RISK ATTITUDE AND RISK PERCEPTION IN AGROFORESTRY DECISIONS: THE CASE OF BABATI, TANZANIA

EPHRAIM M.M. SENKONDO

Propositions

Being part of the dissertation
'Risk attitude and risk perception in agroforestry decisions: The case of Babati, Tanzania'
by E.M.M. Senkondo

1. Although it is inherently difficult and tiresome to undertake risk analysis in the utility theory category, it is certainly useful while to undertake it *(This thesis)*.

2. By focussing risk analysis on researchers' views without giving attention to approaches which starts from the farmers themselves, no proper account is given on what farmers actually perceive as risk and little is understood regarding farmers' behaviour and attitude towards risk *(This thesis)*.

3. In undertaking risk analysis it is important to note that risk is not necessarily measured by a single item or statement, but rather by a group of items or statements *(This thesis)*.

4. For sustained world economic growth there is a need for concerted action by both the industrialised and developing countries. Industrialised nations are to provide a stable and favourable external economic environment through steady but non-inflationary expansion, an open trading system, and continued steady growth in both commercial and capital flows. Developing countries are to adapt both macro and micro policies to increase efficiency (*World Bank, 1983*).

5. In meeting the researchers' and target users' needs, different research methods and analyses are in most cases more complementary to each other than competing - mainly to the surprise of their initiators.

6. Farmers clearly do not reject technologies because they are conservative or ignorant. They rationally weigh the changes in income and risk associated with a particular technology under their natural and economic circumstances to decide whether a technology pays *(Byerlee & Collinson 1980)*.

7. By putting more effort on quantitative risk analysis and ignoring qualitative approaches, we may be missing much of the game. Certainly, farmers and other decision-makers in agriculture have managed risk, with more or less success, without recourse to the esoteric, quantitative analysis of many of the academic researchers *(Hardaker, et al. 1997; this thesis)*.

8. Most universities in Africa have been orienting their students to attain employment within the government and its institutions. This orientation excluded a parallel effort on self-employment, entrepreneurial skills and service to the private sector. The neglected areas need urgent recognition, not in the least because of the economic reforms in developing countries. As a result demand-driven degree programmes will be stimulated.

9. One of the most challenging areas of sustainable natural resource management is how to balance the diverse interests of local communities (who are living with the resources) with those of the state (which is seen as an external agency).

10. Perhaps the most outstanding policy issue involving risk and intervention is to balance risks accruing as a result of government intervention in agriculture and markets on the one hand, and risks due to liberalisation and deregulation on the other hand.

11. Forget not those who attempted it before you. Had they refused to clear the way, it would have been impossible for you to strike the precious stone.

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Dedications

This work is dedicated to my late mother Martina Paul, my late brother Emanuel Manento and my late sister in law Agatha Budotela who passed away during the period of this work. "May almighty God rest their souls in Eternal Peace, Amen"

Abstract

Increasing risks and uncertainties related to stochastic agro-ecological and institutional factors on one hand, and deterioration of land due to unsustainable farming on the other hand, are among the major constraints to agricultural development in the developing countries. Agroforestry is proposed as a land use option and a measure to reduce the above problems mainly because farmers' have to derive their basic needs of food, fibre, shelter and fuelwood predominantly from the land they own. The main question is how and to what extent farmers use agroforestry to reduce risk and derive their major basic needs?

This research was conducted in Babati district located in the southwestern part of Arusha region in the northern part of Tanzania. The research villages were Magugu, Bonga, Singe and Himiti. The main objective of the research was to set an understanding of farmers' attitude and perception towards risk in making agroforestry production decisions.

The data collection procedure involved three major surveys: a preliminary survey of 20 farmers, a single visit general household questionnaire survey with a sample of 100 farmers and a detailed research approach involving 30 farmers.

The data obtained were analysed using the utility theory and the latent variable categories. In addition, the estimation of probability distribution functions was done using the maximum likelihood technique, the utility functions through linear/non-linear regression analysis and the relationship between risk attitude, risk perception and preference ranking of cropping systems with household resources and characteristics was done using linear regression analysis. The main features of the results are as outlined below.

- Farmers' sources of risk and risk management strategies are identified both in agroforestry and in sole cropping. Generally, there were similarities in perceived risk and risk management strategies among the sampled villages
- Using the strength of conviction method, the cropping systems were classified into low risky, medium risky and high risky. Heterogeneity in perceived risk was noted between males and females and among farmer categories. There is a general indication that production of food crops and a mixture of food crops and trees are perceived as less risky as compared to the others.
- Risk attitude measures were derived using the utility theory approach. Generally, there were variations in risk attitude measures among the farmers and the situations analyzed. Risk attitude is influenced by wealth of the farmer, years of education, household size and the age of the respondent.
- Risk attitude using the latent variable category was done using factor analysis. The results show that a substantial number of farmers have a positive attitude towards risk and land resource conservation. However, the attitude towards commercialisation was low, maybe due to poor transport and infrastructure. The attitude towards land resource conservation, the attitude towards commercialisation, the wealth of the respondents and their education significantly explain the positive attitude towards risk.
- Farmers showed a high preference for agroforestry systems namely 'Trees (timber/fuel wood all ages) + mixed food crops' (CS2), followed by food crop systems 'Mixed food crops only' (CS3). Preference ranking of cropping systems is influenced by risk attitude, expected income, risk perception and household resources and characteristics.

- Using the mean-variance analysis and a quadratic utility function, cropping systems were ranked in order of preference. The ranking was more or less in conformity with the actual cropping systems practised by the farmers.

Recommendations were made based on methodology, areas for further research and policy interventions. Policy recommendations were made based on the finding that farmers use agroforestry as part of their risk management strategies. As a result policy recommendations were made towards the role of agroforestry in risk management strategies, such as improvement in infrastructure and socio-economic environment (roads, extension and land tenure) and recommendations on technology development in agroforestry through breeding and selection of crops and tree species for specific suitable characteristics (such as drought tolerance, short maturity, and disease resistance).

Preface and acknowledgments

For many decisions regarding agricultural production and marketing, there is a great deal of uncertainty mainly due to stochastic agro-ecological and institutional factors. Risk considerations are therefore important in day to day decision making in farm management. On the other hand deforestation, scarcity of tree products and increasing environmental degradation have created serious problems for rural land use in many developing countries. Many people, however, have to derive their basic necessities of food, fibre, shelter and fuelwood predominantly from the land holdings they own. Agroforestry, a system in which woody perennials are grown on the same land as agricultural crops and/or livestock, has been increasingly enlisted in the campaign to circumvent these threats to the rural economies. However, more work still remains as to what extent agroforestry is related to risk and specifically how far and to what extent do farmers take risk into account in their agroforestry decision making?

In response to the above problems and recognising the increasing importance of agricultural risk management, a study was conducted in Babati, Tanzania focusing on risk attitude and perception in agroforestry decision making.

In the course of undertaking this study, several institutions and individuals have in one way or another contributed to its successful completion. I wish to express my special thanks to Wageningen University (WU) for offering a sandwich scholarship and to Sokoine University of Agriculture, Morogoro Tanzania for funding the fieldwork. I am particularly indebted to the office of the Deputy Vice Chancellor of Sokoine University of Agriculture for administration of the research funds.

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The contribution of my family has been very enormous and encouraging. I wish to thank my wife Hilda, for her constant encouragement and personal sacrifices during the difficult times of this work. It is difficult to forget my children Michael, Maurice and Martina-Maureen who valued and respected my work. Thanks are due to my parents, brothers and sisters for providing me with the basic foundation in my study and for constantly encouraging me to achieve what we have all been dreaming of. To them the best word is to say *"Nahavacheni"*.

I cannot conclude this note without thanking my colleagues and friends in the Netherlands and Tanzania. I am particularly indebted to the Forest Policy and Forest Management Group WU for providing a comfortable working environment and support. I am also grateful to the staff of the Forest Policy and Forest Management Group WU for their friendliness. Although it is practically impossible to name them all in this two pages of my book, I grateful appreciate their contribution.

Lastly, I would like to say that the responsibility of any errors and/or omissions in this book are my entire responsibility, while all the good outcomes are conferred to everyone with great pleasure.

Morogoro, May 1999

Ephraim Senkondo

List of abbreviations and acronyms

AEZ	Agro-Ecological Zones
BDC	Babati District Council
CE	Certainty Equivalent
CS	Cropping System
DEU	Direct Elicitation of Utility
DOVAP	Dodoma Village Afforestation Project
EM	Experimental Method
EUM	Expected Utility Model
FAO	Food and Agriculture Organisation
FSA	Farming Systems Analysis
FSG	Food Studies Group
FTP	Forest Trees and People
ICRAF	International Centre for Research in Agroforestry
IM	Interval method
LAMP	Land Management Project
LRDC	Land Resources Development Centre
MFC	Marginal Factor Cost
ML	Maximum Likelihood
MOA	Ministry of Agriculture
MOTAD	Minimisation of Total Absolute Deviation
MVP	Marginal Value Product
NM	Neumann Morgenstern
NORAD	Norwegian Agency for International Development
OEB	Observed Economic Behaviour
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
PE	Probability Equivalent
QP	Quadratic Programming
SD	Stochastic dominance
SECAP	Soil Erosion Control and Agroforestry Project
SEU	Subjective Expected Utility
SG	Schmeidler Gilboa
SIDA	Swedish International Development Agency
SUA	Sokoine University of Agriculture
TFAP	Tanzania Forestry Action Plan

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CHAPTER 1

INTRODUCTION

1.1 Background

The world today is experiencing rapid land deterioration. Continued deforestation especially of the tropical rain forests is very rampant. According to Palo (1990:156), the causes of deforestation are many, but perhaps the most important one is land clearing to give way to agricultural production. In land abundant areas, farmers have been benefiting from natural regeneration through shifting cultivation. However, with a rapidly growing population especially in high potential highlands of the tropics and subtropics land becomes scarce. Fallow periods, which were traditionally used for grazing, sources of firewood and gathering of bush foods become too short or are not existing at all. With shortening of the fallow period farmers turn to cultivated land to obtain firewood, grazing and gathering of bush foods what they used to get from the fallow land and the result is removal of organic material.

In dealing with the problems of supply of fuelwood, building materials and timber, the government of Tanzania encouraged village afforestation programmes. These programmes involved voluntary participation of rural communities on a self-reliance basis to establish community woodlots. The government provided free seedlings and advice to the villagers. However, this failed to address the problem of crop and livestock production in the villages. This together with erratic and unpredictable rainfall in many parts of the country seriously affected the implementation of these programmes.

Following the rather slow adoption of village afforestation and recognising the importance of addressing the above problems, the government of Tanzania through the Ministry of Agriculture (MOA), promoted agroforestry by including it in its category one of the research priority areas (MOA, 1991). Agroforestry is defined as a collective name for land use systems and practices where woody perennials (trees, shrubs, bamboo, vines etc.) are deliberately integrated with crops and/or animals in the same management unit. The integration can be either in a spatial mixture or in a temporal sequence. There must be both ecological and economic interactions between the wood and non-wood components to qualify as agroforestry (ICRAF, 1990).

MOA (1991) stresses further that research in agroforestry and climatology has received very little attention to date in Tanzania. Application of agroforestry helps in alleviating the above problems, i.e. agroforestry brings a desirable degree of sustainability, for example soil and water conservation, giving products valuable to the people and easing pressure on natural forests as sources of firewood and building poles. Agroforestry is therefore in a way addressing the low productivity problem of smallholder farmers in Tanzania.

The main broad question among researchers is therefore, how can agroforestry technology be transferred and give the implied benefits to the smallholder? Specifically, what can we learn with respect to farmers' risk management strategies that can improve the design of appropriate agroforestry technologies that will be easily adopted?

Studies of adoption behaviour suggest mainly that risk and uncertainty, farm size, human capital, labour availability, credit and land tenure are important variables in explaining adoption patterns. Smallholder farmers in developing countries are typically constrained by limited resources and access to both land and capital. They depend mainly on family labour as their most readily available and flexible factor of production, and they are producing mainly for subsistence consumption. In making a choice of a particular cropping strategy, a smallholder farmer will specifically rely on its labour requirements and give priority to that strategy meeting her/his subsistence consumption. Given their existing situation, it may appear that risk is a very important factor in explaining farmers' adoption of new technologies and their allocation/choice behaviour.

1.1.1 The need for agroforestry adoption

Most of the developing countries' rural and urban fuel needs are derived from trees. In Tanzania for example about 90% of the energy consumption is derived from trees, and in rural areas, fuelwood is the only dependable source of energy that people have access to (Bhagavan, 1984). However, this has a direct relationship with deforestation and land degradation. Without well-established woodlots and/or agroforestry systems, land degradation will continue if the natural forests and open areas will continue to be major sources of tree and tree products without deliberate efforts of reforestation.

Getting accurate figures of fuelwood consumption in Tanzania is mainly difficult because fuelwood is most often cut and gathered unrecorded by members of the households. Most of the data available are largely based on estimates. One of the most reliable estimates is that of FAO that puts an estimate of about 34 million cubic metres of fuelwood consumption annually in Tanzania which is expected to rise to 60 million cubic metres by the year 2010 (FAO, 1993). Comparing these consumption figures with the available natural forests (which supply more than 98% of the wood collected) they can only supply about 19 million cubic metres without being detrimentally over-exploited (Mnzava, 1985). Such a situation needs deliberate efforts to afforestation. Since the majority of people in the third world are poor, afforestation has to be addressed together with the problems of food/crop and livestock production, for example through agroforestry.

Despite the general agreement that a compatible association of trees and annual crops is likely to sustain productivity without causing severe degradation of the environment, it is also true that trees have both positive and negative effects. For example erosion control, nutrient recycling, nitrogen fixation etc. as positive effects and competition for light, water, allelopathic effects etc. as negative effects. This with the fact that a considerable effort has been put in agroforestry research versus the actual adoption of agroforestry leaves a lot of questions. Is it the negative effects that limit the adoption of agroforestry? Or is it the lack of proper information and/or the low level of farmers' information processing ability? Or has it got to do with farmers' risk attitude and risk perception?

In addressing the above, it is important to take into consideration the argument that very little is known about decision making and farmers' assessments and assessment criteria in agroforestry (Scherr, 1992). More information is needed regarding farmers' views on agroforestry, its potential relevance, impact and implications for the farm household or farming system. Given the importance of risk in decision making, we need to know more about decision making in agroforestry versus other land use options within the context of household-livelihood strategies. This is mainly because risk attitude and risk perception may govern land use decisions among smallholder households.

1.1.2 Diversified/mixed farming system.

Small farmers have to make their production and/or managerial decisions from season to season. These decisions are made in the face of uncertainty about the agro-ecological conditions that will prevail, the incidences of pests and diseases, the prices they will fetch, the performance of new technology, tenure status and the political climate that will prevail. Consequently, farmers' decisions are risky ones. No farmer can ever be perfectly sure of the outcomes of her/his decisions. This is mainly because of their lack of control over the above-mentioned factors. As pointed out in Dillon and Hardaker (1993:28), farm management research has to recognise the existence of uncertainty and the element of personal judgement about risk that influence the small farmer's choices. As a result elucidation of the risks that the farmer faces, how they are perceived and her or his reactions to them are key issues in farm management research (Dillon and Hardaker, 1993:28).

Farm management research in Tanzania has shown that diversification of the cropping system and farming plots are among the most preferred strategies to minimise the variance of expected yield returns (Mtoi, 1984; Dercon, 1993). The use of agroforestry, which is often a type of mixed cropping, has advantages in productive efficiency and risk reduction. Norman (1974) has shown the many advantages of mixed cropping. With the help of production possibility curve and iso-revenue curve concepts, Filius (1983) has also shown that in a situation of competition for light, nutrients etc. between the tree and agricultural components, agroforestry which is often a type of mixed cropping, can be a financially attractive system. This is because of positive interactions between the components of the agroforestry system. With respect to risk reduction, Falconer (1990) has pointed to the supplementary role, the seasonal importance and the buffer food and cash sources for emergencies of tree products. This buffer stems partly from the flexibility of the harvesting schedule (Guggenheim and Spears, 1991). Ranganathan *et al.* (1991) have observed that a positive interaction between the tree and agricultural component of an agroforestry system only occurred in a year with drought. Food security is considered as an important reason for the implementation of agroforestry projects in developing countries.

This research examines risk attitude and risk perception of the farmer in various cropping systems with emphasis on agroforestry systems/strategies.

1.1.3 Low productivity in agriculture

Agricultural growth in Tanzania is increasingly recognised as central for sustained improvement in economic growth of the country and food security and nutrition for the growing population. However, the major contribution of the agricultural output in Tanzania, particularly food crops, is derived from smallholder farming, where the farm production system is mainly traditional and productivity is low. Because of increasing population growth, declining soil fertility, increased deforestation, scarcity of food, decline in foreign exchange earnings and other related problems, researchers and policy makers are hard pressed to develop appropriate farm production systems that would facilitate efficient and sustainable production.

Considering the fact that sub-Saharan Africa carries only 15% of the world's population, but receives 50% of all food aid flowing into developing countries (Yaker, 1993), one cannot fail to appreciate the need to reorient the African agricultural agenda to focus attention on sustainable production.

An increase in smallholder agricultural productivity can be achieved in many ways, including putting more land into cultivation, increasing production factors, or using improved technologies such as agroforestry. Given the limitations of increasing the area under cultivation, increasing use of sustainable production methods has a role to play towards achieving improved agricultural productivity.

1.2 Risk and uncertainty

Knight (1921) suggested a distinction between risk and uncertainty. He viewed risk as a situation where the probability distribution of outcomes associated with risky prospects is known or can be predicted, while in uncertain prospects the probabilities are unknown and cannot be quantified. With the emergence of subjective ideas of probability in modern decision theory, this distinction appears not very useful (Bessler, 1979:1079; Barry, 1984:7), and probabilities associated with uncertain prospects can be quantified in a subjective way. Officer and Halter (1968:258) point out that situations defined as uncertainty by classical workers like Knight, become cases of subjective risk for the Bayesian framework that allows for subjective probability.

