.014	-0.080	0.101	-0.105
	(-1.949)*	(0.349)	(-0.904)	(-0.106)	(-0.892)	(-0.472)	(0.153)	(0.217)	(1.127)	(0.127)	(-0.703)	(0.874)	(-1.108)

Variables	Risk Management strategies												
	FA1_1	**FA2_1**	**FA3_1**	**SPDSL**	**FERGOV**	**FDMCUL**	**INTC**	**COOP**	**STRPR**	**BRW**	**FMOFF**	**SELAST**	**SPDISPT**
ERRN	-0.044	-0.032	0.084	0.229	0.073	0.018	0.239	-0.169	-0.020	0.042	0.081	0.159	0.009
	(-0.713)	(-0.480)	(1.197)*	(2.741)**	(1.201)	(0.211)	(2.771)**	(-1.924)	(-0.244)	(0.491)	(0.935)	(1.799)**	(0.127)
FLST	0.011	-0.057	-0.110	0.058	0.091	0.070	0.100	0.001	-0.002	-0.057	0.080	0.067	0.078
	(0.179)	(-0.894)	(-1.613)	(0.717)	(1.549)	(0.865)	(1.195)	(0.013)	(-0.023)	(-0.697)	(0.963)*	(0.787)	(1.112)
FROBK	0.143	-0.168	-0.074	0.026	0.126	-0.027	-0.034	0.009	0.294	-0.062	-0.321	0.021	-0.388
	(1.261)	(-1.385)	(-0.575)	(0.167)	(1.125)	(-0.171)	(-0.214)	(0.058)	(2)**	(-0.396)	(-	(0.130)	(-
DRT	0.021	0.025	0.040	-0.002	-0.031	0.003	-0.137	0.004	-0.122	-0.020	0.025	-0.095	0.076
	(0.251)	(0.2760	(0.412)	(-0.017)	(-0.372)	(0.025)	(-1.159)	(0.032)	(-1.113)	(-0.175)	(0.208)	(-0.784)	0.763
INSLAB	0.235	0.115	0.057	0.031	0.279	0.134	-0.200	0.079	-0.239	0.009	-0.048	0.033	0.330
	(2.356)**	(1.082)	(0.503)	(0.232)	(2.84)***	(0.986)	(-1.439)	(0.558)	(-1.850)	(0.066)	(-0.345)	(0.232)	(2.83)***
LCKWA	0.057	-0.160	0.098	0.172	0.037	-0.079	0.195	0.002	0.006	-0.015	-0.064	-0.027	-0.226
	(0.682)	(-1.796)	(1.036)	(1.528)	(0.448)	(-0.696)	(1.675)*	(0.014)	(0.059)	(-0.126)	(-0.551)	(-0.230)	(-2.315)*
MKFL	-0.098	0.052	0.015	0.028	0.139	0.014	-0.060	-0.128	0.148	0.132	-0.101	0.029	-0.164
	(-1.246)	(0.616)	(0.164)	(0.259)	(1.785)**	(0.126)	(-0.546)	(-1.146)	(1.454)**	(1.209)	(-0.917)	(0.262)	(-1.774)
DIS	-0.129	-0.120	-0.016	0.032	-0.074	-0.017	0.018	-0.097	0.073	0.111	-0.010	0.011	-0.062
	(-	(-1.784)*	(-0.224)	(0.381)	(-1.195)	(-0.197)	(0.202)	(-1.093)	(0.898)	(1.283)	(-0.116)	(0.122)	(-0.838)
CGPOL	0.016	0.035	0.013	-0.018	-0.032	0.020	-0.033	-0.091	0.114	0.074	0.067	0.120	0.103
	(0.244)	(0.492)	(0.164)	(-0.194)	(-0.482)	(0.222)	(-0.349)	(-0.962)	(1.318)	(0.803)	(0.714)	(1.263)	(1.313)
FER	0.083	0.225	-0.157	-0.148	0.336	-0.032	0.068	0.148	0.245	-0.192	-0.221	0.046	-0.072
	(0.92)***	(2.343)	(-1.543)	(-1.220)	(3.81)***	(-0.263)	(0.546)	(1.164)	(2.106)**	(-1.549)	(-1.764)	(0.363)	(-0.684)
R^2	**0.36**	**0.27**	**0.17**	**0.14**	**0.47**	**0.16**	**0.21**	**0.17**	**0.16**	**0.10**	**0.15**	**0.11**	**0.41**

The asterisks (***, ** and *) represents statistical significance at 1%, 5% and 10% probability levels, respectively.

Figures in parenthesis are the t-values.

House type (HT=1) has a positive statistically significant relationship with membership of cooperative society (COOP) at 5% (P<0.05) level and a negative statistically significant relationship with borrowing (BRW) at 10% (P<0.1) levels. Intercroppers who have modern houses are likely to be wealthy and thus borrowing is perceived as a less relevant risk management strategy.

FAC1_1 "rainfall" factor has a positive statistically significant relationship with FA1_1 "personal and government policy" factor, family member working off-farm (FMOFF) and spreading for diseases and pests (SPDISPT) at 10% (P<0.1), 5% (P<0.05) and 10% (P<0.1) levels, respectively. Storage programme, planning expenditure, *adashe* (rotation savings) and having crop insurance are components of the "personal and government policy" factor which the intercroppers perceived as an important management strategy to combat the risk source "rainfall" factor.

FAC4_1 "inadequate labour" factor has a negative statistically significant relationship with FA1_1 "personal and government policy" factor at 10% (P<0.1) level. The negative relationship implies that income from *adashe* is used to pay for labour in good times before the peak labour demand periods. Farmers store farm produce that they later sell to pay for labour, and thus they perceived inadequate labour as a less important management strategy. FAC4_1 "inadequate labour" factor has a positive statistically significant relationship with FA2_1 "capacity building" factor at 1% (P<0.1) level. The positive relationship arises from the fact that training and education includes knowledge about farm management and planning, thus farmers are able to plan how to utilise labour efficiently. In addition, income from investing off-farm helps farmers to pay for labour.

The FAC5_1 "uncertainties" factor has a negative statistically significant relationship with FA1_1 "personal and government policy" factor at 10% (P<0.1) level. The "uncertainties" factor comprises price fluctuation and change in climatic conditions variables. Storage programme, which is a component of "personal and government policy" factor, serves as a means of balancing the effect of price fluctuation, thus the intercroppers perceived the "uncertainties" factor as a less important management strategy. Having crop insurance is also a component of the "personal and government policy" factor which is used to combat the effect of changes in climatic conditions.

Erratic rainfall (ERRN) has a positive statistically significant relationship with FA3_1 "planning" factor ($P<0.1$), spreading sales ($P<0.05$), intercropping ($P<0.05$) and selling of assets ($P<0.05$). Intercroppers who perceive erratic rainfall as a source of risk see "planning" factor (faith, planning expenditure and reduced consumption), spreading sales, intercropping and selling of assets as important management strategies. Erratic rainfall is associated with climate change. The effect of erratic rainfall can be reduced by intercropping which helps to improve soil fertility, thus reducing the effect of erosion on the soil. In cases where erratic rainfall leads to poor harvest or crop failure, farmers sell assets to purchase food for the family and/or reduce their consumption, and also have faith in God. There was a positive statistically significant relationship between lack of work animals (LCKWA) and intercropping (INTC) at 10% ($P<0.1$) level. This means that the intercropper farmer perceives intercropping as an important risk management strategy to combat lack of work animals as a source of risk. Probably because all the weeding done on intercrop farms is done manually without the use of animal traction, only land preparation is done using work animals.

Market failure (MKFL) has a positive statistically significant relationship with fertiliser provision by government/self (FERGOV) and storage programme (STRPR), both at 5% ($P<0.05$) level. This implies that the more the intercropper perceives market failure as a source of risk, the more the farmer sees fertiliser provision by government/self and storage programme as an important management strategy. Fertiliser unavailability (FER) has a positive statistically significant relationship with FA1_1 "personal and government policy" factor, fertiliser provision by government/self (FERGOV) and storage programme (STRPR) at 1% ($P<0.01$), 5% ($P<0.05$) and 5% ($P<0.05$) levels, respectively. Gathering market information is one of the variables that constitute "personal and government policy". Fertilisers provided by government are subsidised and thus farmers perceived this as an important risk management strategy.

In comparison, it is meaningful to know that FAC1_1 "social factor" has a statistically significant relationship with FA1_1 "production strategies" for both monocroppers and intercroppers. Also, FER (fertiliser unavailability) has a statistically significant relationship with FERGOV (fertiliser provision by government/self) for both mono and intercroppers. This implies that "production strategies" and FERGOV (fertiliser provision by government/self) are important risk management strategies to the farmers. For the monocroppers there was a statistically significant relationship between risk aversion and FA3_1 "extra income, *fadama* cultivation (FDMCUL) and membership of cooperative society (COOP). Extra income, *fadama* cultivation and membership of cooperative society are ways by which monocroppers can cope with risk. For the intercroppers, there were no such relationships.

For the regression results, it is important to note that some of the R^2 values (the coefficients of determination) were low, probably because important variables were not captured and/or because farmers' perceptions on risk are personal and vary between individuals. The second alternative is in agreement with the findings of Meuwissen *et al.* (2001) and Wilson *et al.* (1993). The linear regression models assumed for the analysis might have also affected the R^2 values. Perhaps if other functional forms were used, the R^2 values could have been higher.

The next section presents the factors affecting the choice of cropping pattern for the monocroppers and intercroppers.

5.5 Factors influencing the choice of cropping systems by mono and intercrop farmers

The third objective of this study is to investigate the factors that influence the choice of cropping system in the study area. Farming is associated with risk, such as production/yield risk, price risk, institutional risk, financial risk and personal risk (Drollette, 2009; Schaffnit-Chatterjee, 2010). A relatively greater percentage of farmers in Kebbi State practice intercropping, thus utilizing diversification (KARDA, 2009). The question is, what factors influence the choice of cropping system in the study area? The factors that are thought to influence the choice of cropping systems in the study area are: farming experience, asset value, risk aversion, size of farm land and land degradation.

Table 5.14 below shows the result of the logit regression. The variables were subjected to a multicollinearity test. The result from the correlation matrix shows that there is no correlation between the regressors (see appendix D). All the correlation coefficients were less than 0.3. The VIF is less than or equal to 1.09, condition number is less than 2.2 and the condition index is less than 1.50, also indicating the absence of multicollinearity in the variables used for the logit regression. The predictive efficacy of the logistic model shows that 188 out of the 256 farmers (73.74 %) were correctly predicted.

Table 5.14 Result of Logit regression (dependent variable farm type) for respondents Kebbi State, January, 2012

Regressors	Coefficient	Standard error	Chi-square Beta = 0	Probability level
Intercept	1.4829***	0.5271	7.92	0.005
Farming experience (Years)	-4.19E-02***	0.0159	6.88	0.009
Asset value (Naira)	-1.06E-05***	2.32E-06	20.72	0.000
Risk aversion (Risk aversion coefficients)	0.4901***	0.1538	10.18	0.001
Size of farm land (Hectares)	0.1414	0.1834	0.59	0.441
Land degradation (Yes or no)	0.5049*	0.3025	2.79	0.095
R^2 (Mcfadden)	0.19			
Percent correctly classified	73.44%			

The asterisks (*** and *) represents statistical significance at 1% and 10% probability levels, respectively

Four variables (farming experience, asset value, risk aversion and land degradation) out of the five variables considered in this study were significant in influencing the probability of farmers practicing intercropping (reference group) (Table 5.14 above). Farming experience has a negative influence and reduces the probability of farmers practising intercropping. This is in line with the *a priori* expectation. Farmers with more farming experience are more likely to cope with the risk associated with monocropping; on the other hand, farmers with fewer years of faming experience may not be willing to take the risk of monocropping, probably because they are not familiar with changes in climate and seasonal price variations.

Asset value has a negative influence and reduces the probability of farmers practising intercropping. This confirms the negative sign of the hypothesis of asset value. Farmers with higher asset values are likely to manage the risk associated with monocropping better than farmers with lower asset values. Monocropping requires adequate application of fertilisers and agrochemicals (pesticides, herbicides) for good yields (Iyegha, 2000). Besides, monocropping can be associated with total crop failure in a bad year. Only farmers with high asset values can cope with or manage crop failure, adequate fertiliser and agrochemical application.

The coefficient of risk aversion is positive as hypothesized. Risk aversion enhances the practicing of intercropping. Diversification in the form of intercropping is a risk management strategy for intercrop farmers. Intercropping reduces risk from natural catastrophe and facilitates better disease control and better use of available labour (Beuerlien, 2001). Palitza (2010) has pointed out that the negative consequences of climate change can be mitigated by increasing crop diversity, which can be used to combat total crop failure.

The expected sign of the coefficient of size of farm land is hypothesized to be negative, implying that size of farm land reduces the probability of farmers practising intercropping. Large sizes of farm lands are suitable for monocropping and this encourages mechanization and gives higher total yields (Nelson, 2006, Mmom, 2009). The result from the study reveals that size of farm land has a positive non-significant influence and enhances the probability of farmers practising intercropping, which, however, is contrary to expectation. The probable reason for this is that farmers may prefer to practise intercropping even on large sizes of farm land as a means of diversification to guard against total crop and market failure in a bad year. Morteover, intercrop farmers can maintain low but often adequate and relatively steady production.

Land degradation has a positive influence and enhances the probability of farmers practising intercropping, which is in conformity with the hypothesized sign. Land degradation is the reduction of the economic productivity of arable land owing to soil erosion and desertification (Eswaran, Lal, and Reich 2001; Coxhead and Øygard, 2007). Farmers whose farm lands are degraded are more likely to practise intercropping as a means of replenishing the soil nutrients through planting of leguminous crops which are often intercropped with cereal crops.

The findings reveal that farmers practise intercropping because they are risk averse, they have low farming experience, low asset value and degraded farm lands. Intercropping as a means of diversification reduces risk in farming: intercropping system is less susceptible to pests and diseases, and some of the crop combinations used, e.g. millet, are drought tolerant and can grow in soils with low fertility. Accordingly, this system is suitable for the farmers who have low asset values and cannot afford to practise monocropping because of disadvantages associated with it. Also, the intercropping system is good for degraded soil as the legumes that are used in crop combinations fix nitrogen in the soil which enhances soil fertility, hence the system requires less fertiliser when compared to the monocropping system. Based on the risk aversion of the farmers, nature of soils and low asset values of the farmers, intercropping seems to have the potential for improving crop production in the study area.

5.6 Conclusions

The objectives of this chapter were to determine the risk attitude of farmers, the sources of risk and management strategies and the dimension of the sources of risk and management strategies. In addition, the relationships between risk attitude, farmers' explanatory variables, risk sources and risk management strategies were highlighted. Furthermore, the factors that influence the choice of cropping systems were investigated.

The results of the risk attitudes of the farmers reveal that 92% and 74% of the intercroppers and monocroppers are risk averse, respectively. There is a statistically significant difference between the risk averseness of the monocroppers and intercroppers. This implies that the intercroppers were statistically more risk averse than their counterpart monocroppers. The results of the determination of the sources of risk for both monocroppers and intercroppers reveal that diseases, erratic rainfall, changes in government and agricultural policy, and price fluctuations are the 5 most important sources of risk. The variables rainfall, difficulties in finding labour, theft, market failure, price fluctuation and family relationships were statistically significantly different between monocrop and intercrop farmers.

The main findings from the factor analysis for sources of risk for the monocroppers and intercroppers is that the factors "social", "rainfall" and "uncertainties" are common to both monocrop and intercrop farmers. Since farmers do not have control over the rainfall factor as a source of risk, there is, *inter alia*¸ a need to have an effective agricultural insurance scheme in place for the farmers in Kebbi State.

Regression analyses were carried out in order to investigate the relationships between risk attitude and farmers' characteristics, sources of risk and risk management strategies for the monocroppers and intercroppers. The results show that the variables flood/storm, "extra income" factor, fertiliser provision by government/self, training and education, *fadama* cultivation and *adashe* statistically relate positively with monocrop farmers' risk attitudes. For the intercroppers, "rainfall" factor, "difficulties" factor, fire outbreak, market failure and spraying for diseases and pests statistically relate to risk attitude. None of the potential explanatory variables is statistically related to risk attitudes for both monocroppers and intercroppers (Table 5.8 above and 5.9 above).

Regression was also conducted to explore the relationship between sources of risk and farmers' characteristics, risk attitude, and risk management strategies, for the monocroppers and intercroppers. The results reveals that the monocroppers identified the social factor and the rainfall factor as the most important sources of risk, while the intercroppers perceived the rainfall factor and difficulties as the most important sources of risk. It is meaningful to know that rainfall factor is one of the most important sources of risk for both groups of farmers. For the intercroppers, *fadama* cultivation has an inverse statistically significant relationship with changes in government policy (CGPOL) and lack of work animals (LCKWA). This implies that the intercroppers perceive these factors as less important sources of risk. Hence, *fadama* cultivation is an important way of mitigating risk. There was no such relationship for the monocroppers.

In order to determine the relationships between risk management strategies and farmers' characteristics, risk attitude, and sources of risk for the monocroppers and intercroppers, regression analyses were carried out. The results show that for both monocroppers and intercroppers, the common variables that are statistically significant are, faith, storage programme, market information and household head working off-farm. The result suggests that the storage programme and market information help farmers to obtain better prices for their farm produce since agricultural produce is associated with seasonal price variations. Household head working off-farm suggests that small-scale farmers have limited resources and so there is need to supplement farm income with extra income in order to meet family needs.

A logit regression was conducted to determine the factors that influence the choice of cropping systems by the monocroppers and intercroppers. The findings reveal that farming experience, asset value, risk aversion and land degradation influence the choice of cropping systems in the study area.

CHAPTER 6
TECHNICAL AND COST EFFICIENCY OF MONOCROP AND INTERCROP FARMERS IN KEBBI STATE

Introduction

The objective of Chapter 6 is to investigate the levels of efficiency with which the farmers use their production inputs to produce their crops. The relationships between the efficiency scores and characteristics of the farmers were explored so as to have a better understanding of the characteristics associated with higher levels of efficiency. Comparison between the technical and cost efficiency of the monocropping and the intercropping system is also discussed in order to ascertain which cropping system is the better and whether the technologies have equal efficiency. As mentioned in Chapter 4, the Principal Component extracted from the original variables that were hypothesized to influence technical efficiency was used as the explanatory or environmental variable. For the cost efficiency, the original variable hypothesized to influence cost efficiency were used. For the purpose of the Metatechnology Ratio (MTR) analysis, the technical and cost efficiency scores were estimated using the DEA model in DEAP (Data Envelopment Programme) version 2.1 and the outputs used were converted to farm income. Hence, the average efficiency scores for the bias-corrected technical efficiency and cost efficiency vary from the values obtained for the MTR analysis.

6.1 Technical efficiency and the factors influencing technical inefficiency of the monocrop and intercrop farmers in the study area

Technical efficiency of the monocrop and intercrop farmers was analysed in order to discern the level to which farmers maximise output from inputs available to them. This analysis also allowed an investigation of the explanatory variables that influence technical efficiency in order to have a better understanding of the characteristics associated with higher levels of efficiency.

6.1.1 Technical efficiency of millet/cowpea farmers in Kebbi State

Figure 6.1 below shows the results of the technical efficiency analysis of millet/cowpea farmers in the study area.

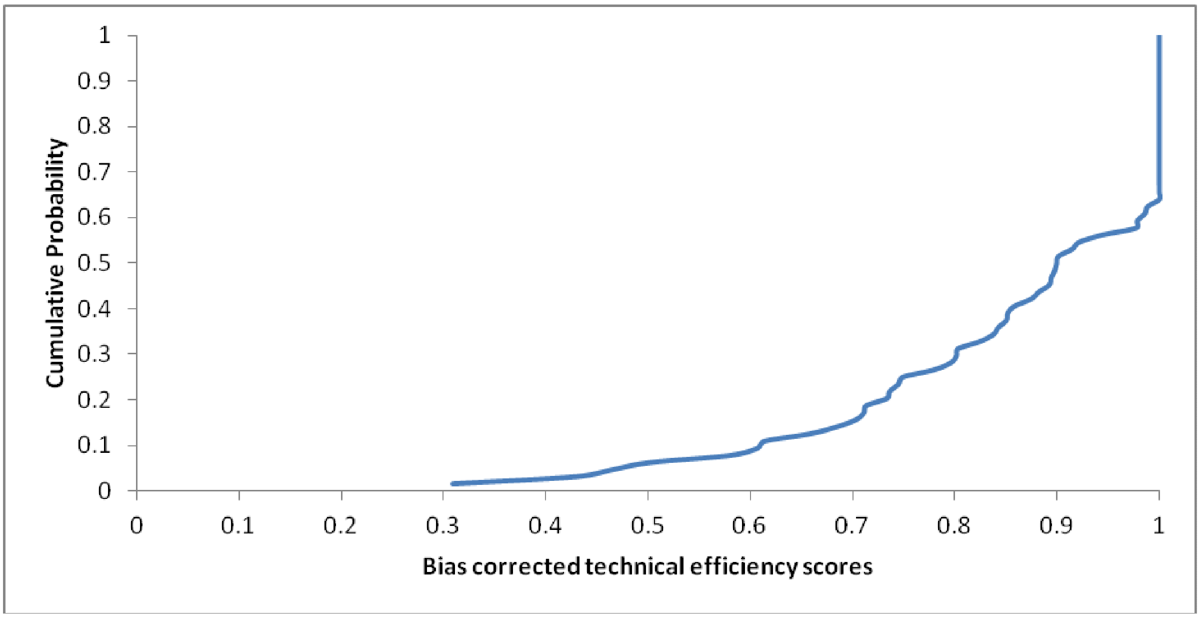

Figure 6.1 Cumulative probability distribution of the bias-corrected technical efficiency scores of the millet/cowpea farmers in Kebbi State, January 2012

The bias-corrected technical efficiency scores of the millet/cowpea farmers range from 0.31 to 1. The average technical efficiency score is 0.86. On average, farmers can expand their output by 16.28% (((1/0.86) -1)*100%) if the farmers were to attain technical efficiency of one. This implies that the farmers can increase their output by 16% by using the existing inputs better.

The result of the average bias-corrected technical efficiency score is similar to those obtained by Wilson *et al*. (2001), Yusuf and Malomo (2007) and Olson and Vu (2009). Millet/cowpea farmers with minimum bias-corrected technical efficiency scores of 0.31 can expand their output by 223% (((1/0.31) -1)* 100%) for the farmers to attain a technical efficiency of one. This shows that there is huge scope for the millet/cowpea farmers to increase their production, given the inputs available to them.

About 39% of the millet/cowpea farmers have bias-corrected technical efficiency scores of 1, which implies that only 39% of the farmers are operating on the production frontier and may be said to be technically efficient. The remaining 61% of the farmers are technically inefficient.

6.1.1.1 Determinants of technical inefficiency of millet/cowpea farmers in the study area

The summary of Eigen values of principal components to identify the number of principal components to include in the analysis of the factors influencing technical inefficiency of millet/cowpea farmers is presented in Table 6.1 below. The results reveal that 6 out of the 16 principal components have Eigen values greater than 1. The 6 principal components explain 67.11% of the variation in the explanatory variables included in the principal components. The 6 components were used in the truncated regression analysis. The summary of the factor loadings is presented in Appendix E.

Table 6.1 Eigen values of principal components for inclusion in the truncated regression analysis of the factors influencing technical inefficiency of millet/cowpea farmers in Kebbi State, January 2012

Principal	Eigenvalue	Individual percent	Cumulative percent
1	2.54	15.87	15.87
2	2.52	15.75	31.62
3	1.49	9.32	40.94
4	1.48	9.22	50.16
5	1.34	8.29	58.46
6	1.39	8.65	67.11
7	0.99	6.24	73.36
8	0.84	5.19	78.54
9	0.76	4.76	83.30
10	0.63	3.93	87.23
11	0.51	3.18	90.41
12	0.46	2.89	93.30
13	0.36	2.28	95.58
14	0.29	1.80	97.38
15	0.22	1.37	98.75
16	0.19	1.25	100.00

The results from truncated regression analysis of the bias-corrected technical inefficiency scores on the 6 principal components with Eigen values greater than 1 is presented in Table 6.2 below. The results reveal that the variation in the bias-corrected technical inefficiency scores of the millet/cowpea farmers is explained by 3 statistically significant principal components.

Table 6.2 Truncated regression results of the bias-corrected technical inefficiency scores on the six principal components (ZPC1 to ZPC6) with Eigen values greater than one, Kebbi State, January, 2012

Variables	Coefficients	Standard error	z-statistic	Probability (z)
Intercept	-0.886	0.159	-5.550	6.825
ZPC1	-0.044	0.183	-0.241	0.810
ZPC2	-0.364**	0.149	-2.433	0.018
ZPC3	-0.116	0.155	-0.747	0.458
ZPC4	-0.039	0.207	-0.193	0.848
ZPC5	0.358*	0.193	1.849	0.069
ZPC6	0.263*	0.153	1.714	0.091

** and * represent statistical significance at 5% and 10% probability levels, respectively.

Table 6.3 below show the results obtained from the regression analysis of the bias-corrected technical inefficiency scores on the respondents' characteristics that were hypothesized to influence technical efficiency of the millet/cowpea farmers. The dependent variable in the regression is the inefficiency index, i.e. the reciprocal of the technical efficiency score; hence, a negative sign of any of the coefficients means that the variable has a positive influence on the technical efficiency level of the millet/cowpea farmer.

The personal characteristics of the respondents, age and experience have statistically significant positive relationship with the technical efficiency of the millet/cowpea farmers as expected; contrary to an *a priori* expectation, education has a statistically significant negative association with technical efficiency of the respondents. Specifically, there is a positive statistically significant relationship between age and technical efficiency ($P<0.05$). The result is in line with the findings of Msuya *et al*. (2008) and Amos (2007). Farmers' experience increases with age and resource endowment, hence the increases in efficiency. In other words, older farmers are expected to be more experienced, which ultimately aids decision-making related to farming enterprise, thus resulting in higher efficiency. The result obtained for this study is not in agreement with the findings of Ajibefun *et al*. (2004), Ogundele, (2003) and Gul *et al*. (2009) who reported that age has a negative relationship with technical efficiency. The researchers argued that the older a farmer is, the less physical efforts the farmers put into farming.