Hardaker *et al.* (1997) have also argued that the distinction proposed above is not a useful one since cases where probabilities are objectively 'known' are the exception rather than the rule in making decisions.

Following risk and uncertainty literature, there might be no consensus regarding the definition of risk. Based on this, Roumasset *et al.* (1979) point out that researchers should specify which definitions of risk and risk aversion they are using. In this research, uncertainty was viewed as a state of mind in which individual farmers perceive alternative outcomes to a particular action (Roumasset *et al.*, 1979). In other words, uncertainty relates to insufficient acquaintance or familiarity with knowledge. Uncertainty is therefore concerned with farmers' risk perception regarding returns of alternative cropping strategies they are undertaking based on their actual knowledge and familiarities with the strategies.

Risk is the possibility of loss or a chance to win or lose anything. It is more related to action, i.e. one takes risks by doing a particular action. The chance of winning or losing is commonly measured in probability or variance. Risk will for example be looked at as a piece of information about frequency distribution that with the expected value, serves as an approximation of the density function in prescribing or explaining choice under uncertainty. The piece of information can be either the variance of the frequency distribution or the probability for each distribution (Roumasset *et al.*, 1979). The present research specifies distribution functions using data derived from smallholder farmers. The moments of the distribution functions (i.e. mean, variance and skewness) are used to describe farmers' risk perceptions.

1.2.1 Risk and uncertainty aversions

In recent literature it has been shown that there is a distinction between risk aversion and uncertainty aversion (Dow and Werlang, 1992a, 1992b; Aizenman, 1997). Aizenman (1997) for example elaborates on Knightian risk and uncertainty. He argues that if uncertainty cannot be summarised by a known distribution, the investor is exposed to Knightian uncertainty as opposed to risk, where there is a unique distribution that summarises the stochastic environment of new activities.

Following the Schmeidler-Gilboa (SG)[1] approach, agents are allowed to be averse to both risk (randomness with known probabilities) and uncertainty (randomness with unknown probabilities), where the two aversions are modelled independently. Uncertainty adverse agents would prefer (*ceteris paribus*) more transparent information. If activities are endogenously determined, uncertainty aversion leads agents to make choices so they do not end up bearing uncertainty. This framework allows for (subjective) non-additive[2] probabilities, which together with the utility function allow a representation of behaviour of agents operating under Knightian uncertainty. In the absence of Knightian uncertainty therefore, the predictions of the SG approach are equivalent to the standard utility theory under risk where probabilities are additive. The SG framework therefore extends the standard utility theory to situations where the uncertainty cannot be summarised with unique priority.

From above we can learn that emphasis on information is important in situations of uncertainty, because Knightian uncertainty implies that agents confronting uncertainty in developing countries may refrain from investments in modern and non-traditional techniques from which they do not have adequate information, thereby reducing growth. Aizenman (1997) illustrates the potential importance of Knightian uncertainty by contrasting the behaviour of risk neutral, uncertainty adverse agents with those of risk averse Bayesian agents. Unlike the case of uncertainty aversion (where uncertainty may induce first order losses), risk aversion alone leads to second order losses proportional to the perceived variance of the distribution. Aizenman (1997) concludes that uncertainty aversion may matter much more than risk aversion in situations where agents have vague information. This has implications in developing countries where there is imperfect information/knowledge regarding, for example climatic conditions, factor markets and technology.

While appreciating the efforts made by the proponents of the SG approach in understanding the roles played by risk and uncertainty averse agents, this approach was not applied in this research. However, similar to this research, the emphasis of the above approach is to treat separately the analysis of different aversions. In this research risk attitude derived from the

[1] Interested readers are referred to Schmeidler (1982, 1989) and Gilboa (1987) for axiomatic modelling of decision-making under uncertainty, Dow and Werlang (1992a, 1992b) for a review and application of the SG approach. The SG approach is also explained in Aizenman (1997).

[2] The SG approach uses non-additive subjective probabilities, while this research follows the most commonly used Bayesian additive probabilities. For k symmetric events, the Bayesian approach assigns probability $1/k$ to all events, while non-additive assigns the same probability say p, but their sum (kp) is used to record the degree of confidence in the assigned probabilities (See Aizenman, 1997).

estimation of expected utility functions are treated separately from risk perception which are derived from farmers' subjective probabilities of returns of different cropping systems using the strength of conviction method (See chapters 2 and 4).

1.2.2 Risk, uncertainty and agroforestry

Various hypotheses about the potential benefits and usefulness of agroforestry technologies have been given. For example, Young (1989) gives ten hypotheses of the potential beneficial contribution of agroforestry to soils. Among the potential benefits of agroforestry technology is that it has an important potential of **reducing** the **risks** and **uncertainties** of farmers in the semiarid areas of the tropics. However, one categorises instances where agroforestry technology reduces risk and where it increases risk.

Areas where agroforestry reduces risk are as follows: -

- Agroforestry realises diversified outputs and as such it reduces risk of total crop failure (Blandon, 1985; Hoekstra, 1987). By planting tree crops alongside agricultural crops, the portfolio of the farmer is diversified and made less vulnerable to sudden changes in market and environmental conditions (Blandon, 1985).
- Traditionally tree products in Africa act as insurance cover, for example in emergency periods especially in times of drought, famines, floods and wars. In case of crop failure, tree products may provide emergency foods and products that can be gathered for sale (Becker, 1983; Campbell, 1986). For resource-poor farmers, trees may provide one of the few assets for liquidation during emergency periods (i.e. trees as a form of savings). In areas without legal land ownership, planting trees on farmlands acts as a form of traditional land ownership.
- Potential benefits of trees on soil fertility and ecological stability can reduce crop failure due to soil fertility increase.

An interrelationship between an agricultural crop and a tree crop on a single piece of land may be supplementary, complementary or competitive. In the former two cases agroforestry is always an attractive option. Regarding the last case, agroforestry can only be an attractive option if positive interactions between the crops are there. Examples of instances where agroforestry can increase risk are:

- Tree products are mainly sold in an uncertain future, where prices are not known with certainty during the planting period. The long time taken by trees to realise output as compared to annual crops may act as an impediment to adoption.
- A combination of trees and crops may promote diseases and pests. For example, agroforestry technology versus tsetse re-invasions. Otsyina (1993) points out that the question on whether experiences with tsetse flies in Shinyanga Tanzania would limit adoption of agroforestry or not is yet to be answered through research.
- Tree product markets in developing countries are still underdeveloped thus acting as a potential source of risk in agroforestry income.

Because of the above three instances, an agroforestry research strategy needs to be based on the bottom line question "how and to what extent can one prove that agroforestry systems resulting from current research enhance the farmer's capability and options to improve or reduce risk and uncertainty in his or her production system?" If we can show that an agroforestry system does reduce risk, it will have great economic value to agriculture (Avila, 1989). The present research is designed to find out how farmers perceive actual agroforestry systems with respect to risk reduction. Do farmers perceive it as reducing risk as it is advocated, or is it scientific over-expectation? Information on how risk relates to decisions on cropping systems is also explored.

1.3 Problem statement

Based on the background information, two main research problems emerge. The first research problem which is described in this chapter relates to smallholder farmers and their research needs. The second research problem is associated with the previous research methodologies in assessing risk attitude and risk perception. This is described in chapter 4 (Methodological framework) after the presentation of a review of the literature and the measurement procedures in chapter 2 and the conceptual framework in chapter 3.

Smallholder farmers in Tanzania are confronted with many problems, which result into the observed differences between realised production and potential production. It is further argued that productivity of agricultural resources among smallholder farmers in Tanzania has not changed significantly despite the technological recommendations advanced to them and these appear to have failed to create sufficiently the expected change of productivity of resources of the small farmer operators (Mtoi, 1984). Yet, farmers have to satisfy their diverse needs from agricultural production, ranging from food, feed, fuel, fibre, pharmaceuticals, cash income and source of pride. Based on this, it appears that farmers are not only focusing on increased yields of one crop, but rather on a long-term stability of yields and reduced risks, i.e. farmers would like to minimise the chances of a disastrous season.

Specifically, farmers are confronted with the problem of making decisions, which are seriously affected by both institutional and stochastic agro-ecological factors. As a result, one of the research needs is to have an understanding of farmers' decision making in situations of risk and uncertainty and the way households adjust themselves in these situations. Naturally, it is important to note that not in all the farm management decisions the farmers need to account for risk. As Hardaker *et al.* (1997) indicate, risk accounting is important when there are major differences between good and bad consequences necessitating the farmer to give more attention to choice among possible/available alternatives.

The problems of deforestation, land degradation and increased fuelwood needs put more emphasis on agroforestry. This is mainly because food and forestry products as well as sustainability in land use are basic requirements of the rural communities. The problems are worsened by the dynamics of the forest functions emanating from changes in demand from different social categories with respect to forest products. In addition, the relations between forestry and other rural land use structures will have to be adjusted as a result of institutional changes with respect to forest utilisation and management. As the population increases and institutions and infrastructure change as well, more and more land will be required for cultivation, thus increasing land degradation. Babati district in particular has been experiencing a series of land degradation problems such as floods, which are mainly blamed on progressing environmental degradation.

Combining all the above, the research need shifts to the understanding of farmers' decision making in situations of risk and uncertainty in agroforestry, with the overall aim of suggesting ways of improving their production decisions. Based on the above, the research problem related to smallholder agroforestry farmers can be formulated. Farmers are expected (based on the aforementioned) to take into consideration risks and uncertainty in decision making (decisions where the difference between the good and bad consequences are significant) **but in how far and to what extent do they use/consider risk in their agroforestry decision making?** This forms the main premise of this research. As already pointed out, very little is known regarding decision making and farmers' assessment and assessment criteria in agroforestry (Scherr, 1992).

1.4 Objective of the research

Based on the background information and the problem statement presented in the previous sections, there is a need for examining how and to what extent do farmers in the research area include risk in their agroforestry production decisions. The broad objective of this research is therefore designed to contribute to this.

The broad objective of this research is: **To establish an understanding of farmers' attitude and perception towards risk in making agroforestry production decisions as well as its relationship with the social and economic environment.**

Specific objectives to attain the broad objective depend on information regarding the extent of previous researches in risk analysis and decision making, which are presented in chapter 2. In addition, information regarding the farmers' decision conceptual framework and the level of analysis adopted in this research contributes to the formulation of specific research objectives. As a result, the specific research objectives are presented in chapter 3 after the review of literature on risk analysis and decision making in chapter 2.

1.5 Focus of the research

Following the description of risk, uncertainty and agroforestry in section 1.2, a general remark can be made regarding the approach of the present research. Since there appears to be no consensus regarding the definition of risk and uncertainty there is a need for defining/elaborating these terms in the context of this research. **Uncertainty** is viewed as the state of mind in which individual farmers perceive alternative outcomes to a particular action. It is related to familiarity with knowledge. **Risk** is more related to action i.e. the chance to win or lose as a result of undertaking a particular action. It is measured in terms of variance of the outcomes. The two concepts are studied under the title risk attitude and risk perception in agroforestry. Specifically, the research looks into the influence of risk attitude and risk perception on the choice of various cropping systems.

The research therefore focuses on the understanding of smallholders' decision making in agroforestry, using Babati district as a case study. The choice of Babati, among others is due to the efforts made by the Babati District Council in collaboration with the Land Management Project (LAMP) in the development of agroforestry. Although Babati is a representative of such efforts in Tanzania, it is important to note that there are many such efforts in different parts of the country. To mention a few examples, the Soil Erosion Control and Agroforestry Project (SECAP) in Lushoto Tanga, Tanzania Forest Action Plan (TFAP), Dodoma Village Afforestation Project (DOVAP) etc. While the research recognises the efforts made by these organisations, it was not possible given the time and budgetary constraints to cover all those initiatives in this research. Nevertheless, the information gathered from this research is expected to be useful in many parts of the country with agroforestry initiatives.

Another important focus of the research is the direct use of the decision-makers to generate information in studying risk attitude and risk perception, rather than making prior assumptions and deliver recommendations regarding decision making to the farmers. This approach is appealing in the sense that one gets the first hand information on the way farmers perceive and react to risks and from their own point of view and relate these to theoretical models. Yet, there are instances when the decision-maker may not be available to give her/his views for elicitation and also when extension to a large number of people is required. This necessitates the use of normative approaches, for example Stochastic Dominance (SD) analysis (briefly explained in chapter 2). The continued use of the positive approach may impede rather than stimulate the development of the normative approach, although the contrary has been happening. Another problem that may emanate from the positive approach is that farmers may not always see risk in the way that analysts do and therefore time is needed to translate the technical concepts of risk to farmers to have a common understanding. This may be more complicated when translating these terms into 'Kiswahili', the local language in the research area. The research therefore focused on a relatively small sample where translations and understanding could be easily made before the measurement procedures were carried out.

The research also advocated studying risk attitude and risk perception separately in order to have a clear understanding of these concepts separately in practice. The separation was to be found important because recommendations can be made separately to have a wider set of alternatives to smallholder problems. For example, perceived risk in production activities may depend in part on the farmer's ability to react adequately to controllable risk factors, and hence differs across farmers with different resource endowments. In other words, risk perception may change depending on the risk control capacity of the farmers. Perceived risks act as a guideline for not considering activities at all or leads to slowing down the adoption process until more information is obtained. In risk attitude, under-investment may be due to risk adverse behaviour, which stems from farmer's inability to take risks. If this is the case, it is easy to recommend distinct opportunities to design measures that will not only increase total output but also increase risk-taking capabilities.

To ensure reliability of measurement procedures, the original plan, in addition to applying multiple techniques in risk analysis, was to carry out the measurement procedures for two consecutive seasons to monitor any changes in decision making with passage of time. However, due to time and financial constraints the measurement procedures were taken only once.

Decision analysis was done using returns[3] from cropping systems as the evaluation criteria. The stochastic component was assumed to be returns. However, cost or prices could also be

[3] Returns are defined as the income/value from/of output derived from the components of the cropping system.

thought of as stochastic components. However, in addition to simplifying the decision problem, the situation in Babati shows that returns were more unstable and subject to risks and uncertainties as compared to prices. Finally, tree components of an agroforestry system give benefits over a long time horizon. As a result considerations should have been made regarding the time aspect. Again the time and financial constraints affected this type of analysis. As a result only single season data were used. However, the data collection exercise took place in a more or less normal year in terms of rainfall (Chapter 5). Almost all agricultural production activities in the area depend largely on rainfall which is unfortunately subjected to a lot of uncertainties.

1.6 Set-up of the thesis

The report is organised into nine chapters. Chapter 2 gives a review of literature on risk and decision-making analysis. Operationalisation of risk attitude and risk perception measures and procedures are given. Approaches in risk analysis, i.e. the utility theory and decision analysis and the use of questions related to psychology (latent variable approach) are presented. Assessments of utility functions, alternative utility functional forms and their estimation procedures, and the limitations of the expected utility theory approach are reviewed. A review of methods of eliciting and measuring risk perception and methods of fitting various probability distribution functions is also presented in this chapter.

Chapter 3 presents the conceptual framework used in this research. In addition, the chapter gives the level of analysis applied in this research, the specific research objectives and the research questions.

Chapter 4 presents the methodology used in this research. The chapter presents the definition and specification of research problems related to the methods of empirical measurement. The most important presentation of this chapter has certainly been the operationalisation of the conceptual framework, which is viewed as a continuous process throughout this research. In addition, the chapter gives the empirical measurements of risk attitude, risk perception (using the utility theory), and preference ranking of cropping systems which was applied in this research. Chapter 4 also presents the variables and measurement procedures using a structured questionnaire with much emphasis on the use of the latent variable approach. The chapter also presents the choice of the research villages as well as the sampling and interview procedure. Finally, the chapter gives the linkage between research objectives, concepts, questions and the methods of data analysis.

Chapter 5 gives a description of the research area. Location of the research area, the climatic characteristics and the agro-ecological zones of the area are presented. A general socio-economic description of the research area is also presented, with particular reference to agricultural production systems and household resources and characteristics.

Chapter 6 gives the empirical results of risk attitude measurements. The first part presents the results and discussion of risk attitude using the utility theory. The second part gives results and discussion of risk attitude measurements using items/statements included in a structured questionnaire (Latent variable approach).

In chapter 7, the results and the discussion of risk perception measurements are presented.

The first part presents the results and the discussion of risk perception measurements using the structured questionnaire (Structured questionnaire approach). The second part gives the results and discussion of risk perception measurements using the strength of the conviction method.

Chapter 8 gives the implications of preference ranking, risk attitude and risk perception results emanating from this research. In this chapter, the relationship has been studied between on the one hand various measures of risk attitude, risk perception and background socio-economic variables of smallholder agroforestry farmers and on the other hand preference ranking of cropping systems.

Chapter 9 presents the general discussion, conclusions and recommendations. The first part presents reflections on the research approaches and assumptions, the conceptual framework, the research methodology and the results of this research. The discussion centres on specific limitations and strengths of the research in trying to validate the results. The second part gives conclusions and recommendations regarding the results, methods used policy implications and on future research needs.

CHAPTER 2

RISK ANALYSIS AND DECISION MAKING

This chapter presents a review of concepts and measurement procedures used in risk analysis and decision making. The objective of this review is to get an understanding of what has been done in risk analysis and decision making in agriculture, the methodologies used (and where possible their setbacks) and what remains to be addressed. Most of the attention is devoted to various approaches that have been used in conceptualising, modelling and measuring risk attitude and risk perception of smallholder farmers.