Contrary to expectation, education has a negative statistically significant relationship with technical efficiency ($P<0.01$). The result is consistent with the results reported by Ogundari and Ojo (2007) and Koc *et al*. (2011). The probable reason for the inverse relationship between education and technical efficiency is that the educated millet/cowpea farmers consider farming as a secondary occupation and so they do not give proper attention to farming.

Farming experience has a positive statistically significant association with technical efficiency ($P<0.01$). This result is as hypothesised. The greater the farming experience, the more technically efficient the farmer is, because over time the farmer has acquired farm management and agronomic skills which enhance technical efficiency. This result is in consonance with the findings of Ogunniyi and Ojedokun (2012), Ogisi *et al*. (2012) and Gul *et al*. (2009).

Table 6.3 Results from the truncated regression of the bias-corrected technical inefficiency scores on its determinants for the millet/cowpea farmers, Kebbi State, January, 2012

Variable	Variable description	Coeff[1]	Std error	z-stat	Prob (z)
Personal characteristics					
Age	Age of household head, years	-0.155**	0.068	-2.267	0.028
Education	Education of the household head in years of schooling	0.302***	0.095	3.162	0.003
Farming experience	Farming experience of household head in years	-0.176**	0.066	-2.663	0.011
Risk attitude	Risk aversion coefficients	-0.086	0.074	-1.157	0.253
Household size	Number of individuals living under the same roof and eating from the same pot with the household head	-0.082	0.051	-1.597	0.117
Wealth generation					
Credit	Dummy: 1 if the household head benefitted from financial institution or 0 if otherwise	0.245**	0.109	2.2475	0.029
House type	Dummy: 1 if the farmer has a modern house and 0 if otherwise	0.099*	0.053	1.879	0.066
Asset value	The amount of assets (e.g. house, oxen, bicycle etc) valued in naira	0.100*	0.057	1.771	0.083
Traction	Dummy: 1 if the household head use animal traction or 0 if otherwise	0.086	0.052	1.662	0.103
Natural resource					
Land fragmentation	Dummy: 1 if the farmers land is fragmented into more than two plots or 0 if otherwise	-0.068	0.063	-1.085	0.283
Land degradation	Dummy: 1 if the farmer perceives his soil fertility is low and eroded or 0 if otherwise	-0.041	0.041	-1.019	0.313
Fadama	Dummy 1 if the household head is involved in *fadama* cultivation or 0 if otherwise	-0.082*	0.048	-1.732	0.09
Social capital					
Cooperative	Dummy: 1 if the household head belong to any farmers organisation or 0 if otherwise	-0.070*	0.036	-1.938	0.059
Human capital					
Extension	Dummy: 1 if the farmer had a contact with an extension agent, 0 if otherwise	-0.243**	0.109	-2.211	0.032
Other characteristics					
Kilometre	Distance travelled by the farmer from house to farm	0.026	0.045	0.575	0.568
Market	Dummy: 1 if the farmer has access to market or 0 if otherwise	0.069	0.115	0.602	0.55

Note[1] The dependent variable is the inefficiency index, i.e the reciprocal of the technical efficiency (TE) score; hence a negative sign of the coefficients means that the variable has a positive influence on the TE level of the millet/cowpea farmer. ***, ** and * represents statistical significance at 1%, 5% and 10% probability levels, respectively.

Credit, house type and asset values have a negative statistically significant association with technical efficiency of the millet/cowpea farmers. These variables are grouped as wealth generation characteristics. Agricultural credit has a negative statistically significant effect on technical efficiency of the millet/cowpea farmers ($P<0.05$). The result is opposite to the *a priori* expectation. This result implies that access to agricultural credit decreases the technical efficiency of the farmers. A similar result was reported by Baruwa and Oke (2012). The probable reason is that the farmers divert the credit for other purposes (for example, marrying more wives, funeral ceremonies or naming ceremonies, or for investment off-farm (Mejeha, 2005; Nwosu *et al.*, 2010; Oboh and Ekpebu, 2011; Baruwa and Oke, 2012).

House type and asset value have an inverse statistically significant relationship with technical efficiency ($P<0.1$). This result is not as expected. The probable reason for the negative relationship between house type and technical efficiency is that millet/cowpea farmers with modern houses that are thought to be wealthy and do not invest their resources into the farming enterprise because of the risk in farming, hence resulting in low efficiency. The most likely reason why asset value has an inverse association with technical efficiency is that farmers with more assets tend to invest in off-farm businesses.

The results suggest that the farmers who are thought to be wealthy in the study area do not invest much of their resources in farming, hence their wealth has negative influence on their efficiency. These farmers are likely to be technically less efficient.

Among the natural resource capital, land degradation, fragmentation and *fadama* elements, only *fadama* has a statistically significant relationship with the technical efficiency of the millet/cowpea farmers. Access to *fadama* has a positive statistically significant relationship with technical efficiency ($P<0.1$). This is in line with the hypothesis of access to *fadama* and technical efficiency for this study. *Fadama* cultivation is a form of enterprise diversification which allows farmers to generate extra income that can be used to finance other farm enterprises, such as the millet/cowpea, thus improving farm efficiency.

Social capital (cooperative) has a positive statistically significant relationship with technical efficiency, as hypothesized: membership of a cooperative society has a positive statistically significant relationship with technical efficiency ($P<0.1$). Membership of a cooperative society gives farmers better access to loans (Oboh and Ekpebu, 2011), to farm inputs, and to farm management training on how to improve agronomic practices, thus improving efficiency. Similar results were reported by Obare *et al*. (2010) and Nyagaka *et al*. (2010).

Access to agricultural extension as a human capital development variable has a positive statistically significant influence on technical efficiency ($P<0.05$). The positive relationship between access to agricultural extension and technical efficiency is in accordance with the initial hypothesis. The result is similar to results reported by Kamruzzaman and Hedayetul Islam (2008), Solís *et al*. (2009), Nyagaka *et al*. (2010) and Akinbode *et al*. (2011). Farmers who have access to agricultural extension acquire better skills and knowledge over time from the extension agents. The skills help them to improve on their farm management practices that can enhance efficiency.

The millet/cowpea farmers are relatively efficient, although there is opportunity for improving efficiency. Personal characteristics (age, and farming experience) were found to have a positive statistically significant relationship with technical efficiency. Wealth generation characteristics (credit, house type and asset value) have an inverse association with technical efficiency. The result implies that the farmers who are thought to be wealthy in the study area do not invest much in agriculture, probably because of the risk involved agriculture. Social and human capital development (cooperative societies and extension) have direct relationships with the technical efficiency of the millet/cowpea farmers. Policies to improve extension services and cooperative societies should be enhanced.

6.1.2 Technical efficiency of the sorghum/cowpea farmers in the study area

The technical efficiency results for the sorghum/cowpea farmers in Kebbi State are shown in Figure 6.2 below. The minimum and maximum bias-corrected technical efficiency score is 0.31 and 1 respectively.

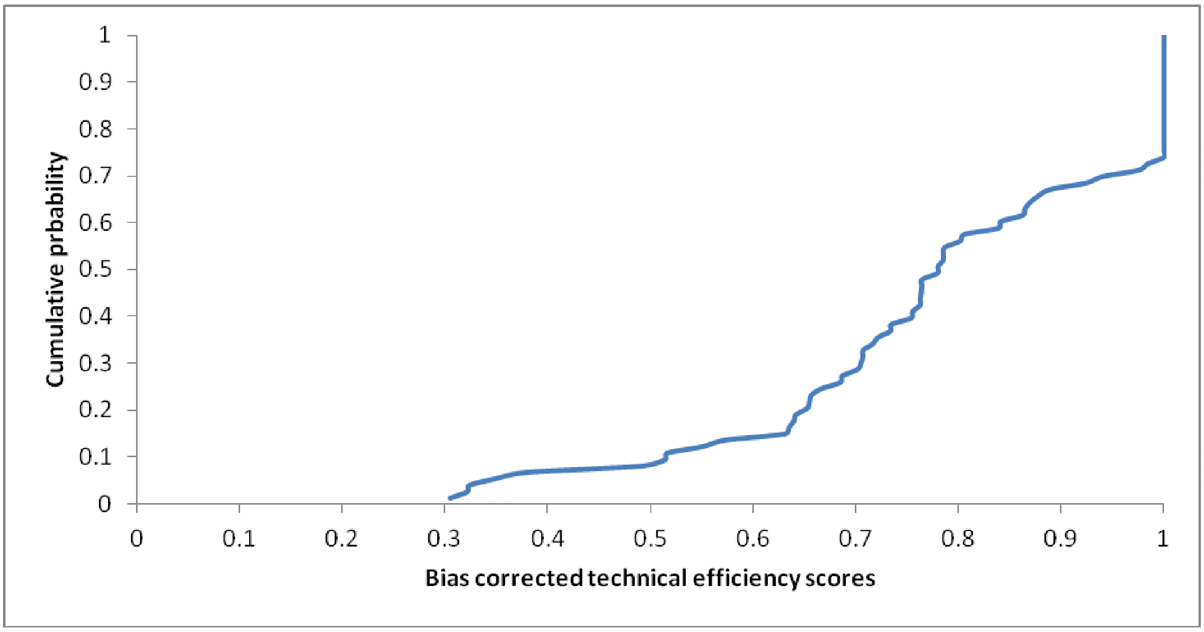

Figure 6.2 Cumulative probability distribution of the bias-corrected technical efficiency scores of the sorghum/cowpea farmers in Kebbi State, January 2012

The average bias-corrected technical efficiency score is 0.79. About 27% of the sorghum/cowpea farmers have bias-corrected technical efficiency scores of 1. This implies that only about 27% of the sorghum/cowpea farmers are technically efficient and are said to be operating on the production frontier. The remaining 73% have bias-corrected technical efficiency scores less than 1, thus they are technically inefficient, and could increase production with current input and technology set.

On average, the farmers' output could be expanded by 27% (((1/0.79) -1)* 100%) if the farmers were to increase their technical efficiency score to 1. The farmers with minimum efficiency scores of 0.31 could expand their output by 223% (((1/0.31) -1)* 100%) if the farmers were to increase their technical efficiency level to 1. Thus, there is scope to increase technical efficiency levels of the sorghum/cowpea farmers, and hence their ability to increase output levels.

6.1.2.1 Determinants of the technical inefficiency of sorghum/cowpea farmers in Kebbi State

None of the variables included in the model have a statistically significant influence on the technical efficiency of the sorghum/cowpea farmers. However, it is important to note that the fact that the variables were not significant does not mean that the variables are not important. It only means that the variables could not adequately explain the variation in the efficiency levels of the sorghum/cowpea farmers. This implies that there is inadequate knowledge on the factors that influence technical efficiency. Therefore, there is a need to investigate other dynamics that influence technical efficiency.

6.1.3 Technical efficiency of sorghum farmers in Kebbi State

The bias-corrected technical efficiency scores of the sorghum farmers range from 0.25 to 1, as revealed in Figure 6.3 below.

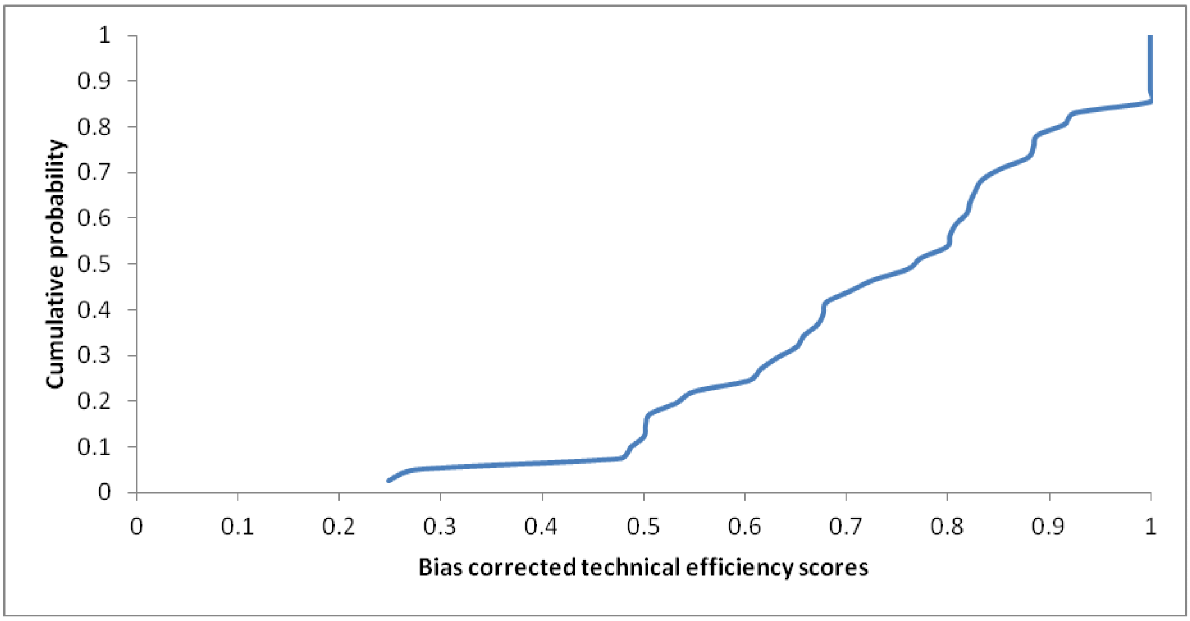

Figure 6.3 Cumulative probability distribution of the bias-corrected technical efficiency scores of the sorghum farmers in Kebbi State, January 2012

The average bias-corrected technical efficiency score is 0.75. On average, the farmers could expand output by 33% (((1/0.75) -1)* 100%) if they were to increase their efficiency level to 1. About 19% of the sorghum farmers attained technical efficiency scores of 1 and they are said to be technically efficient. A farmer with minimum bias-corrected technical efficiency score could expand output by 300% (((1/0.25)-1)*100%) if he or she were to increase technical efficiency score by 1. This implies that there is abundant scope to increase the technical efficiency levels of the sorghum farmers, which will lead to increased output.

6.1.3.1 Determinants of technical inefficiency of sorghum farmers in Kebbi State

The environmental variables z_i are the ZPCs (Principal components) obtained from the principal component regression. The summary of the Eigen values of the principal component of the variables initially hypothesized to influence the technical inefficiency of the sorghum farmers are shown in Table 6.4 below. The summary of the factor loadings is presented in Appendix F. Six out of the sixteen principal components have Eigen value greater than one. The six principal components explain 70.03% of the variation in the explanatory variables included in the principal component analysis. The six components were used in the truncated regression analysis.

Table 6.4 Eigen values of principal components for inclusion in the truncated regression analysis of the factors influencing technical inefficiency of sorghum farmers in Kebbi State, January 2012

Principal	Eigen value	Individual percent	Cumulative percent
1	2.69	16.80	16.80
2	1.91	11.94	28.75
3	1.94	12.09	40.84
4	1.87	11.69	52.53
5	1.36	8.49	61.02
6	1.44	9.01	70.03
7	0.88	5.47	75.50
8	0.82	5.15	80.65
9	0.76	4.75	85.40
10	0.58	3.60	89.00
11	0.52	3.25	92.26
12	0.44	2.77	95.02
13	0.27	1.69	96.72
14	0.23	1.46	98.18
15	0.20	1.28	99.46
16	0.09	0.54	100.00

Table 6.5 below reveals the results of the truncated regression analysis. The results show that the variation in the bias-corrected technical inefficiency scores of the sorghum farmers in Kebbi State is explained by 4 significant principal components.

Table 6.5 Truncated regression results of the bias-corrected technical inefficiency scores on the six principal components (ZPC1 to ZPC6) with Eigen values greater than one, Kebbi State, January, 2012

Variable	Coefficient	Standard error	z-statistic	Probability (z)
Intercept	-1.052	0.177	-5.950	6.664
ZPC1	-0.066	0.094	-0.703	0.486
ZPC2	0.157	0.139	1.127	0.267
ZPC3	0.172*	0.103	1.681	0.101
ZPC4	0.171*	0.099	1.717	0.094
ZPC5	-0.209*	0.118	-1.774	0.084
ZPC6	0.189**	0.073	2.587	0.014

** and * represent statistical significance at 5% and 10% probability levels, respectively.

Table 6.6 below reveals the results obtained from the regression analysis of the bias-corrected technical inefficiency scores on the explanatory variables that were hypothesized to influence technical efficiency of the sorghum farmers.

The personal characteristics of the respondents (age, education, risk aversion and household size) were hypothesized to have positive associations with technical efficiency. All the variables conform to the *a priori* expectations, except age.

Contrary to expectation, there is an inverse statistically significant relationship between age and the technical efficiency of the sorghum farmers ($P<0.01$) as shown in Table 6.6 below. The result is consistent with that reported by Ajibefun and Abdulkari (2004); Ajibefun *et al*. (2006); Ogundele, (2003) and Otitoju and Arene (2010). The probable reason for the inverse association between age and technical efficiency is that, as the farmer becomes older, the physical energy he or she puts into the farm declines, and furthermore, older farmers are slow or conservative in the adoption of innovation that might enhance technical efficiency.

There is a positive statistically significant relationship between education and technical efficiency of the sorghum farmers ($P<0.1$). This is as expected, the more educated the farmer is, the more the farmer has access to information and the more willing the farmer is to adopt innovations. Educated farmers are also better in terms of planning and managerial skills, hence they are more efficient. The result is in agreement with the findings of various researchers who also reported positive relationships between education and technical efficiency (Abdulai and Eberlin 2001; Adeoti, 2002; Solís *et al*., 2009; Kyei *et al*., 2011; Ogisi *et al*., 2012 and Jordaan, 2012).

As expected, there is a positive significant relationship between risk attitude and technical efficiency ($P<0.05$). This result is in agreement with the findings of Dhungana *et al*. (2004). Risk-averse farmers are more likely to be technically efficient, which, according to Dhungana *et al*. (2004), could be attributed to their tendency to allocate resources under their discretion more optimally. The risk-averse farmers are more careful in the use of their resources and they tend to avoid risk by choosing the correct input. Technical efficiency may be related to farmers' perceptions of production uncertainty (Dhungana *et al*., 2004).

Table 6.6 Results from the truncated regression of the bias-corrected technical inefficiency scores on its determinants for the sorghum farmers, Kebbi State, January, 2012

Variable	Description	Coeff	Std error	z-stat	Prob(z)
Personal characteristics					
Age	Age of household head, years	0.114***	0.026	4.467	0.001
Education	Education of the household head in years of schooling	-0.109*	0.061	-1.786	0.086
Farming experience	Farming experience of household head in years	0.05	0.033	1.54	0.136
Risk attitude	Risk aversion coefficients	-0.055**	0.024	-2.314	0.029
Household size	Number of individuals living under the same roof and eating from the same pot with the household head	-0.063***	0.019	-3.233	0.003
Wealth generation characteristics					
Credit	Dummy: 1 if the household head benefitted from financial institution or 0 if otherwise	-0.099**	0.039	-2.47	0.021
House type	Dummy: 1 if the farmer has a modern house and 0 if otherwise	-0.104***	0.024	-4.395	0
Asset value	The amount of assets (e.g. house, oxen, bicycle etc) valued in naira	0.060*	0.036	1.691	0.103
Traction	Dummy: 1 if the household head use animal traction or 0 if otherwise	-0.005	0.039	-0.139	0.89
Natural resource capital					
Land fragmentation	Dummy: 1 if the farmers land is fragmented into more than two plots or 0 if otherwise	0.019	0.045	0.439	0.664
Land degradation	Dummy: 1 if the farmer perceives his soil fertility is low and eroded or 0 if otherwise	0.149***	0.055	2.751	0.011
Fadama	Dummy: 1 if the household head is involved in *fadama* cultivation or 0 if otherwise	-0.086**	0.04	-2.095	0.046
Social capital					
Cooperative	Dummy: 1 if the household head belong to any farmers organisation or 0 if otherwise	0.03	0.068	0.446	0.659
Human capital development					
Extension	Dummy: 1 if the farmer had a contact with an extension agent, 0 if otherwise	0.046*	0.025	1.821	0.081
Other characteristics					
Kilometre	Distance travelled by the farmer from house to farm	0.009	0.041	0.214	0.832
Market	Dummy: 1 if the farmer has access to market or 0 if otherwise	-0.062	0.067	-0.919	0.366

The dependent variable is the inefficiency index, i.e the reciprocal of the technical efficiency score, hence a negative sign of the coefficients means that the variable has a positive influence on the technical efficiency level of the sorghum farmer.
***, ** and * represent statistical significance at 1%, 5% and 10% probability levels, respectively.

The positive statistically significant relationship between household size and technical efficiency ($P<0.01$) is in line with the initial hypothesis. Large household sizes where members contribute to family labour are likely to improve the technical efficiency of the farm. The result is consistent with the findings of a number of researchers who have reported positive associations between household size and technical efficiency (Abdulai and Eberlin, 2001; Haji, 2007; Amos, 2007; Douglas, 2008; Maseatile, 2011; Kyei *et al*., 2011).

Credit, house type and asset value were grouped as wealth generation characteristics and these variables were hypothesized to have a positive association with the technical efficiency of the sorghum farmers. The results of the variables credit and house type are as hypothesized: wealthy farmers are expected to be more technically efficient than the less wealthy farmers, because the farmers who are thought to be wealthy can afford to apply inputs at the recommended rates and in good time.

As expected, access to credit has a positive statistically significant relationship with technical efficiency ($P<0.05$). Access to credit enables farmers to purchase adequate farm inputs timely, thus improving their efficiency. Tanko and Jirgi (2008), Nyagaka *et al*. (2010) and Jordaan (2012) reported similar results.

As hypothesized, there is a positive significant relationship between house type and technical efficiency ($P<0.01$). Sorghum farmers who have modern houses are thought to be wealthy and so they can afford to purchase adequate farm inputs and pay for labour, thus enhancing technical efficiency.

Asset value has an indirect association with the technical efficiency of the sorghum farmers, which result is not consistent with the initial hypothesis of this study. Asset value has a statistically significant inverse influence on technical efficiency ($P<0.1$). The possible reason for the inverse relationship between asset value and technical efficiency is that farmers who have higher asset values invest in ventures other than sorghum production. Hence, the effect of asset value does not reflect on the technical efficiency of sorghum enterprise.

There is an inverse relationship between the human capital development variable (access to agricultural extension) and technical efficiency ($P<0.1$). This result is not as expected. The reason for the inverse association could be that the extension services are not targeted to the right farmers. Another possible reason could be that the farmers are not applying the training they receive from the extension agents, or the farmers lack adequate resources to apply the training properly. Similar result was reported by Haji (2007). This shows that the provision of extension services without providing the farmers with inputs (such as fertiliser subsidies and seed) may not yield adequate results. Thus, extension services must be complemented with the provision of adequate inputs at prices that are affordable to the farmers.

The natural resource capital (and degradation and *fadama*) were expected to have negative and positive relationships with technical efficiency, respectively. Land degradation has an inverse significant relationship with technical efficiency ($P<0.01$). This result is as hypothesised. Land degradation leads to low soil fertility and accordingly decreases efficiency. This result is consistent with the findings of Wadud and White (2000).

As hypothesized, the natural resource capital (*fadama* cultivation) has a positive significant relationship with technical efficiency ($P<0.05$). Farmers who cultivate *fadama* obtain extra income from *fadama* enterprise which is used to complement other enterprises (such as sorghum), hence improving efficiency in sorghum production.

6.1.4 Conclusions

In conclusion, both the sorghum/cowpea and millet/cowpea farmers were relatively efficient. Twenty-seven per cent of the sorghum/cowpea farmers operated at the production frontier. Sorghum farmers were also relatively efficient: 19 % of the farmers maximised their inputs to produce on the production frontier. The results for the sorghum/cowpea and millet/cowpea and sorghum farmers suggest that there is scope for expanding output using the existing technology**.** The results of the determinants of technical efficiency of the sorghum farmers reveal that personal characteristics (education, risk aversion and household size) have a direct relationship with technical efficiency. For the millet/cowpea farmers, personal characteristics (age, education and experience) influence technical efficiency. Wealth generation characteristics (credit and house type) have a direct association with technical efficiency of the sorghum farmers. There is an indirect association between the wealth generation characteristics of the farmers, specifically, credit, house type and asset value have negative relationships with technical efficiency. This suggests that the millet/cowpea farmers do not invest much of their wealth in farming. The results suggest that more sorghum farmers invest their wealth in agriculture compared to the sorghum/cowpea farmers. Asset value has an inverse association with the technical efficiency of the sorghum farmers. The natural resource capital (*fadama* cultivation) has positive relationship with technical efficiency of the farmers. The natural resource capital (land degradation) has negative relationship with technical efficiency of the farmers. The result implies that an increase in fadama cultivation will enhance technical efficiency. Policies geared towards improving wealth generation characteristics and natural resource capital (*fadama*) should be enhanced. Specifically, *fadama* users should be encouraged by providing them with irrigation pumps and improved technology. Deliberate efforts should be made by individuals and the State government to mitigate land degradation by intercropping and afforestation.

6.1.5 Comparison between the technical efficiency of the monocroppers and intercroppers metatechnology ratio (MTR), in Kebbi State

The comparison between the metatechnology ratios of the technical efficiency of monocroppers and intercroppers was carried out for the purpose of comparing the technical efficiency for the different groups of cropping systems in Kebbi State; the results are presented in Table 6.7 below.

For metatechnology ratio (MTR), a higher value implies a smaller technology gap between the group frontier and the metafrontier. A value of 100% is equivalent to a point where the group frontier is equal to the metafrontier.

The results for the sorghum, sorghum/cowpea, and millet/cowpea groups show that, on average, sorghum farmers produce output under conditions that are more restrictive than the sorghum and millet/cowpea groups. The average (MTR) for sorghum group (0.79) implies that the sorghum group could at best produce 79 % of the output that could be produced using the (unrestricted) metatechnology. The sorghum group has 0.79 MTR compared to the sorghum/cowpea and millet/cowpea groups who have MTRs of 0.87 and 0.89, respectively. The high value of the MTR for the millet/cowpea group suggests that the group is closest to the metafrontier. Sorghum farmers can borrow technology from millet/cowpea and/or sorghum/cowpea group.