2.1 Normative versus positive analysis

Various approaches have been employed in conceptualising, modelling and measuring risk attitude of smallholder decision-makers. Broadly, two main research approaches can be identified as normative and positive analyses.

Normative approach

This approach starts from researchers' hypotheses about the economic rationality of individual decision making. These hypotheses are tested based on the predictive power of alternative models. In other words the approach tries to find out how closely the observed behaviour conforms to researchers' hypothesis about the farmers' behaviour. Models that consider decision making in the whole farm-planning context, for example Quadratic Programming (QP) and minimisation of total absolute deviation (MOTAD) are typical examples. Normally, these studies assume that decision-makers have specified utility functions. Significant amounts of literature on the application of these models are available. Application of QP under Tanzanian conditions was done by Mtoi (1984).

According to Huijsman (1986) this approach can point out clearly the research direction. Huijsman (1986) further points out that, in a case where a theoretical framework is lacking on the basis of which hypotheses are formulated the approach may identify incorrect causal relations due to a wrong or incomplete specification of the model.

Positive approach

The positive approach, which starts from the farmers, focuses on the question how farmers arrive at various decisions. The approach entails close observation of farmers' behaviour and attitude, and understands what types of decision those farmers take and in which situation. The approach can also be used to explain how different households with different endowments differ in decision making. After understanding what farmers do, a theoretical model is developed and tested in the light of the observed behaviour. Extensions of these models are studied and they focus on predicting risky choices based on empirical measures of risk. Examples of applications of this approach include researches by Huijsman (1986) and Smidts (1990).

This approach is commonly called the behavioural approach to the analysis of farmers' decision making and broadly falls under 'positive analysis'. The method has the advantage of attaining a better descriptive theory of choice and solutions to choice problems faced by farmers in a real world (Day, 1979; Barlett, 1980 and Huijsman, 1986). In the present research, this approach is opted for because of lack of a satisfactory theoretical framework on which to base relevant hypotheses concerning decision making of rural households near the subsistence level of living. In fact, it appears that due to the predominant use of the normative approach, the development of the positive approach has been impeded rather than stimulated (Huijsman, 1986).

Werner (1983) views 'normative' analysis as giving farmers advice on right behaviour in risk i.e. how people should behave in order to attain specific goals and 'positive' analysis as trying to explain how people behave towards risk. In other words, the main problem in risk analysis is to estimate the underlying probabilities, that is either to use the best guess probabilities of the analyst (normative analysis) or estimating the subjective probabilities of the farmer/decision maker (positive/descriptive analysis).

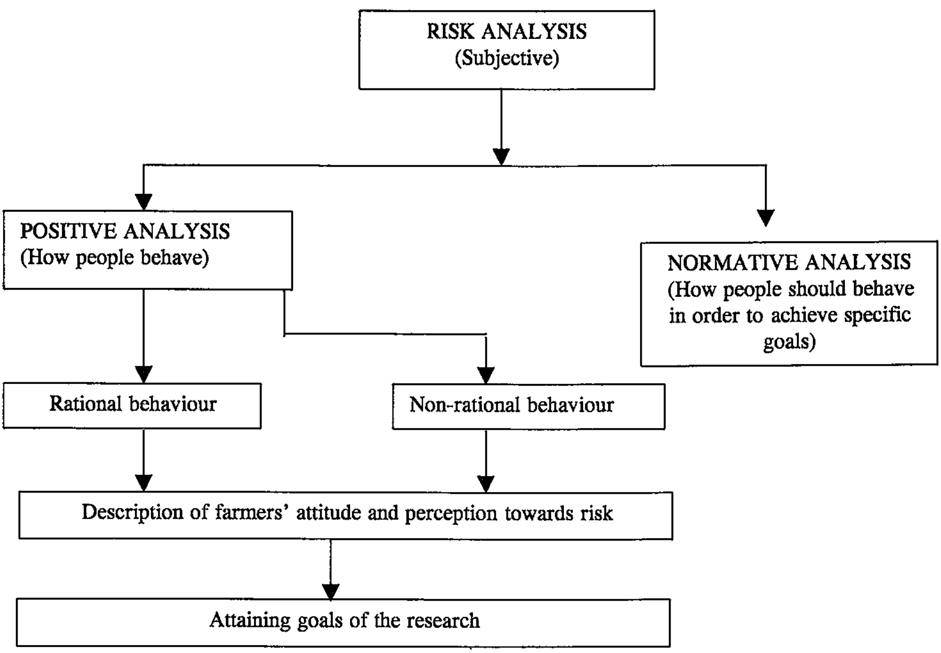

Figure 2.1 The analytical framework

The analytical framework (Figure 2.1) was adopted and modified from Werner (1983). The main assumption in this framework of analysis is that smallholder farmers behave rationally, but non-rational decisions are not ruled out completely, which could be interpreted as 'bounded rationality'.

In this research, farmers are assumed to be rational, which means that the decision makers choose, after careful considerations, the 'best' from a set of alternatives available to them. Byerlee and Collinson (1980) pointed out that farmers clearly reject technologies not because they are conservative or ignorant. But because they rationally weigh the changes in incomes and risks associated with the given technologies under their natural and economic circumstances and decide that for them the technology does not pay. Founders of economic theories assumed rationality, however defined, and saw their theories as tools that could be used both to identify wise decisions and to predict the actual behaviour of man (Werner, 1983). Viewed differently, by assuming that decision-makers are 'irrational' does not form an explanation of behaviour. It is pointed out that the assumption of rational behaviour has been supported by Schultz (1964), and has been confirmed by several econometric tests (Roumasset, 1976:9). Although rationality is the basic assumption of this research, note that there are important doubts about this assumption. Werner (1983:xvii) argues that:

"...Suppose everyone accepts a set of axioms as devices for rational behaviour. Does it necessarily follow that their implications will also be accepted? The fact that this question cannot be self-evidently answered positively is one reason for the mentioned doubts".

This research is undertaken because establishing farmers' risk attitude and risk perception in making production decisions is important, rather than simply stating that agroforestry has several advantages and reduces risk and therefore can easily be adopted. Despite the perceived/demonstrated advantages of agroforestry to smallholder farmers, its adoption will greatly depend on how farmers themselves perceive it in terms of risk and uncertainties.

A tremendous body of literature has been accumulated in the field of "normative" risk research both at theoretical and applied level. However, "positive" research on farmers' risk attitude and risk perception has been given little attention (Huijsman, 1986). In agroforestry economic literature for example, the role of risk has been widely emphasised and given much attention (Arnold, 1983; Etherington and Matthews, 1982; Blandon, 1985; Hoekstra, 1987; and Broder and Odronic, 1990). Unfortunately, much of this attention has been placed on a "normative approach". For example research on designing optimal farm plans with risk considerations can be found in many studies (Blandon, 1985; Lilieholm and Reeves 1991; Babu and Rajasekaran, 1991; Reeves and Lilieholm, 1993), while very little effort has been placed on "positive approach" in risk attitude and risk perception. Specific studies of farmers' risk attitude and risk perception in an agroforestry context do not appear to have been reported. Caveness and Kurtz (1993) made an attempt to investigate risk attitude and risk perception between adopters and non-adopters of agroforestry practices in Senegal. The analysis was based on a mean-variance criterion of yields, income and other household characteristics, elicited at the household level. Land ownership and labour availability were identified as the most significant factors, which contribute to agroforestry adoption. Although the research did not directly elicit farmers' subjective probabilities towards uncertain situations, its considerations of the household resources in farmers' decision making was found useful in the present research.

2.2 Risk attitude and risk perception

In most literature, risk attitude, risk perception and choice criteria are lumped together under the title of risk. The present research, however, examines risk attitude and risk perception separately.

Risk attitude is defined as the farmer's evaluation of the desirability of what happens when he or she adopts a practice. Risk attitude is often related to permanence, i.e. long-lasting clusters of feelings, beliefs and behavioural tendencies directed to risk. It is assumed that risk attitude contributes significantly to the economic construct of risk preference. Risk attitude is therefore useful in analyses geared towards policy perspectives (Walker, 1981). Dillon and Hardaker (1993) define risk attitude as the extent to which a decision-maker seeks to avoid risk (i.e. risk aversion) or is willing to face risk (i.e. risk preference), measured quantitatively by the coefficient of relative risk aversion or coefficient of absolute risk aversion.

Risk perception is a mental interpretation of the physical sensations produced by an external stimulus, e.g. risk. Risk perception of say yield is specific to a particular technique, location, and time. They are thus not permanent and are shaped if new information is obtained. Risk perception of a cropping system depends on the current decision environment, household characteristics, information availability and processing, the experience with the cropping systems and the nature and characteristics of the cropping system.

Walker (1981) argues that, farming systems research literature emphasises on concurrence in perception among farmers, extensionists and researchers. On-farm testing is aimed at bringing rapid convergence of perception on the expected benefits of new technologies under farmers' agro-climatic and socio-economic conditions. If perception markedly conditions adoption, it is therefore necessary to know what farmers perceive as the sources of risk, how their perception are formed and change, and how their subjective judgements compare with objective measurements (Walker, 1981).

Risk perception of an uncertain outcome can therefore be viewed as a necessary condition for the emergence of risk attitude and choice criteria. Studies by O'mara (1971) cited in Walker (1981) and by Walker (1981) prove this proposition. For example, Walker (1981) showed that there were no differences in risk attitude between a community that has adopted a new maize variety and that which has not, and found that their different risk perception led to differential adoption patterns. The community, which did not adopt experienced higher incidences of drought and perceived the new maize variety as less drought resistant.

Based on the above, a distinction between risk attitude and risk perception exists and thus a need for studying the two concepts separately. In this research, the two concepts were studied in relation to smallholder decision making with respect to the choice of cropping systems. The link between risk attitude and risk perception with smallholder decision making is presented in chapter 3.

2.2.1 Scheme of major concepts used

The major concepts in this research are risk perception, risk attitude, risk attitude in a wider context (positive and negative attitude towards risk), preference ranking of cropping systems, risk preference, and choice behaviour (See also table 4.3 in chapter 4). Before presenting the concepts, it is worthwhile to look at the attitude itself as a concept. According to Musser and Musser (1984), attitude has three important components. The first is the 'evaluative' component, which consists of general positive or negative feelings about a person, object or issue. This is closely related to our latent variable approach in risk attitude, where individuals agree or disagree with items measuring risk attitude (See chapter 4). The second component is 'belief' which refers to the information people possess. This component is related to the measures of risk perception which depends much on the information people have about a cropping system. Finally, attitude has a 'behavioural' component, which represents an overt action. This can be related to the measures of risk aversion where individuals act according to whether they are risk averse, -neutral or -lover.

Table 2.1 Concepts and methods of measurements used in this research

Concept	Method Measurement	Data needed and analysis
Risk attitude -Risk preference -Risk aversion	Elicitation of certainty equivalent of 50/50 lotteries to assess utility function for four situations.	- Elicited certainty equivalents. - Estimate utility functions and derive coefficients of relative and absolute risk aversions for four situations: situation when the farmer has adequate food stocks, when the farmer has inadequate food stocks, when the farmer has adequate cash and when the farmer has inadequate cash.
Risk attitude in a wider context (incorporating both aspects of a positive and negative attitude to risk)	- Using the attitudinal aspects of the questionnaire (Latent Variable Approach), and determine the factors affecting attitude towards risk measured using latent variables	Data from a structured questionnaire. Perform factor analysis. Cross tabulate the attitudinal concepts with all the respondents. Estimate the factors affecting positive attitude towards risk using regression analysis (from attitudinal measures and farm/farmer resources and characteristics)
Risk Perception	- Using strength of conviction, elicit points of probability distribution functions on income from various cropping systems - Get data from the perception aspects included in the structured questionnaire	- The elicited points for each cropping system. Data on farmer characteristics. Calculate mean variance and skewness and estimate probability distribution functions. - Cross tabulates the data/information from perception aspects of a structured questionnaire.
Preference ranking	Ranking of cropping system by the farmers	Ranks of the cropping systems strategies. Data from the characteristics of farmers.
Choice behaviour	Assessing the relationship between risk perception, risk attitude and the actual cropping strategies	Data from a structured questionnaire, and from 30 farmers studied in detail.

Similarly based on the definition of risk attitude by Dillon and Hardaker (1993), (i.e. the extent to which a decision-maker seeks to avoid or is willing to face risks), two aspects of interest to this research emerge as negative and positive attitudes towards risk. When a decision-maker seeks to avoid risk, she or he has a negative attitude towards risk, whereas, when she or he is willing to take risk she or he has a positive attitude towards risk. This was examined as risk attitude in wider context using the latent variable approach.

The concept of preference ranking as used in this research refers to the preference ranking of cropping systems by farmers. Many factors might be involved in farmers' preference ranking decisions. Risk perception is associated with what farmers perceive as risks of various cropping systems. Two ways of assessing risk perception were used: using direct questioning by including perception aspects in the questionnaire, and the use of the strength of conviction method to elicit farmers' subjective probabilities of various cropping systems (Table 2.1).

Choice behaviour in this research was used to explain the relationship between risk perception, risk attitude and other variables on the one hand and behaviour with respect to application of having cropping systems on the other hand.

2.3 Risk attitude and risk perception studies

Agricultural economics literature has a long history in the study of risk attitude and risk perception, and methods for improving decision making under risk. A summary of such developments is broadly covered in Roumasset *et al.* (1979) and Barry (1984). The work by Anderson *et al.* (1977) provided a landmark in agricultural risk analysis. Their approach to decision analysis under risk is based on the decision-makers'/farmers' personal strength of belief about the occurrence of risky events and their personal evaluation of potential consequences. The work by Huirne *et al.* (1997) and that of Hardaker *et al.* (1997) give recent contributions in risk analysis and management strategies in agriculture. The authors revisit methods of risk analysis presented by earlier authors after a considerable period of trying and learning what is possible and what is impossible among the procedures presented by authors such as Anderson *et al.* (1977). In revisiting risk analysis and management strategies, the authors took advantages of the revolutionary improvements in computing techniques (using microcomputers) that were not available in the late seventies.

One of the important contributions to risk that is worth mentioning is the theory of risk adverse behaviour developed by Kenneth Arrow (1974). Arrow observed that individuals tend to display aversion to the taking of risks and risk aversion is an explanation for many phenomena observed in an economic world. While this is an important assertion, it is worthwhile to note that many farmers' production strategies and practices, often erroneously identified as resulting from risk averse behaviour, serve the dual purpose of reducing risk and attaining the best economic results (Huijsman, 1986). On the same argument Huijsman (1986) argues that from a production point of view, farmers cannot simply be classified as risk seekers or risk averters, but they are in fact fitting in both categories. Walker (1981) shared the same argument. He argues that the idea of risk aversion is used too loosely to explain lack of technology adoption and often cloud the fact that the technologies may not perform well under farmers' conditions. All these call for farm level studies aimed at soliciting farmers' risk attitude and risk perception when making production decisions. However, noting that these types of research issues are inherently difficult to analyse is important because they relate to feelings of people and as such do not follow a relatively straight forward research strategy based on direct questioning (Huijsman, 1986).

Generally, risk attitude and risk perception studies can be categorised into two main categories. The first category includes those studies that use the utility theory and decision analysis approach. These are directly linked to the expected utility theory, by assessing a utility function $u(x)$. The shape of the utility function, which is characterised by the Arrow-Pratt coefficients of risk aversion, indicates risk attitude of individuals. This category was used in this research and is discussed in section 2.3.1. Likewise, the study of risk perception using the utility theory category involves the elicitation of subjective probability distributions and derive measures of risk perception and expected income using the parameters of the estimated probability distribution functions. This approach is also used in this research and is presented in section 2.3.2.

The second category of risk attitude and risk perception studies is that generally found in the social sciences and is more related to psychology. The criticisms that are put upon the expected utility theory and the elicitation of subjective probabilities tempt the use of this category. In this category some samples of indicators about risk attitude/risk perception are developed, for example respondents showing the extent to which they agree or disagree with several statements concerning risky choice behaviour. This category is also called 'latent variable'[4] approach (Von Bach and Nuppenau, 1995, Smidts, 1990; Plewis, 1985; and Goldberger, 1977). Risk perception studied using the items included in the structured questionnaire (Appendix 1) is presented in section 2.3.4 and in chapter 4.

2.3.1 Risk attitude studies using the utility theory category.

Before discussing various approaches in measuring risk attitude, examining two main sources of probability distributions from which alternative risk concepts originate is important. These are either objective or subjective sources. Subjective refers to measures elicited from the decision-maker while objective refers to those computed from historical observations. Subjective probabilities are of more interest to the present research. As pointed out in Lee *et al.* (1985:840) subjective probability distributions appear preferable to objective probability distributions when the aim of the research is concerned with soliciting information about the actual behaviour of farmers.

The central theme of utility analysis or risk preference theory points out that if individuals make decisions in accord with a few specific but reasonable rules, then they should attempt to maximise expected utility in all their decision making (Francisco and Anderson, 1972). Risk preference theory is thus primarily consisting of belief in occurrence of events (i.e. subjective

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[4] 'Latent variable' in this research refers to the hidden factors that are generated during factor analysis. Factor analysis of items may generate a factor with highest loading that measures a hidden variable such as intelligence, love, and risk attitude or altruism. Hence, the name 'latent variable' approach. This may differ from latent variable approach in other applications.

probabilities) and the degree of preference for risky outcomes (i.e. utilities). In this research risk attitude and risk perception are studied separately, and belief in occurrence of events is related to risk perception while preference for risky prospects (utilities) is related to risk attitude.

Subjective probability is the decision-maker's degree of belief or expectations about the outcome of a future uncertain event. Its value is between zero and one and conforms to normal rules of probability. A subjective probability distribution is personal and cannot be labelled as correct or incorrect. It is an expression of individuals' belief generated from available information and personal information processing ability (Grisley and Kellogg, 1983:74). If a decision-maker is responsible for his decisions, his strengths of conviction about future events are appropriate rather than those of someone else (Francisco and Anderson, 1972).

It is argued, however, although subjective probabilities are inherent to decision-making, there are some discrepancies between responses and what subjects perceive during elicitation, thus introducing biases (Grisley and Kellogg, 1983). The present research uses the subjects' subjective probability, and elicitation techniques were selected so that biases are reduced as much as possible. Approaches in studying risk attitude of decision-makers in agriculture are discussed in Young (1979) and in Robinson *et al.* (1984). These approaches are Direct Elicitation of Utility functions (DEU), Interval Measures of risk aversion (IM), Experimental Methods (EM), and Observed Economic Behaviour (OEB).

Direct Elicitation of Utility (DEU)

This involves direct contact with the decision-makers to specify their risk attitude. DEU focuses on a single valued utility function and on lexicographic utility or on the broader concept of multiple goals. Most of the DEU applications involve the expected utility approach. Several elicitation procedures exist, each yielding a series of points in utility-monetary outcome space that can be expressed as a utility function (Robinson *et al.*, 1984). The best-known variations of the DEU are the Von Neumann- Morgenstern (VN), the modified VN and the Ramsey method. Each method implements the certainty[5] axiom of the expected utility method in repeated applications of hypothetical gambles.

Despite its wide applications, (for example Conklin *et al.* (1977) on Oregon orchardists; Lin *et al.* (1974) on large scale California farmers; Francisco and Anderson (1972) on Australian pastoralist; and Dillon and Scandizzo (1978) on small farmers and share croppers in Brazil), various criticisms have been put against the DEU. It is argued that DEU is subject to bias arising from different interviewers, preference for specific probabilities (e.g. 50:50 bet), confounding from extraneous variables and negative preference towards gambling (Binswanger, 1980; Robinson, 1982). In addition, care must be exercised in the specification of the utility functional form. Inappropriate functional form of the utility function leads to undesirable implications (Lin and Chang, 1978).

Interval Method (IM)

[5] If a_1 is preferred to a_2 and a_2 is preferred to a_3 then some probability p exists that the decision-maker is indifferent to having a_2 for certain or receiving a_1 with probability p and a_3 with probability $(1-p)$. Thus a_2 is the certainty equivalent of $pa_1 + (1-p)a_3$.

To improve on DEU, King and Robinson (1981a, 1981b) developed the IM. It was designed to take care of any possible errors in measurement. The method is based on identifying a confidence interval for the Arrow-Pratt measure of absolute risk aversion estimated by asking decision makers to order pairwise comparison of probability density functions (Robinson *et al.*, 1984).

The IM is based on the assumption that the constant risk aversion measure over a small range, is a good approximation of the 'true' absolute risk aversion function. The method allows greater generality in the relationship between a decision-maker's absolute risk aversion and the level of monetary outcomes. In other words an individual's absolute risk measure could increase, decrease, or remain constant over a range of monetary values as compared to algebraically specified utility functions that have specific patterns of absolute risk aversion. IM is described in detail in King and Robinson (1981a, 1981b).

Experimental Method (EM)

Binswanger (1978a: 45) pointed out that evidence on risk aversion from pure interviews is unreliable, non replicable and misleading, even if one is interested only in a distribution of risk aversion rather than reliable individual measurements. As a result, Binswanger (1980) developed an experimental method for measuring the risk attitude of 350 peasant farmers in rural India. The approach is based on gaming situations conducted in a series of visits over several weeks. It involved financial compensations at significant levels. The realistic experimental approach is said to remake some flaws of DEU. Walker (1981) using data from El Salvador, and Grisley and Kellogg (1983) using data from Northern Thailand have also applied the approach in a modified form. The main set back of this approach in the light of the present research is the limited funding available to cover the financial compensations, which are needed. If not well planned, this approach can promote motivational biases (i.e. conscious or subconscious adjustments in subjects' responses motivated by his or her perceived system of personal rewards for various responses) (Spetzler and von Holstein 1975).

Observed Economic Behaviour (OEB)

OEB draws inferences about risk attitude based on the relationship between the actual behaviour of decision-makers and the behaviour predicted from empirically specified models. They are indirect measures, which compare observed economic behaviour with respect to factor demand and output supply to behaviour predicted by theoretical models incorporating risk and risk preferences (Young, 1979:1066).

For example, in production resource allocation, it is required that the Marginal Value Product of the resource i, (MVP_i) be equated to the resource price (also called Marginal Factor Cost, MFC). To incorporate risk to resource allocation above mentioned, risk adjustment R_aI_r is added. The risk adjustment factor consists of entrepreneur's local risk aversion/risk preference R_a and the marginal contribution to risk of additional input use (I_r)

i.e. , equating $E(MVP_i) = MFC_i$. (Deterministic) *(2.1)*

$E(MVP_i) = MFC_i + R_aI_r$, (Stochastic) *(2.2)*
$i = 1,\ldots,n;$

Where,

$E(MVP_i)$ = Expected marginal value product of input *i*

MFC_i = Non stochastic marginal factor cost of input *i*

R_aI_r = Risk adjustment

R_a = Entrepreneur's local risk aversion

I_r = Marginal contribution to risk of additional input use.

Advantages of OEB include its ability to generate quantitative measures of risk aversion, allowing the analyst to handle a large amount of sample data, less costly and avoids measuring risk attitude from hypothetical gaming situations (Robinson *et al.,* 1984). This approach has been applied by Wolgin (1975) on smallholder agriculture in Kenya and Moscardi and de Janvry's (1977) in Puebla, Mexico within the safety first framework.

One problem of this method is that the observed differences or 'residual' between the expected profit-maximising MVP and MFC may have other causes than risk alone and thus bias the estimated risk. For example differences in credit costs may contribute to the differences. Terry Roe (1982) also points out that one problem is that the expected MVP is not the farmers' subjective estimate. Instead estimates of MP are obtained by regressing the observed yield on input variables.

Which approach to use?

After a critical analysis of the above methods in view of applying them for formulating micro-economic policy and predictive applications, Young (1979) pointed out the following:

1) If the problem requires strictly risk preferences of individual producers rather than 'typical' preferences of classes of producers, EM proposed by Binswanger (1980) appears to be most likely to provide reliable replicable measures of risk aversion assuming the method is well funded and conscientiously executed.

2) For cases where objectives other than profit alone are likely to be important, multiple objective approaches (i.e., approaches that consider the importance of risk to the farmer as compared with other business or personal goals, see for example in Robinson *et al.* 1984:28-30) are more preferred.

Young (1979) argues that there are two options:

(i) Estimate risk aversion coefficients for a large sample of individuals whose members vary according to the class attribute of interest (e.g. the different cropping strategies). Then, relate risk aversion level and personal or business attributes using regression and multivariate analysis, as used by Dillon and Scandizzo (1978) in a DEU context. (The business and personal attributes for example age, resource available, education, household income etc. may be viewed based on the farmers' main goals for example subsistence goals versus other goals.)

(ii) Use OEB approach to estimate aggregate risk aversion coefficients or risk responses directly using econometric or risk programming models if data is available.

In evaluating the approaches, all of them clearly have pitfalls in their applications. The main theme of the present research leans more towards obtaining information about risk attitude from the decision-makers themselves. This with the problems of obtaining adequate time series data, or time series data combined with cross-sectional data, rules out the use of the OEB approach. The remaining two approaches seem applicable to the present research. However, the requirement of actual financial compensation when executing the EM became a financial constraint to this research.

Based on the above and in line with the positive approach, a well-planned DEU which involves the Expected Utility Model (EUM) was used to study risk attitude in the present research. Since subjective probability distributions are used, the EUM is also referred to as the Subjective Expected Utility model (SEU model).

The Expected Utility Model (EUM)

EUM infers that decision-makers who obey certain axioms should choose actions that maximise their expected utility. It delineates between a decision-maker's perception of the uncertainty involved and his or her attitude towards additional income. Von Neumann and Morgenstern (1947) used this model in describing utility, based on a theorem derived from a set of axioms about individual behaviour. It is referred to as the von Neumann-Morgenstern model (NM model). The axioms can be summarised as follows: ordering of choice; transitivity among the choices; substitution axiom and certainty equivalent (Anderson *et al.*, 1977; Robinson *et al.*, 1984; Smidts 1990).

Defining a set of choice alternatives as $a = a_i$, $i = 1, 2, \ldots, n$

A set of outcomes as $X = x_j$, $j = 1, 2, \ldots, k$

A set of probabilities as $P = p_i(x_j)$, $i = 1, 2, \ldots, n; j = 1, 2, \ldots, k$

Where $p_i(x_j)$ is the probability of an outcome x_j with an alternative a_i. These sets are assumed to be known with certainty. If the choice is to be made before they are known, uncertainty comes in. Then the choice alternatives a_i, are each represented by a probability distribution.

Based on the axioms, it can be proved that[6] a utility index $u(x)$ exists, unique up to positive linear transformation[7], so that computing expected utilities will give a preference ordering $u(.)$. The preference ordering $u(.)$ takes different forms depending on the probabilities.

For a discrete probability function applies:

$$u(a_i) = \Sigma p_i(x_j)u(x_j) \tag{2.3}$$

While for continuous probability function applies:

$$u(a_i) = \int f_i(x)u(x)\, dx \tag{2.4}$$

Where, $u(a_i)$ = expected utility of alternative a_i

$p_i(x_j)$ = probability of outcome x_j with alternative a_i

$f_i(x)$ = probability density function of alternative a_i

$u(x)$ = utility function

The preference ordering is therefore the expected value of the utility outcome weighted by the

[6] Interested readers are referred to Sinn (1983) for more detailed explanations in deriving expected utility.

[7] $u(x)$ is defined up to positive linear transformation means that the function say $g(x) = a + bu(x)$ where $b > 0$ results in the same ordering of probability (See also Anderson *et al.* 1977:68).

respective probabilities.

The decision-maker's risk attitude is inferred from the shape of his utility function. A linear utility function implies risk neutral, a concave to the origin implies risk aversion and convex refers to risk preferring attitude. A decision-maker having concave and convex segments of the utility curve implies that the risk attitude changes for different monetary outcomes.

To allow interpersonal comparison Arrow (1965) and Pratt (1964) independently, suggested two measures:

(1) Absolute risk aversion given as

$$R_a(x) = -u''(x)/u'(x) \tag{2.5}$$

Where, $u'(x) = d/dx\ u(x)$ and $u'' = d^2/dx^2\ u(x)$

(2) Relative or proportional risk aversion is given as

$$R_r(x) = -xu''(x)/u'(x) = x\ R_a(x) \tag{2.6}$$

If the second derivative $[u''(x)]$ is negative for all x, then $u(x)$ is concave and the decision maker is risk averse $[R_a(x) > 0$ and $R_r(x) > 0]$. If the second derivative is positive for all x, then $u(x)$ is convex, meaning that the decision maker is risk preferring/seeking $[R_a(x) < 0$ and $R_r(x) < 0]$.

Criticisms of SEU model in agricultural applications

The SEU model can be viewed as both a normative and a positive/descriptive model (Smidts, 1990:59). In a normative model, the decision-maker who agrees with the set of axioms, will prefer the alternative with the highest expected utility. By specifying the decision maker's preference/utility function $u(x)$, prescribing how and what risk decisions to be made is possible (given objective or subjective probability distributions). If a decision-maker does not agree with the axioms, his choices would depart from the EUM (Smidts, 1990).

As a positive/descriptive tool, decision-makers choose between alternatives with uncertain outcomes as if they were maximising expected utility. Although there are many questions regarding decision-makers' information processing capacity and perception (i.e. regarded as limited and imperfect), it is assumed that decision-makers behave according to the axioms when confronted with serious economic decisions. As a result, EUM should at least give an approximation of behaviour (Sinn, 1983).

As a descriptive model SEU has received several criticisms (Smidts, 1990). Generally, the criticisms lie in the predictive validity. It is argued that the predictive validity is low.

Its application to agricultural producers has also received criticisms, for example in Young, (1979). Studies by Lin *et al.* (1974) and Officer and Halter (1968) tested the SEU hypothesis against other decision criteria in agriculture. In both cases, the predictive validity was found to be low, although some support for SEU was shown. Robinson (1982) argues that, due to a lack of adequate test designs, making hard conclusions about the SEU-model is difficult but views the model as the most available and useful decision model in agricultural decisions.

Other criticisms against the SEU-model have been the failure to recognise various psychological principles of judgement and choice as discussed in Schoemaker (1982) and

Musser and Musser (1984).

People use heuristic[8] judgements to reduce the difficult mental tasks of complex decisions to simpler ones. Knowledge of these heuristics is important because, besides explaining why people show biases in evaluating probabilities, it also provides information about the type of bias that might occur under different assessments, and suggests how to conduct interviews to reduce those biases. Tversky and Kahnemann (1982) discuss two heuristics commonly employed by persons in making decisions regarding the occurrence of uncertain events. These are availability of instances and adjustment and anchoring. As regard to availability, instances which are easily retrieved will appear more numerous than those that are less easily retrievable. In other words, people put more weight on recent information. In cases where recent information is not representative, this could lead to bias in judgement. As far as adjustment and anchoring is concerned, often people make estimates by starting from an initial value. For example if one starts eliciting a median yield, the maximum and minimum yields will be based on the elicited median yield, and if this adjustment is insufficient it will lead to biased maximum and minimum yields. Sonka and Patrick (1984) describe two techniques of eliciting probability distributions: The strength of conviction, and triangular distribution techniques. The present research uses strength of conviction rather than the triangular distribution method, because the former is less susceptible to adjustment and anchoring problems as compared to the latter. Although it requires less information and is easy to use, the triangular distribution method involves elicitation of the frequent value, minimum and maximum values which may impose adjustment and anchoring problems to the respondents.

Apart from the above-mentioned cognitive biases, other discrepancies between responses to elicitation procedures and what actually people perceive may occur. These may be due to motivational biases, careless response from the subject, due to a long boring interviewing procedure, and biases resulting from elicitation methods that involve concepts which are new to the subjects or have meanings that are different from those of the researcher.

Based on the assumption that farmers have enough information and information processing ability to think about the future in probability terms, adequate training, motivating respondents and structuring of the questions can assist in reducing the overall bias. Jungerman (1983) elaborates further on the biases by distinguishing two groups in the debate of the SEU-model as those who are on the decision-makers' biases and those who are on researchers' biases.

There is evidence in Economics and Behavioural Science that individuals violate the expected utility in practice to a greater or lesser extent, depending upon the circumstances (Kahnemann and Tversky, 1979). However, it is argued that this is perhaps fortunate or a challenge to decision analysis, otherwise there would be no scope for improved methods of decision making (Bunn, 1984).

Many alternative descriptive models have been formulated to correct the deficiencies inherent in the SEU-model. These include the prospect theory of Kahnemann and Tversky (1979), the regret theory of Bell (1982, 1985) and Looms and Sudgen (1982), the generalised expected utility model of Machina (1982) and the optimism/pessimism approach of Hey (1984).

[8] Heuristic (adj.), Heuristics (n) is defined according to the advanced Learners Oxford Dictionary as a method of solving problems by learning from past experience and investigating practical ways of finding a solution.

Most of the alternative models are still close to the principles of the SEU-model, while some deviate largely from the SEU-theory, for example, the prospect theory, but generally, they do not provide real alternatives to the SEU-model. Smidts (1990:70) argues in favour of the SEU-model as follows;

"... We conclude therefore that, not only for the decision problem of this research but in GENERAL... SEU model will remain an adequate reference model for studying actual decision making under risk".

Most recently, Anderson (1997) argued that according to literature, application of the SEU model is accelerating and has been a major achievement although its adoption within agricultural risk management community was somewhat slow. It is further pointed out that despite the practical problems and theoretical doubt about the application of SEU, SEU hypotheses are so appealing that many agricultural economists are reluctant to abandon, even when those axioms are violated. The fact that the model continues to be so widely used suggests that others agree (Hardaker *et al.*, 1997).

Apparently nothing has been done so far to our knowledge regarding application of the SEU-model in agroforestry context. In this research all sampled farmers practice agroforestry. Their risk attitude was evaluated using four situations namely, when farmers have adequate food stocks, when they have inadequate food stocks, when farmers have adequate cash, and when they have inadequate cash. The aim of formulating these situations is to find out if there are differences in risk attitude when farmers are faced by the above mentioned situations.

Assessment of the utility function

Several techniques exist in assessing the NM utility function. However, it is important to note that assessment of utility, i.e. behavioural research on decision making is subject to many biases regarding structure, question format, response mode, individual perspectives etc., which can sometimes change the risk preference response of an individual decision maker (Farquhar, 1984). Such biases have been reported, for example in Tversky and Kahnemann (1981) and in Hogarth (1982). In other words utility assessment is a difficult task and needs to be handled with great care. The main assumption on the respondents is according to the axioms of the EUM and this has been the main area of criticisms in EUM, see for example Allais (1979), who contends that decision makers do not choose in accordance with the independent axiom.

Smidts (1990) points out that careful assessment in utility analysis involves providing a clear and unambiguous decision context, specifying the attribute of interest clearly, training the respondents and interviewer in the assessment task, checking for inconsistency in response and use of more than one technique in order to study convergent validity.

A comprehensive discussion of utility assessment methods is covered in Farquhar (1984). About two dozen of utility assessment methods from which half appeared for the first time are critically examined. Farquhar (1984) classified the assessments basing on four criteria namely probability equivalent (PE), value equivalent (VE), certainty equivalent (CE), and hybrid methods (HM) classified over paired gamble and standard gamble techniques (Farquhar, 1984:1285). Of the four criteria, CE and PE are commonly used. Officer and Halter (1968) compared the predictive validity of CE and PE criteria and found that the CE technique was superior. Other studies in which CE and or PE were applied are for example in Fishburn and Kochenberger (1979); Hazell and Scandizzo (1977); Hamal and Anderson (1982) and Smidts

(1990). However, it is argued that PE and CE do not generally yield the same results making it difficult to decide which one reflects the "true" risk preferences of the decision makers (Smidts, 1990). To avoid this the use of the two techniques together is advocated. However, many studies with agricultural applications have been applying the CE criteria, for example Hazell and Scandizzo (1977) and Dillon and Scandizzo (1978) etc. The present research uses the CE method and the assessment criteria are presented in chapter three. The CE were solicited on the above mentioned four situations facing the farmer.