Table 6.7 Data Envelopment Analysis estimates of technical efficiency and metatechnology ratios of the monocroppers and intercroppers, Kebbi State, January 2012

Enterprise group	Mean	SD	Minimum	Maximum
Technical efficiency with respect to the (DEA-h) group frontiers				
Sorghum	0.59	0.18	0.27	1
Sorghum/cowpea	0.52	0.17	0.18	1
Millet/cowpea	0.7	0.19	0.31	1
Metatechnology ratio (DEA-MTR)				
Sorghum	0.79	0.13	0.55	1
Sorghum/cowpea	0.87	0.08	0.66	1
Millet/cowpea	0.89	0.07	0.66	1
Technical efficiency with respect to the metafrontier (DEA-MF)				
Sorghum	0.46	0.16	0.21	1
Sorghum/cowpea	0.45	0.14	0.15	1
Millet/cowpea	0.62	0.16	0.28	1

DEA-h: Deta Envelopment Analysis for group, DEA-MTR: Data Envelopment Analysis for Metatechnology Ratio and DEA-MF: Data Envelopment Analysis for Metafrontier.

The high value of the MTR for the millet/cowpea group could arise from the fact that millet/cowpea cropping system (intercropping) under a small-holder setting is often superior to monocropping, because the former lends itself to better disease control, better use of available labour, reduced risk from natural calamities and better monetary income than monocropping (Beuerlien, 2001; Banik and Sharma, 2009). Palitza (2010) has pointed out that the negative consequences of climate change can be addressed by increasing crop diversity (and a move away from monocropping) to diminish the risk of crop failure through intercropping. These advantages of the millet/cowpea intercropping system could have contributed to the high efficiency

The relatively low average MTR for the sorghum group could be because the cropping system is associated with soil depletion and erosion, plant disease epidemics of enhanced severity, increased use of pesticides and nutrients, and vulnerability to climate change (Saleem, Shah, Malik & Munir, 2000; Nelson 2006; Iyegha, 2000). These disadvantages of monocropping could have contributed to the lower technical efficiency of the sorghum group.

The variation in the DEA metafrontiers (DEA-MF) of the three groups of cropping system suggests that there is a scope for increasing the technical efficiency in the cropping systems in Kebbi State. The maximum values of 1 for the DEA-MF show that there must have been at least one DMU that used an input-output combination that placed it at the point of tangency between their group frontier and the metafrontier[3].

Comparison of efficiency across different cropping systems is intended to ascertain the relevance of catching-up, i.e. of productivity gains attainable by increasing technical efficiency (Battese *et al*., 2004, O'Donnell *et al*., 2008, Moreira and Bravo-Ureta 2010). The result from this study reveals that the sorghum and sorghum/cowpea groups can improve their technology by learning from the prevailing agricultural practices of the millet/cowpea group who are operating close to the metafrontier.

6.1.6 Comparison of the DEA technical efficiency metafrontier (MF) scores of the monocroppers and intercroppers using Wilcoxon Rank-Sum Test

Table 6.8 below presents the Wilcoxon Rank-Sum Test for the differences between the metafrontier scores of the sorghum and sorghum/cowpea farmers.

[3] Since the metafrontier and group frontiers are formed as the intersection of several hyperplanes, there is at least one DMU in the groups who operated at a point where the hyperplane of their group frontier touched a hyperplane of the metafrontier (O'Donnell *et al*., 2008).

Table 6.8 Wilcoxon Rank-Sum Test for the differences between the technical efficiency metafrontier scores of the sorghum and sorghum/cowpea farmers, Kebbi State, January 2012

Enterprise		Ranks		
	Count	**Wilcoxon sum rank**	**Mean of Wilcoxon**	**STD DEV of Wilcoxon**
Sorghum MF	42	2553	2436	172
Sorghum/cowpea MF	73	4117	4234	172
Ties	13			
Z	0.68			
P value	0.49			

The Wilcoxon Rank-Sum Test, which was used to test for the differences between technical efficiency metafrontier scores of the sorghum and sorghum/cowpea farmers, is not significant. The result shows that there is no statistical significant difference between sorghum and sorghum/cowpea farmers' technical efficiency metafrontier scores. Based on the average technical efficiency metafrontier scores of the sorghum (0.46) and sorghum/cowpea (0.45) farmers (Table 6.7 above), the sorghum farmers have the same efficiency in the utilisation of farm inputs as their counterpart sorghum/cowpea farmers. However, the results suggest that there is opportunity for both groups of farmers to improve their technical efficiencies.

Table 6.9 Wilcoxon Rank-Sum Test for the differences between the technical efficiency metafrontier scores of the sorghum and millet/cowpea farmers, Kebbi State, January 2012

Enterprise	Ranks			
	Count	Wilcoxon sum rank	Mean of Wilcoxon	STD DEV of Wilcoxon
Sorghum MF	42	1526	2268	157
Millet/cowpea MF	65	4252	3510	157
Ties	7			
Z	-4.73			
P value	0.00			

The results in Table 6.9 above show that the technical efficiency metafrontier scores for sorghum (monocrop) and millet/cowpea (intercrop) is significant: Z = -4.73, P<0.01. This indicates that there is a statistically significant difference between the technical efficiency metafrontier scores for sorghum (monocrop) and the counterpart millet/cowpea (intercrop). The two groups have different technical efficiency metafrontier scores. The mean technical efficiency metafrontier scores for the sorghum and millet/cowpea is 0.46 and 0.62, respectively (Table 6.7 above). The results suggest that the millet/cowpea farmers are better in terms of resource utilisation than their counterpart sorghum farmers. The possible reason why the millet/cowpea farmer is better in terms of technical efficiency is that the intercrop requires less fertiliser because cowpeas fix nitrogen into the soil and the crops are less exposed to infestation of pests and disease (Beuerlien, 2001; Banik and Sharma, 2009). Particularly, millet is drought tolerant and suffers less from pests and diseases than sorghum, maize and wheat NRC (1996), de Rouw (2004) and de Rouw and Winkel (1998).

6.2 Results of cost efficiency of monocrop and intercrop farmers in Kebbi State

6.2.1 Cost efficiency of the sorghum/cowpea farmers in Kebbi State

Estimated cost efficiency scores of the sorghum/cowpea farmers in Kebbi State is presented in Figure 6.4 below. The results reveal that the cost efficiency levels of the sorghum/cowpea farmers range from 0.27 to 1, with an average of 0.52. The cost efficiency score of 0.27 for the farmer who performed the worst in terms of cost efficiency implies that the farmer could have produced his sorghum/cowpea at only 27% of his current cost. The results show that farmers could improve their financial performance if given the necessary support to use production inputs in a cost effective way. About 8% of the sorghum/cowpea farmers achieved a cost efficiency of 1, meaning that these farmers produce their output at minimum costs, i.e. the farmers are cost efficient. The remaining 92% of the farmers are cost inefficient. These farmers could have produced their output at lower costs by selecting a cost-minimising combination of farm inputs.

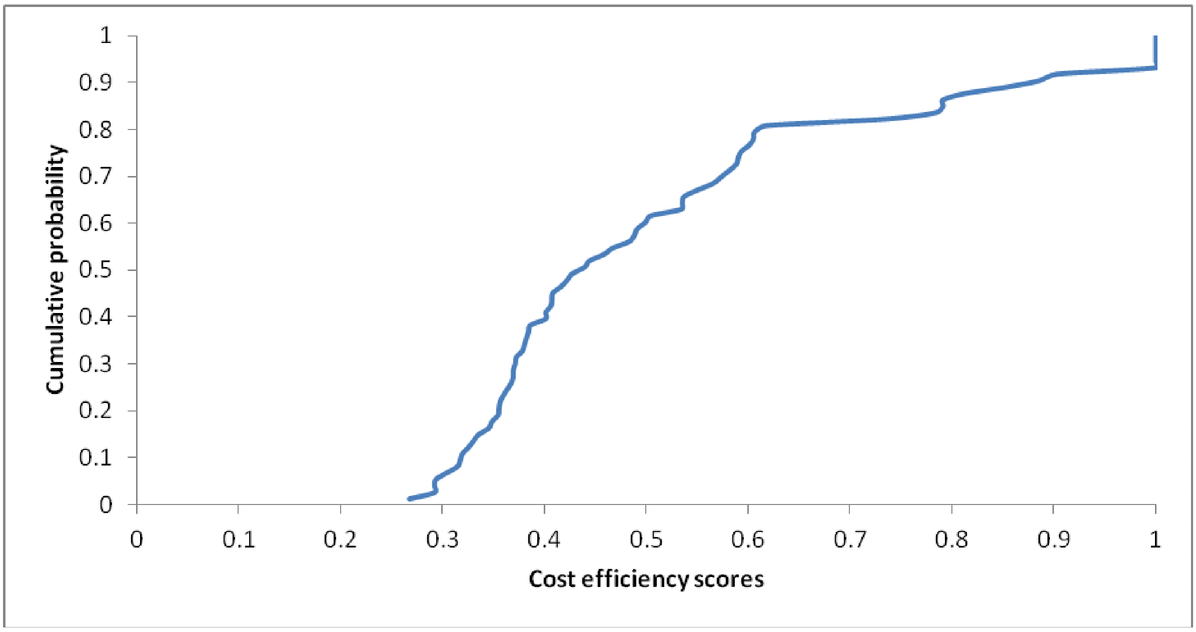

Figure 6.4 Cumulative probability distribution of the cost efficiency scores of the sorghum/cowpea farmers in Kebbi State, January 2012

6.2.1.1 Determinants of cost efficiency of sorghum/cowpea farmers in Kebbi State

OLS regression was used to identify factors explaining the differences in cost efficiencies between farmers. Based on the recommendation of McDonald (2009), the dependent variable, i.e. cost efficiency, was logged. It is important to keep in mind that since the aim is not to predict the cost efficiency of farmers, but rather to identify the explanatory variables that are likely to influence cost efficiency levels, a probability of 15% is still considered acceptable (Jordaan, 2012; Van Der Merwe, 2012). The OLS regression results are presented in Table 6.10 below.

The R^2 value for the regression is 0.35, implying the independent variables included in the model explain 35% of the variation in the cost efficiency levels of the sorghum/cowpea farmers. The multicollinearity test results show that the variance inflation factor for the entire farm enterprises considered is less than 4. The condition number is also less than 100. Hence, multicollinearity is not a problem in the regression models estimated. The model meets the assumptions of the OLS regression.

Table 6.10 Ordinary Least Squares (OLS) regressions results of the explanatory variables affecting cost efficiency of sorghum/cowpea farmers

Variable		Coefficient	Std Error	t-stat	Prob
Intercept		-0.946	0.283	-3.339	0.001
Personal	**Variable description**				
Education	Education of the household head in years of schooling	0.003	0.011	0.235	0.815
Experience	Farming experience of household head in years	0.021**	0.009	2.358	0.022
Age	Age of household head, years	0.015*	0.008	1.775	0.081
Risk attitude	Risk aversion coefficients (standardised)	-0.044	0.044	-1.015	0.314
Wealth generation					
Credit	Dummy 1: if the household head benefitted from financial	-0.259*	0.131	-1.965	0.054
Asset value	The amount of assets (e.g. house, oxen, bicycle etc)	-1.99E-0	6.54E-07	-0.304	0.762
Human capital					
Extension	Dummy 1: if the farmer had a contact with an extension	0.075	0.098	0.775	0.441
Natural resource					
Fadama	Dummy 1 if: the household head is involved in *fadama*	0.024	0.094	0.248	0.805
Land Fragmentatio	Dummy: 1 if the farmers land is fragmented into more than	-1.643***	0.632	-2.60	0.001
Social					
Cooperatives	Dummy 1 if: the household head belong to any farmers	-0.127	0.121	-1.046	0.299
R-squared		0.35			
Prob(F-		2.85			

The asterisks ***, **and * represent statistical significance at 1%, 5% and 10% probability levels, respectively.

The personal characteristics of the respondents (experience and age) were hypothesized to have a direct relationship with cost efficiency. The results show that experience has a positive statistically significant relationship with cost efficiency (P<0.05). The positive relationship between experience and cost efficiency is in accordance with the *a priori* expectation. Farmers who are more experienced are better in terms of planning, managerial ability, adoption of innovation, hence more efficient in terms production efficiency (Anyanwu, 2011; Doss and Morris, 2001). The result is consistent with the findings of Okoye *et al*. (2006) and Jordaan, (2012) who also reported positive relationships between experience and cost efficiency.

As hypothesized, age has a positive statistically significant relationship with the cost efficiency of the sorghum/cowpea farmers (P<0.1). Age goes with the farming experience of a farmer: older farmers are likely to be more experienced in the choice of input at minimum cost, and hence they are more cost efficient (Khan and Saeed, 2011).

There is an inverse relationship between wealth generation characteristics (access to agricultural credit) and cost efficiency (P<0.1). The negative influence of access to agricultural credit on cost efficiency is opposite to the hypothesis. The reason for the inverse association could be either that the farmers are not getting adequate amounts for loans or the loans are diverted to off-farm activities (Mejeha, 2005; Nwosu *et al*., 2010; Oboh and Ekpebu, 2011). Similar results were reported by Okoye *et al*., 2006; Mbanasor and Kalu, 2008; Obare *et al*., 2010; Khan and Saeed, 2011).

On average, the cost efficiency of sorghum/cowpea farmers is relatively low. The farmers could have produced their output at lower costs by selecting the cost minimising combination of farm inputs. The results of the OLS regression reveal that human capital (experience) has a positive statistically significant relationship with cost efficiency. Age also has positive association with cost efficiency. Agricultural programmes should focus on training and education of young farmers who are inexperienced in the farming enterprise. Natural resource capital (land fragmentation) has a negative statistically significant association with cost efficiency (P<0.01). The possible reason could be that land fragmentation increases production costs, causes an increase in travelling time between land parcels which is an impediment to efficiency in crop production. This corroborated the findings of Bizimana *et al* (2004) who reported that land fragmentation measured in terms of number of arable plots cultivated is negatively and significantly related with economic efficiency among farmers in Southern Rwanda.

The fact that the R-squared value of the OLS model is relatively low indicates that some important variables were not included in the analysis.

6.2.2 Cost efficiency for millet/cowpea farmers in Kebbi State

Estimated cost efficiency scores of the millet/cowpea farmers in Kebbi State are presented in Figure 6.5 below. The minimum and maximum cost efficiency levels of the millet/cowpea farmers are 0.42 and 1, respectively. The average cost efficiency is 0.73, implying that the average farmer could have produced his millet/cowpea at 73% of his or her current cost. The cost efficiency score of 0.42 of the farmer who performed worst in terms of cost efficiency implies that the farmer could have produced his millet/cowpea at only 42% of his current costs. Only 6% of the millet/cowpea farmers achieved a cost efficiency of 1, which implies that the farmers produce their output at minimum cost. Ninety-four per cent of the millet/cowpea farmers did not produce their output at minimum costs.

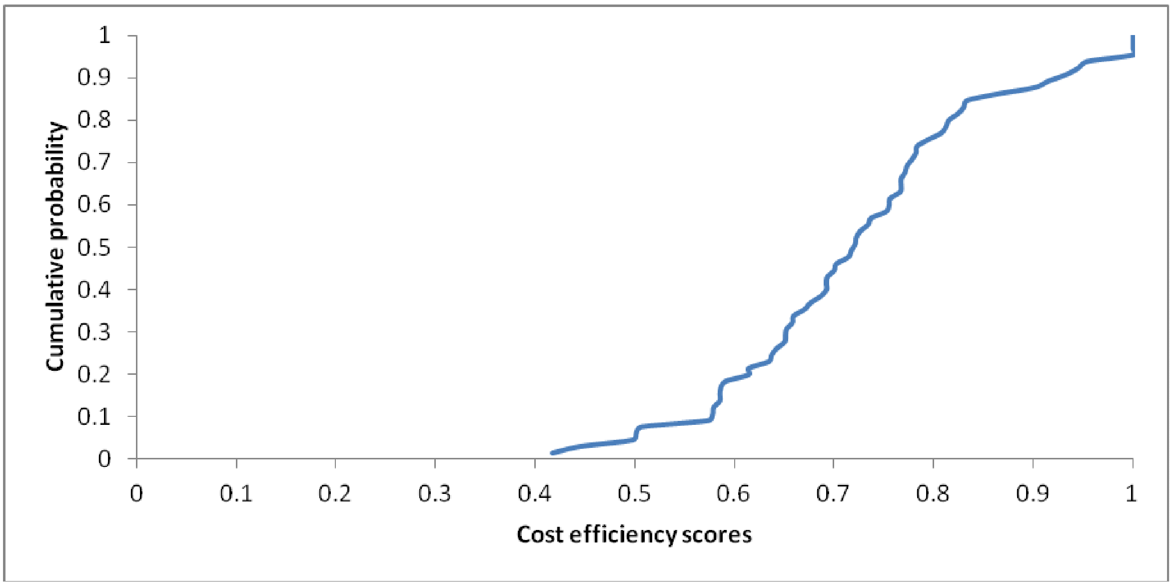

Figure 6.5 Cumulative probability distribution of the cost efficiency scores of the millet/cowpea farmers in Kebbi State, January 2012

6.2.2.1 Determinants of cost efficiency of millet/cowpea farmers in Kebbi State

The results from the factors influencing cost efficiency show that none of the variables hypothesized to influence cost efficiency are significant in explaining the cost efficiency of the millet/cowpea farmers. From theory, the variables hypothesized would influence cost efficiency, although the result from this study does not confirm the initial expectation. Jordaan (2012) also found that most of the variables hypothesized to influence cost efficiency were not significant in explaining the cost efficiency of raisin farmers in Eksteenskuil, South Africa. Jordaan (2012) argued that the timely and sufficient application of important production inputs was hardly being achieved by the raisin farmers because they had only limited resources at their disposal. Farmers tend to apply whatever quantities of inputs are available to them or the quantities of inputs they can afford. Section 3.3.14 showed that farmers in Kebbi State use farm inputs below the recommended rates. The selection of inputs mix at minimum cost does not seem to be the primary goal of the farmers. Hence, there is a need to investigate the effective manner in which the farmers make their decisions about input use.

Ninety-four per cent of the millet/cowpea farmers did not produce their output at minimum costs and accordingly the farmers could improve their cost efficiency by selecting input combinations at less cost. The variables hypothesized to influence the cost efficiency of millet/cowpea farmers were not significant in explaining the farmers' cost efficiency. The results are thus not discussed. The selection of inputs mix at minimum cost does not seem to be the primary goal of the farmers. There is need to investigate the effective manner in which the farmers make their decisions about input use.

6.2.3 Cost efficiency of sorghum farmers in study area

The estimated cost efficiency levels of sorghum farmers in the study area are shown in Figure 6.6 below. The minimum and maximum cost efficiency of the sorghum farmers is 0.32 to 1. Only about 12% of the sorghum farmers are cost efficient. Thus, these farmers could have produced their sorghum output at minimum costs by selecting the cost minimising combination of inputs. The average cost efficiency score is 0.68 and accordingly an average sorghum farmer could have produced his sorghum at only 68% of his current cost of production. The results reveal that there is scope for improving the financial performance of the sorghum farmers by selecting input combination at lower cost to produce sorghum.

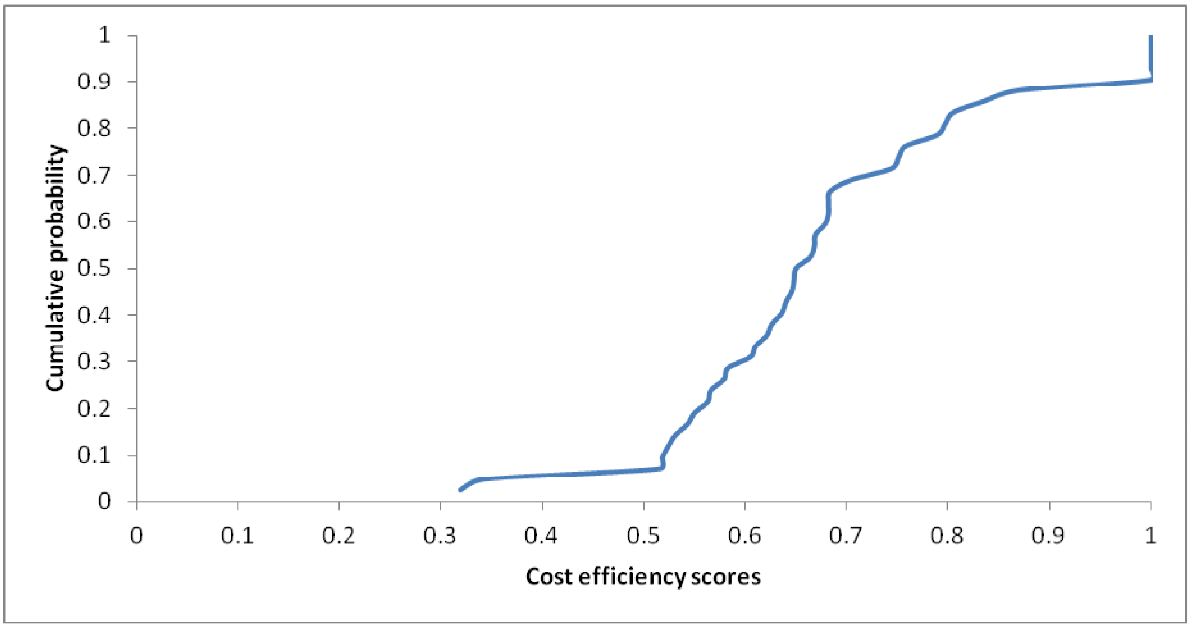

Figure 6.6 Cumulative probability distribution of the cost efficiency scores of the sorghum farmers in Kebbi State, January 2012

6.2.3.1 Determinants of cost efficiency of sorghum farmers in Kebbi State

Table 6.11 below shows the explanatory variables affecting cost efficiency of sorghum farmers. The R^2 is 0.37 which implies that the independent variables included in the regression model explained 37% of the variation in cost efficiency levels of the sorghum farmers. Probably, the existing knowledge about variables that explain cost efficiency of the farmers is inadequate to explain the remaining variation in efficiency levels of the farmers.

Table 6.11 Ordinary Least Squares (OLS) regressions results of the characteristics affecting cost efficiency of sorghum farmers, Kebbi State, January 2012

Variable		**coefficient**	**Std Error**	**t-stat**	**prob**
Intercept		-0.304	0.376	-0.81	0.424
Personal characteristics					
Education	Education of the household head in years of	-0.006	0.013	-0.468	0.643
Experience	Farming experience of household head in years	0.006	0.01	0.574	0.57
Age	Age of household head, years	0.009	0.011	0.808	0.425
Risk attitude	Risk aversion coefficients (standardised)	0.031	0.054	0.584	0.563
Wealth generation					
Credit	Dummy: 1 if the household head benefitted	0.059	0.129	0.461	0.648
Asset value	The amount of assets (e.g. house, oxen, bicycle etc)	1.29E-06*	8.7E-07	1.476	0.149
Human capital development					
Extension	Dummy: 1 if the farmer had a contact with an	-0.083	0.116	-0.714	0.481
Natural resource capital					
Fadama	Dummy: 1 if the household head is involved	-0.122	0.092	-1.33	0.193
Land fragmentation	Dummy: 1 if the farmers land is fragmented into	-0.079***	0.022	-3.60	0.000
Social capital					
COOP	Dummy: 1 if the household head belong to	0.087	0.083	1.048	0.303
R-squared		0.37			
Prob(F-statistic)		3.11			

***, * represents statistical significance at 1%, 15% probability levels, respectively.

Among the determinants of cost efficiency of sorghum farmers, only asset value has a significant positive relationship with the cost efficiency of the sorghum farmers. Agricultural programmes that empower farmers will help to enhance cost efficiency of the farmers in the study area.

Among the wealth generation characteristics, asset value is the only variable that has a statistically significant influence on cost efficiency. Also, natural resource capital (land fragmentation) has an inverse relationship with cost efficiency of the sorghum farmers. The other variables could not adequately explain the variation in the cost efficiency level of the sorghum farmers. This suggests that the existing knowledge on the factors that influence cost efficiency is inadequate. Hence, there is need to explore other dynamics that influence cost efficiency of the sorghum farmers in order to enhance their performance.

Asset value of the farmers has a statistically significant positive relationship with the cost efficiency of sorghum farmers, at 15%. The positive relationship between asset value and cost efficiency is as predicted. Farmers with high asset values are able to purchase adequate farm inputs and implements, and in good time, thus improving cost efficiency. Haji (2007) found a similar result for farmers in Ethiopia.

As hypothesized, the natural resource (land fragmentation) has an inverse statistically significant relationship with cost efficiency of the sorghum farmers (P0.01). This is probably because land fragmentation increases production cost (Kawasaki, 2010, King and Burton, 1982.), thus decreasing efficiency on the farm.

6.2.4 Comparison between the cost efficiency of the monocroppers and intercroppers using metatechnology ratio (MTR) in Kebbi State

The MTRs are comparable with the lower values, being inferior production technology and higher values, indicating the adoption of superior production technology relative to the metatechnology. Comparison of the average cost efficiency scores and the cost efficient farmers based on metatechnology ratio (MTR) is shown in Table 6.12 below. The MTR estimated for the sorghum group is 0.53. The MTR for sorghum/cowpea and millet/cowpea is one and 0.66, respectively.

The maximum DEA-MF values of 1 for the sorghum/cowpea group indicates that all the DMUs used input combinations at minimum cost to obtain their output. The sorghum/cowpea group are operating on the metatechnology frontier. The result suggests that the sorghum/cowpea farmers were tangent to the metafrontier cost function where the value of the MTR is one, which implies that the sorghum/cowpea group could serve as the benchmark for other decision-making units (DMUs) in each group (sorghum and millet/cowpea group).