Risk has also been assessed based on farmers' objectives or goals. For example Robinson *et al.* (1984) discuss the application of Lexicographic Utility within the safety first approaches, where sequential ordering of multiple goals facing the farmers can be done. Examples of studies that have applied Lexicographic Utility analysis are presented in Robinson *et al.* (1984). Another example of risk assessment based on farmers' goals is the research by Dillon and Scandizzo (1978). Using data from northern Brazil, Dillon and Scandizzo (1978) assessed risk based on farmers' goal of achieving subsistence consumption.

Estimation of parameters of the utility function

A major critical step in the application of the EUM in decision analysis is the choice among several utility functional forms. Musser and Musser (1984) and Zuhair *et al.* (1992) have shown that the choice of the functional form in utility analysis affects both the classification of risk attitude and the prediction of the analysed strategies.

Tsiang (1972) put forward the following properties of a utility function for wealth:

(a) $u'(x) > 0$, i.e., marginal utility for wealth is positive

(b) $u''(x) < 0$, i.e., marginal utility for wealth decreases with an increase in wealth

(c) $d[-u''(x)/u'(x)]/dx \leq 0$, i.e., marginal risk aversion should if anything, decrease with an increase in wealth

(d) $d[-xu''(x)/u'(x)]/dx \geq 0$, i.e., marginal relative (proportional) risk aversion should if anything increase with an increase in wealth.

Conditions (a), (b), and (c) are generally accepted, while for condition (d) it is argued that there are no compelling reasons why utility functions must be bounded both from above and below (Tsiang, 1972).

Hamal and Anderson (1982) have done applications of these conditions in agriculture. For example, they fitted an exponential function to a sample of farmers in Nepal. The farmers were found to be generally averse to risk, with diverse levels of absolute risk aversion that tend to diminish as wealth increases, i.e. confirming the decreasing absolute risk aversion assumption.

A desirable utility functional form should have the following properties (Zuhair *et al.*, 1992):

- Strictly positive marginal utility of income,
- Ease of estimating the parameters of the function,
- Ease with which the function can be mathematically manipulated to determine summary measures and
- A utility function exhibiting decreasing absolute risk aversion.

According to Tsiang (1972) polynomials cannot satisfy the stated conditions. As pointed out in Lin and Chang (1978) polynomials exhibit increasing absolute risk aversion or negative marginal utility and were thus found to bias the utility maximisation hypothesis. The consensus among researchers is that utility functions imply a decreasing absolute risk aversion and not a constant or increasing one and that the theoretical constraint of diminishing marginal utility be satisfied.

Alternative utility functions

Various functional forms of utility have been used, for example exponential utility functions, power functions and logarithmic utility functions.

A function having a variable base and a constant exponent is a power function i.e., $Y = x^a$ where a is a constant exponent and x a variable base. Examples are quadratic and cubic functions and other equilateral hyperbolas. Whereas a function having a constant base and a variable exponent is an exponential function i.e., $Y = a^x$ where a is a constant base and x a variable exponent. Logarithmic functions are those expressed in logarithm (common) and natural logarithm. There is a relationship between logarithm and exponential functions i.e., if Y is an exponential function of x, then x is a logarithmic function of Y. Examples of alternative utility functions are as follows:

(a) ***Power Functions***

$$u(x) = a + bx + cx^2 \tag{2.7}$$

Equation 2.7 is a quadratic utility function where a, b and c are parameters and $u(x)$ is a utility index.

$u'(x) = b + 2cx$

$u''(x) = 2c$

If $u''(x) < 0$ marginal utility decreases with an increase in x, implying a declining marginal utility ruling out risk preferring behaviour.

If $u''(x) > 0$ marginal utility increases over the entire range of x implying risk preferring behaviour. $R_a = 2c/b+2cx$, R_a will remain positive for $x < (b/2c)$ i.e. increasing risk aversion and for values of $x > (b/2c)$, the function will exhibit decreasing risk aversion.

$$u(x) = a_o + bx^{1-c} \tag{2.8}$$

Equation 2.8 is another formulation of a power function[9]

$u'(x) = b(1-c)x^{-c}$

$u''(x) = -bc(1-c)x^{-c-1}$

$R_a(x) = -u''(x)/u'(x) = c/x$

$R_i(x) = x\, r_a(x) = x\, c/x = c$

Where,

$R_a(x)$ is the Arrow-Pratt coefficient of absolute risk aversion,

$R_i(x)$ is the Arrow-Pratt coefficient of relative/proportional risk aversion.

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[9] This formulation of a power function was tested in this research. Throughout this research, it is the only formulation that is referred to as power function. Other forms of power functions are referred to by their exponent e.g. quadratic and cubic functions

If $0 < c < 1$, this implies risk averse and if $c < 0$ it implies risk seeking. This formulation of a power function exhibits a decreasing absolute risk attitude and a constant relative/ proportional risk attitude.

The cubic utility function can be expressed as:

$$U(x) = a + bx + cx^2 + kx^3 \tag{2.9}$$

Where a, b, c, and k are parameters.
The second derivative depends on the sign and magnitude of the parameters c, k and the level of income x. As a result increasing and decreasing marginal utility are both possible.
R_a is given as $-[(2c+6kx)/b+2cx+3kx^2)]$.

It is worthwhile to note that although polynomials (especially the quadratic utility function) have been useful in empirical applications of utility analysis, they have been highly criticised. Anderson *et al.* (1977) discuss these criticisms and their possible remedy. Three important set backs have been proposed. First, polynomial utility functions are not everywhere monotonically increasing. According to Anderson *et al.* (1977) this is not a big problem because utility functions are estimated over a particular range of losses and gains and no use beyond this range is recommended. Secondly, polynomial of degree n implies that only the first n moments of probability distribution of outcomes are taken into account. This can never lead to error if the decision-maker's utility is truly quadratic or if the risky prospect's distribution is normal. Thirdly, the polynomial function for utility of wealth fails to meet the intuitive requirement of decreasing risk aversion with increasing wealth. According to Anderson *et al.* (1977), this is not too serious for utilities of gains and losses but may be significant in utility of wealth. Interested readers are referred to Anderson *et al.* (1977) for more details.

(b) Exponential functions

$$u(x) = a_o + b\,e^{-cx} \tag{2.10}$$
$$u'(x) = bce^{-cx}$$
$$u''(x) = -bc^2e^{-cx}$$
$$R_a(x) = -u''/u' = c$$
$$R_i(x) = x\,r_a(x) = xc$$

Where:
$R_a(x)$ is the Arrow-Pratt coefficient of absolute risk aversion.
$R_i(x)$ is the Arrow-Pratt coefficient of relative/proportional risk aversion
The exponential function implies constant absolute risk aversion and increasing relative/ proportional risk aversion.

(c) Logarithm functions

$$u(x) = a + b\ln(x+c) \tag{2.11}$$
$$u'(x) = b/x+c$$
$$u''(x) = -b(x+c)^{-2}$$
$$R_a(x) = -u''/u' = 1/(x+c)$$
$$R_i(x) = x/(x+c)$$

A logarithmic function implies a decreasing absolute risk attitude and a constant proportional/relative risk attitude if $c = 0$, an increasing proportional/relative risk attitude if $c > 0$ and a decreasing proportional/relative risk attitude when $c < 0$.

It is pointed out in Smidts (1990) and Zuhair *et al.* (1992) that all the functional forms explained above meet the four conditions stated by Tsiang (1972). Fishburn and Kochenberger (1979) conclude that the power and exponential functions fit better than linear fits. Zuhair *et al.* (1992) found that the exponential function was the best predictor of harvesting strategy as compared to the two power functions tested, i.e. cubic and quadratic utility functions. Clemen (1991) and Hennessy (1998) also suggested the use of the negative exponential utility function.

Three other utility functional forms have also been suggested in the literature. These are Expo-power utility function, Hyperbolic Absolute Risk Aversion (HARA) and Szpiro's utility functional form. Saha *et al.* (1994) point out that an Expo-power function exhibits decreasing, constant or increasing absolute risk aversion and decreasing or increasing relative risk aversion depending on parameter values. In addition, the Expo-power utility function gives the structure of risk preference. The risk adverse coefficients R_a and R_i are within the values estimated in other studies. However, it is pointed out in Hennessy (1998) that the Expo-power function demonstrated by Saha *et al.* (1994) has not yet been studied in sufficient detail to understand desirable parameter magnitudes. As a result this functional form was not used in this research.

Other utility function forms worth mentioning are HARA (Hyperbolic Absolute Risk Aversion) and Szpiro's functional form. Wolf and Pohlman (1983) applied the HARA utility functional form. This function has the flexibility of exhibiting decreasing absolute risk aversion and increasing absolute risk aversion depending on parameter values. However, it exhibits constant risk aversion only if one of its parameters approaches infinity (asymptotic limit). As a result it poses some estimation problems.

Szpiro (1986) applied a utility function of the following form:

$$A(w) = w^{-\alpha} \tag{2.12}$$
$$A'(w) = -\alpha w^{-(1+\alpha)}$$

Where w is wealth and the coefficient α explains risk aversion. If α is positive a decreasing absolute risk aversion is implied. If α is negative or 1, increasing absolute risk aversion and constant absolute risk aversion respectively are exhibited. The main set back of this function is, as pointed out in Saha *et al.* (1994), that it leaves the underlying utility function unspecified. Based on the above, HARA and Szpiro's functional forms were not tested in this research.

Table 2.2 gives a summary of the results of other studies in agriculture that estimated measures of risk aversion. The table was used as a basis of comparing the results of the estimated coefficients of risk aversion in other researches to those measures obtained from this research (See chapter 9).

Table 2.2 . Summary of the results of other studies in agriculture on measures of risk aversion.

Research	Year	Utility function used	R_a	R_i
Freund and Blume	1975	Mean Variance	-	1-3
Simon and Pomareda	1975	Mean Variance	0.5	-
Wiens	1976	$U(w)=\theta - e^{-\alpha w}$	0.0085 to 0.091	-
Brink and Maccarl	1978	Mean Variance	0 to 0.25	-
Buccola	1982	Exponential and Quadratic	0.00129-0.00196	-
Hansen and Singleton	1982	Power	-	0-2
Wolf and Pohlman	1983	Hyperbolic Absolute Risk Aversion (HARA)	4	4
Szpiro	1986	$A(w) = \beta w^{-\alpha}$	-	1.21-1.79
Antle	1987	Econometric	3.272	-
Smidts	1990	Negative exponential (elicitation)	0.031 to 0.043[a]	-
Zuhair, *et al.*	1992	Cubic, negative exponential and quadratic	-0.0001 to 0.000433[b]	-
Chavas and Holt	1993	Parametric	4.54-14.75	1.42-6.76
Saha, *et al.*	1994	Expo-power $U(w) = \theta - \exp[-\beta w^{\alpha}]$	Small 0.0083 Large 0.0045 overall 0.0075	Small 3.759 large 4.075 overall 5.4
Huirne, *et al.*	1997	Negative exponential	-0.0007 and 0.0036	-
Bar-Shira *et al.*	1997	Econometric	0.0000045	0.611

Source: Adopted and appended from Saha *et al.* (1994)

[a] The values are mean figures for 1984 (0.043) and 1985 (0.031)

[b] Calculated mean values from Zuhair *et al.* 1992. Means were 0.000433 for exponential and quadratic forms and –0.0001 for cubic utility form.

- Means that the measurement was not done in that particular research

2.3.2 Approaches in studying risk perception in the utility theory category

Smidts (1990) discusses two approaches in measuring perception in the utility theory context: Direct and indirect measurements. In indirect measurement, the perception of an attribute of interest, for example price, yield, drought, income etc. is modelled explicitly as a subjective probability distribution. It involves direct contact with the decision-maker, to elicit several points of the cumulative distribution function. The probability distribution function is then fitted to these points, and mean, median, standard deviation and skewness are derived from the distribution. It is called indirect because the measures of central tendency and variation are indirectly derived from the probability distribution function.

The direct measurement approach involves a straightforward method of asking the farmer to state the mean of the attribute and the associated risk. The risk of the attribute is then measured on a general scale by means of magnitude estimation. The approach does not lead to a subjective probability distribution, and this limits the use of risk perception measured, by refraining from the use of models like a subjective probability distribution.

The present research uses indirect measurements of perception. The descriptions of the measurement procedures are given in the following subsections below, and in chapter 4. Returns of various cropping systems were elicited using the strength of conviction method modified from Sonka and Patrick (1984:112) (See also chapter 4). Probability distribution functions were then fitted from the elicited points as described in the subsections below.

Measurement of risk perception in the utility theory category

After identification of a variable/variables of interest (for example yield, price, income), elicitation of the decision-maker's probability distribution function is necessary when measuring perception of that variable.

By combining their experiences in production, farmers will form an impression of the variable of interest. To obtain this information, it involves the use of various techniques to elicit farmers' subjective probability distributions. It refers to beliefs held by individual agents (people) that reflect their degree of uncertainty about some idea, event or propositions. A subjective probability distribution is therefore a set of subjective beliefs defined over a set of mutually exclusive and exhaustive ideas, events or propositions (Bessler, 1980).

According to Anderson *et al.* (1977), the elicited subjective probability distribution must satisfy the following conditions:

- Probability of any individual event must be between 0 and 1 inclusive.
- The probability of two or more mutually exclusive events occurring is the sum of the probabilities of each individual event and,
- The sum of the probabilities of all possible events must equal one.

Various techniques of eliciting subjective probability distributions exist and are discussed in detail in Spetzler and Von Holstein (1975), Winkler (1967), Raiffa (1968) and Anderson *et al.* (1977). These include the **visual counter technique** as applied by Francisco and Anderson (1972) in eliciting wool prices and rainfall. Bessler (1980) elicited yield estimates of various crops, Lee *et al.* (1985) elicited some income distributions for alternative conservation measures. Smidts (1990) applied the interval technique in various marketing strategies. Carlson (1970) and Pingali and Carlson (1985) applied the **direct questioning** method. Huijsman (1986) applied direct questioning and visual counter techniques in the Philippines in eliciting yield distributions of rice, and concluded that direct questioning of minimum, maximum and modal values were better suited for the low educated farmers.

However Sonka and Patrick (1984) argue that direct elicitation of probabilities from decision-makers may not satisfy the conditions stipulated in Anderson *et al.* (1977). As a result, simple procedures have been developed to translate a decision-maker's beliefs about future events into probability statements. Among the procedures, the **strength of conviction** and **the triangular** distribution are easy to use and explain. The strength of the conviction procedure requires according to Sonka and Patrick (1984), the following four steps to generate a set of probabilities:

(1) Divide the range of possible events into a small number of logical groups. If the range of one event appears too large, subdivide the category and repeat the process.

(2) Specify the decision-maker's strength of conviction about the relative occurrence of each event on a numerical scale (i.e. a scale of 0 to 10, with 0 implying that the event cannot occur and 10 implying certainty).
(3) Sum the degree of conviction for all events.
(4) Find the subjective probability of each event by dividing the degree of conviction for that event by the sum calculated in 3.

The conviction method yields information about the expected value and variability of the subjective probability distribution. The mean and variance are all weighted averages.

The use of triangular distribution requires three items from the decision-maker: The most likely value to occur, the lowest possible value and the highest possible value. This procedure is simple to use but less accurate (Sonka and Patrick, 1984). Once one item has been specified by decision-makers, the rest of the items are likely to be biased by the first item. Thus, introducing bias in the calculated probabilities. The present research therefore used the strength of conviction procedure.

Fitting a probability distribution function from the elicited points

The above procedures will have elicited several points on the cumulative probability distribution for the several events. Among the ways of analysing the elicited points, fitting a probability distribution function to the points and to use the moment of the distribution function to explain the elicited points with respect to their events is more convenient. It is also more convenient to fit the same distribution function to each of the selected strategies - in this research cropping systems strategies - for each farmer so that differences between the selected strategies and farmers are only expressed by the differences in parameters of the distribution function fitted.

According to Smidts (1990) a suitable distribution function should satisfy the following requirements:

- The function should be flexible to account for a whole range of skewed distributions.
- The number of parameters should be small to satisfy the number of points elicited and
- The estimation technique should be as simple as possible because of the large numbers of distributions that has to be estimated. The Ordinary Least Squares (OLS) method is the more convenient one.

Various linearizable cumulative probability distribution functions exist with a varying number of parameters (Johnson and Kotz, 1970). For example the cumulative lognormal and the Weibull distributions fall in the class of two parameters, distribution functions.

(1) The cumulative lognormal distribution

$$F(x) = N(\ln x, \mu, \sigma) = N(\ln x - \mu/\sigma, 0, 1) \qquad (2.13)$$

Where N denotes the normal distribution function.
The distribution in equation (2.13) can linearize to

$$\ln(x_i) = \mu + \sigma w_i + u_i, \qquad (2.14)$$

x_i = The aggregated income of the cropping system based on the returns elicited from the respondents, $i = 1,2...,n$ = number of elicited points, w = points on the standard normal distribution with probability levels calculated. For example if the calculated probability levels are 0.99, 0.75, 0.5, 0.25 and 0.01 then from the standard normal distribution, vector w will have the values -2.576, -0.67, 0, 0.67 and 2.576. u_i is an independently and identically distributed disturbance term. Under this assumption, OLS can be used to estimate the relationship.

The estimated μ and σ were used for computing mean, median, standard deviation and skewness of the estimated function.

(2) The cumulative Weibull distribution

$$F(x) \equiv Z = 1 - e^{(-x/a)b} \tag{2.15}$$

Where a and $b > 0$
Equation (2.15) can be written as

$$ln(x_i) = ln(a) + ln(1/1\text{-}z)/b \tag{2.16}$$

Equation (2.16) can be estimated using OLS as

$$ln(x_i) = \alpha + \beta ln\ ln(1/1\text{-}z_i) + u_I \tag{2.17}$$

Where, $a = e^{\alpha}$, $b = 1/\beta$ and z_i =elicited probabilities from farmers for each cropping system. σ and β were used to calculate the moments of the Weibull distribution.

To make a choice between the distribution functions above, normally the distribution with the lowest residual variance is preferred (Smidts, 1990).

2.3.3 Combining risk attitude and risk perception measured in the utility theory category[10]

As pointed out earlier in this chapter, risk attitude and risk perception analyses are separately undertaken. The results obtained from the individual analyses can be combined together to give more information regarding the choice of cropping systems.

The combination of the results of risk perception and risk attitude can be done using the quadratic utility function form and the mean-variance (EV) analysis. For a quadratic utility function form (ignoring the constant term) we have

$$u(x) = x + bx^2 \tag{2.18}$$

Where x is the certainty equivalent of all risky prospects whose utility is equal to an index $u(x)$ (See also chapter 6). In equation (2.18), $b>0$ implies increasing marginal utility as x increases; $b<0$ implies decreasing marginal utility as x increases and if $b=0$ marginal utility is constant as x increases. From equation (2.18) taking the expected value and defining x as a

[10] This subsection draws much of its materials in a modified form from Anderson *et al.* (1977:90-96)

risky prospect (in our case risk prospects are the cropping systems) the quadratic utility function can be written as

$$u(x) = E(x) + b[E(x)]^2 + bM_2(x) \tag{2.19}$$

Where $M_2(x)$ is the variance of x and $E(x)$ is the mean of x . To suit our convenience, equation (2.19) can be written as

$$u = E + bE^2 + bV \tag{2.20}$$

Equation (2.20) is a utility surface of the risky prospects in three-dimension u, E and V. Assuming that u is constant or given as u^*, the equation in (2.20) can be written after re-arranging as

$$V = u^*/b - E/b - E^2 \tag{2.21}$$

Equation (2.21) represents an E-V locus of all mean-variance combinations that yields the same level of utility (i.e. iso-utility contours or indifference curves). The relevant range of this function (iso-utility) corresponds to those of the quadratic function. The decision makers substitution or trade-off between mean and variance - in our case of cropping systems - is given by the slope of the iso-utility curve, i.e. the marginal rate of substitution between mean and variance of the cropping systems which is

$$dE/dV = -b/(1+2bE) \tag{2.22}$$

In the quadratic utility function $(1+ 2bx) = du/dx$ and must be positive, it is also expected that the value $(1+2bE)$ from the slope of the iso-utility curve (equation 2.22) must be positive. Therefore, the slope of the iso-utility curve dE/dV will be negative, positive, or zero within the relevant range according to whether b is negative, positive or zero.

The second derivative of the iso-utility curve is given as

$$d^2E/dV^2 = [2b^2(1 + 2bE)^2](dE/dV) \tag{2.23}$$

The term in the squared bracket in equation (2.23) is always positive, and as pointed out above, dE/dV can be positive or negative depending on the sign of b. It follows therefore that for a risk averter the $(E\text{-}V)$ indifference curve has an increasing slope i.e. the rate of trade-off increases as V increases and for a risk taker/preferrer the $(E\text{-}V)$ indifference curve will have a negative slope as V increases. For a risk neutral/indifferent farmer, $b= 0$ and the iso-utility is horizontal to the origin. These are depicted in figure 2.2 (a), (b) and (c).

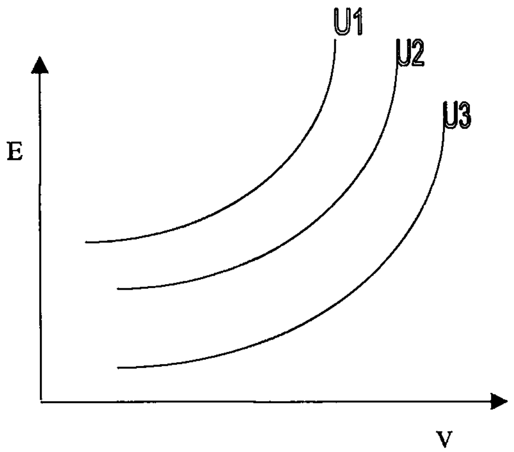

Figure 2.2a Indifference/iso-utility curves for a risk adverse farmer (b<0) derived from $u = E + bE^2 + bV$

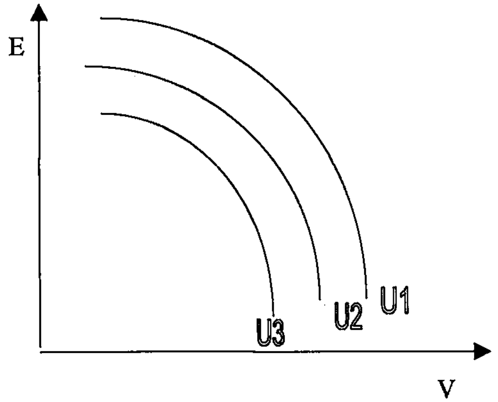

Figure 2.2b Indifference curves for a risk seeking farmer (b>0) derived from $u = E+ bE^2 + bV$

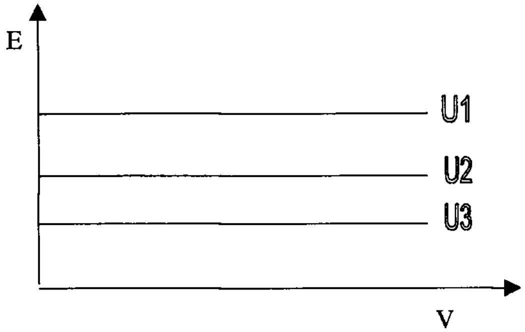

Figure 2.2c Indifference curves for a risk neutral farmer (b=0) derived from $u = E + bE^2 + bV$

Prospects to which a choice has to be made can also be depicted on an E-V frontier. In this research the prospects considered are the cropping systems, where a decision based on the trade-off between mean and variance, has to be made. These prospects are reported in chapter 7 (derived from the estimates of the Lognormal distribution).
The prospects have more than two moments. However, as pointed out in Anderson *et al.* (1977) in the context of E-V analysis, such higher moments are assumed as irrelevant to choice. When the prospects are depicted in an E-V space, the preferred risky prospect is indicated as the one that lies on the highest iso-utility curve. From figure 2.2 a to c, the preferred prospect is that depicted by the indifference curve U1 for all categories of risk aversion.

2.3.4 Measurement of risk attitude and risk perception using the Latent Variable Approach

In an analysis where socio-economic/psychological variables are linked to economic analysis, working with 'soft/latent' variables that cannot directly be observed by the researchers is desirable (Plewis, 1985; Von Bach and Nuppenau, 1995). The latent variable approach has therefore been widely used. For example Von Bach and Nuppenau (1995) applied an extended model of four latent variables in measuring interdependent socio-economic variables affecting development and their impact on agriculture. Smidts (1990) applied the latent variable technique in analysing marketing strategies.

It is rarely provided in theory that things like love, risk, altruism or creativity can be measured directly. Unlike variables such as weight, temperature, humidity etc. that can be measured using instruments and in units e.g. kilograms, degrees centigrade etc., the above-named variables cannot be measured directly. One can look at them as unifying constructs or labels that characterise responses to a related group of variables. Therefore, several indicators can be attributed to these latent variables. For example, answers of 'strongly agree' to items such as she sends me flowers, listens to my problems, shares my jokes, gazes at me deeply etc. may lead to the conclusion that the 'love factor' is there (Norusis, 1992).

There are so many items that can measure or show indications of love, risk, creativity etc., and since we cannot use them all, we need to apply a factor analysis. Factor analysis identifies a relatively small number of factors that can be used to represent relationships among a set of many interrelated variables.

To measure things such as love, risk attitude, altruism etc. there is a need for constructing some type of measuring device, usually a scale or test composed of a variety of related items. The question such as how good is the scale then arises. Although a small number of items will be included in the scale, we would like to draw conclusions about their reliability and validity. For example a reliable pen can write anytime when used by anybody, i.e. behave the same under a variety of circumstances, its performance is repeatable. A test can be reliable to be useful, but must also be valid, i.e. measure what it is intended to measure. Items have to be both reliable and valid. The selection of items to measure various constructs needs to be based on their respective validity.

In this research the latent variable approach is used to measure various attitudinal variables namely attitude towards risk, land resource conservation, and attitude towards commercialisation. This approach was carried out in this research by including 25 items/statements concerning the above attitudinal variables in the questionnaire (Appendix 1 and chapter 4). The 25 items were then clustered into the above attitudinal variables. Factor analysis was then used to pick the most reliable groups of items in measuring a particular attitudinal variable. A similar approach to studying risk attitude using factor analysis was done by Patrick *et al.* (1993) and Patrick and Musser (1997), in a research of large-scale corn farmers of the USA.

2.4 Decision analysis with risk preferences unknown

The methods described so far are based on the assumption that the decision-maker will be available to provide her/his information for elicitation. But as is evident from above, a difficulty often encountered in applying the SEU model is the elicitation of the decision-makers' utility function. Despite the fact that the method of making assumptions about the risk preference of the decision-makers (normative approach) is not applied in this research, it is worthwhile to review some of the procedures involved and trying to justify their ultimate omission in the analyses employed in this research. Such types of analyses are called efficiency analyses. They were devised in an attempt to rank choices without specifying a utility function except in limited information terms. This avoids the task of eliciting utility functions from the decision-makers. Stochastic Dominance Analysis (SD) analysis is one of these types of analysis.

According to Anderson *et al.* (1977), SD is a well known and simple rule of reducing the number of alternatives to an efficient set of alternatives without knowing the exact utility function of the decision maker; what is needed are the general assumptions concerning the utility function. The aim in SD analysis is to segregate the set of possible decision options into two: The first is a 'preferred' or 'dominant' set of alternatives, amongst which any farmer whose risk perception conform with the assumptions will find her/his most preferred option. The second one is a 'dominated' set that is of no interest to that same group of farmers (Dillon and Hardaker, 1993).

The methods of SD analysis are applied to probability distributions of consequences, described by their cumulative distribution functions. From a set of such distributions corresponding to a set of decision options, a series of pairwise comparisons is made. SD rules are usually limited to three degrees: first, second and third degrees with cumulative restrictions placed on the utility function. For all the three degrees of SD the ranking rule is transitive i.e. if a probability function A stochastically dominates B and B stochastically dominates C then A must dominate C. Those readers interested in more discussion in SD analysis are referred to Anderson *et al.* (1977), Raskin and Cochran (1986), Goh *et al.*, (1989) and Hardaker *et al.* (1997)

Since SD analyses are based on the assumption that farmers are risk averse, the methods may be unrealistic if risk aversion assumption does not hold. However, it is a useful method when it is difficult to get the decision-maker to give her/his risk preferences. It is further pointed out that until these methods of SD become much more effective and user friendly the methods requiring direct contact with decision-makers will still prevail (Hardaker *et al.*, 1997).

Based on the above and the preference for a positive approach to risk research, the above SD analyses are not implemented in this research.

2.5 Major findings and conclusions

This chapter has reviewed literature on risk analysis and decision-making studies as well as the measurement procedures that have been used to measure and analyse risk. Four major ways of dealing with farmers' decision making are made apparent. The first is assuming risk indifference and therefore the goal is to maximise or minimise the expected monetary gains or losses. The second one is specifying utility functions based on previous studies and using methods such as Observed Economic Behaviour (OEB) to arrive at measures of risk. The third one is risk analysis when the risk preferences are unknown. A good example is the use of SD analysis, which does not require the specification of a particular utility function. The fourth one is the use of direct elicitation of subjective probability distributions.

Two main approaches to research risk emanate as positive and normative analyses. Positive analysis, which was chosen for this research, involves the fourth way of dealing with farmers' decision analysis i.e. direct elicitation of farmers' subjective probabilities. Further, a distinction was made between measurements of risk attitude and risk perception using the utility theory and the use of the latent variable approach. The latter is a result of criticisms that have been put in the use of the former. Therefore, both approaches were adopted for this research.

Four main conclusions can be made from this chapter. First, emphasis has been placed on the normative approach to risk analysis that impedes the development of a positive approach. In agroforestry, there are very few researches that applied positive approach, and, as far as known, there has been no application of the SEU model in agroforestry.

Secondly, it can be concluded that the use of the expected utility model through elicitation of the probability distribution needs to be taken with care, as there are some recorded limitations. If possible the use of a multiple approach is advocated. Thirdly, it is desirable to separate the analysis of risk attitude and risk perception in order to give a wider coverage on implications of the results emanating from them separately. Results of risk attitude and risk perception can be combined after separate analyses. The final conclusion from this chapter is that there are numerous utility functional forms as well as probability distribution functional forms, which necessitates careful specification and selection.

CHAPTER 3

THE CONCEPTUAL FRAMEWORK AND THE RESEARCH QUESTIONS

After having presented the background information in chapter 1 and the review of literature and measurement procedures in risk and decision analysis in chapter 2, it is now appropriate to give the conceptual framework and the research questions before embarking on the methodological framework.

In this chapter, farmers' decision framework, which is assumed to be influenced to a large extent by risk and uncertainty, is restructured and presented. The level of analysis, which defines from what level of the farming systems hierarchy the data is derived is also presented and discussed.

Based on the background information, the problem statement and the broad objective in chapter 1 and the review of literature and measurement procedures in risk and decision analysis in chapter 2, the specific objectives and the research questions are derived in this chapter.

3.1 Farmers' choice process with respect to cropping systems (A conceptual framework)

Wollenberg (1985) points out that despite its wide attention in many disciplines, risk is no longer viewed as the sole stumbling block discouraging innovations, but rather a criterion within a complex decision making environment facing the farmer, which influences his decisions. As a result, the analysis of risk attitude and risk perception in the present research is more closely related to farmers' decision making.

Smallholder decision making is influenced by several but most often interrelated factors. Broadly, smallholder decision making depends on the decision environment and its constituent elements. As pointed out in Wollenberg (1985), six sets of the constituent elements of the decision environment can be identified. The first set comprises the ecological elements, which include climate, water regime, sustainability and succession pattern. The second one is about demographic elements consisting of population pressure, distribution of and access to resources, household composition and other characteristics. The third set of elements of the decision environment is on logistical issues, which include planning horizons, communication networks and access to information. Economic elements constitute the fourth element covering labour, credit consumption etc. The fifth element is about political considerations, which include local government, ethnic relations, government policies etc. and the last one consists of technological considerations, involving crop storage and processing, seed viability, seed sources, tools etc.

Although cultural aspects are not considered in this research, acknowledging their contributions in smallholder decision making is important. To some extent, the decision-making framework of smallholder farmers is described by the culture of which they are a product and whose complex values, cognition beliefs, and experiences are important components. A distinction can be made between aspects that are exogenous to the households, about which the household has little control (the decision environment) and those aspects that the household has under its control, such as household resources and characteristics.

Household objectives/criteria are important in explaining the observed differences in decision making among smallholder farmers. These are influenced by the decision environment and the household resources and characteristics. According to McConnel (1992) and Reijntjes *et al.* (1992) the household's objectives which play an important role in smallholder land allocation decisions include productivity, profitability, security/ stability, continuity/sustainability, identity, diversity, time dispersion and compatibility. It is important to note that these objectives are influenced by risk and uncertainty i.e. they are influenced by the stochastic agro-ecological and institutional factors.

The above factors determining smallholder decision making, suggest that choice about land use, for example cropping strategies to be adopted, involve a complicated array of interrelated considerations. Therefore, to simplify the complex decision making process and at the same time to make this research manageable, risk and uncertainty are singled out as the critical elements in smallholder decision making.

Figure 3.1 shows the conceptual framework of farmers' decision making with respect to the choice of cropping systems. The elements of the decision environment influence the household resources and characteristics, which in turn influence the farmers' risk attitude and risk perception. Risk attitude and risk perception influence the household objectives and ultimately the preference ranking and choice of cropping systems.

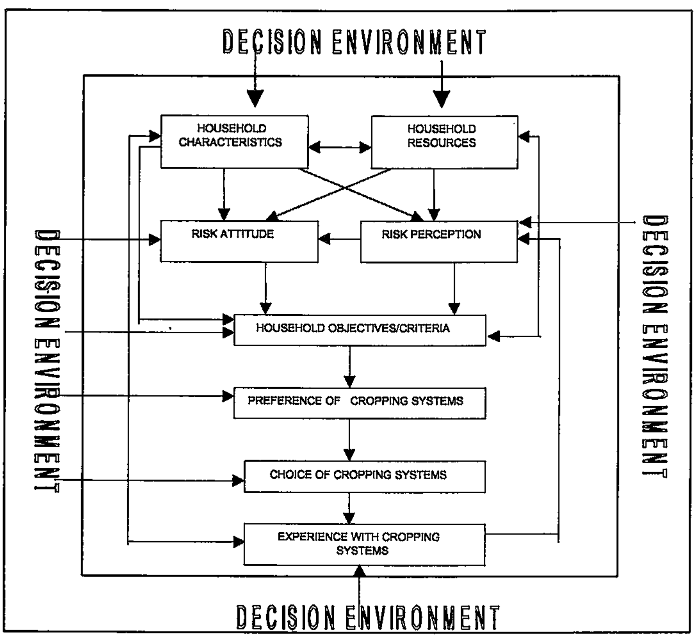

Figure 3.1 Smallholder decision model with respect to the choice of cropping systems (A conceptual framework)

It is assumed that farmers' decisions include returns of cropping systems as the evaluation criterion. There are many factors affecting returns and some cannot be known with certainty. As a result, returns to cropping systems are stochastic/random variables, and choosing between alternative cropping systems based on returns, constitutes decision making under risk. Return of cropping systems as an evaluation criterion has some specific elements (preference elements) which farmers use to make choices among the crop varieties/tree species. These are for example disease and pest resistance, drought tolerance, high yielding, good quality firewood etc. of the cropping systems.