Table 6.12 Data Envelopment Analysis estimates of cost efficiency and metatechnology ratios of the monocrop and intercrop farmers in Kebbi State, January 2012

Enterprise group	Mean	SD	Minimum	Maximum
Cost efficiency with respect to the (DEA-h) group frontiers				
Sorghum	0.57	0.18	0.26	1
Sorghum/cowpea	0.32	0.12	0.11	1
Millet/cowpea	0.58	0.15	0.27	1
Metatechnology ratio (DEA-MTR)				
Sorghum	0.53	0.02	0.52	0.58
Sorghum/cowpea	1	0	1	1
Millet/cowpea	0.66	0	0.65	0.66
Cost efficiency with respect to the metafrontier (DEA-MF)				
Sorghum	0.31	0.09	0.14	0.53
Sorghum/cowpea	0.32	0.12	0.11	1
Millet/cowpea	0.38	0.1	0.18	0.66

DEA-h: Data Envelopment Analysis for group, DEA-MTR: Data Envelopment Analysis for Metatechnology Ratio and DEA-MF: Data Envelopment Analysis for Metafrontier.

The maximum DEA-MF values of 0.53 and 0.66 for the sorghum and millet/cowpea groups indicate that the DMUs did not produce their output at minimum costs. The MTR for sorghum (0.53) and millet/cowpea (0.66) shows that the two groups are far from the frontier. Sorghum group are further away from the frontier than the millet/cowpea, and this could probably arise from the fact that monocropping requires more fertiliser, intensive labour and agrochemicals than the intercrops. In situations where farmers do not apply adequate inputs to monocrops, their efficiency level will definitely be low.

The result suggests that there is scope for the sorghum and millet/cowpea farmers to improve their cost efficiency. Improvement in cost efficiency can be achieved if the sorghum and millet/cowpea "borrow" technology from the sorghum/cowpea group.

6.2.5 Comparison of the DEA cost efficiency metafrontier scores of the monocroppers and intercroppers using Wilcoxon Rank-Sum Test

The Wilcoxon Rank-Sum Test was used to obtain more reliable information on the differences in the cost efficiency metafrontier scores of the monocrop and intercrop farmers. The result is presented in Table 6.13 below.

Table 6.13 Wilcoxon Rank-Sum Test for the cost efficiency metafrontier of the sorghum and sorghum/cowpea farmers, Kebbi State, January 2012

Enterprise	**Ranks**			
	Count	**Wilcoxon sum rank**	**Mean of Wilcoxon**	**STD DEV of Wilcoxon**
Sorghum MF	42	2321	2436	172
Sorghum/cowpea MF	73	4349	4232	172
Ties	18			
Z	-0.67			
P value	0.50			

The cost efficiency metafrontier scores for sorghum (monocrop) and sorghum/cowpea (intercrop) farmers are not statistically significant. This implies that there is no statistically significant difference between the sorghum (monocrop) and sorghum/cowpea (intercrop) cost efficiency metafrontier scores. The result suggests that, based on average (0.31), the sorghum farmers have the same cost efficiency metafrontier as their sorghum/cowpea (0.32) counterparts.

The results in Table 6.14 below shows that the cost efficiency metafrontier scores for sorghum (monocrop) and millet/cowpea (intercrop) is significant: Z = -0.71, P<0.01.

Table 6.14 Wilcoxon Rank-Sum Test for the cost efficiency of the sorghum and millet/cowpea farmers, Kebbi State, January 2012

Enterprise	**Ranks**			
	Count	**Wilcoxon sum rank**	**Mean of Wilcoxon**	**STD DEV of Wilcoxon**
Sorghum MF	42	2157	2268	157
Millet/cowpea MF	65	3621	3510	157
Ties	7			
Z	-0.71			
P value	0.00			

This indicates that there is a statistically significant difference between the cost efficiency metafrontier scores of sorghum (monocrop) and the millet/cowpea (intercrop) groups. The two groups have different cost efficiency metafrontier scores. The mean cost efficiency metafrontier scores for the sorghum and millet/cowpea are 0.31 and 0.38, respectively (Table 6.12 above). This implies that both groups were relatively low in the utilisation of inputs at minimum cost.

It is meaningful to note that, based on MTR, the millet/cowpea group was more technically efficient than the sorghum and sorghum/cowpea groups, while the sorghum/cowpea group was more cost efficient than the other two groups. Both in terms of technical and cost efficiency, the intercroppers performed better than the monocroppers. This suggests that the use of crop diversification to manage risk sources has the potential for improving crop productivity in Kebbi State.

6.3 Conclusions

The objective of Chapter 6 was to investigate the levels of efficiency with which the farmers use their production inputs to produce their crops. The relationship between the efficiency scores and characteristics of the farmers was explored. The efficiencies of the monocrop and intercropping systems were also compared.

The results reveal that farmers using monocropping and farmers using intercropping systems differ in their levels of technical and cost efficiencies. The result of the technical efficiency analyses suggests that there is scope for increasing the technical efficiency levels of both mono and intercrop farmers, and hence their ability to increase output levels at current levels of input, and within the existing technology set. Both cropping systems have relatively low efficiencies relative to the metafrontier technology, although the comparisons between the different systems show that the intercroppers were more technically efficient than the monocroppers. The millet/cowpea group were more efficient than the sorghum and sorghum/cowpea group. This suggests that, while crop diversification in order to manage risk sources has the potential of improving crop productivity, crop combinations prove to play an important role. Care should be taken to select the optimal combination of crops to include in the intercropping system.

In terms of cost efficiency, farmers in the study area were relatively cost inefficient. The MTR for cost efficiency shows that the sorghum/cowpea group was more cost efficient than the sorghum and the millet/cowpea groups. Application of farm inputs at minimum cost will help to reduce production cost and hence improve profitability of the farmers. Low levels of technical and cost efficiency suggest major scope to increase performance of the farmers, even at their current output levels and within their existing technology set. Support services, such as subsidies on farm inputs, provision of credit and extension services, should be improved.

The determinants of efficiency differ between the sorghum, sorghum/cowpea and millet/cowpea farmers. It is also interesting to note that the determinants also differ between intercrop groups. The differences can be attributed to the fact that the different groups of farmers operate under different technology sets. A Technology set is more than only physical capital; it is based on how human, social, physical and financial capital influence the decisions farmers make in the production processes. Therefore, improvement on human, social, physical and financial capital should be considered in agricultural policies formulation so as to improve the efficiency levels of the farmers. The results also suggest that the existing knowledge on the various factors that influence both technical and cost efficiency is not exhaustive and accordingly there is a need to explore other characteristics that influence the farmers' decision process within their technology sets. Since a technology set is based on human, social, physical and financial capital, further research should focus on every component of the technological set in the study area.

Based on the levels of the technical and cost efficiencies of the two cropping systems in the study area, both mono and intercropping systems seem to have potentials for improving crop production in Kebbi State. Policies towards increasing farmers' performance should be enhanced. Further research on the optimal crop combination should be conducted as the three cropping systems analysed in this study are not the only cropping systems practised in the study area (see chapter 3, section 3.1.4)

CHAPTER 7

SUMMARY, ACHIEVEMENT OF OBJECTIVES AND RECOMMENDATIONS

Introduction

In the first part of this chapter a summary of the thesis is presented. This is followed by an outline of the main conclusions of the study with regard to the achievement of the objectives and concludes with recommendations.

7.1 Summary

7.1.1 Background and motivation

The alarming increase in the population of Nigeria demands an increase in agricultural productivity. In spite of the country's vast resources it has a low gross domestic product (GDP) per capita, high level of poverty, high unemployment rate, low industrial capacity utilisation, high birth rate and high dependence on agriculture (Jhingan, 2005; NBS, 2012). Agriculture plays an important role in the Nigerian economy through the provision of employment, poverty reduction and foreign exchange (Udoh, 2000; NBS, 2006; Agenor, 2004). The agricultural sector grew by 7% to 8% per annum during 2000-2010 (CBN, 2009, 2010, 2011). Despite the growth in the agricultural sector, the growth targets have not been achieved. Nigeria's agriculture remains largely subsistence based, with about 80% of agricultural output coming from the rural poor. Several programmes have been launched to improve agriculture in the country, but these programmes have not yielded the desired objectives (Uniamikogbo and Enoma 2001; Ajibefun and Aderinola, 2003; Sanyal and Babu, 2010; Izuchukwu, 2011). The expected effectiveness of the programmes was substantially curtailed by lack of consistency and continuity in the policies adopted by successive administrations in the country and by a lack of understanding of the actual farm-level situation. These efforts can only yield a good result if, *inter alia*, farm-level planning, the type of cropping system practised by the farmers, and the characteristics of farm households are given the desired attention. Two main cropping systems practised in Nigeria are mono and intercropping. The question of how the cropping systems compare in terms of technical and cost efficiency has not yet been answered.

7.1.2 Problem statement and objectives

Despite government efforts to improve agriculture, returns from the agricultural sector have been much below the potential (Izuchukwu, 2011; Nwafor, 2011). Food crop production growth in Nigeria has been driven entirely by expansion in area planted rather than by increasing productivity per hectare through improved technology and development of high yielding varieties of arable crops (Report of the Vision 2020, 2009). The gap between potential and actual crop yields obtained by farmers suggests abundant scope for improvement in productivity.

Agricultural production is highly characterized by risks, and for this reason knowledge about the types and extent of risk and farmers' attitudes towards risk is imperative in understanding their behaviour, adoption of new technology and managerial decisions (Ayinde *et al*., 2008; Binici *et al*., 2003; Knight *et al*., 2003; Liu, 2008; Alpizar *et al*., 2010). Some researchers have quantified risk attitudes of farmers in Nigeria by applying the Safety First Behaviour model to measure risk attitude of farmers (Ajetumobi and Binuomote, 2006; Ogunniyi and Ojedokun, 2012). Binswanger (1981) has criticised the Safety First Behaviour model because of the fact that it is difficult to determine the relative influence of risk and other factors on the decisions of the individuals. Thus, no reliable knowledge is available on these issues. There is also scanty research on the sources of risk and management strategies in the study area (Alimi and Ayanwale, 2005). The understanding of risk and the coping strategies of monocroppers and intercroppers is important in order to ascertain the decision-making behaviours of the farmers and to develop appropriate risk coping strategies.

Productivity can be enhanced if there is reliable empirical knowledge available on technical and allocative efficiency of resource allocation and the factors that determine such efficiencies. Most of the studies on efficiency have not considered the risk attitudes of the farmers. Risk attitudes of farmers are important in determining efficiency because they are associated with the decision-making behaviour of an individual. Information on risk attitude as a determinant of technical and allocative efficiency is scanty in the study area.

Methodologies to investigate efficiency of farmers in the study are limited by deficiencies. Few researchers have used the two-stage Data Envelopment Analysis (DEA) approach to investigate the determinants of efficiency of farmers (Yusuf and Malomo, 2007; Ajibefun, 2008). In stage one, the efficiency scores are estimated. Tobit regression is used in the second stage owing to the belief that the dependent variable obtained in stage one is censored. However, Simar and Wilson (2007) question the appropriateness of the two-stage approach. By applying an incorrect approach, the information generated by researchers may not be reliable and thus be of limited practical value. Research on the comparison of efficiencies in agriculture is limited. Some research conducted to compare the efficiency of technologies used the highest average DEA score to indicate which decision-making units (DMU) are more efficient. Such comparisons are inappropriate because high efficiency scores among a group of DMUs only give a measure of relative homogeneity among the efficiency of the DMUs (Frey *et al*., 2012). The use of Metatechnology Ratio (MTR) to compare efficiencies between different groups was introduced by Battese, (2004). MTR is a more reliable approach for comparing efficiencies of different groups of enterprises.

Thus, although the topic of efficiency and risk has received attention by researchers in recent times, there is a lack of reliable information on the determinants of efficiency, comparison of efficiencies between different farm enterprises, sources of risk and management strategies, risk attitudes and also the influence of risk attitudes on the decision-making behaviour of the farmers.

Against this background, the main objective of the study was to examine attitudes towards risk, risk sources and management strategies and technical and cost efficiency of farmers in Kebbi State, with the aim of generating reliable knowledge on the influence of risk attitudes on the decision-making behaviour of farmers and determinants of efficiency.

The main objective was achieved through pursuing the following specific objectives.

1. Explore the risk attitudes of the farmers. Risk aversion coefficients were quantified and regressed on characteristics of the farmers in order to determine the factors that influence risk attitudes of the farmers. This information is important in designing strategies for agricultural development.

2. Explore the sources of risk and coping strategies that farmers use to manage their exposure to risk and also determine their dimensions in terms of the underlying latent factor. The relationships between sources of risk and coping strategies, risk

attitudes and farmers' characteristics were investigated. Understanding the relationships between farmers' characteristics, risk attitudes, risk sources and management strategies is important in determining best-coping strategies for farmers.

3. Determine whether farmers' attitudes towards risk and other characteristics influence their choice of cropping system in order to make recommendations on the programmes that will improve monocropping or intercropping.

4. Investigate the levels of efficiency with which the farmers use their production inputs to produce crops. The levels of technical and cost efficiencies were quantified in order to ascertain how efficient the farmers were. The relationships between the efficiency scores and characteristics of the farmers were explored so as to have a better understanding of the characteristics associated with higher levels of efficiency. Also, the efficiencies of the monocrop and intercropping systems were compared in order to determine which system is better and to ascertain whether the systems have equal efficiency.

7.1.3 Literature review

The purpose of literature review was to determine the state of research on risk preference, sources of risk and management strategies, efficiency and their determinants and to identify the gaps in knowledge on these issues.

- The review from the literature shows that only few researchers have applied the experimental gambling approach to investigate the risk attitudes of farmers.

- Risk preference studies on experimental gambling approach revealed that respondents exhibited risk aversion in most cases and that certain farmers' characteristics have an influence on the risk preferences of farmers.

- Data Envelopment Analysis or the Stochastic Frontier Model are the popular approaches used to determine technical and cost efficiency, and the Tobit or OLS regression models to explain the influence of farmers' characteristics on technical and cost efficiency.

- Few researchers have applied the two-stage DEA approach to explore the determinants of efficiency of farmers. In the two-stage DEA approach, efficiency scores are estimated in the first stage using DEA, and in the second stage, Tobit regression is used to investigate the determinants of efficiency. Tobit regression is used in the second stage owing to the belief that the dependent variable is censored.

- Simar and Wilson (2007) have argued that the DEA efficiency scores are serially correlated and biased when used in the two-stage DEA approach and that the efficiency scores are censored. The researchers have proposed the use of the Double Bootstrapping approach in order to obtain more reliable information on efficiency and its determinants.

- By applying an incorrect approach, the information generated by a researcher may not be reliable.

- The literature review of the efficiency studies both in Nigeria and at international level suggested that farmers have varying levels of technical and cost efficiency and that inefficiency in input utilisation exists among most farmers. Various farmer characteristics, such as age, educational level, use of extension services, access to credit, farm size, off/non-farm income, asset value, crop diversification, among others, have influences on technical and cost efficiency and differ from one study area to another.

- From the literature reviewed (international and Nigerian studies), it appeared that only a few researchers have applied the Double Bootstapping approach.

- In terms of efficiency comparison for different groups of enterprises, some researchers have indicated that the group with the highest average efficiency scores are more efficient than those with lower average efficiency scores. The use of averages to compare efficiency of groups has, however, been criticised as being inappropriate. The proper approach is to use a Metafrontier approach.

- There are only a few efficiency studies that have included the risk attitude of farmers as a determinant of efficiency. The Double Bootstrapping procedure applied in the two-stage DEA approach gives unbiased and consistent estimates, hence there is a need to conduct more research on efficiency using this approach. Also, since farmers' risk attitudes affect their behaviour in decision making, the influence of risk attitude of farmers on efficiency should be given due attention.

Although the topics of efficiency and risk have received attention by researchers in recent times, there is a lack of reliable information on the determinants of efficiency, sources of risk and management strategies, risk attitudes and also the influence of risk attitudes on the decision-making behaviour of farmers.

7.1.4 Study area, data collection and characteristics of respondents

The aim of Chapter 3 was to describe the study area, the method of data collection and the relevant characteristics of the respondents in Kebbi State.

The State is located in the north-western part of Nigeria. The population of the State is 3 238 628 (NPC, 2006) and occupies an area of about 36 229 square kilometres. Kebbi State falls within the dry savannah agro-ecological zone of Nigeria. Agriculture is mainly rainfed with one cropping season. The mean annual rainfall is 1 020 mm. Agriculture is the major source of revenue in the State, hence it is the backbone of the economy.

- The major ecological problem faced by farmers in the study area is desertification as a result of desert encroachment on arable lands; this gives rise to land degradation which has a negative effect on agriculture. The other ecological problem is flooding which leads to the devastation of farm lands.

- Farmers in the study area practise monocropping and intercropping. The typical mixtures of the intercrops are sorghum/cowpea, millet/sorghum, sorghum/groundnut, millet/cowpea and sorghum/cowpea/rice. All of these crops are also cultivated as monocrops. Farmers also cultivate vegetable crops on *fadama* lands.

- Animal husbandry is also practised by farmers in the State. Complementary relationships exist with the livestock fed on crop-residues: the animals provide draught power, manure, source of protein, income, savings and reserve against risk.

- The types of labour source used by farmers are hired, family and communal labour. Labour is scarce during the peak periods of crop production.

- The majority of the farmers in the State have inadequate access to agro inputs (improved seed, herbicides and pesticides). Where such inputs are available, the prices are not affordable to the farmers.

- Land ownership is basically by inheritance, which leads to subdivision of land, hence farmers are faced with the problem of land fragmentation.

- Access to agricultural finance is limited, hence farmers resort to borrowing money from friends or relatives.

The data used for the study was mainly collected from primary sources through a questionnaire survey of 256 farmers, comprising 98 monocroppers and 158 intercroppers. Data was obtained so as to achieve the different objectives of the study. Data was collected on farm inputs and outputs and their prices, sources of risk, and management strategies, among others. The data was analysed using various methodologies in accordance with the objectives of the study.

Regarding respondents' characteristics, some conclusions are that there are huge levels of illiteracy in Kebbi State and that the majority of the farmers have relatively few years of farming experience. The socio-economic variables, age, years of farming experience, household size, asset values, kilometres travelled and size of farm land of the monocroppers all differ significantly from those of intercroppers. Land acquisition is mainly by inheritance. It is also evident that the farmers experience land fragmentation and degradation. The use of farm inputs is below recommended rates and the yields are below the potential levels.

7.1.5 Procedures

Chapter 4 describes the procedures that were used to achieve the objectives of the study.

- Following Binswanger (1980), the experimental gambling approach within the expected utility framework was used to estimate the risk aversion coefficients of the farmers. The experimental approach gives more reliable estimates of risk aversion than the Safety First Behaviour and portfolio model.

- Factor analysis was next used to examine the dimensions of the perceived risk sources and management strategies.

- The relationships between risk attitude, farmers' characteristics, risk sources and management strategies were then explored using multiple regression analysis. In order to determine the factors that influence the choice of cropping systems in Kebbi State, a logit model was used.

- The DEA model was used to explore the levels of efficiency with which farmers use their production inputs to produce their crops. The determinants of efficiencies were also determined. Mindful of the criticisms of using Tobit in the two-stage DEA, the Double Bootstrapping procedure was applied in order to overcome the limitations of using Tobit in the two-stage DEA. The Double Bootstrap procedure was used within the framework of Principal Component Regression (PCR) in order to reduce the dimensionality of the data in which there are a large number of correlated variables, while retaining the variation present in the data set.

- The technical and cost efficiencies of the mono and intercrop farms were compared using the Metatechnology Ratios, following O'Donnell *et al*. (2008).

The findings that have emanated from applying the procedures described in Chapter 4 provide more reliable results than previous studies and will add to the existing knowledge on risk attitudes, risk sources and management strategies and efficiencies of the farmers in Kebbi State.

7.1.6 Results and discussion of risk attitude, risk sources and management strategies of the monocrop and intercrop farmers

Respondents' risk attitudes, the sources of risk and management strategies and the dimension of the sources of risk and management strategies were determined in Chapter 5. In addition, the relationships between risk attitude, farmers' explanatory variables, risk sources and risk management strategies were explored. Also, the factors that influence the choice of cropping systems were investigated.

- The results of the risk attitudes of the farmers reveal that there are more intercroppers in the risk-averse class (92%) than monocroppers (74%). The Chi Square test shows that there are statistically significant differences between the risk averse and the neutral to preferring risk classes of the mono and intercrop respondents.

- The results of the determination of the sources of risk for both monocroppers and intercroppers indicate that diseases, erratic rainfall, changes in government and agricultural policy, and price fluctuations are the five most important sources of risk. The variables rainfall, difficulties in finding labour, theft, market failure, price fluctuation and family relationships were statistically significantly different between monocrop and intercrop farmers.

- The main finding from the factor analysis for sources of risk for the monocroppers and intercroppers is that monocroppers perceived drought as more important than the intercroppers. This could be because of the fact that some of the combination of crops used by the intercroppers are drought tolerant, e.g. millet. The factors "social", "rainfall" and "uncertainties", as defined in Chapter 5, are common to both monocrop and intercrop farmers. Since farmers do not have control over the rainfall factor as a source of risk, there is a need to have an effective agricultural insurance scheme in place for the farmers in Kebbi State.

- The regression results from the relationships between risk attitude and farmers' characteristics, sources of risk and risk management strategies for the monocroppers and intercroppers reveal that the variables flood/storm, "extra income" factor, fertiliser provision by government/self, training and education, *fadama* cultivation and *adashe* statistically relate to monocrop farmers' risk attitude. For the intercroppers, "rainfall" factor, "difficulties" factor, fire outbreak, market failure and spraying for diseases and pests statistically relate to risk attitude. None of the explanatory variables were statistically related to risk attitudes of both monocroppers and intercroppers.

- The relationships between sources of risk and farmers' explanatory variables, risk attitude, and risk management strategies for the monocroppers and intercroppers were explored using regressions analyses. The findings reveal that the monocroppers identified “social” factor (insufficient labour, loss of land/ethnic clash and theft) and “rainfall” factor (pests, excessive and insufficient rainfall) as the most important sources of risk, while the intercroppers perceived “rainfall” factor (pests, excessive and insufficient rainfall) and “difficulties” factor (illness of household member and difficulties finding labour) as the most important sources of risk. It is meaningful to note that the rainfall factor is one of the most important sources of risk for both the mono and intercrop groups.

- Regression analysis was used in order to determine the relationships between risk management strategies and farmers’ explanatory variables, risk attitude, and sources of risk for the monocroppers and intercroppers. The findings show that for monocroppers and intercroppers, the common variables that form the important factors are faith, storage programme, market information and household head working off-farm. This result suggests the need to provide an effective price support policy in order to encourage farmers to produce more.

- Logit regression was used in order to explore the factors that influence the choice of cropping system. The result shows that farming experience, asset value, risk aversion and land degradation are the most important factors that influence the choice of cropping system in the study area.

7.1.7 Technical and cost efficiency of monocrop and intercrop farmers in Kebbi State

The objective of Chapter 6 was to investigate the levels of efficiency with which the farmers use their production inputs to produce their crops. The levels of technical and cost efficiency were quantified in order to ascertain how efficient the farmers were. The relationship between the efficiency scores and characteristics of the farmers was explored so as to have a better understanding of the characteristics associated with higher levels of efficiency. Also, the efficiencies of the monocrop and intercropping systems were compared in order to determine which technology is better and to ascertain whether the technologies have equal efficiency.

- The technical efficiency results reveal that there is significant variation in the technical efficiencies of the farmers in Kebbi State. The result from Bootstrapping of the technical efficiency estimates shows some evidence of bias in the un-corrected technical efficiency scores of the farmers. The bias was removed by applying the Bootstrapping procedure as recommended by Simar and Wilson (2007). Hence, more reliable technical efficiency estimates were obtained. The average technical efficiency scores obtained for the various enterprises show that there is scope for improvement.

- For the millet/cowpea farmers, the personal characteristics (age, farming experience, risk aversion), social capital (cooperative), human development capital (extension) and natural resource capital (*fadama*) have positive influences on the technical efficiency levels of the farmers.

- The positive significant influence of access to extension on technical efficiency indicates that an increase in access to extension will, for instance, enhance farmers' knowledge of using innovations to improve technical efficiency. The result also implies that access to information through the extension agents enhances technical efficiency. Given the importance of extension in improving technical efficiency, there is a need to improve the extension agent to farmer ratio in the study area.

- The positive significant relationship between cooperatives and technical efficiency indicates that farmers who belong to cooperatives are likely to be more technically efficient than their counterparts. Cooperatives have a statistically significant positive influence on technical efficiency of the millet/cowpea farmers.

- Access to *fadama* has a significant positive relation with technical efficiency. An increase in access to *fadama* utilisation and empowerment of the *fadama* users will enhance the efficiency of the farmers. Studies have shown that *fadama* II projects have enhanced the productivity of farmers in Nigeria. Policies geared towards improved *fadama* utilisation should be promoted.

- The significant positive influence of risk aversion on technical efficiency implies that the higher the risk aversion, the more the likelihood of a farmer being technically efficient. The more risk-averse the farmers are, the more likely they are to allocate/apply resources.

- The results from the determinants of technical efficiency of the sorghum/cowpea farmers reveal that none of the explanatory variables had significant influence on the technical efficiency of the farmers. This does not mean that the variables are not important. It only means that there are other dynamics that explain the efficiency level of the farmers which need to be researched.

- The results from the determinants of technical efficiency for the sorghum farmers reveal that personal characteristics (education, household size, risk attitude), wealth generation characteristics (credit, house type) and natural resource capital (*fadama*) have statistically significant positive influence on technical efficiency.

- The significant positive influence of education on technical efficiency implies that education enhances farmers' ability to understand, plan and better develop managerial skills to improve technical efficiency. Household size also has a significant positive influence on technical efficiency. This indicates that large household sizes, where members contribute to family labour, are likely to improve the technical efficiency of the farm.

- The positive statistically significant influence of access to credit on technical efficiency means that the availability of credit eases the cash constraints of the farmers and, for instance, enables farmers to acquire inputs timely which they could not ordinarily purchase, given the resources available to them. The establishment of more microfinance banks for agricultural purposes is advocated.

  The result of the wealth generation characteristics of the sorghum farmers also implies that the sorghum farmers invest their resources in farming, unlike the millet/cowpea farmers.

The overall results of the cost efficiency results for the monocroppers and intercroppers show that the farmers in Kebbi State are relatively cost inefficient. This implies that the farmers do not produce at minimum cost. The farmers could have produced their output at lower cost by moving closer to the cost minimising combination of farm inputs. Selection of optimal combination of inputs by the farmers will help to reduce production costs. Reduction in production costs will also help farmers to apply the recommended farm inputs, which is also likely to influence technical efficiency positively. This will lead to increase in the benefits from improving cost efficiency of the farmers in Kebbi State.

- The results from the determinants of cost efficiency for the sorghum/cowpea farmers reveal that personal characteristics (experience, age) significantly contribute to efficient management of farm inputs which enhances the ability of farmers to allocate resources more efficiently. Farming experience can be enhanced through training by extension agents. This will go a long way in improving the cost efficiency of the farmers. Policies geared towards training of farmers through extension agents will improve the knowledge of the farmers and thus enhance efficiency.

- None of the variables hypothesized to influence the cost efficiency of the millet/cowpea farmers significantly explained cost efficiency. This suggests that the existing knowledge on the factors that influence cost efficiency is inadequate. Hence, there is a need to explore other dynamics that influence the cost efficiency of the millet/cowpea farmers in order to enhance their performance.

- The wealth generation characteristic (asset value) is the only variable that was significant among all the variables hypothesized to influence cost efficiency of the sorghum farmers. Asset value has a direct statistically significant relationship with cost efficiency. This suggests that the farmers invest their assets in farming, hence improving their cost efficiency.

- The results from the MTR indicate that the intercroppers were more technically and cost efficient than their monocropper counterparts. Hence, agricultural programmes to promote intercropping should be designed in order to improve the efficiencies of the monocroppers. Agricultural policies should focus on providing incentives to enable the less-efficient farmers opportunity to catch-up with the best practice groups and for the more efficient farmers to improve further to become also internationally more competitive.

7.2 Achievement of objectives

In order not to repeat what has already been mentioned in this chapter, only major conclusions will be highlighted with reference to the extent to which the specific objectives of the study have been achieved.

The first objective of the study was to explore the risk attitudes of the farmers.

- This objective has been fully achieved. The results from the survey of the risk attitudes of the farmers show, for instance, that the intercroppers were statistically significantly more risk averse than the monocroppers. This suggests that the intercroppers tend to safeguard against crop failure by diversification in their cropping system.

The second objective of the study was to explore the sources of risk and coping strategies that farmers use to manage their exposure to risk and also determine their dimensions in terms of the underlying latent factor. The relationships between sources of risk and coping strategies, risk attitudes and farmers' characteristics were investigated. This aim has also been fully achieved as supported, *inter alia,* by the following.

- The analysis of the important sources and risk management strategies shows that "rainfall" and uncertainties are common sources of risk for both mono and intercroppers. Since farmers do not have control over the rainfall factor source of risk, there is a need to have, for instance, an effective agricultural insurance scheme in place for the farmers in Kebbi State. Drought is perceived as a more important source of risk for the monocroppers than the intercroppers. Thus, intercropping should be encouraged as some of the crops used in intercrop combinations are drought tolerant, e.g. millet.

- Having crop insurance (HAVINS) has a negative statistically significant relationship with "social factor", price fluctuation (PCFLUC) and changes in climatic conditions (CHCLIM). This means that the more the monocropper is insured, the less the farmer sees "social" factor, price fluctuation and changes in climatic conditions as risk sources. Hence, there is the need to put in place an effective agricultural insurance scheme, since insurance plays an important role in mitigating sources of risk. There was no significant relationship between HAVINS and the risk sources of the intercroppers. This could arise from the fact that intercropping is a form of diversification that is practised in order to mitigate sources of risk.

- There is a positive statistically significant relationship between risk aversion (RA) and "extra income", *fadama* cultivation (FDMCUL) and membership of a cooperative society (COOP). The result is as hypothesized: the more risk averse the monocropper is, the more the farmer perceives extra income, *fadama* cultivation and membership of cooperative society as important management strategies. Extra income, *fadama* cultivation and membership of a cooperative society are ways by which monocrop farmers can cope with risk. Hence, farmers can work off-farm to obtain extra income and farmers who cultivate *fadama* land should be encouraged by providing them with small irrigation pumps, improved seed, fertiliser and agrochemicals at affordable prices. For the intercroppers, risk attitude did have a significant influence on risk management strategies. This suggests that intercroppers do not perceive extra income, *fadama* cultivation and membership of cooperative society as important management strategies because the practice of intercropping is an important risk management strategy.

The third objective of the study was to determine whether farmers' attitudes towards risk and other characteristics influence their choice of cropping system. Again, this objective has also been achieved.

- The results from the survey of the factors that influence the choice of cropping system indicate that experience, asset value, risk aversion and land degradation influence the choice of cropping system significantly. This result implies that the choice of cropping system depends on the financial, natural resource, and personal characteristics of the farmers. Particularly, farmers practise intercropping because their farm lands are degraded, the lands are low in soil fertility and are eroded. Hence, there is a need to improve soil fertility by planting cover and leguminous crops such as cowpea (as it is used in intercropping) so as to regain the fertility of the soil. The application of fertilizers at recommended rates will also help in improving the fertility of the soil.

The fourth objective of the study was also successfully addressed. The objective was to investigate the levels of efficiency with which the farmers use their production inputs to produce their crops. The levels of technical and cost efficiency were quantified in order to determine how efficient the farmers were. The relationships between the efficiency scores and characteristics of the farmers were explored so as to have a better understanding of the characteristics associated with higher levels of efficiency. Also, the efficiencies of the monocrop and intercropping systems were compared in order to ascertain which system is better.

- The monocropping and intercropping systems differ in their levels of technical and cost efficiencies. The result of the technical efficiency analyses suggests that there is scope for increasing the technical efficiency levels for both mono and intercrop farmers. Given the existing technology set, farmers can enhance their ability to increase output levels at current input levels. The comparisons between the mono and intercropping farmers show that the intercroppers were technically more efficient than the monocroppers. The millet/cowpea group were more efficient than the sorghum and sorghum/cowpea group. Accordingly, crop productivity in the study area can be improved by crop diversification. Crop combinations, however, prove to play an important role. Farmers should carefully select the optimal combination of crops to include in their intercropping system.

- The MTR for cost efficiency reveals that the sorghum/cowpea group were more cost efficient than the sorghum and the millet/cowpea group. Production costs can be reduced by selecting inputs at minimum cost levels and so improve the profitability of the farmers. Low levels of technical and cost efficiency suggest that major scope exists to increase the performance of the farmers, even at their current output levels and within their existing technology sets. In order to improve the performance of the farmers, support services, such as subsidies on farm inputs, provision of credit and extension services, should be improved.

- The determinants of efficiency differ between the three cropping systems and within the intercrop groups. The differences can be attributed to the fact that the different groups of farmers operate under different technology sets. A technology set is more than only physical capital. The technology set influences the decisions farmers make in the production processes. Therefore, improvement on human, social, physical and financial capital should be considered in agricultural policy formulations so as to improve the efficiency levels of the farmers.

7.3 Recommendations

Based on the findings of the study, the following recommendations are made. Firstly, the policy recommendations are discussed, and secondly, recommendations for further research are made.

7.3.1 Policy recommendations

The policy recommendations are aimed at addressing the issues discussed on farm characteristics, risk preferences, sources of risk and management strategies and the efficiencies of the respondents in the study area.

- The knowledge concerning the risk attitudes of farmers, important sources of risk and management strategies should serve as a guide to formulating and implementing insurance and agricultural development policies that will improve the agricultural sector.

- The results from the study show that the unavailability of farm inputs, especially fertiliser, is an important source of risk to the farmers, and that inefficiency in the utilisation of inputs exists among farmers. The current government policy on the agricultural transformation agenda through growth enhancement support, which was launched in the 2012 cropping season, is consistent with the findings of this study. One of the packages of the growth enhancement support policy provides fertilisers to farmers at 50 % subsidy, as well as free hybrid seed and agrochemicals. This package will enhance the technical and cost efficiency of farmers and it will also reduce the risk source of fertiliser unavailability to farmers.

- Having crop insurance plays an important role in mitigating risk and so the current government transformation agenda on agriculture should also focus on providing agricultural insurance against flood/storm, excessive, insufficient and erratic rainfall. Since insurance was perceived as a more important coping strategy by the monocroppers, insurance policies should be designed to fit the specific needs of farmers.

- Based on the levels of the technical and cost efficiencies of the two cropping systems in the study area, both mono and intercropping systems seem to have the potential to improve crop production in Kebbi State. Policies towards enhancing farmers' performance should be promulgated. Other crop combinations should also be researched as the three-crop combinations used in this study are not the only cropping systems practised.

- The results from the survey of the determinants of efficiencies show that human development capital has a positive relationship with efficiency. Hence, the current agricultural transformation agenda of empowering the Agricultural Development Programmes (ADPs) and the efforts of the Federal Ministry of Agriculture and Rural Development and state ministries to improve extension services and technology transfer are also in line with the findings of this study. Extension services should be targeted to the appropriate farmers in order to achieve results. This will help to improve the human capital development characteristics of the farmers in the study area.

- There is a need to enhance the human, social, physical and financial capital of the farmers in order to improve their performance. The social capital can be improved by reviving the agricultural cooperatives and farmers' associations in the rural areas. Physical capital can be enhanced by providing infrastructure, especially in the rural areas where the bulk of agricultural produce is produced. The natural resource capital (*fadama* and land degradation) can be improved by providing farmers with irrigation pumps in addition to improved inputs. The current afforestation programme should be pursued with all vigour.

- The current agenda for improving the agricultural sector by empowering the commercial banks and microfinance banks to provide credit to farmers at 8% interest rate will surely improve the financial capital of the farmers because of the important role credit plays in enhancing technical and cost efficiency. The agricultural transformation agenda seems to have the potential for improving the agricultural sector and the success of the agenda will depend on how consistent and sustainable it will be applied.

7.3.2 Recommendations for further research

From the findings of the study, the following specific research projects for the study area are recommended:

- As the existing knowledge on the various factors that influence both technical and cost efficiency is not comprehensive for Kebbi State, there is a need to explore other characteristics that influence the farmers' decision processes within their technology set. Further research should address every component of the technological set in the study area. For instance, further research should be conducted on the influence of risk management strategies on technical and cost efficiencies for the study area.

- Whereas this project only determines the factors that are responsible for the shift of group frontiers, but not for the shift in the Metafrontier, there is a need to explore the factors affecting movement in the Metafrontier as this information can also be useful in improving farming performance.

- With regard to research on risk management strategies, research should be conducted on the importance and impact of a price support policy.

- Research should also be conducted on mono versus intercrop income risk variability.

- In addition, more research should be carried out on the impact of *fadama* on the livelihood of the farmers.

- Since there are differences in the levels of efficiency of the mono and intercroppers, and also between intercropping systems, the optimal crop combination for intercropping should, *inter alia*, be researched.

- As insurance is identified as very important for risk management, especially for monocroppers, but has certain deficiencies, an investigation of the insurance needs of the farmers to improve the existing insurance scheme is needed.

- Agriculture extension is rated very important by the farmers and in order to improve it, the farmers' needs for extension services, as well as their education needs, must be further explored.

The following more comprehensive research project is also recommended.

- Since the experimental gambling approach, Double Bootstrapping, Meta Frontier Analysis, etc., used to investigate the risk preference and technical efficiencies of the farmers was limited to farmers in Kebbi State, there is a need to expand such comprehensive research to other States of Nigeria, so as to obtain more reliable and comparable knowledge for all the farmers in Nigeria. This information will be useful for national policy development on these issues.

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APPENDICES

APPENDIX A: FORMAL SURVEY QUESTIONNAIRE FOR THE FARMERS IN KEBBI STATE

DEPARTMENT OF AGRICULTURAL ECONOMICS

UNIVERSITY OF THE FREE STATE, BLOEMFONTEIN, SOUTH AFRICA

FORMAL SURVEY QUESTIONNAIRE: 2011 CROPPING SEASON

OBJECTIVE: This questionnaire is intended to obtain primary information concerning monocropping, intercropping production practices of farmers in Kebbi State, Nigeria, by JIRGI A.J. towards Ph.D degree at the above named institution. **All the information will be strictly confidential.**

Date of interview: ....

Time: Start............... Finish................

Respondent's number: ....

Enumerator's name: ....

A. PERSONAL INFORMATION

1. Name of Village/Town ....
2. Name of District ....
3. Local government area ....
4. Farmer's name (optional) ....
5. Head of household: 1. Male ☐ 2.Female ☐ (tick the appropriate response)
6. Age of household head: ....years

7. Please indicate the age category you belong to:

a. Below 20 ☐ b. 21-30 ☐ c. 31-40 ☐ d. 41-50 ☐ e. 51-60 ☐ f. 60 & Above ☐

8. Marital status :(a) Married....... (b) Single.......(c) Widowed....... (d) divorced.......(e) separated.......

9. Do you have formal education? 1. Yes ☐ 2. No ☐ (tick the appropriate response)

10. If yes, how many years did you spend in school (total)? ....

11. For how long have you been farming?........................years

12. How many people are living in your household in past six months?

13. If you undertake other occupations, kindly indicate the average amount realized per month from any of the following that apply to you and the members of your household that contribute to household income.

Source	**Income realized/ month(₦)**
1.Livestock e.g sheep, goats, cattle	**.......................................**
2. Live stock products e.g manure, milk,hides/skin, meat	**.......................................**
3. Non – farm activities e.g Petty trading,	

fishing, hunting, tailoring, handicraft	
4.Processing farm produce	....
5.Working for other farmers	....
6.Off- farm employment e.g civil service,	....
guard etc	....
7.Others specify	....

B. PRODUCTION INFORMATION/ INPUT INFORMATION

14. Which type of cropping system do you practice?

(a) Monocropping ☐ (b) Intercropping ☐ (c) Both as monocropping and intercropping ☐

15. Please indicate the crops you grow as monocrops or intercrops (example: monocrop= sorghum or cowpea or millet etc.; Intercrops= sorghum/cowpea or Millet/ cowpea etc.) and the area allocated to each in 2011cropping season:

	Crop	Area allocated to the crop(s) in hectares
a. Monocrops crops	i.	
	ii.	
	iii.	
b. Intercrops	i.	

	ii.	
	iii.	
	iv	

16. How did you acquire the land for your crop production activities? (Tick the correct response(s))

No.	Forms of tenure		Area(hectares)	No.	Forms of tenure		Area(hectares)
1	Purchased			4	Leasehold		
2	Rented			5	Inheritance		
3	Pledge			6	Allocation by village leader		
7	Others specify						

17. If rented, how much did you pay as rent during the 2011 cropping season? ₦.......................

18. If purchased for how much did you buy the land? ₦.............Year of purchase...............

19. Total farm size....................hectares.

20. Do you own land which was not cultivated in 2011? (1). Yes ☐ (2). No ☐

21. What is the size of the uncultivated land you own in hectares........................

22. What is your reason for not cultivating the land ....

23. Indicate the type of change in your farm size during the last ten years (2000 – 2010):

1. Increased	3. Both increase and decrease

2. Decreased	4. No change

24. How many distinct parcels of land do you have? ....

25. What is the average distance between your house to parcels?........................ kilometres.

26a. Is land fragmentation or fragmented holding a problem? (a) Yes ☐ (b) No ☐

b. Is land degradation (soil erosion/low soil fertility) a problem? (a) Yes ☐ (b) No ☐

27. Please provide information requested in the following tables for the crops you cultivated in 2011 cropping season.

Name of crop 1 grown (monocrop)...

M= Male, F= Female, C= Child, A= Aged

Operation	Family Labour			Hired labour		
	No. of people M F C A	No. Of days spent M F C A	Cost of food(₦)	No. of people M F C A	No. of days spent M F C A	Amount paid (₦)
1. Land preparation						
2. Planting						
3. First weeding						
4. Second weeding						
5. Third weeding						
6. First fertilizer application						
7. Second fertilizer application						
8. Harvesting						
9. Threshing						
10. Winnowing						
11.Others specify						

Name of crop 2 grown (sole)..

M= Male, F= Female, C= Child, A= Aged

Operation	Family Labour			Hired labour		
	No. of people M F C A	No. Of days spent M F C A	Cost of food(₦)	No. of people M F C A	No. of days spent M F C A	Amount paid (₦)
1. Land preparation						
2. Planting						
3. First weeding						
4. Second weeding						
5. Third weeding						
6. First fertilizer application						
7. Second fertilizer application						
8. Harvesting						
9. Threshing						
10. Winnowing						
11.Others specify						

Name of crop 3 grown (sole)...

M= Male, F= Female, C= Child, A= Aged

Operation	Family Labour			Hired labour		
	No. of people M F C A	No. Of days spent M F C A	Cost of food(₦)	No. of people M F C A	No. of days spent M F C A	Amount paid (₦)
1. Land preparation						
2. Planting						
3. First weeding						
4. Second weeding						
5. Third weeding						
6. First fertilizer application						
7. Second fertilizer application						
8. Harvesting						
9. Threshing						
10. Winnowing						
11.Others specify						

Name of crops intercropped 1: (e.g Sorghum/ Cowpea) ……………………………………………………………

M= Male, F= Female, C= Child, A= Aged

Operation	Family Labour			Hired labour		
	No. of people M F C A	No. Of days spent M F C A	Cost of food(₦)	No. of people M F C A	No. of days spent M F C A	Amount paid (₦)
1. Land preparation						
2. Planting						
3. First weeding						
4. Second weeding						
5. Third weeding						
6. First fertilizer application						
7. Second fertilizer application						
8. Harvesting						
9. Threshing						
10. Winnowing						
11.Others specify						

Name of crops intercropped 2: ....

M= Male, F= Female, C= Child, A= Aged

Operation	Family Labour			Hired labour		
	No. of people M F C A	No. Of days spent M F C A	Cost of food(₦)	No. of people M F C A	No. of days spent M F C A	Amount paid (₦)
1. Land preparation						
2. Planting						
3. First weeding						
4. Second weeding						
5. Third weeding						
6. First fertilizer application						
7. Second fertilizer application						
8. Harvesting						
9. Threshing						
10. Winnowing						
11.Others specify						

28. How many people actively participated in farming activities such as planting, weeding e.t.c in your household? 1. Men....... 2. Women......... 3. Children........ 4. Old men/women.......

29. How many days in a week are available for farm work in your household? ....days

30. How many people actively participated in farming activities such as planting, weeding e.t.c as hired labourers? 1. Men....... 2. Women......... 3. Children........ 4. Old men/women.......

31. What was the average wage rate paid labourers for each of the following categories for a day's job? 1. Men ₦........... 2. Women ₦........... 3. Children ₦.......... 4. Old men/women ₦...........

32. How much did you spend on labour hiring for crop production in 2011? ₦.....................

33 a. Do you use animal traction for your production activities? 1. Yes ☐ 2. No ☐

b. Do you own or hire traction animals for your production activities?

1. Own ☐ 2. Hire ☐

34. How much do you pay the person(s) operating the work animals per day? ₦.....................

35. If you hired work animals, how much did you spend on hiring them for crop production activities in 2011? ₦.....................

36. Please supply the following information about the animal traction labour you utilised:

Activity	**Owned**		**Hired**		**Amount paid (₦)**
	No. of days	**No. of hours**	**No. of days**	**No. of hours**	
Ploughing	....	....	....	....	....
Ridge making	....	....	....	....	....
First weeding	....	....	....	....	....
Second wedding	....	....	....	....	....

37. Do you own or hire a plough? 1. Own ☐ 2. Hire ☐ 3. Both own or hire ☐

4. None of the above ☐

38. If you hired a plough, how much did you spend as cost for plough hiring in 2011? N................

39. Do you own or hire tractor? 1. Own ☐ 2. Hire ☐ 3. Both own or hire ☐

4. None of the above ☐

40. How much did you spend as cost for tractor hiring for crop production in 2011? N................

41. How many hours did the tractor spend on your farm for the following farm operations?

Operation	**Cropping system No. of Hrs spent**	**Amount spent (N)**
	Sole	
Ploughing and harrowing		
Ridging		
	Intercropping	
Ploughing and harrowing		
Ridging		

42. Please provide the following information about the inputs you used in 2011 cropping season.

Input(s)	Crop..................../		Crop................../		Crop..................		Crop............................	
	Qty(specify unit of measurement)	Total Amt. Spent(₦)	Qty(specify unit of measurement	Total Amt. Spent (₦)	Qty(specify unit of measurement)	Total Amt. Spent(₦)	Qty(specify unit of measurement)	Total Amt. Spent(₦)
1. Herbicides								
2. Insecticides								
3.Fertilizers								
4. Manures								
5. Seeds								
6. Others (specify)								

43. Please provide the following information about the farm implements you used in 2011 cropping season.

Input(s)	Crop................../				Crop.........................					
	Qty	Total Amt. Spent(₦)/unit	Present value (₦) / unit	Yr of purchase	Qty	Total Amt. Spent(₦) /unit	Present value/unit(₦)	Yr of purchase		Present value /unit
1. Hoes										
2. Axes										
3. Oxen drawn ploughs										
4. Sickles										
5. Ridger										
6.Tractor Drawn plough										

7. Harrow										
8. Baskets										
9.Cuttlasses										
10. Knapsack sprayer										
11.Tractor										
12. Others (specify)										

C. ACCES TO SERVICES

44. Please provide information about your usage of the following services (tick the appropriate response)

Type	Farmers Response	
1. Credit services	Yes	No
2. Agric. Extension services	Yes	No
3. Veterinary services	Yes	No
4. Improved seeds	Yes	No
5. Fertilizer	Yes	No
6. Do you belong to farmer's association?	Yes	No
7. *Fadama* land	Yes	No
8. Insurance company	Yes	No
9. Access to market	Yes	No

45. If you used credit facilities, how much did you receive as agricultural credit in 2011?

₦ ....

46. At what interest rate did you obtained the credit .... %

47. What is the amount of money expected to be paid back in 2011?

48. How many times did the extension agents visit you in 2011?..................

D. CROP OUTPUT, DISPOSAL AND INCOMES

48. How much did you spend for the following activities for the crops cultivated?

Activity	Crop................Dist ance(K	No. of times	Amt spent(₦)	Crop.....	No. of times	Amt spent(₦)	Crop.....	No. of times	Amt spent(₦)	Crop.....	No. of times travelled	Amt spent(₦)
1.**Trans**												
b.Store												
2.												
3.												

49. What is the total output, quantity sold and cash income realized from the sale of the following crops you produced for 2011?

Crop	**Size of bag (Kg)**	**Total output (bags)**	**Quantity sold (bags)**	**Price per bag**	**Gross income from sales (₦)**
Monocrops:					
1.....................					
2.....................					
3.....................					
Intercrops:					
1........................					
2........................					
3.......................					
4......................					

50. What was the estimated quantity of food required for consumption by your family per month or for 2011?

Food Item	Quantity consumed (Kg)per month	Size of bag(Kg)	Quantity consumed (bags)	Total value (₦) per year
1.Sorghum				
2.Cowpea				
3.Millet				
4.Maize				
5.Groundnuts				
6.Others specify				

E. LIVESTOCK INFORMATION

51. How many livestock do you own in 2011?

Livestock type	**Number**	**Average Price per head(₦)**	**Livestock type**	**Number**	**Average Price per head(₦)**
1.Oxen			8.Sheep		
2.Cows			a. Lamb		
3.Heifers			b. Ewe		
4.Calves			9.Goats		
5.Bulls			a. He goat		
6.Donkeys			b. She goat		

7. Horses			10.Poultry		
			11.Others(specify)		

52. Estimate the sales of livestock and livestock products in 2011.

Livestock type	**Number**	**Average Price per head(₦)**	**Livestock type**	**Number**	**Average Price per head(₦)**
1.Oxen			12.Sheep		
2.Cows			a. Lamb		
3.Heifers			b. Ewe		
4.Calves			13.Goats		
5.Bulls			a. He goat		
6.Meat (Kg)			b. She goat		
7.Manure(Kg)			14. Milk(calabash)		
8.Donkeys			15.Hides/Skin		
9.Horses					
11.Poultry					

F. ASSET INFORMATION

59. Which of the following assets do own?

Asset	Number	Value at purchase (₦)	Present monetary value per unit (₦)
1.House			
2.Car/Pick-up/Truck			
3.Motorcycle			
4.Bicycle			
5.Grinding machine			
6.Permanent trees			
7. Storage facilities (*Rumbu*)			
8. Others specify			

60. Please indicate the type of house you own.

1. Modern (cemented, roofed with zinc) ☐ 2. Local (not cemented, roofed with thatched grass) ☐

G. PRODUCTION CONSTRAINTS

61. Please indicate constraints faced in crop production, rank them according to their importance.

	Constraints	Not at all important				Very
	Inadequate land	1	2	3	4	5
	Inadequate labour	1	2	3	4	5
	Inadequate capital/money	1	2	3	4	5
	High fertilizer and seed price	1	2	3	4	5
	Low price for output	1	2	3	4	5
	Erosion problem	1	2	3	4	5
	Yield decline	1	2	3	4	5
	Lack of improved seed	1	2	3	4	5
	Diseases and pests problem	1	2	3	4	5
	Others specify	1	2	3	4	5

62. Rank the main constraints to the use of improved seeds based on their importance.

No.	Constraints	Not at all important				very
1	Not available	1	2	3	4	5
2	High price of improved seed	1	2	3	4	5

3	Lack of credit	1	2	3	4	5
4	Weather not good	1	2	3	4	5
5	Low price of output	1	2	3	4	5
6	Lack of knowledge	1	2	3	4	5
7	High price of fertilizer	1	2	3	4	5
8	Inadequate land	1	2	3	4	5
9	Poor straw quality	1	2	3	4	5
10	Others specify	1	2	3	4	5

63. Rank main constraints to the use of fertilizer based on their importance.

No.	Constraints	Not at all important				very
1	Not available	1	2	3	4	5
2	High price of fertilizers	1	2	3	4	5
3	Lack of credit	1	2	3	4	5
4	Low price of output	1	2	3	4	5
6	Lack of knowledge	1	2	3	4	5
7	High price of improved seed	1	2	3	4	5
8	Inadequate land	1	2	3	4	5
9	Late input delivery	1	2	3	4	5

64. The following scenarios represent the outcomes from a game played by tossing up a coin. The coin either appears on heads, or tails. Please choose the game that you will like to play. Note that the game is hypothetical.