Costs and prices could also be considered as evaluation criteria. Nevertheless, given the existing situations of Tanzania's smallholders (i.e. among other goals it is to produce for subsistence consumption), returns rather than costs or prices might be an important evaluation criterion, given the mixed cropping nature of the farming systems. However, in making production decisions, farmers are most often confronted with costs and prices.

Using the evaluation criterion and the preference elements, farmers are able to make preference ranking and finally make choices for their cropping systems. Finally, the experiences gained by farmers from the choice of cropping systems will influence subsequent decisions (Figure 3.1). For example higher returns realised may change the risk perception in the coming years. Higher returns may also make farmers richer (i.e. improve the household characteristics) and thus less risk averse in the coming years. Farmers will also have accumulated substantial information regarding that particular cropping system, as a result uncertainty will be reduced (i.e. improvement in uncertainty aversion)

3.2 The level of analysis

Farming systems of most smallholders in Tanzania are typically composed of a number of different crops and livestock production activities. Crop production activities are undertaken in more than one separate but distinct plot. The crop production activities may be undertaken at different times of the year. The cropping pattern can also be different from the individual plots of the household, implying that an agroforestry farmer can have agroforestry systems in one of the plots with other cropping systems located in other plots. The overall influence of risk on these activities and plots may differ substantially, and farmers are using these differences to manage the overall risk.

Huijsman (1986) discusses levels of aggregating risk analysis following the hierarchies used in farming systems analysis, and points out that different levels view and react to risks differently. Based on this, specifying the level of analysis in this research is therefore important.

In studying smallholder farmers, a Farming Systems Analysis (FSA) is most appropriate because of the diversified nature of the production systems. Generally, FSA is concerned with diagnosis and analysis of farm level variables (Fresco *et al.*, 1989). According to Fresco (*op. cit.*), FSA distinguishes systems at various hierarchical levels, ranging from plant systems through the crop systems, the cropping systems, the farm systems to the higher levels of land use systems (village or watershed and regional or national systems).

The focus of this research is on cropping/livestock systems' level. This allows comparison between agroforestry interventions and other cropping practices in risk analysis, based on the aforementioned characteristics of the households (Figure 3.1). However, the farm household unit is the basic sampling unit and the behaviour and attitude towards risks in agroforestry decision making of this unit is the main reference in attaining the objectives of the research.

According to Poate and Daplyn (1988) a household consists of a group of people who share dwelling houses, may cultivate the same land and recognise the authority of one person (head of household) who is the ultimate decision maker for that household. This does not mean that other members of the household and factors beyond the household level do not affect its decision making. Attention is therefore also paid to the contribution of members other than the head of the household in decision making.

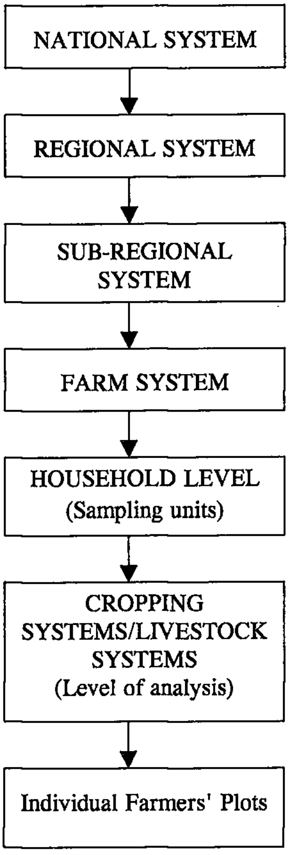

Figure 3.2 Hierarchy of systems.
Source: Modified from Fresco *et al.* (1989:27).

As already mentioned, individual plots owned by farmers represent specific cropping systems. Therefore an individual plot approach is also considered in studying cropping systems.

3.3 Specific research objectives

Based on the broad objective of the research presented in chapter 1, the presentation of the review of risk analysis and decision making in chapter 2 and the conceptual framework and the level of analysis presented above, the research aims to attain the following specific objectives:

(a) To identify what farmers perceive as returns and risks of various cropping systems with particular attention to agroforestry systems.

Perceived attributes of a technology are important in conditioning adoption. Attributes such as returns and risks of a technology as perceived by the users are important in drawing useful implications to the adoption of a technology. Many studies concerned with technology adoption, have been focusing mainly on researchers' attributes of the technology, while they have given farmers' attributes little attention (Adesina and Zinnah, 1993). This objective tries to contribute to this by looking at farmers' attributes of returns and risks of cropping systems with particular reference to agroforestry.

(b) To establish farmers' risk attitude in wider context and under different situations facing the farmers

Because of the existence of both positive and negative aspects of agroforestry to farmers, two important scenarios for investigation emerge for examining how agroforestry reduces/increases risks and how farmers cope with risks in agroforestry production.

Following the review of literature and measurement procedures in risk and decision analysis as well as the problem statement, three conclusions can be drawn. Firstly, there has been much attention on normative approach in risk analysis as compared to positive approach. This necessitates deliberate efforts to use the latter approach, especially in agroforestry. As already pointed out in chapter 2, apparently nothing has been done so far to our knowledge regarding the application of the Subjective Expected Utility (SEU) model in an agroforestry context. Secondly, the application of the expected utility model has received a lot of criticisms ranging from measurement procedures to actual utility analysis and estimation. Some of these criticisms are the failure to take into consideration some psychological principles of judgement and choice and also the failure to recognise the many items which can be referred to as expressing risk attitude by farmers. The third conclusion is that many studies in risk analysis use prior selection/assumption of utility functional forms without actually testing their statistical fit. All the above conclusions support the statement by Smidts (1990:3) that decision analysis is typically a field of intersection of economics, psychology, statistics, operations research and computer science. The above stated specific objectives will therefore try to address the issues related to methodology in risk analysis.

(c) To assess farmers' preference ranking and choice of cropping systems.

(d) To identify any relationship between risk attitude, risk perception and preference ranking of cropping systems with household resources and characteristics.

According to Young (1979), if risk attitude and risk perception are related to structural features such as farm sizes, legal forms of land ownership and other socio-economic characteristics, these concepts could contribute to the formulation of micro-economics policy and in predictive applications. Objective (c) and (d) are therefore designed to contribute to this. Information/results obtained from objective (d) (and the other three) will be useful in the development and assessment of the potential policy instruments and incentives designed to improve the adoption of agroforestry to smallholder farmers.

3.4 The research questions

So far the chapter has given the basic premise of this research by structuring the conceptual framework. In addition, the chapter has also given the level of analysis that has been used to get the required data/information as well as presenting the specific objectives of the research. The following questions have been composed from the theoretical background mentioned in chapters 1 and 2:

(1) What things do farmers perceive as enhancing risks and which do they perceive as reducing risks in production?
(2) How do farmers perceive returns of cropping systems especially with respect to risk?
(3) Are there variations in risk perception among farmers and between cropping systems?
(4) How do the perceived cropping systems compare with the actual cropping systems?
(5) What is the position of agroforestry in farmers' actual cropping systems?
(6) Are there any methods/techniques used by farmers to cope with these perceived risks in general and in agroforestry in particular? If yes what are the main methods used?
(7) Are there different utility functional forms for different situations facing farmers in the real world?
(8) Are there different risk attitudes in different situations facing the farmers?
(9) What are the factors determining risk attitude in a wider context?
(10) What is the position of agroforestry in farmers' preference ranking of cropping systems?
(11) Is the choice of agroforestry in production systems influenced by risk?
(12) Is there any relationship between risk attitude, risk perception and preference ranking of cropping systems with household resources and characteristics?

CHAPTER 4

METHODOLOGICAL FRAMEWORK

In the previous chapters the decision framework of farmers with respect to cropping systems was structured and presented. A conceptual framework for the decision process was proposed in chapter 3. Based on this and on the literature review, the problem statement, the objectives and the research questions, the methodology of data collection and analysis is described in this chapter.

The conceptual framework structured and described in chapter 3 needs to be operationalised and put into perspective of this research. The review of the literature has shown an indication that there are research problems, emanating from the methods of measurement and analysis. These are presented in this chapter, before embarking on the description of data collection and analysis.

Data collection and analysis was built up from the methodologies reviewed but with orientation towards the objectives of this research and the proposed conceptual framework. As will be evident, data collection was mainly done using surveys i.e., a structured questionnaire survey (Appendix 1) and a set of measurement procedures described in subsequent sections below.

After operationalisation of the conceptual framework, empirical measurements of risk attitude and risk perception using the utility theory category are presented. Measurements of preference ranking of cropping systems strategies and the method used in measuring risk attitude using the latent variable approach are also presented. The chapter also dwells on the research area by describing the justification of selecting the research area and research villages, sampling stages, interview procedures and the data collection exercise. Finally, the chapter tabulates the summary of linkages between specific research objectives, concepts, questions, methods and data analysis.

4.1 Operationalisation of the conceptual framework

The conceptual framework described in chapter three shows a highly simplified way in which risk attitude and risk perception link up with decision making. Farmers are confronted with many decisions ranging from production, consumption, storage and marketing. The decisions are made under conditions that are characterised by seasonality, uncertainty and imperfect or absence of product and factor markets. The aim of the farmer is assumed to be maximising the utility of these decisions subject to a set of constraints. Many of these decisions are influenced by stochastic agro-ecological and institutional factors, which are the sources of risks and uncertainties.

It is assumed that farmers base their decisions on the returns from various cropping systems as the main evaluation criterion. Returns, as evaluation criterion constitute some preference elements which farmers use to make choices among crop varieties and tree species. Farmers choose cropping systems solely on the expected aggregate returns of the various components. In this case the random variable was assumed to be the returns and we are solely dealing with production decisions.

Farmers will therefore make choices of their cropping systems based on their beliefs about the occurrence of alternative uncertain consequences influencing the returns. The decision-makers' beliefs are reflected by the probability she/he assigns to uncertain events in this case the return from the cropping systems. The probabilities assigned through elicitation (i.e. subjective probabilities) are used to fit distribution functions to generate the moments of the distributions. Certainty equivalents elicited from farmers are used to derive farmers' utility functions, and consequently their risk preferences are determined by the coefficients of risk aversion. The biggest task is to elicit these certainty equivalents and the subjective probability distributions, the procedures which are described in subsequent sections of this chapter (Sections 4.3.1 and 4.3.2). These, together with the measurement procedures, data analysis and interpretations constitute the operationalisation of the conceptual framework.

4.2 Problems related to methodologies of studying risk

Two main approaches have been used to conceptualise modelling and measuring risk attitude and risk perception of smallholder farmers. These are normative and positive analyses (Chapter 2). Whereas a tremendous body of literature has been accumulated in the area of normative approach to risk research both at theoretical and applied level, little attention has been placed on positive approach. The main research problem **is to what extent can a positive approach (which has received little attention, especially in agroforestry) be useful in understanding smallholder risk attitude and risk perception in agroforestry?** One of the important features of a positive approach is that it starts from the farmers in the way they perceive and react to risks and then relate this information to theoretical models of risk. This is opposed to the normative approach, which first gives attention to researchers' hypotheses about farmers' risk attitude and risk perception.

Many of the instances in literature of risk analysis show that risk attitude, risk perception and choice criteria have been lumped together under the title of risk and uncertainty. The literature shows also that there is a need for looking at these two concepts separately. A village level research of adoption of maize hybrids in El Salvador shows that risk attitude is about the same for adopters and non-adopters in the areas. Regional differences in adoption are largely explained by the differences in risk perception (which reflect actual risk conditions). Under-investment in maize hybrids caused by farmers' risk aversion is not great (Walker, 1981). The question here **is to what extent can the separation in analysing risk attitude and risk perception contribute to agroforestry decision making? Can risk attitude and risk perception (studied separately) be combined and used to design farmers' choice of cropping systems?**

The application of the utility theory approach to risk analysis has been under criticisms in its application to agriculture for example due to the failure to recognise various psychological principles of judgement and choice (Schoemaker, 1982 and Musser and Musser, 1984). The argument here is that there are many items, which can be considered as showing the indication of risk among small farmers. How do we take them into account when analysing risk attitude? The question here is: **can the application of the 'latent variable' approach be a solution in understanding risk attitude at their broad sense? What is the relationship between risk attitude measured in this way and other attitudinal measures?**

Finally, many studies in positive risk analysis have had prior assumptions/selection of utility and probability distribution functional forms. While it is agreed that literature can give a good indication of models that have been applied elsewhere in analysing risk attitude and risk perception, the question of the model fitting the data well and fulfilling the required research problem is also important. As Zuhair *et al.* (1992) have observed, a critical step in many applications of decision analysis under the utility theory approach is the specification and estimation of a suitable functional form that fits the data well. This entails the selection of the functional forms that fulfil the required criteria of analysis. The method used in this research to select functional forms was based on a statistical fit of the data, and was used to answer research problems such as: does the same functional form explains/predicts farmers' risk attitude in all situations? Are there different functional forms in different farmers' situations?

4.3 Measurements of risk attitude and risk perception in the utility theory category

In this section a description of the actual measurements of risk attitude and risk perception is presented. The information used in designing these measurements is derived from a preliminary survey of the area, a general household survey (See section 4.6.3) and from the review of literature on the measurement procedures presented in chapter 2.

4.3.1 Risk perception

The method used to measure risk perception of cropping systems is the strength of conviction method, modified from Sonka and Patrick (1984) (See chapter 2). The first step was to select the cropping systems to be used for this analysis. The decision to choose the six cropping systems listed below was reached after both a preliminary survey and a general household survey. The decision was based specifically on the frequency of these cropping systems among the agroforestry farmers in the survey area.

The second step is to describe the procedure of strength of conviction. The highest and lowest incomes from various cropping systems in the area were grouped into logical groups and farmers were asked the following question: What return do you expect in monetary terms if you have one acre of the following cropping systems?

1. Timber trees/fuel wood species (all ages, mixed stand species)
2. Mixed fruit tree species (Oranges, mangoes, guava, and coconuts)
3. Food crops (Mixed cropping of maize, beans)
4. Cash crops (Mixed cropping of pigeon peas, rice, and sugarcane)
5. Timber/Fuel wood species + Food crops
6. Mixed fruit species + food crops.

The following key was used to assess the cropping systems:

	TSH [11]
No harvest	0
Below	50 000
Between	50 000 and 60 000
Between	60 000 and 70 000
Between	70 000 and 80 000
Between	80 000 and 90 000
Between	90 000 and 110 000
Between	110 000 and150 000
Above	150 000

Farmers were asked to put numbers 0 to 10. 0 means you are sure the event cannot occur and 10 means you are sure the event will occur. Round cards of different sizes with the above numbers were given to the selected farmers (smallest with 0 and largest with 10) each farmer was requested to assess each cropping system.

4.3.2 Risk attitude

The aim was to elicit a series of Certainty Equivalents (CEs) that will be used in estimating the utility function. The CEs were elicited from farmers for four different situations (adequate food, inadequate food, adequate cash and inadequate cash). The main assumption of the elicitation worth noting is that farmers are assumed to be faced with one situation at a time, while other situations remain constant. This is rather a simplifying assumption because farmers may be faced by a combination of the different situations presented above.

Most CE elicitation in literature (refer chapter 2) have been undertaken using the assumption that farmers' attitude towards risk are the same under different situations they are facing. This research therefore is an attempt to find out if there are differences in risk attitude when farmers are experiencing different situations of real life.

It is expected that in an adequate cash or food situation farmers will be less risk averse as compared to situations where they have inadequate cash or food. In an adequate cash situation farmers are expected to be less risk averse as compared to all the situations as cash can be easily converted (in most cases) into food.

From the survey it was clear that farmers' incomes from various cropping systems evidently ranged between TSH 50 000 and 150 000 per acre on average. Certainty equivalents were assessed between these points (They are scaled 0 to 1, i.e. 50 000 = 0 and 150 000 = 1 for convenience purposes).

A 50:50 lottery (a standard gamble) method was used to assess several points of certainty equivalent for each farmer and for the four situations (refer chapter 2). Farmers were asked the following questions for each point of elicitation and cropping system: What would you prefer?

A. Farming, which is giving you a sure annual income of THS 50,000.

[11] By the time of the survey, the mean exchange rate of TSH (Tanzanian Shillings) to the USD was about 600.

B. Farming, which in 2 out of 4 years gives you TSH 150,000 and in the other 2 out of 4 years no income will be generated.

If A is preferred over B the amount in A is reduced by TSH 10,000 until the farmer is indifferent or switches to B. If B is preferred over A the amount in A is increased by TSH 15,000 until the farmer is indifferent or switches to A.

A pictorial depiction of the above was done to facilitate easy understanding by the farmers. Several points of CE were then elicited for each farmer for the four situations.

Figure 4.1 illustrates how different points of CE are elicited per respondent. Between the minimum and maximum values TSH 50,000 and 150,000 respectively CE1 is elicited. Between point *a* and the minimum, CE2 is elicited. CE3 is elicited between point *a* and the maximum etc. (Figure 4.1).