	Amount to be won if:	
Game	Heads	Tails
O	₦ 5000	₦ 5000
A	₦ 4500	₦ 9500
B	₦ 4000	₦ 12000
C	₦ 3000	₦ 15000
D	₦ 1000	₦ 19000
E	₦ 0	₦ 20000

65. Given the game you have chosen to play in the previous question, please indicate the amount I will pay you not to play the game but instead take the money i will offer you?

	O	A	B	C	D	E
1		₦ 5000	₦ 6300	₦ 7200	₦ 8300	₦ 10000
2		₦ 5300	₦ 6500	₦ 7500	₦ 8700	₦ 10400
3		₦5600	₦ 6700	₦ 7700	₦ 9100	₦ 10800
4		₦ 5900	₦ 6900	₦ 8000	₦ 9500	₦ 11200
5		₦ 6200	₦ 7100	₦ 8200	₦ 9900	₦ 11500

66. Please indicate how important these sources of risk are to you.

Sources of risk	**Not at all important**				**very**
Flood/storm	1	2	3	4	5
Pests	1	2	3	4	5
Diseases	1	2	3	4	5
Erratic rainfall	1	2	3	4	5
Excessive rainfall	1	2	3	4	5
Insufficient rainfall	1	2	3	4	5
Drought	1	2	3	4	5
Fire outbreak	1	2	3	4	5
Change in government and agricultural policy	1	2	3	4	5
Illness of household member	1	2	3	4	5
Difficulties for finding labour	1	2	3	4	5
Insufficient family labour	1	2	3	4	5
Loss of land/ ethnic clash	1	2	3	4	5
Theft	1	2	3	4	5
Market failure	1	2	3	4	5
Price fluctuation(of input and output)	1	2	3	4	5

Family relationships	1	2	3	4	5
Insufficient work animals	1	2	3	4	5
Lack of work animals	1	2	3	4	5
Fertilizer	1	2	3	4	5
Changes in climatic conditions	1	2	3	4	5

67. Please indicate how important these risk management strategies are to you.

Risk management Strategies	**Not at all important**				**very**
Spreading sales	1	2	3	4	5
Fertilizer provision by government/self	1	2	3	4	5
Training and education	1	2	3	4	5
Investing off- farm	1	2	3	4	5
Fadama cultivation	1	2	3	4	5
Intercropping	1	2	3	4	5
Adashe (cash contribution)	1	2	3	4	5
Cooperative societies	1	2	3	4	5
Storage programme	1	2	3	4	5
Gathering market information	1	2	3	4	5
Having crop insurance	1	2	3	4	5

Price support	1	2	3	4	5
Borrowing (cash or grains)	1	2	3	4	5
Family members working off- farm	1	2	3	4	5
Household head working off-farm	1	2	3	4	5
Reduced consumption	1	2	3	4	5
Selling of assets	1	2	3	4	5
Faith in God	1	2	3	4	5
Planning expenditures	1	2	3	4	5
Spraying for diseases and pests					

68. What other issues can you point out about crop production not covered in the discussion so far.

1. ....

2. ....

3. ....

4. ....

Thank you for your cooperation.

APPENDIX B: FACTOR ANALYSIS RESULTS FOR MONOCROPPERS AND INTERCROPPERS

APPENDIX B1: VARIABLES USED IN FACTOR ANALYSIS FOR SOURCES OF RISK FOR THE MONOCROPPERS AND INTERCROPPERS

For the monocrop and intercrop farmers, 21 sources of risk variables were initially used for the factor analysis. Ten out of the 21 variables for monocroppers have KMO-value greater than 0.5 and these were the variables retained for the factor analysis. Eleven variables which include flood/storm, diseases, erratic rainfall, fire outbreak, difficulties for finding labour, market failure, price fluctuation (of input and output), family relationships, lack of work animals, fertiliser and changes in climatic conditions have KMO-values less than 0.5 and hence they were excluded from the factor analysis. For the intercroppers, 11 out of the 21 variables has KMO-value greater than 0.5 and were retained for the factor analysis. Ten variables namely; flood/storm, diseases, erratic rainfall, drought, fire outbreak, change in government and agricultural policy, insufficient family labour, market failure, lack of work animals, and fertiliser has KMO-values less than 0.5 and hence were not included for the factor analysis. However all the variables excluded in the factor analysis were used in the regression analysis in the subsequent sections. Table B1a shows the KMO-values of the variables included in the factor analysis for the sources of risk for the monocroppers and intercroppers.

APPENDIX B1a: Result of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for sources of risk for monocrop and intercrop farmers, Kebbi State, January 2012

Variables	Monocroppers KMO-Value	Intercroppers KMO-Value
PST	0.689	0.696
EXRN	0.665	0.627
INRN	0.635	0.710
DRT	0.640	

CGPOL	0.646	
ILL	0.765	0.635
INSLAB	0.725	
LLEC	0.721	0.566
THEFT	0.695	0.545
INSWA	0.700	0.607
DFLAB		0.621
PCFLUC		0.517
FRSP		0.614
CHCLIM		0.711
OVERALL	0.691	0.630

The result contained in Table B1a reveals that all the variables have KMO's greater than 0.5 which is an indication that the variables can be used for the factor analysis. The variables are interpreted as follows:

PST (VAR 2) indicates that the farmer identified pest as a source of risk which might reduce crop yield.

EXRN (VAR 5) farmers perceive excessive rain as a source of risk. Excessive rain does not only lead to poor harvest but it also affects the quality of grains which in turn influence the price farmers receive for the produce.

INRN (VAR6) indicates that farmers sees insufficient rainfall as a source of risk, insufficient rainfall reduces crop yield.

DRT (VAR7) indicates that the farmer perceived drought as a source of risk. The occurrence of drought depending on the intensity can lead to total crop loss on the farm.

CGPOL (VAR 9) farmers indicated that change in government policy is a source of risk, examples of such policies is price support and subsidy on farm inputs.

ILL (VAR10) indicates the illness of a household member as a source of risk which can have negative effect on labour input and finances.

INSLAB (VAR12) insufficient labour is a source of risk to the farmer**.**

THEFT (VAR 14) indicates that theft is a source of risk aversion to the farmers.

INSWA (VAR 18) indicates insufficient work animals as a source of risk which can cause delay in farm operations.

DFLAB (VAR 11) imply that difficulty in finding labour is a source of risk to the farmer. Untimely planting, weeding and harvesting can have a detrimental effect on crop yields.

PCFLUC (VAR 16) farmers perceived price fluctuation as a source of risk that could affect their profit or farm income.

FRSP (VAR 17) indicates that the farmer sees family relationships as a source of risk, lack of cordial family relationship can affect the farmer's ability to borrow money or grains in times of need. Family relationships can also affect labour availability especially where farmers practice communal labour.

CHCLIM (VAR 21) climate change is perceived as a source of risk to farmers because it is associated with flood/storm, drought and irregular rainfall.

The next step in the factor analysis was to determine the number of factors to be specified in the analysis. The principal component analysis was employed for this purpose. Factors with Eigen values greater than 1 were considered acceptable for inclusion in the factor analysis. For the risk source (monocroppers) three factors have Eigen values greater than 1, and explained 61.49% of the total variation in the original variables. Risk source (intercroppers) have five factors with Eigen values greater than 1, which explained 69.79% of the total variation in the original variables (Table 5.4).

APPENDIX B2: VARIABLES USED IN FACTOR ANALYSIS FOR RISK MANAGEMENT STRATEGIES FOR THE MONOCROPPERS AND INTERCROPPERS

Twenty risk management strategy variables were initially used for the factor analysis. Twelve out of the 20 variables for monocroppers have KMO-values less than 0.5 and hence they were removed from the factor analysis. The variables excluded from the factor analysis are spreading sales, fertiliser, provision of fertiliser by government/self, training and education, investing off-farm, *fadama* cultivation, adashe (rotation savings), cooperative societies, having crop insurance, borrowing (cash or grains), family members working off-farm, reduced consumption and selling of assets.

For the intercrop farmers, 10 out of the 20 variables has KMO-value greater than 0.5 and were retained for the factor analysis. Ten variables which are, spreading sale, fertiliser provision by government/self, *fadama* cultivation, intercropping, cooperative societies, storage progamme, borrowing (cash or grains), family member working off-farm, selling of assets has KMO-values less than 0.5 and hence were not included in the factor analysis. However all the risk management strategy variables that were excluded in the factor analysis were used in the regressions in the subsequent section. Appendix B2a shows the KMO-values of the variables included in the factor analysis for the risk management strategy for monocroppers and intercroppers.

APPENDIX B2a: Result of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for risk management strategy for monocrop and intercrop farmers, Kebbi State, January 2012

Variable	Monocroppers KMO-value	Intercroppers KMO-value
STRPR (VAR 9)	0.519	
GTHMKIN	0.446	0.829
FAITH	0.591	0.564
PLEXPT	0.603	0.650
PRSUP	0.449	0.791
INTC	0.621	
HHOFF	0.589	0.799
SPDISPT	0.575	
TRED		0.683
INVOFF		0.661

ADSH		0.923
HAVINS		0.803
RDCON		0.694
OVERALL	**0.559**	**0.741**

The variables used for the factor analysis are described as follows.

STRPR (VAR 9) indicates storage programme as a risk management strategy among monocrop farmers. Storage programme ensures that the farmer does not sell all the farm produce immediately after harvest when the prices are low. Farmers store some farm produce until planting time so as to get better prices for the produce.

GTHMKIN (VAR 10) indicates gathering market information; this is a management strategy which a farmers use in order to obtain good produce prices, thus more profit from the farm business.

FAITH (VAR 18) faith in God is indicated as a risk management strategy by the monocroppers, that is trusting God that the farms are secured and the harvest for the year will be good.

PLEXPT (VAR 19) indicates planning expenditure as a risk management strategy, planning expenditure helps the farmers to reduce the cost of buying inputs. With good financial planning farmers can buy inputs when the prices are relatively cheap thus reducing the cost of production.

PRSUP (VAR 12) Price support is perceived as a risk management strategy by the moncroppers. Farmers are sure of better produce prices with the price support policy.

INTC (VAR 6) indicate that the farmer consider intercropping as a risk management strategy.

HHOFF (VAR 15) indicates household head working off farm as a risk management strategy. Off-farm work serves as a means of getting extra income for the household.

SPDISPT (VAR 20) indicate spraying for diseases and pests as a risk management strategy, because monocrops are susceptible to pests and diseases and its occurrence can devastate the whole farm.

TRED (VAR 3) indicates that the intercrop farmers perceived training and education as an important risk management strategy. Training and education expose the farmers to best agronomic management practices that can improve productivity.

INVOFF (VAR 4) investing off–farm is indicated as a risk management strategy, it is a source of extra income to the farmer in addition to serving as a reserve in case of crop failure.

ADSH (VAR 7) adashe (rotation savings) is perceived as a risk management strategy by the intercrop farmers, in hard times farmers can fall back on their savings.

HAVINS (VAR 11) indicates having crop insurance as a management strategy. Insurance is aimed at protecting farmers in the event of uncertainty due to natural and man-made disasters for example drought, flood and fire outbreak.

RDCON (VAR16) indicates reduced consumption. Farmers reduce food consumption during hunger periods especially shortly before harvest when most of the storage barns are becoming empty.

The principal component analysis was used to determine the number of factors to be specified in the factor analysis. Eigen values greater than 1 were considered acceptable for the selection of the number of factors to be used for the factor analysis.

Risk management (monocroppers) have 3 factors with Eigen value greater than 1, that explained 62.68% of the total variation in the original variables. While for risk management (intercroppers) three factors has Eigen value greater than 1, and explained 71.25% of the total variation in the original variables (Table 5.6).

APPENDIX B3: MONOCROP RISK SOURCE

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
VAR00002	2.1939	1.03204	98
VAR00005	1.9388	.89462	98
VAR00006	1.9184	.75537	98
VAR00007	2.5000	1.13292	98
VAR00009	2.7551	1.09414	98
VAR00010	2.1327	.97004	98
VAR00012	2.1837	.98804	98
VAR00013	2.0204	1.07435	98
VAR00014	1.9490	1.02919	98
VAR00018	2.4694	1.10485	98

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.691
Bartlett's Test of Sphericity	Approx. Chi-Square	225.566
	df	45
	Sig.	.000

Communalities

	Initial	Extraction
VAR00002	1.000	.673
VAR00005	1.000	.752
VAR00006	1.000	.693
VAR00007	1.000	.534
VAR00009	1.000	.544
VAR00010	1.000	.554
VAR00012	1.000	.674
VAR00013	1.000	.625
VAR00014	1.000	.593
VAR00018	1.000	.508

Extraction Method: Principal Component Analysis.

Correlation Matrix

		VAR00002	VAR00005	VAR00006	VAR00007	VAR00009	VAR00010	VAR00012	VAR00013	VAR00014	VAR00018
Correlation	VAR00002	1.000	.471	.430	.278	-.058	.036	-.056	-.134	-.088	-.099
	VAR00005	.471	1.000	.603	.183	.048	.188	.304	.184	.209	.019
	VAR00006	.430	.603	1.000	.108	-.087	.071	.227	.053	-.058	-.065
	VAR00007	.278	.183	.108	1.000	.183	.145	-.129	-.017	.066	.165
	VAR00009	-.058	.048	-.087	.183	1.000	.322	.061	.031	.190	.352
	VAR00010	.036	.188	.071	.145	.322	1.000	.265	.294	.451	.336
	VAR00012	-.056	.304	.227	-.129	.061	.265	1.000	.482	.405	.100
	VAR00013	-.134	.184	.053	-.017	.031	.294	.482	1.000	.476	.235
	VAR00014	-.088	.209	-.058	.066	.190	.451	.405	.476	1.000	.194
	VAR00018	-.099	.019	-.065	.165	.352	.336	.100	.235	.194	1.000

Anti-image Matrices

		VAR0	VAR000	VAR000	VAR000	VAR000	VAR000	VAR000	VAR000	VAR000	VAR000
Anti-image Covariance	VAR00002	0.642	-0.189	-0.106	-0.157	0.053	-0.044	0.069	0.08	0.04	0.053
	VAR00005	-0.189	0.492	-0.252	-0.041	-0.046	0.005	-0.078	-0.038	-0.103	0.007
	VAR00006	-0.106	-0.252	0.555	-0.013	0.065	-0.04	-0.105	0	0.134	0.019
	VAR00007	-0.157	-0.041	-0.013	0.828	-0.103	-0.035	0.14	-0.012	-0.047	-0.099
	VAR00009	0.053	-0.046	0.065	-0.103	0.785	-0.149	-0.026	0.103	-0.035	-0.203
	VAR00010	-0.044	0.005	-0.04	-0.035	-0.149	0.678	-0.041	-0.039	-0.197	-0.145
	VAR00012	0.069	-0.078	-0.105	0.14	-0.026	-0.041	0.631	-0.198	-0.121	0.015
	VAR00013	0.08	-0.038	0	-0.012	0.103	-0.039	-0.198	0.63	-0.172	-0.123
	VAR00014	0.04	-0.103	0.134	-0.047	-0.035	-0.197	-0.121	-0.172	0.593	0.029
	VAR00018	0.053	0.007	0.019	-0.099	-0.203	-0.145	0.015	-0.123	0.029	0.773
Anti-image Correlation	VAR00002	.689[a]	-0.336	-0.178	-0.215	0.075	-0.066	0.108	0.126	0.065	0.075
	VAR00005	-0.336	.665[a]	-0.482	-0.064	-0.073	0.008	-0.14	-0.068	-0.191	0.011
	VAR00006	-0.178	-0.482	.635[a]	-0.019	0.098	-0.066	-0.177	0.001	0.233	0.029
	VAR00007	-0.215	-0.064	-0.019	.640[a]	-0.128	-0.047	0.193	-0.017	-0.067	-0.123
	VAR00009	0.075	-0.073	0.098	-0.128	.646[a]	-0.205	-0.037	0.147	-0.052	-0.261
	VAR00010	-0.066	0.008	-0.066	-0.047	-0.205	.765[a]	-0.063	-0.06	-0.31	-0.201
	VAR00012	0.108	-0.14	-0.177	0.193	-0.037	-0.063	.725[a]	-0.314	-0.199	0.022
	VAR00013	0.126	-0.068	0.001	-0.017	0.147	-0.06	-0.314	.721[a]	-0.281	-0.176
	VAR00014	0.065	-0.191	0.233	-0.067	-0.052	-0.31	-0.199	-0.281	.695[a]	0.043
	VAR00018	0.075	0.011	0.029	-0.123	-0.261	-0.201	0.022	-0.176	0.043	.700[a]

a. Measures of Sampling Adequacy(MSA)

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.633	26.331	26.331	2.633	26.331	26.331	2.224	22.245	22.245
2	2.039	20.390	46.722	2.039	20.390	46.722	2.127	21.267	43.512
3	1.478	14.776	61.498	1.478	14.776	61.498	1.799	17.986	61.498
4	.811	8.107	69.605						
5	.724	7.238	76.842						
6	.617	6.169	83.012						
7	.507	5.071	88.083						
8	.447	4.473	92.556						
9	.430	4.302	96.858						
10	.314	3.142	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
VAR00002	.161	.774	.219
VAR00005	.577	.644	-.071
VAR00006	.350	.742	-.141
VAR00007	.231	.259	.643
VAR00009	.364	-.277	.579
VAR00010	.680	-.195	.232
VAR00012	.645	-.066	-.503
VAR00013	.645	-.267	-.370
VAR00014	.692	-.309	-.133
VAR00018	.439	-.348	.441

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
VAR00002	-.222	.788	.056
VAR00005	.300	.812	.056
VAR00006	.134	.809	-.141
VAR00007	-.254	.368	.578
VAR00009	.042	-.077	.732
VAR00010	.457	.099	.579
VAR00012	.801	.159	-.081
VAR00013	.786	-.017	.082
VAR00014	.703	-.023	.314
VAR00018	.197	-.122	.674

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.778	.389	.494
2	-.292	.919	-.264
3	-.557	.062	.828

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

RELIABILITY TEST

OVERALL

Case Processing Summary

		N	%
Cases	Valid	98	100.0
	Excluded[a]	0	.0
	Total	98	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.653	10

Item Statistics

	Mean	Std. Deviation	N
VAR00002	2.1939	1.03204	98
VAR00005	1.9388	.89462	98
VAR00006	1.9184	.75537	98
VAR00007	2.5000	1.13292	98
VAR00009	2.7551	1.09414	98
VAR00010	2.1327	.97004	98
VAR00012	2.1837	.98804	98
VAR00013	2.0204	1.07435	98
VAR00014	1.9490	1.02919	98
VAR00018	2.4694	1.10485	98

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
22.0612	24.903	4.99033	10

Factor 1

Case Processing Summary

		N	%
Cases	Valid	98	100.0
	Excluded[a]	0	.0
	Total	98	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.714	3

Item Statistics

	Mean	Std. Deviation	N
VAR00012	2.1837	.98804	98
VAR00013	2.0204	1.07435	98

VAR00014	1.9490	1.02919	98

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
6.1531	6.090	2.46774	3

Factor 2

Case Processing Summary

		N	%
Cases	Valid	98	100.0
	Excluded[a]	0	.0
	Total	98	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.737	3

Reliability Statistics

Item Statistics

	Mean	Std. Deviation	N

VAR00002	2.1939	1.03204	98
VAR00005	1.9388	.89462	98
VAR00006	1.9184	.75537	98

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
6.0510	4.791	2.18888	3

Factor 3

Case Processing Summary

		N	%
Cases	Valid	98	100.0
	Excluded[a]	0	.0
	Total	98	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.568	4

Item Statistics

	Mean	Std. Deviation	N
VAR00007	2.5000	1.13292	98
VAR00009	2.7551	1.09414	98
VAR00010	2.1327	.97004	98
VAR00018	2.4694	1.10485	98

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
9.8571	8.082	2.84297	4

APPENDIX B4: RISK SOURCE FOR INTERCROPPERS

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
VAR00002	2.1019	1.02021	157
VAR00005	1.9045	.83038	157
VAR00006	2.0510	.81489	157
VAR00010	2.3057	1.00424	157
VAR00011	2.3694	1.08182	157

VAR00013	1.9554	.93606	157
VAR00014	1.6369	.87084	157
VAR00016	2.5605	1.11710	157
VAR00017	2.2229	1.14690	157
VAR00018	2.4968	1.20695	157
VAR00021	2.6561	1.21272	157

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.630
Bartlett's Test of Sphericity	Approx. Chi-Square	302.029
	df	55
	Sig.	.000

Correlation Matrix

		VAR00002	VAR00005	VAR00006	VAR00010	VAR00011	VAR00013	VAR00014	VAR00016	VAR00017	VAR00018	VAR00021
Correlation	VAR00002	1.000	.360	.487	.145	.273	.199	-.009	.056	.057	.125	.158
	VAR00005	.360	1.000	.547	.174	.068	.093	.218	-.108	.245	.009	.203
	VAR00006	.487	.547	1.000	.192	.182	.264	.162	-.032	.146	.091	.186
	VAR00010	.145	.174	.192	1.000	.485	.171	.252	.006	.091	.112	.124
	VAR00011	.273	.068	.182	.485	1.000	.124	.068	.204	.083	.227	.176
	VAR00013	.199	.093	.264	.171	.124	1.000	.468	-.086	.033	.059	.082
	VAR00014	-.009	.218	.162	.252	.068	.468	1.000	-.106	.088	-.010	.172
	VAR00016	.056	-.108	-.032	.006	.204	-.086	-.106	1.000	.057	.077	.252
	VAR00017	.057	.245	.146	.091	.083	.033	.088	.057	1.000	.290	.171
	VAR00018	.125	.009	.091	.112	.227	.059	-.010	.077	.290	1.000	.144
	VAR00021	.158	.203	.186	.124	.176	.082	.172	.252	.171	.144	1.000

Anti-image Matrices

		VAR00002	VAR00005	VAR00006	VAR00010	VAR00011	VAR00013	VAR00014	VAR00016	VAR00017	VAR00018	VAR00021
Anti-image Covariance	VAR00002	.673	-.124	-.190	.022	-.123	-.112	.124	-.031	.057	-.046	-.032
	VAR00005	-.124	.595	-.248	-.047	.049	.109	-.112	.096	-.150	.076	-.077
	VAR00006	-.190	-.248	.572	-.024	-.020	-.114	.014	.007	-.004	-.022	-.029
	VAR00010	.022	-.047	-.024	.702	-.315	-.006	-.124	.052	-.011	-.005	-.001
	VAR00011	-.123	.049	-.020	-.315	.660	-.019	.022	-.137	.006	-.113	-.038
	VAR00013	-.112	.109	-.114	-.006	-.019	.701	-.317	.053	.006	-.025	.015
	VAR00014	.124	-.112	.014	-.124	.022	-.317	.676	.053	-.019	.040	-.111
	VAR00016	-.031	.096	.007	.052	-.137	.053	.053	.854	-.045	.012	-.220
	VAR00017	.057	-.150	-.004	-.011	.006	.006	-.019	-.045	.841	-.242	-.061

	VAR00018	-.046	.076	-.022	-.005	-.113	-.025	.040	.012	-.242	.853	-.069
	VAR00021	-.032	-.077	-.029	-.001	-.038	.015	-.111	-.220	-.061	-.069	.831
Anti-image Correlation	VAR00010	.033	-.073	-.038	.635[a]	-.463	-.008	-.180	.067	-.014	-.006	-.001
	VAR00011	-.185	.078	-.033	-.463	.612[a]	-.027	.033	-.183	.007	-.150	-.052
	VAR00013	-.163	.168	-.180	-.008	-.027	.566[a]	-.461	.069	.007	-.032	.020
	VAR00014	.183	-.176	.022	-.180	.033	-.461	.545[a]	.070	-.025	.052	-.148
	VAR00005	-.196	.627[a]	-.425	-.073	.078	.168	-.176	.134	-.212	.107	-.109
	VAR00006	-.306	-.425	.710[a]	-.038	-.033	-.180	.022	.010	-.006	-.031	-.043
	VAR00016	-.040	.134	.010	.067	-.183	.069	.070	.517[a]	-.053	.014	-.262
	VAR00017	.076	-.212	-.006	-.014	.007	.007	-.025	-.053	.614[a]	-.286	-.073

	VAR00002	.696[a]	-.196	-.306	.033	-.185	-.163	.183	-.040	.076	-.061	-.043
	VAR00018	-.061	.107	-.031	-.006	-.150	-.032	.052	.014	-.286	.607[a]	-.082
	VAR00021	-.043	-.109	-.043	-.001	-.052	.020	-.148	-.262	-.073	-.082	.711[a]

Measures of Sampling Adequacy(MSA)

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.679	24.358	24.358	2.679	24.358	24.358	1.977	17.972	17.972
2	1.515	13.773	38.131	1.515	13.773	38.131	1.584	14.404	32.376
3	1.309	11.902	50.033	1.309	11.902	50.033	1.537	13.970	46.347
4	1.140	10.366	60.399	1.140	10.366	60.399	1.307	11.884	58.231
5	1.033	9.394	69.793	1.033	9.394	69.793	1.272	11.562	69.793

6	.881	8.013	77.806							
7	.672	6.110	83.916							
8	.536	4.871	88.788							
9	.448	4.070	92.858							
10	.428	3.894	96.752							
11	.357	3.248	100.000							

Extraction Method: Principal Component Analysis.

Communalities

	Initial	Extraction
VAR00002	1.000	.666
VAR00005	1.000	.689
VAR00006	1.000	.723
VAR00010	1.000	.653
VAR00011	1.000	.772
VAR00013	1.000	.592
VAR00014	1.000	.794
VAR00016	1.000	.740
VAR00017	1.000	.727
VAR00018	1.000	.637
VAR00021	1.000	.684

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component				
	1	2	3	4	5
VAR00002	.606	.018	-.389	-.383	-.010
VAR00005	.625	-.287	-.459	.073	.020
VAR00006	.711	-.219	-.386	-.143	.020
VAR00010	.538	.117	.459	-.260	-.268
VAR00011	.525	.452	.330	-.381	-.193
VAR00013	.470	-.411	.428	.064	.120

VAR00014	.438	-.449	.516	.293	.219
VAR00016	.075	.662	.030	-.069	.539
VAR00017	.363	.228	-.166	.676	-.241
VAR00018	.313	.460	.035	.372	-.435
VAR00021	.449	.307	-.009	.254	.569

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
VAR00002	.747	-.106	.291	-.061	.090
VAR00005	.784	.181	-.103	.176	-.015
VAR00006	.827	.155	.110	.054	.022
VAR00010	.100	.284	.744	.080	-.047
VAR00011	.117	-.002	.846	.084	.190
VAR00013	.149	.731	.177	-.051	-.035
VAR00014	.034	.888	.037	.047	.036
VAR00016	-.101	-.204	.154	-.035	.814
VAR00017	.146	.081	-.089	.827	.087
VAR00018	-.016	-.094	.308	.729	.032
VAR00021	.205	.237	-	.186	.742

			.018		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Component Transformation Matrix

Component	1	2	3	4	5
1	.696	.424	.449	.300	.213
2	-.253	-.555	.402	.357	.581
3	-.636	.591	.487	-.096	.009
4	-.216	.315	-.517	.760	.098
5	.034	.252	-.364	-.443	.779

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

RELIABILITY TEST

Case Processing Summary

		N	%
Cases	Valid	157	100.0
	Excluded[a]	0	.0
	Total	157	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.648	.662	11

Item Statistics

	Mean	Std.	N
VAR00002	2.1019	1.02021	157
VAR00005	1.9045	.83038	157
VAR00006	2.0510	.81489	157
VAR00010	2.3057	1.00424	157
VAR00011	2.3694	1.08182	157
VAR00013	1.9554	.93606	157
VAR00014	1.6369	.87084	157
VAR00016	2.5605	1.11710	157
VAR00017	2.2229	1.14690	157

VAR00018	2.4968	1.20695	157
VAR00021	2.6561	1.21272	157

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.206	1.637	2.656	1.019	1.623	.096	11
Item Variances	1.064	.664	1.471	.807	2.215	.086	11

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
24.2611	28.451	5.33391	11

Factor 1

Case Processing Summary

		N	%
Cases	Valid	157	100.0
	Excluded[a]	0	.0
	Total	157	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.711	.723	3

Item Statistics

	Mean	Std. Deviation	N
VAR00002	2.1019	1.02021	157
VAR00005	1.9045	.83038	157
VAR00006	2.0510	.81489	157

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.019	1.904	2.102	.197	1.104	.011	3
Item Variances	.798	.664	1.041	.377	1.567	.044	3

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
6.0573	4.554	2.13410	3

Factor 2

Case Processing Summary

		N	%
Cases	Valid	157	100.0
	Excluded[a]	0	.0
	Total	157	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.636	.637	2

Item Statistics

	Mean	Std. Deviation	N
VAR00013	1.9554	.93606	157
VAR00014	1.6369	.87084	157

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.796	1.637	1.955	.318	1.195	.051	2
Item Variances	.817	.758	.876	.118	1.155	.007	2

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
3.5924	2.397	1.54818	2

Factor 3

Case Processing Summary

		N	%
Cases	Valid	157	100.0
	Excluded[a]	0	.0
	Total	157	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.652	.654	2

Item Statistics

	Mean	Std. Deviation	N
VAR00010	2.3057	1.00424	157
VAR00011	2.3694	1.08182	157

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.338	2.306	2.369	.064	1.028	.002	2
Item Variances	1.089	1.008	1.170	.162	1.160	.013	2

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
4.6752	3.234	1.79821	2

Factor 4

Case Processing Summary

		N	%
Cases	Valid	157	100.0
	Excluded[a]	0	.0
	Total	157	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.449	.450	2

Item Statistics

	Mean	Std. Deviation	N
VAR00017	2.2229	1.14690	157
VAR00018	2.4968	1.20695	157

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.360	2.223	2.497	.274	1.123	.038	2
Item Variances	1.386	1.315	1.457	.141	1.107	.010	2

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
4.7197	3.575	1.89071	2

Case Processing Summary

		N	%
Cases	Valid	157	100.0
	Excluded[a]	0	.0
	Total	157	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.402	.403	2

Item Statistics

	Mean	Std. Deviation	N

VAR00016	2.5605	1.11710	157
VAR00021	2.6561	1.21272	157

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.608	2.561	2.656	.096	1.037	.005	2
Item Variances	1.359	1.248	1.471	.223	1.179	.025	2

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
5.2166	3.402	1.84432	2

APPENDIX B5: RISK MANAGEMENT STRATEGIES FOR MONOCROPPERS

Descriptive Statistics

	Mean	Std. Deviation	Analysis N	
VAR00006	2.4082	.97216	98	
VAR00009	2.5714	1.12149	98	
VAR00010	2.4592	1.17682	98	
VAR00012	2.3163	1.05123	98	
VAR00015	2.1837	.93442	98	

VAR00018	2.2347	1.05323	98	
VAR00019	2.5000	1.09592	98	
VAR00020	3.2347	1.13792	98	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.559
Bartlett's Test of Sphericity	Approx. Chi-Square	158.678
	df	28
	Sig.	.000

Communalities

	Initial	Extraction
VAR00006	1.000	.527
VAR00009	1.000	.538
VAR00010	1.000	.558
VAR00012	1.000	.631
VAR00015	1.000	.722
VAR00018	1.000	.640
VAR00019	1.000	.777
VAR00020	1.000	.622

Extraction Method: Principal Component Analysis.

Correlation Matrix

		VAR00006	VAR00009	VAR00010	VAR00012	VAR00015	VAR00018	VAR00019	VAR00020
Correlation	VAR00006	1.000	-.112	.123	-.007	.268	.208	.232	.332
	VAR00009	-.112	1.000	.213	.300	.115	.007	.017	-.211
	VAR00010	.123	.213	1.000	.356	.063	.162	.084	-.181
	VAR00012	-.007	.300	.356	1.000	-.028	.081	.192	.136
	VAR00015	.268	.115	.063	-.028	1.000	.249	.151	.153
	VAR00018	.208	.007	.162	.081	.249	1.000	.692	.306
	VAR00019	.232	.017	.084	.192	.151	.692	1.000	.442
	VAR00020	.332	-.211	-.181	.136	.153	.306	.442	1.000

Anti-image Matrices

		VAR00006	VAR00009	VAR00010	VAR00012	VAR00015	VAR00018	VAR00019	VAR00020
Anti-image Covariance	VAR00006	.790	.070	-.161	.078	-.177	.011	-.038	-.190
	VAR00009	.070	.807	-.037	-.223	-.154	.014	-.039	.169
	VAR00010	-.161	-.037	.735	-.275	-.016	-.103	.016	.213
	VAR00012	.078	-.223	-.275	.722	.077	.067	-.074	-.172
	VAR00015	-.177	-.154	-.016	.077	.852	-.118	.045	-.067
	VAR00018	.011	.014	-.103	.067	-.118	.482	-.298	-.018
	VAR00019	-.038	-.039	.016	-.074	.045	-.298	.446	-.148
	VAR00020	-.190	.169	.213	-.172	-.067	-.018	-.148	.622
Anti-image Correlation	VAR00006	.621[a]	.088	-.211	.104	-.216	.018	-.064	-.271
	VAR00009	.088	.519[a]	-.049	-.292	-.185	.023	-.064	.238
	VAR00010	-.211	-.049	.446[a]	-.377	-.020	-.173	.028	.315
	VAR00012	.104	-.292	-.377	.449[a]	.098	.113	-.130	-.257
	VAR00015	-.216	-.185	-.020	.098	.589[a]	-.184	.074	-.092
	VAR00018	.018	.023	-.173	.113	-.184	.591[a]	-.642	-.032
	VAR00019	-.064	-.064	.028	-.130	.074	-.642	.603[a]	-.280
	VAR00020	-.271	.238	.315	-.257	-.092	-.032	-.280	.575[a]

a. Measures of Sampling Adequacy(MSA)

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.322	29.020	29.020	2.322	29.020	29.020	2.063	25.791	25.791
2	1.629	20.358	49.379	1.629	20.358	49.379	1.647	20.586	46.377
3	1.064	13.300	62.679	1.064	13.300	62.679	1.304	16.301	62.679
4	.917	11.459	74.138						
5	.836	10.453	84.590						
6	.590	7.374	91.965						
7	.372	4.656	96.621						
8	.270	3.379	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
VAR00006	.537	-.191	.450
VAR00009	.001	.718	.149
VAR00010	.207	.699	.160
VAR00012	.279	.661	-.341
VAR00015	.431	.006	.732
VAR00018	.791	.025	-.116
VAR00019	.828	.001	-.303
VAR00020	.645	-.387	-.236

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
VAR00006	.302	-.076	.656
VAR00009	-.158	.714	.049
VAR00010	.022	.731	.149
VAR00012	.313	.681	-.264
VAR00015	.058	.115	.840
VAR00018	.750	.152	.233
VAR00019	.868	.125	.084
VAR00020	.727	-.285	.112

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.887	.168	.430
2	-.129	.985	-.118
3	-.443	.049	.895

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

RELIABILITY TEST

Overall

Case Processing Summary

		N	%
Cases	Valid	98	100.0
	Excluded[a]	0	.0
	Total	98	100.0

a. Listwise deletion based on all variables in the procedure.

Item Statistics

	Mean	Std. Deviation	N
VAR00006	2.4082	.97216	98
VAR00009	2.5714	1.12149	98
VAR00010	2.4592	1.17682	98
VAR00012	2.3163	1.05123	98
VAR00015	2.1837	.93442	98
VAR00018	2.2347	1.05323	98
VAR00019	2.5000	1.09592	98
VAR00020	3.2347	1.13792	98

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.489	2.184	3.235	1.051	1.481	.108	8
Item Variances	1.146	.873	1.385	.512	1.586	.030	8

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
19.9082	18.971	4.35556	8

Factor 1

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.732	.735	3

Item Statistics

	Mean	Std. Deviation	N
VAR00018	2.2347	1.05323	98
VAR00019	2.5000	1.09592	98
VAR00020	3.2347	1.13792	98

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.449	2.316	2.571	.255	1.110	.016	3
Item Variances	1.249	1.105	1.385	.280	1.253	.020	3

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
7.3469	5.899	2.42879	3

Factor 2

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.547	.550	3

Item Statistics

	Mean	Std. Deviation	N
VAR00009	2.5714	1.12149	98

VAR00010	2.4592	1.17682	98
VAR00012	2.3163	1.05123	98

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.449	2.316	2.571	.255	1.110	.016	3
Item Variances	1.249	1.105	1.385	.280	1.253	.020	3

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
7.3469	5.899	2.42879	3

C3

Case Processing Summary

		N	%
Cases	Valid	98	100.0
	Excluded[a]	0	.0
	Total	98	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.423	.423	2

Item Statistics

	Mean	Std. Deviation	N
VAR00006	2.4082	.97216	98
VAR00015	2.1837	.93442	98

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.296	2.184	2.408	.224	1.103	.025	2
Item Variances	.909	.873	.945	.072	1.082	.003	2

APPENDIX B6: RISK MANAGEMENT STRATEGIES FOR INTERCROPPERS

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
var00003	2.1656	.96906	151
var00004	2.1391	.98685	151
var00007	2.0795	.87577	151
var00010	2.2715	.97935	151
var00011	2.4040	1.04038	151
var00012	2.3377	1.01907	151
var00015	2.1258	.94731	151
var00016	2.0662	.90678	151
var00018	2.0530	1.10023	151
var00019	2.2848	1.06694	151

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.741
Bartlett's Test of Sphericity	Approx. Chi-Square	821.035
	df	45
	Sig.	.000

Communalities

Initial	Extraction
1.000	.889
1.000	.841
1.000	.562
1.000	.741
1.000	.806
1.000	.671
1.000	.482
1.000	.621
1.000	.760
1.000	.752

Extraction Method: Principal Component Analysis.

Correlation Matrix

		var00003	var00004	var00007	var00010	var00011	var00012	var00015	var00016	var00018	var00019
Correlation	var00003	1.000	.875	.401	.570	.456	.254	.297	.071	.204	.393
	var00004	.875	1.000	.404	.485	.406	.271	.402	.183	.226	.475
	var00007	.401	.404	1.000	.558	.586	.388	.414	.212	.162	.211
	var00010	.570	.485	.558	1.000	.755	.569	.416	.167	.265	.276
	var00011	.456	.406	.586	.755	1.000	.669	.482	.226	.168	.280
	var00012	.254	.271	.388	.569	.669	1.000	.377	.401	.204	.334
	var00015	.297	.402	.414	.416	.482	.377	1.000	.386	.288	.215
	var00016	.071	.183	.212	.167	.226	.401	.386	1.000	.351	.242
	var00018	.204	.226	.162	.265	.168	.204	.288	.351	1.000	.623
	var00019	.393	.475	.211	.276	.280	.334	.215	.242	.623	1.000

Anti-image Matrices

		var00003	var00004	var00007	var00010	var00011	var00012	var00015	var00016	var00018	var00019
Anti-image Covariance	var00003	.183	-.148	.007	-.063	-.028	.030	.067	.046	-.025	.022
	var00004	-.148	.178	-.029	.011	.028	.003	-.098	-.050	.061	-.091
	var00007	.007	-.029	.592	-.072	-.104	.030	-.061	-.042	.006	.008
	var00010	-.063	.011	-.072	.318	-.131	-.084	-.005	.057	-.095	.064
	var00011	-.028	.028	-.104	-.131	.292	-.139	-.097	.022	.058	-.037
	var00012	.030	.003	.030	-.084	-.139	.439	.001	-.179	.068	-.100
	var00015	.067	-.098	-.061	-.005	-.097	.001	.587	-.123	-.111	.090
	var00016	.046	-.050	-.042	.057	.022	-.179	-.123	.671	-.154	.050
	var00018	-.025	.061	.006	-.095	.058	.068	-.111	-.154	.489	-.288
	var00019	.022	-.091	.008	.064	-.037	-.100	.090	.050	-.288	.434
Anti-image Correlation	var00003	.683[a]	-.821	.022	-.261	-.121	.105	.204	.131	-.084	.078
	var00004	-.821	.661[a]	-.089	.045	.123	.010	-.303	-.144	.207	-.328
	var00007	.022	-.089	.923[a]	-.166	-.251	.059	-.103	-.067	.011	.017

var00010	-.261	.045	-.166	.829[a]	-.428	-.226	-.011	.124	-.240	.171
var00011	-.121	.123	-.251	-.428	.803[a]	-.390	-.235	.049	.154	-.103
var00012	.105	.010	.059	-.226	-.390	.791[a]	.001	-.330	.146	-.229
var00015	.204	-.303	-.103	-.011	-.235	.001	.799[a]	-.196	-.207	.179
var00016	.131	-.144	-.067	.124	.049	-.330	-.196	.694[a]	-.269	.092
var00018	-.084	.207	.011	-.240	.154	.146	-.207	-.269	.564[a]	-.626
var00019	.078	-.328	.017	.171	-.103	-.229	.179	.092	-.626	.650[a]

a. Measures of Sampling Adequacy(MSA)

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.424	44.238	44.238	4.424	44.238	44.238	3.069	30.687	30.687
2	1.398	13.983	58.221	1.398	13.983	58.221	2.189	21.893	52.580
3	1.303	13.029	71.251	1.303	13.029	71.251	1.867	18.671	71.251
4	.796	7.961	79.212						

5	.631	6.308	85.520						
6	.518	5.178	90.697						
7	.413	4.131	94.828						
8	.236	2.358	97.186						
9	.188	1.878	99.064						
10	.094	.936	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
var00003	.718	-.208	-.575
var00004	.736	-.081	-.541
var00007	.678	-.286	.142
var00010	.806	-.294	.068
var00011	.799	-.310	.265
var00012	.684	-.029	.451
var00015	.641	.052	.262
var00016	.430	.480	.453
var00018	.469	.730	-.084
var00019	.579	.562	-.316

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
var00003	.274	.898	.088
var00004	.266	.852	.212
var00007	.683	.308	.005
var00010	.739	.439	.047
var00011	.853	.277	.031
var00012	.782	.002	.245
var00015	.615	.115	.301
var00016	.428	-.249	.613
var00018	.067	.155	.855
var00019	.070	.441	.743

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

Component Transformation Matrix

Component	1	2	3

1	.750	.532	.394
2	-.324	-.223	.919
3	.576	-.817	.005

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Case Processing Summary

		N	%
Cases	Valid	151	100.0
	Excluded[a]	0	.0
	Total	151	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.853	10

Item Statistics

	Mean	Std. Deviation	N

var00003	2.1656	.96906	151
var00004	2.1391	.98685	151
var00007	2.0795	.87577	151
var00010	2.2715	.97935	151
var00011	2.4040	1.04038	151
var00012	2.3377	1.01907	151
var00015	2.1258	.94731	151
var00016	2.0662	.90678	151
var00018	2.0530	1.10023	151
var00019	2.2848	1.06694	151

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
21.9272	42.308	6.50446	10

Factor1

Case Processing Summary

	N	%

Cases	Valid	151	100.0
	Excluded[a]	0	.0
	Total	151	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.846	5

Item Statistics

	Mean	Std. Deviation	N
var00007	2.0795	.87577	151
var00010	2.2715	.97935	151
var00011	2.4040	1.04038	151
var00012	2.3377	1.01907	151
var00015	2.1258	.94731	151

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
11.2185	14.692	3.83300	5

Factor 2

Case Processing Summary

		N	%
Cases	Valid	151	100.0
	Excluded[a]	0	.0
	Total	151	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.800	3

Item Statistics

	Mean	Std. Deviation	N
var00003	2.1656	.96906	151
var00004	2.1391	.98685	151
var00019	2.2848	1.06694	151

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
6.5894	6.537	2.55675	3

Factor 3

Case Processing Summary

		N	%
Cases	Valid	151	100.0
	Excluded[a]	0	.0
	Total	151	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.512	2

Item Statistics

	Mean	Std. Deviation	N
var00016	2.0662	.90678	151
var00018	2.0530	1.10023	151

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
4.1192	2.732	1.65299	2

APPENDIX C: MULTICOLLINEARITY TEST

APPENDIX C1 MONOCROP: RISK AVERSION VERSUS RISK SOURCE, EXPLANATORY VARIABLES AND RISK MANAGEMENT STRATEGY

Multiple Regression Report

Dependent RA

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Multicollinearity Section

	Variance	R2		Diagonal
Independent	**Inflation**	**Versus**		**of X'X**
Variable	**Factor**	**Other I.V.'s**	**Tolerance**	**Inverse**
ADSH	2.3107	0.5672	0.4328	3.571153E-02
ASV	0.0000			0
BRW	2.0558	0.5136	0.4864	1.906427E-02
CHCLIM	1.8539	0.4606	0.5394	1.425539E-02
(COOP=1)	1.4866	0.3273	0.6727	7.599601E-02
COOPx	2.0848	0.5203	0.4797	1.564385E-02
DFLAB	1.9423	0.4851	0.5149	0.0144945
DIS	1.3057	0.2341	0.7659	9.699004E-03
EDU	1.7223	0.4194	0.5806	1.427139E-03
ERRN	1.8197	0.4505	0.5495	1.073178E-02
EXP	2.7040	0.6302	0.3698	3.533313E-04
FA1_1	2.9457	0.6605	0.3395	3.036803E-02
FA2_1	4.4503	0.7753	0.2247	4.587913E-02
FA3_1	2.4669	0.5946	0.4054	2.543231E-02

FAC1_1	2.5146	0.6023	0.3977	2.592405E-02
FAC2_1	2.2367	0.5529	0.4471	2.305914E-02
FAC3_1	2.1101	0.5261	0.4739	2.175356E-02
(FDM=1)	2.0535	0.5130	0.4870	9.126501E-02
FDMCUL	2.0292	0.5072	0.4928	1.415615E-02
FER	2.9919	0.6658	0.3342	2.589227E-02
FERGOV	2.7239	0.6329	0.3671	2.822653E-02
FLST	1.6244	0.3844	0.6156	1.116606E-02
FMOFF	1.5989	0.3746	0.6254	1.125562E-02
FROBK	2.4861	0.5978	0.4022	3.389529E-02
FRSP	4.0582	0.7536	0.2464	5.069567E-02
FS	2.0898	0.5215	0.4785	0.0293864
GM	0.0000			0
HAVINS	3.9079	0.7441	0.2559	3.463955E-02
HHS	2.7815	0.6405	0.3595	1.638522E-03
(HT=1)	2.4658	0.5945	0.4055	0.101025
INVOFF	2.9420	0.6601	0.3399	0.032135
KM	1.7263	0.4207	0.5793	7.323991E-04
LCKWA	2.1780	0.5409	0.4591	0.0161019
MKFL	2.1641	0.5379	0.4621	2.282379E-02
PCFLUC	1.9475	0.4865	0.5135	1.434458E-02
RDCON	3.3330	0.7000	0.3000	3.015427E-02
SELAST	1.9270	0.4811	0.5189	1.444677E-02
SPDSL	1.6459	0.3924	0.6076	1.130203E-02

Multiple Regression Report

Dependent RA

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Multicollinearity Section

	Variance	R2		Diagonal
Independent	**Inflation**	**Versus**		**of X'X**
Variable	**Factor**	**Other I.V.'s**	**Tolerance**	**Inverse**
TRED	3.0170	0.6686	0.3314	3.748363E-02

Eigenvalues of Centered Correlations

		Incremental	Cumulative	Condition
No.	**Eigenvalue**	**Percent**	**Percent**	**Number**
1	4.6382	11.893	11.893	1.000
2	2.8255	7.245	19.138	1.642
3	2.4812	6.362	25.500	1.869
4	2.2606	5.796	31.296	2.052
5	2.0302	5.206	36.502	2.285
6	1.8881	4.841	41.343	2.457
7	1.8607	4.771	46.114	2.493
8	1.5915	4.081	50.195	2.914
9	1.4508	3.720	53.915	3.197
10	1.4096	3.614	57.529	3.290
11	1.3441	3.446	60.975	3.451
12	1.2821	3.288	64.263	3.618
13	1.1445	2.935	67.198	4.053

14	1.0503	2.693	69.891	4.416
15	0.9651	2.475	72.365	4.806
16	0.8917	2.287	74.652	5.201
17	0.8693	2.229	76.881	5.335
18	0.8157	2.092	78.972	5.686
19	0.7672	1.967	80.940	6.045
20	0.7459	1.912	82.852	6.219
21	0.7160	1.836	84.688	6.478
22	0.6106	1.566	86.254	7.596
23	0.5878	1.507	87.761	7.891
24	0.5157	1.322	89.083	8.994
25	0.4917	1.261	90.344	9.433
26	0.4897	1.256	91.599	9.472
27	0.4721	1.210	92.810	9.825
28	0.4196	1.076	93.886	11.053
29	0.3844	0.986	94.871	12.067
30	0.3239	0.831	95.702	14.318
31	0.3044	0.781	96.483	15.237
32	0.2878	0.738	97.221	16.115
33	0.2163	0.555	97.775	21.445
34	0.1998	0.512	98.288	23.209
35	0.1819	0.466	98.754	25.502
36	0.1443	0.370	99.124	32.141
37	0.1315	0.337	99.461	35.265
38	0.1142	0.293	99.754	40.631
39	0.0960	0.246	100.000	48.310

All Condition Numbers less than 100. Multicollinearity is NOT a problem.

APPENDIX C2: INTERCROPS: RISK ATTITUDE VERSUS EXPLANATORY VARIABLES, RISK SOURCE AND RISK MANAGEMENT STRATEGY

Multiple Regression Report

than the machine zero of 0.0000000001.

Multicollinearity Section

	Variance	R2		Diagonal
Independent	**Inflation**	**Versus**		**of X'X**
Variable	**Factor**	**Other I.V.'s**	**Tolerance**	**Inverse**
ASV	0.0000			0
BRW	1.3299	0.2481	0.7519	6.497546E-03
CGPOL	1.3966	0.2840	0.7160	6.140568E-03
(COOP=1)	1.4829	0.3256	0.6744	5.308615E-02
COOPx	1.3280	0.2470	0.7530	5.687702E-03
DIS	1.3418	0.2547	0.7453	5.818387E-03
DRT	1.6635	0.3989	0.6011	9.574352E-03
EDU	1.3680	0.2690	0.7310	5.344784E-04
ERRN	1.5364	0.3491	0.6509	6.274763E-03
EXP	1.6798	0.4047	0.5953	1.32681E-04
FA1_1	3.1475	0.6823	0.3177	2.098342E-02
FA2_1	3.8087	0.7374	0.2626	2.539122E-02
FA3_1	2.2044	0.5464	0.4536	1.469629E-02
FAC1_1	2.6037	0.6159	0.3841	1.696945E-02
FAC2_1	1.9020	0.4742	0.5258	1.305015E-02
FAC3_1	2.1758	0.5404	0.4596	1.468387E-02

FAC4_1	1.5371	0.3494	0.6506	1.024659E-02
FAC5_1	1.3716	0.2709	0.7291	9.148602E-03
(FDM=1)	1.2203	0.1805	0.8195	3.814963E-02
FDMCUL	2.6987	0.6294	0.3706	1.254625E-02
FER	2.3145	0.5680	0.4320	1.302148E-02
FERGOV	4.2318	0.7637	0.2363	2.402285E-02
FLST	1.4226	0.2970	0.7030	5.324353E-03
FMOFF	1.6347	0.3883	0.6117	7.407433E-03
FROBK	2.7432	0.6355	0.3645	0.0190814
FS	1.7317	0.4225	0.5775	1.897673E-02
GM	0.0000			0
HHS	1.6990	0.4114	0.5886	1.128971E-03
(HT=1)	2.1342	0.5314	0.4686	6.381595E-02
INSLAB	2.3152	0.5681	0.4319	1.521442E-02
INTC	1.4427	0.3068	0.6932	6.002506E-03
KM	1.2511	0.2007	0.7993	4.73344E-04
LCKWA	1.7264	0.4207	0.5793	1.019243E-02
MKFL	1.6032	0.3763	0.6237	9.194282E-03
SELAST	1.3467	0.2575	0.7425	6.13551E-03
SPDISPT	2.4064	0.5844	0.4156	1.072172E-02
SPDSL	1.2840	0.2212	0.7788	6.245381E-03
STRPR	1.4132	0.2924	0.7076	7.32736E-03

Multiple Regression Report

Dependent RA

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Eigenvalues of Centered Correlations

		Incremental	Cumulative	Condition
No.	**Eigenvalue**	**Percent**	**Percent**	**Number**
1	3.9250	10.329	10.329	1.000
2	2.4606	6.475	16.804	1.595
3	2.1811	5.740	22.544	1.800
4	1.9305	5.080	27.624	2.033
5	1.7945	4.722	32.347	2.187
6	1.7267	4.544	36.890	2.273
7	1.6027	4.218	41.108	2.449
8	1.4773	3.888	44.996	2.657
9	1.3888	3.655	48.650	2.826
10	1.3632	3.587	52.238	2.879
11	1.2499	3.289	55.527	3.140
12	1.2027	3.165	58.692	3.263
13	1.1283	2.969	61.661	3.479
14	1.0980	2.889	64.551	3.575
15	1.0844	2.854	67.404	3.619
16	1.0336	2.720	70.124	3.798
17	1.0038	2.642	72.766	3.910
18	0.9328	2.455	75.221	4.208
19	0.8404	2.212	77.432	4.670

20	0.7870	2.071	79.503	4.987
21	0.7488	1.970	81.474	5.242
22	0.7405	1.949	83.422	5.301
23	0.6981	1.837	85.259	5.622
24	0.6409	1.687	86.946	6.124
25	0.5567	1.465	88.411	7.050
26	0.5479	1.442	89.853	7.164
27	0.5212	1.371	91.225	7.531
28	0.4798	1.263	92.487	8.181
29	0.4648	1.223	93.710	8.445
30	0.4212	1.108	94.819	9.318
31	0.3516	0.925	95.744	11.162
32	0.3168	0.834	96.578	12.391
33	0.3101	0.816	97.394	12.658
34	0.3059	0.805	98.199	12.831
35	0.2612	0.687	98.886	15.027
36	0.1822	0.479	99.365	21.547
37	0.1421	0.374	99.739	27.617
38	0.0990	0.261	100.000	39.642

All Condition Numbers less than 100. Multicollinearity is NOT a problem.

APPENDIX C3: MONOCROPPERS RISK SOURCE VERSUS EXPLANATORY VARIABLES, RISK ATTITUDE AND MANGEMENT STRATEGY

Multiple Regression Report

Dependent FAC1_1

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Multicollinearity Section

	Variance	R2		Diagonal
Independent	**Inflation**	**Versus**		**of X'X**
Variable	**Factor**	**Other I.V.'s**	**Tolerance**	**Inverse**
ADSH	1.9556	0.4887	0.5113	3.022411E-02
ASV	0.0000			0
BRW	1.7147	0.4168	0.5832	1.590092E-02
(COOP=1)	1.3598	0.2646	0.7354	6.951736E-02
COOPx	1.6968	0.4107	0.5893	1.273256E-02
EDU	1.2213	0.1812	0.8188	1.011969E-03
EXP	2.0059	0.5015	0.4985	2.621101E-04
FA1_1	1.6514	0.3944	0.6056	1.702438E-02
FA2_1	2.4915	0.5986	0.4014	2.568536E-02
FA3_1	2.0495	0.5121	0.4879	2.112862E-02
(FDM=1)	1.5765	0.3657	0.6343	7.006861E-02
FDMCUL	1.7011	0.4122	0.5878	1.186718E-02
FERGOV	2.2678	0.5590	0.4410	2.350014E-02
FMOFF	1.3076	0.2353	0.7647	9.205475E-03
FS	1.8305	0.4537	0.5463	2.574059E-02
GM	0.0000			0

HAVINS	2.3889	0.5814	0.4186	2.117497E-02
HHS	2.3278	0.5704	0.4296	1.371266E-03
(HT=1)	2.1379	0.5322	0.4678	8.758842E-02
INVOFF	2.7252	0.6331	0.3669	2.976743E-02
KM	1.2665	0.2105	0.7895	5.373592E-04
RA	1.5128	0.3390	0.6610	1.056847E-02
RDCON	1.9483	0.4867	0.5133	1.762715E-02
SELAST	1.5924	0.3720	0.6280	1.193825E-02
SPDSL	1.5513	0.3554	0.6446	1.065187E-02
TRED	2.4130	0.5856	0.4144	2.997877E-02

Dependent FAC1_1

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Eigenvalues of Centered Correlations

	Incremental	**Cumulative**	**Condition**	
No.	**Eigenvalue**	**Percent**	**Percent**	**Number**
1	3.3379	12.838	12.838	1.000
2	2.5568	9.834	22.672	1.305
3	2.0082	7.724	30.396	1.662
4	1.7916	6.891	37.286	1.863
5	1.7533	6.743	44.030	1.904
6	1.4850	5.711	49.741	2.248
7	1.2867	4.949	54.690	2.594
8	1.2645	4.864	59.554	2.640
9	1.1195	4.306	63.859	2.982

10	1.0408	4.003	67.862	3.207
11	1.0296	3.960	71.823	3.242
12	1.0140	3.900	75.723	3.292
13	0.8362	3.216	78.939	3.992
14	0.7727	2.972	81.911	4.320
15	0.6441	2.477	84.388	5.182
16	0.5857	2.253	86.641	5.699
17	0.5770	2.219	88.860	5.785
18	0.5271	2.027	90.887	6.333
19	0.4720	1.815	92.703	7.072
20	0.4051	1.558	94.261	8.240
21	0.3631	1.396	95.657	9.193
22	0.3048	1.172	96.829	10.950
23	0.2548	0.980	97.809	13.102
24	0.2140	0.823	98.632	15.598
25	0.1837	0.707	99.339	18.169
26	0.1719	0.661	100.000	19.420

All Condition Numbers less than 100. Multicollinearity is NOT a problem.

APPENDIX C4: INTERCROPPERS RISK SOURCE VERSUS EXPLANATORY VARIABLES, RISK ATTITUDE AND RISK MANGEMENT STRATEGY

Dependent FAC1_1

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Multicollinearity Section

	Variance	R2		Diagonal
Independent	**Inflation**	**Versus**		**of X'X**
Variable	**Factor**	**Other I.V.'s**	**Tolerance**	**Inverse**
ASV	0.0000			0
BRW	1.2548	0.2031	0.7969	6.130764E-03
(COOP=1)	1.2683	0.2115	0.7885	4.540404E-02
COOPx	1.1986	0.1657	0.8343	5.133555E-03
EDU	1.2000	0.1666	0.8334	4.688148E-04
EXP	1.5012	0.3339	0.6661	1.185745E-04
FA1_1	2.4095	0.5850	0.4150	1.606352E-02
FA2_1	2.6612	0.6242	0.3758	1.774109E-02
FA3_1	1.8325	0.4543	0.5457	1.221653E-02
(FDM=1)	1.1073	0.0969	0.9031	3.461801E-02
FDMCUL	2.3506	0.5746	0.4254	0.010928
FERGOV	2.6732	0.6259	0.3741	1.517473E-02
FMOFF	1.4736	0.3214	0.6786	6.677173E-03
FS	1.3860	0.2785	0.7215	1.518827E-02
GM	0.0000			0
HHS	1.5535	0.3563	0.6437	1.03232E-03

(HT=1)	2.0147	0.5036	0.4964	6.024114E-02
INTC	1.3004	0.2310	0.7690	5.410367E-03
KM	1.1454	0.1270	0.8730	4.333452E-04
RA	1.2094	0.1731	0.8269	2.945446E-03
SELAST	1.1965	0.1643	0.8357	5.451285E-03
SPDISPT	1.9173	0.4784	0.5216	8.542544E-03
SPDSL	1.1819	0.1539	0.8461	5.748861E-03
STRPR	1.2329	0.1889	0.8111	6.392899E-03

Dependent FAC1_1

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Eigenvalues of Centered Correlations

		Incremental	**Cumulative**	**Condition**
No.	**Eigenvalue**	**Percent**	**Percent**	**Number**
1	2.5397	10.582	10.582	1.000
2	2.0174	8.406	18.988	1.259
3	1.9633	8.180	27.168	1.294
4	1.7341	7.225	34.393	1.465
5	1.4464	6.027	40.420	1.756
6	1.3334	5.556	45.976	1.905
7	1.2276	5.115	51.091	2.069
8	1.1235	4.681	55.772	2.261
9	1.1148	4.645	60.417	2.278
10	1.0667	4.445	64.862	2.381

11	1.0318	4.299	69.161	2.461
12	0.9521	3.967	73.128	2.667
13	0.8538	3.557	76.685	2.975
14	0.7852	3.272	79.957	3.235
15	0.7467	3.111	83.068	3.401
16	0.7381	3.076	86.144	3.441
17	0.6884	2.868	89.012	3.689
18	0.6144	2.560	91.572	4.133
19	0.4889	2.037	93.610	5.194
20	0.4678	1.949	95.559	5.429
21	0.3847	1.603	97.162	6.602
22	0.3200	1.333	98.495	7.937
23	0.2034	0.847	99.343	12.487
24	0.1578	0.657	100.000	16.096

All Condition Numbers less than 100. Multicollinearity is NOT a problem.

APPENDIX C5: MONOCROP MANAGEMENT VERSUS EXPLANATORY VARIABLES, RISK ATTITUDE AND SOURCES OF RISK

Dependent FA1_1

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Multicollinearity Section

	Variance	**R2**		**Diagonal**
Independent	**Inflation**	**Versus**		**of X'X**
Variable	**Factor**	**Other I.V.'s**	**Tolerance**	**Inverse**
ASV	0.0000			0
CHCLIM	1.5027	0.3345	0.6655	1.155501E-02
(COOPx=1)	1.1474	0.1285	0.8715	5.865818E-02
DFLAB	1.5560	0.3573	0.6427	1.161171E-02
DIS	1.1456	0.1271	0.8729	8.509932E-03
EDU	1.4959	0.3315	0.6685	1.239527E-03
ERRN	1.1761	0.1498	0.8502	6.936381E-03
EXP	1.7905	0.4415	0.5585	2.339632E-04
FAC1_1	1.8328	0.4544	0.5456	1.889471E-02
FAC2_1	1.6178	0.3819	0.6181	1.667869E-02
FAC3_1	1.6710	0.4016	0.5984	1.722665E-02
(FDM=1)	1.3508	0.2597	0.7403	6.003744E-02
FER	1.5548	0.3568	0.6432	0.0134553
FLST	1.3977	0.2845	0.7155	9.607303E-03
FROBK	1.7146	0.4168	0.5832	2.337657E-02
FRSP	2.2085	0.5472	0.4528	2.758873E-02
FS	1.4356	0.3034	0.6966	2.018771E-02

GM	0.0000			0
HHS	1.8030	0.4454	0.5546	1.062085E-03
(HT=1)	1.9431	0.4854	0.5146	7.961015E-02
KM	1.3984	0.2849	0.7151	5.932829E-04
LCKWA	1.6996	0.4116	0.5884	1.256463E-02
MKFL	1.5289	0.3460	0.6540	1.612528E-02
PCFLUC	1.3794	0.2750	0.7250	1.016005E-02
RA	1.2979	0.2295	0.7705	0.0090671

Dependent FA1_1

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Eigenvalues of Centered Correlations

		Incremental	Cumulative	Condition
No.	**Eigenvalue**	**Percent**	**Percent**	**Number**
1	2.8380	11.352	11.352	1.000
2	2.1978	8.791	20.143	1.291
3	1.9149	7.660	27.803	1.482
4	1.7360	6.944	34.747	1.635
5	1.6057	6.423	41.170	1.767
6	1.4874	5.950	47.119	1.908
7	1.4575	5.830	52.949	1.947
8	1.1738	4.695	57.645	2.418
9	1.0614	4.246	61.890	2.674
10	1.0306	4.122	66.013	2.754
11	0.9924	3.970	69.982	2.860

12	0.8855	3.542	73.524	3.205
13	0.8127	3.251	76.775	3.492
14	0.7591	3.037	79.812	3.738
15	0.7347	2.939	82.751	3.863
16	0.6734	2.694	85.444	4.215
17	0.6541	2.617	88.061	4.339
18	0.5206	2.083	90.143	5.451
19	0.4977	1.991	92.134	5.703
20	0.4729	1.892	94.026	6.001
21	0.3704	1.482	95.507	7.661
22	0.3543	1.417	96.925	8.009
23	0.3058	1.223	98.148	9.280
24	0.2528	1.011	99.159	11.226
25	0.2102	0.841	100.000	13.503

All Condition Numbers less than 100. Multicollinearity is NOT a problem.

APPENDIX C6: INTERCROPPERS MANGEMENT VERSUS EXPLANATORY VARIABLES, RISK ATTITUDE AND RISK SOURCES

Dependent FA1_1

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Multicollinearity Section

	Variance	R2		Diagonal
Independent	**Inflation**	**Versus**		**of X'X**
Variable	**Factor**	**Other I.V.'s**	**Tolerance**	**Inverse**
ASV	0.0000			0
CGPOL	1.2974	0.2292	0.7708	5.704495E-03
(COOPx=1)	1.1568	0.1355	0.8645	4.141156E-02
DIS	1.1141	0.1024	0.8976	4.830942E-03
DRT	1.5165	0.3406	0.6594	8.728076E-03
EDU	1.2521	0.2013	0.7987	5.029762E-04
ERRN	1.2963	0.2286	0.7714	5.294167E-03
EXP	1.5612	0.3595	0.6405	1.240623E-04
FAC1_1	2.1947	0.5444	0.4556	0.0143037
FAC2_1	1.6360	0.3888	0.6112	1.122512E-02
FAC3_1	1.8121	0.4482	0.5518	1.222919E-02
FAC4_1	1.2638	0.2087	0.7913	8.424908E-03
FAC5_1	1.2484	0.1990	0.8010	8.32669E-03
(FDM=1)	1.2003	0.1669	0.8331	0.0379978
FER	1.8619	0.4629	0.5371	1.047497E-02
FLST	1.2843	0.2214	0.7786	4.806853E-03

FROBK	2.5516	0.6081	0.3919	1.774896E-02
FS	1.2939	0.2272	0.7728	1.366862E-02
GM	0.0000			0
HHS	1.5946	0.3729	0.6271	1.013481E-03
(HT=1)	1.6753	0.4031	0.5969	5.116782E-02
INSLAB	1.9102	0.4765	0.5235	1.255299E-02
KM	1.1651	0.1417	0.8583	4.438905E-04
LCKWA	1.5494	0.3546	0.6454	9.147787E-03
MKFL	1.3564	0.2628	0.7372	7.779073E-03
RA	1.2836	0.2210	0.7790	2.890561E-03

Dependent FA1_1

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Eigenvalues of Centered Correlations

		Incremental	Cumulative	Condition
No.	**Eigenvalue**	**Percent**	**Percent**	**Number**
1	2.8637	11.014	11.014	1.000
2	2.2567	8.679	19.694	1.269
3	1.6785	6.456	26.149	1.706
4	1.5787	6.072	32.221	1.814
5	1.5117	5.814	38.036	1.894
6	1.3778	5.299	43.335	2.078
7	1.3274	5.105	48.440	2.157
8	1.2633	4.859	53.299	2.267
9	1.1367	4.372	57.671	2.519

10	1.1149	4.288	61.960	2.569
11	1.0407	4.003	65.962	2.752
12	1.0012	3.851	69.813	2.860
13	0.9727	3.741	73.554	2.944
14	0.8899	3.423	76.977	3.218
15	0.8209	3.157	80.134	3.489
16	0.7046	2.710	82.844	4.064
17	0.6676	2.568	85.412	4.289
18	0.6069	2.334	87.746	4.718
19	0.5588	2.149	89.895	5.125
20	0.5005	1.925	91.820	5.722
21	0.4633	1.782	93.602	6.180
22	0.4253	1.636	95.238	6.734
23	0.3988	1.534	96.772	7.181
24	0.3362	1.293	98.065	8.519
25	0.3220	1.238	99.303	8.894
26	0.1812	0.697	100.000	15.805

All Condition Numbers less than 100. Multicollinearity is NOT a problem.

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APPENDIX D: LOGIT REGRESSION

APPENDIX D1: CORRELATION

	FRMTYP	*EXP*	*ASV*	*RA*	*FS*	*LD*
FRMTYP	1					
EXP	-0.18675	1				
ASV	-0.34975	0.104984	1			
RA	0.274752	-0.07761	-0.19344	1		
FS	-0.06704	0.206713	0.225044	-0.0334	1	
LD	0.102065	0.042705	-0.00576	0.039864	-0.0015	1

APPENDIX D2: MULTICOLLINEARITY TEST VARIABLES INFLUENCING THE CHOICE OF CROPPING SYSTEM

Multiple Regression Report

Dependent FRMTYP

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Run Summary Section

Parameter	**Value**	**Parameter**	**Value**
Dependent Variable	FRMTYP	Rows Processed	256
Number Ind. Variables	6	Rows Filtered Out	0
Weight Variable	None	Rows with X's Missing	1

R2	0.2012	Rows with Weight Missing	0
Adj R2	0.1819	Rows with Y Missing	0
Coefficient of Variation	0.7101	Rows Used in Estimation	255
Mean Square Error	0.1935903	Sum of Weights	255.000
Square Root of MSE	0.439989	Completion Status	Normal Completion
Ave Abs Pct Error	57.707		

Regression Equation Section

Independent Variable	Regression Coefficient b(i)	Standard Error Sb(i)	T-Value to test H0:B(i)=0	Prob Level	Reject H0 at 5%?	Power of Test at 5%
Intercept	0.8946	0.0976	9.166	0.0000	Yes	1.0000
ASV	0.0000	0.0000	0.000	1.0000	No	0.0500
EXP	-0.0074	0.0031	-2.374	0.0184	Yes	0.6571
FS	0.0252	0.0354	0.713	0.4766	No	0.1095
(LD=1)	0.1144	0.0595	1.923	0.0557	No	0.4822
(LD=2)	-0.3239	0.4492	-0.721	0.4716	No	0.1109
RA	0.0948	0.0282	3.358	0.0009	Yes	0.9170

Dependent FRMTYP

Warning: At least one value was reset to 0.0 because it was less than the machine zero of 0.0000000001.

Multicollinearity Section

Independent	Variance Inflation	R2 Versus	Diagonal of X'X

Variable	Factor	Other I.V.'s	Tolerance	Inverse
ASV	0.0000			0
EXP	1.0791	0.0733	0.9267	5.063669E-05
FS	1.0933	0.0853	0.9147	6.461802E-03
(LD=1)	1.0114	0.0113	0.9887	1.829933E-02
(LD=2)	1.0384	0.0370	0.9630	1.042502
RA	1.0472	0.0450	0.9550	4.119148E-03

Eigenvalues of Centered Correlations

		Incremental	Cumulative	Condition
No.	**Eigenvalue**	**Percent**	**Percent**	**Number**
1	1.4694	24.489	24.489	1.000
2	1.1021	18.369	42.858	1.333
3	1.0368	17.280	60.138	1.417
4	0.9210	15.351	75.488	1.595
5	0.7771	12.951	88.440	1.891
6	0.6936	11.560	100.000	2.118

All Condition Numbers less than 100. Multicollinearity is NOT a problem.

Logistic Regression Report

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Response FRMTYP

Parameter Estimation Section

Variable	Regression Coefficient	Standard Error	Chi-Square Beta=0	Prob Level	Last R-Squared
Intercept	1.482909	0.527094	7.92	0.004903	0.030808
EXP	-4.19E-02	0.015962	6.88	0.008722	0.026883
ASV	-1.06E-05	2.32E-06	20.72	0.000005	0.076828
RA	0.490639	0.1538	10.18	0.001422	0.039266
FS	0.141385	0.18349	0.59	0.440985	0.002379
LD	0.504953	0.302461	2.79	0.095022	0.01107

R2 = 0.19

DF = 5	Model chi-square = 57.84	Model Prob = 0.0000

Response	FRMTYP	(1=inter, 0= mono)

Predicted Classification Section

Total correctly predicted

188

% of correct prediction

73.4375

APPENDIX E: SUMMARY OF FACTOR LOADINGS FOR MONOCROP AND INTERCROP FARMERS

APPENDIX E1: PRINCIPAL COMPONENTS REPORT

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Database

SORGHUM/COWPEA

Eigenvectors after Varimax Rotation

Factors

Variables	**Factor1**	**Factor2**	**Factor3**	**Factor4**	**Factor5**
AGE	0.464368	0.193201	0.262244	-0.065246	0.208704
EDU	-0.302350	0.006233	-0.033347	0.109174	0.437575
EXP	0.430442	0.207061	0.265505	-0.066274	0.165944
HHS	0.444687	0.078501	-0.029187	0.262386	0.085579
AGX	0.143745	0.010932	-0.198757	0.449010	-0.018938
CRT	-0.010263	0.013328	-0.476530	0.226489	-0.227013
LF	-0.287542	-0.084535	0.356166	0.144932	0.197994
LD	-0.239856	0.015068	0.511963	0.041974	-0.168175
HT	-0.205392	0.483536	-0.144359	-0.180054	0.062071
ASV	-0.167641	0.557422	-0.121197	-0.148924	0.003555
KM	-0.186187	-0.101805	0.210784	0.244019	-0.179637
RA	0.170641	-0.150758	-0.073900	-0.284658	-0.150202
TR	-0.052680	0.495069	0.018100	0.149117	-0.342922
COOP	-0.048305	-0.216413	-0.331614	-0.301559	0.322870

FDM	0.027207	-0.048399	-0.072441	0.512912	0.018017
MKT	-0.094967	0.184495	-0.047578	0.251964	0.574344

Variables	**Factor6**
AGE	-0.088507
EDU	0.220442
EXP	-0.041036
HHS	-0.039131
AGX	-0.351830
CRT	-0.052499
LF	0.015999
LD	-0.027530
HT	-0.064401
ASV	-0.013172
KM	-0.357310
RA	0.575166
TR	0.124346
COOP	-0.297480
FDM	0.484131
MKT	0.107961

MILLET/COWPEA (Factor loadings)

Eigenvectors after Varimax Rotation

Factors

Variables	**Factor1**	**Factor2**	**Factor3**	**Factor4**	**Factor5**
AGE	0.332074	0.440151	-0.002003	-0.059332	-0.056546
EDU	-0.110579	-0.276246	-0.240663	-0.156459	0.189604
EXP	0.326510	0.424417	0.065443	0.005914	-0.087383
HHS	0.421794	0.329419	-0.039766	-0.036407	0.056146
AGX	-0.035953	-0.011379	-0.283000	-0.044819	-0.542916
CRT	0.049195	0.031090	-0.275182	0.193388	0.523293
LF	-0.084042	0.098981	-0.427082	0.126044	-0.257464
LD	-0.060221	0.111538	-0.587574	-0.168358	0.128580
HT	0.421016	-0.316593	-0.057296	0.114279	-0.103922
ASV	0.406911	-0.363719	-0.111909	-0.032103	-0.009259
KM	0.046317	0.156777	-0.102125	-0.593472	0.052818
RA	-0.148728	0.044329	-0.136533	-0.504766	0.136291
TR	0.406659	-0.328909	-0.151012	-0.175121	-0.077683
COOP	-0.140759	0.223223	-0.239734	0.314329	-0.030635
FDM	0.052683	0.001332	-0.356951	0.346232	-0.001076
MKT	0.153365	0.029941	0.013683	0.128710	0.509339

Factor6

AGE	0.096650
EDU	0.507189
EXP	0.038287
HHS	0.066836
AGX	-0.196223
CRT	0.263856
LF	0.228635
LD	-0.177412
HT	0.081590
ASV	-0.107672
KM	0.244317
RA	-0.451321
TR	-0.023660
COOP	0.083501
FDM	-0.309838
MKT	-0.387878

SORGHUM

Eigenvectors after Varimax Rotation

Factors

Variables	Factor1	Factor2	Factor3	Factor4	Factor5
AGE	-0.466359	0.164621	0.018985	-0.223305	-0.059426
EDU	0.096388	-0.308780	0.051168	0.275870	0.457026
EXP	-0.465824	0.104780	-0.076383	-0.075505	0.169530

HHS	-0.402226	-0.026592	0.121963	-0.126783	0.108238
AGX	0.047167	0.092596	-0.603336	0.093212	-0.197265
CRT	-0.293491	0.280520	0.050995	-0.134463	0.317369
LF	-0.305869	-0.241976	0.175876	0.114411	-0.352338
LD	-0.262038	-0.195877	-0.166070	0.320002	-0.374031
HT	-0.150666	-0.460140	-0.074138	-0.091577	0.144223
ASV	-0.120969	-0.512523	-0.193992	-0.202725	0.199915
KM	-0.199254	-0.098422	-0.068895	0.406479	0.035870
RA	-0.182622	0.054134	-0.483324	0.027434	-0.003385
TR	0.111627	-0.360858	-0.010063	-0.329833	0.091127
COOP	0.098627	-0.198389	-0.128435	-0.362412	-0.400915
FDM	0.105887	0.154523	-0.475425	-0.240210	0.258891
MKT	0.008496	-0.034686	-0.164562	0.443510	0.212924

Variables	**Factor6**
AGE	0.119626
EDU	0.124522
EXP	0.331615
HHS	-0.064948
AGX	-0.023073
CRT	0.007192
LF	0.175289
LD	-0.019609
HT	-0.165528
ASV	-0.220095
KM	-0.108644
RA	-0.320891

TR	0.225033
COOP	0.436463
FDM	0.176852
MKT	0.601057