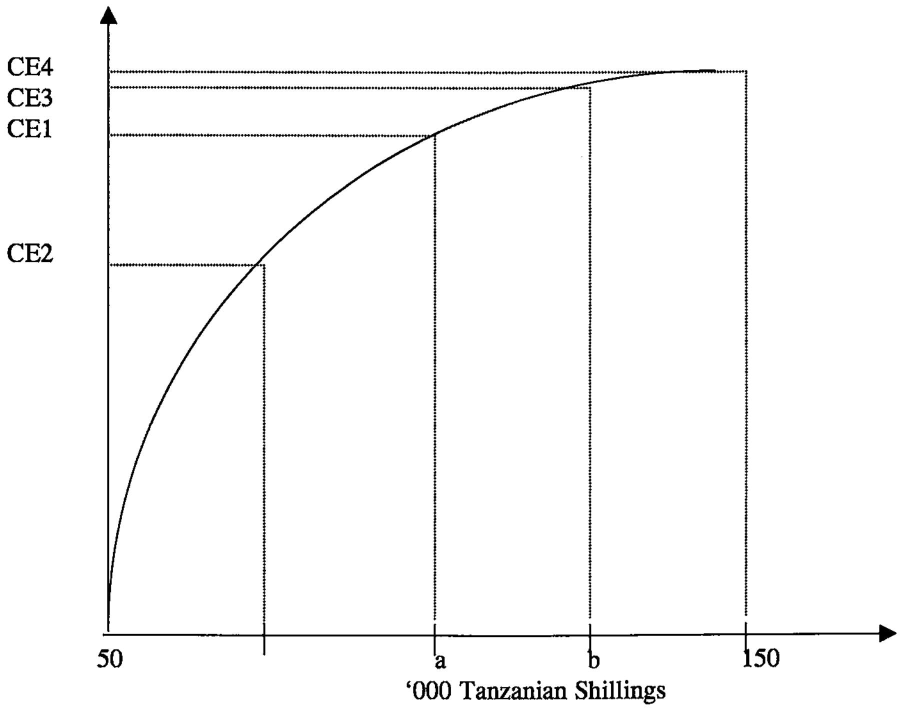

Figure 4.1 An example of the way different points of Certainty Equivalents (CEs) were obtained per farmer

4.4 Preference ranking of cropping systems

The six cropping systems described in section 4.3.1 representing different combinations of crops grown are used in this analysis. The aim of this exercise is to rank the cropping systems to be able to explore the relationship between preference ranking and farmer/household resources and characteristics as well as risk attitude and risk perception.

The cropping systems were then depicted by means of drawings on manila sheets. Farmers were given five (5) numbered cards and asked to rank the cropping systems' strategies. Placing card number 1 means the strategy is least preferred, while placing card number 5 means most preferred.

4.5 Variables and measurements using the structured questionnaire (latent variable category)

Respondents were presented various statements/items (25 statements) believed to be measuring a given concept and they were asked to state whether they strongly agree, agree, disagree, strongly disagree and undecided (Appendix 1). A wider choice of responses was made to ensure that farmers give as correct choices as possible. Later in the analysis, responses of 'strongly agree' and 'agree' were combined into 1 showing agreement with the statement and responses in 'strongly disagree' and 'disagree' were re-coded into 2 showing disagreement. Responses with neither 'agree' nor 'disagree' are not included in the analysis. The combination of responses was mainly done to simplify the process of data analysis.

The 25 statements/items were either derived from other studies (Magayane, 1995) and adapted or newly constructed, based on the objectives of the research as well as on their validity. Factor analysis, in stead of the method of Cronbachs alpha, of the postulated groups of items was used to pick the reliable groups of items. In this case, factor analysis was used as a method of item analysis and later on a factor scale/score was developed to measure that factor/latent variable.

All the 25 items were clustered into research variables such as attitude towards risk, commercialisation and land resource conservation and then subjected to factor analysis. The aim of factor analysis is to identify a relatively small number of factors that can be used to represent relationships among sets of many interrelated items/variables.

In factor analysis, Principal Components Analysis (PCA)[12] the default method for factor extraction in SPSS/PC+ was used as a method of factor extraction. As pointed out in Kim and Mueller (1978:11), PCA is effective and widely used as a means of exploring the interdependence among the variables. The use of PCA makes it possible to identify the 'best' factors in terms of explaining the variance of the sample. It gives uncorrelated, linear combinations of the observed variables in a rank order. Ranking is based on the amount of variance in the sample accounted for by the linear combinations. The first linear combination of observed variables (principal components) accounts for the largest amount of variance in the sample followed by the second and so on. The total variance explained is shown by the Eigen Value. Eigen Value was therefore used as a measure of variability of the factors. Selection of the items/variables was based on the Eigen Value of the extracted factor. Items falling under the factor with the highest Eigen Value have their respective factor loading. The higher the factor loading the more that item contributes to the total score

[12]Interested readers are referred to Hotelling (1933); Kim and Mueller (1978) and Norusis (1992) for a more detailed explanation of factor analysis.

of that factor. Eigen Value and factor loading are generated directly by SPSS/PC+ during factor analysis (Norusis, 1992). The factor with the highest Eigen Value (normally >1.0) was selected to give the score for the attitudinal concept/latent variable depending on the relative factor loading of the items. A factor loading of items of at least 0.4 is preferred. According to Kim and Muller (1978:10), a factor loading of < 0.3 is not normally considered as substantial. Varimax was used as the method of rotation, which minimises the number of variables that have a high loading on a factor, thereby enhancing the interpretation of the factors. Pairwise deletion was the method used for treating the missing variables.

4.5.1 Variables included in the structured questionnaire

Questions in the structured questionnaire covered attitudinal, perception and non-attitudinal aspects. Non-attitudinal aspects on the questionnaire schedule covered things such as physical environment, e.g. slope; personal variables such as age, gender, education; income; ownership of consumer durables etc. (Appendix 1). Attitudinal and perception aspects of the questionnaire are as described below.

(a) Attitudinal aspects in the questionnaire

Attitudinal aspects in the questionnaire schedule included the following items: risk attitude, attitude towards land conservation and attitude towards commercialisation.

Attitude towards risk in this case was viewed as individual's positiveness or negativeness towards risk. A negative attitude towards risk is related to the concept of risk aversion and a positive attitude towards risk is related to the concept of risk preference in the utility theory category (See scheme of major concepts). The attitude towards land conservation is one's positiveness or negativeness towards land resource conservation. The positiveness or negativeness is indicated by one's agreement or disagreement with statements that are in favour or disfavour of land conservation.

An individual who places more emphasis on producing agricultural products for sale than for his/her own household consumption would have a higher score on the commercialisation scale. On the other hand, if one places more emphasis on the production of goods for own household consumption he would have a lower score on this scale.

(b) Perception aspects in the questionnaire

Perception aspects included the following variables: Perceived effect of trees on other crops; yield perception; risk perception in production with and without trees; perceived easiness of contact with extension workers and perceived land productivity decline.

To understand the perceived effect of trees on the output of other crops, farmers were asked to rank cropping systems as increasing other crops' output = 1; decreasing other crops' output = 2; and not affecting other crops = 3.

To obtain farmers' perception on yields of various cropping systems, they were asked to comment on yields realised as follows: Very bad = 1; Bad = 2; Insufficient = 3; Sufficient = 4; Good = 5; and Very good = 6. Responses 1 and 2 were combined in the data analysis suggesting that the yields were perceived as being bad. Responses 5 and 6 were combined to show that the yields are perceived as good.

Risk perception in production with and without trees was aimed at giving an understanding of whether farmers have different risk perceptions regarding the two types of cropping systems, i.e. agroforestry and non-agroforestry or not.

In obtaining farmers' perception regarding extension agents (who are the main source of technical information to farmers), farmers were asked how easy it is for them to contact an extension agent for matters related to agroforestry whenever they want. The responses were set as Very easy =1; Fairly easy = 2; and Not easy at all =3. Responses 1 and 2 were recorded as 1 i.e., perceived as easy in contacting extension agent and response 3 under category 2, i.e. a household having difficulty in contacting an extension agent. Alternatively, farmers could have been asked whether an extension agent has contacted them in the past farming season or whether they had contacted an extension agent in the past season or not. These questions, however, are not reliable in obtaining summary measures about extension. Problems of memory make the items asking about past seasons' contacts with an extension agent less reliable. Farmers' easiness of contact with extension agents is a more reliable measure of contact as it does not rely on memory and it is a summary measure that incorporates all that goes into expression of feeling (Magayane 1994).

It is postulated that issues related to land degradation and declines in soil fertility play an important role as a source of risk to crop production. This can be perceived by farmers in the form of yield decline and/or fertility decline. In trying to understand whether farmers perceive decline of land productivity or not, they were asked to comment on decline in soil fertility and yields by applying the following rankings: Have it = 1 and Do not have it = 2, to the following statements: Declining yields from your farms and decreased fertility of your farms.

The aim of including these two statements is to find out how farmers perceive land productivity decline i.e., is it a decline in fertility, a decline in yields or both?

4.6 Data collection

This section describes the choice of the research area and data collection procedures. The research was conducted using Babati district as a case study (See chapter 5 for a detailed description of the research area). The reasons for the choice of the research area and the research villages are presented in this section. The section also presents the sampling and interview procedures.

4.6.1 Choice of the research area

Several factors were considered in reaching the decision to choose Babati district. The choice of Babati district was based on the efforts that have been put so far in the management and utilisation of trees through the Forest Trees and People (FTP) project. The project was run from 1987 to 1989 in this district. The project was financed by SIDA, implemented by FAO and the Swedish University of Agricultural Sciences. In the meantime the project has shifted its emphasis to land management issues, i.e. the LAnd Management

Project (LAMP). The research therefore is an extra input to the already existing efforts of developing smallholder agriculture in Tanzania. This project provided most of the background literature and data to this research besides logistical support during the fieldwork.

Another important reason for selecting Babati district is due to a series of environmental problems that have been affecting the district, especially Babati town. For example in 1963/64, 1978/79, and 1989/90 the district experienced severe floods which destroyed farms and other properties (Kahurananga, 1992). The seasons 1978/79 and 1988/89 had a particularly high total annual rainfall (See also figure 5.3).

Even when heavy rains are the immediate cause of floods in Babati, it is pointed out that environmental degradation especially deforestation, increased settlement, agriculture and grazing pressure could also be implicated (Kahurananga, 1992).

Shifting cultivation is the typical method of farming used in most of Tanzania, but population pressure and the cultivation of cash crops have led to a shortening of the fallow period. This trend, coupled with ubiquitous bush fires, overgrazing and common felling of trees for various purposes are leading to serious environmental degradation in many parts of the country, particularly those marginal areas (for example Mbugwe division of Babati district) where natural regeneration of the vegetation is slow.

4.6.2 Choice of the survey villages

Three important considerations were made in reaching the decision to choose the research villages. These were the agro-ecological zones (AEZ)[13] of Babati district, the LAnd Management Programme (LAMP) target and the extent of agroforestry practices.

The AEZ of Babati district are described in chapter 5. The district is categorised into five AEZ namely humid highland (I), sub-humid highland (II), semi-humid upland (III), semi-arid semi-humid midland (IV) and semi-arid lowland (V). AEZ I mainly consists of a forest reserve, while three other AEZ i.e. II, III and V are mainly occupied by an agropastoral system. The AEZ IV has agrosilvopastoral systems. Among the agropastoral zones, AEZ III and V were selected mainly to have a comparison between semi-arid lowland zones and humid upland zones. AEZ IV was included in the sample because it has a peculiar production system in the district (Agrosilvopastoral), and is located in a transition zone between semi-arid and semi-humid climates. Whereas LAMP has been concentrating much in AEZ II, III and IV, AEZ V has been incorporated only recently, thus making a good basis for comparison. Figure 5.4 shows a map of Babati district with the different AEZ.

Based on those factors, Singe (AEZ IV), Bonga, (AEZ III); Himiti (AEZ IV) and Magugu (AEZ V) villages were selected. The production systems of the selected villages ranged from agrosilvopastoral to agropastoral. All the four villages are now included in LAMP target areas where, among other interventions, integration of trees in the farming system has been a major thrust.

[13] AEZ was used mainly in selecting the villages and to ensure coverage of different production systems, but the research was not designed to capture the differences in risk attitude and perception of different AEZ.

Administrative wise, Bonga village is located in Gorowa division, Magugu village in Mbugwe division and Himiti and Singe villages in Babati division (See also chapter 5 and figure 5.1).

4.6.3 Sampling and interview procedure

The data collection procedure included three major surveys: a preliminary survey of the area which included 20 respondents from the research villages; a single visit general household survey where 100 respondents were interviewed and a detailed research approach in which 30 respondents were involved.

The preliminary survey was done between April and May 1994. The objectives of the preliminary survey were:
(1) To establish the sampling units;
(2) Pre-testing of the questionnaire used in the single visit household survey (Appendix 1);
(3) Selecting farmers for the detailed research and
(4) Gathering preliminary information on the farming operations, and the general description of the research area. The information was used as input in designing/ modifying some questions in the questionnaire.

In the preliminary survey, a sample of 20 farmers (i.e. 20% of the sample size) was used for pre-testing the questionnaire. These farmers were picked at random from the list of farmers in the respective village registers. A small sample sufficed because the aim was to get an insight into the farming operations and to use the information for further probing the questionnaire. The sample was also enough to test the adequacy of the designed questionnaire.

The single visit general household survey was carried out by one hired interviewer (Sokoine University graduate) and the researcher during January 1995 to August 1995. The survey included formal and informal discussions, participant observations, the 'teacher pupil' relations where the informant is the teacher, and the use of a structured/standardised interview. A sample of 100 farmers including about 26% women respondents, was used in this survey. From a list of farmers in the villages, the farmers to be included in the survey were picked at random from the lists.

The rationale for including women respondents was that women carry out major responsibilities for both subsistence agriculture and domestic work. Time use studies consistently show that women spend more hours than men per day in productive activities (FAO, 1995). Although decision making at the household level continues to be male dominated in all farming related activities, joint decision making is common (FAO, 1995). As a result, decisions related to risk taking might be influenced by both. However, it was also important to investigate whether there are gender differences in risk attitude and risk perception.

The objective of the single visit household survey was to obtain data for describing the agroforestry farmers in the research area and specifically describing the three categories of variables: attitudinal, non-attitudinal and perception. Risk attitude using the latent variable approach derives most of its data from this survey.

The detailed research was carried out by the researcher and one university graduate enumerator, during the period between September 1996 to April 1997. A relatively small number of farmers were involved. This approach was used despite the analytical disadvantages in using this procedure, for example sampling errors and problems of statistical inference. The method was selected mainly because an adequate analysis of risk requires close monitoring of farmers with an in-depth interviewing to find out the reasons behind their choice decisions on the one hand and because of time and budget constraints on the other hand. As pointed out by Noell and Odening (1997) farmers may not always see risk in the way analysts do and do not always match their responses to risk very closely to their risk perception. As a result more information and education on part of the respondents may improve the results of elicitation and this can be done well using a small sample, given the time constraint.

The objective of the detailed research was to obtain data for constructing measurements of peoples' risk attitude, risk perception and preference ranking of cropping systems with particular reference to agroforestry using the utility theory approach. Initially it was planned to undertake the data collection procedure for two consecutive seasons (using the same sample) to test for reliability of measurement procedures over time, but due to time constraints this was not possible. As a result only single season data were used.

Based on the results of the general household survey, 30 farmers were selected for the detailed research. Three items were considered in deciding the farmers to be included in the sample, i.e. Farm size, Total number of trees planted and the asset index[14]. These household characteristics were expected to have a major influence on household decision making and farm management strategies. The asset index, farm size and number of trees planted are expected to determine to a large extent the risk taking capabilities of the households.
Of the three items, farm size was selected as an indicator in choosing the farmers included in the detailed research. Several reasons were considered in selecting farm size. Perhaps the most important reason was that correlation analysis of the three items suggested that both the asset index and total number of trees planted were positively and significantly correlated to the farm size (P= 0.001, Table 4.1).

Table 4.1 Statistics of farm size, total number of trees and the asset index (n=100)

	Mean	Std Dev	Lowest value	Highest value	Correlation with farm size
Asset index	6.8	3.2	0.0	15.0	0.434*
Total number of trees	59	78	1	400	0.367*
Farm size (ha)	2.80	1.98	0.8	11.6	1.000

* Significant at $p \leq 0.05$

However, it is important to note that farm size may also not be a good indicator of selecting

[14] See appendix 2 for the calculation of the asset index.

the respondents. This is because farm size under small-scale farmers may be influenced by the household size i.e. a farm may appear big but is supporting a large family size. As a result the sample was picked to ensure a fair representation of the AEZ included (See chapter 5 for description of the AEZ of the area).
The 100 sampled farmers were then categorised on the basis of farm size. Three logical categories were made (Using SPSS PC+ percentiles); Large, Medium and Small. Farmers were then picked proportionally according to the frequency of the three categories (Table 4.2).

Table 4.2 Sampling Distributions of the respondents by category of farm size

Category	Range of farm size (ha)	% (no. of farmers) in household survey	Sample of detailed research farmers
Small	0 - 2	63 (63)	19
Medium	3 - 6	22 (22)	7
Large	> 7	15 (15)	4
Total		100 (100)	30

The resulting sample of 30 farmers consisted of 18 males and 12 female respondents.

4.7 Linkages between research objectives, concepts, questions, methods and data analysis

So far research problem, research objectives, major concepts and research questions have been presented separately in the first four chapters. To provide continuity, there is a need for having clear linkages between the specific objectives, the major concepts, the research questions and the research methodology presented in this chapter. Table 4.3 gives a summary of the linkages between research problem, specific research objectives, concepts, research questions and the method of data collection and analysis used.

4.8 Summary

After operationalisation of the decision conceptual framework (which is a continuous process) and defining and specifying problems related to methods of measurement and analysis, attention was paid to the description of empirical measurements of risk attitude and risk perception. The application of both utility function and latent variable approaches is presented. Simple measurements were designed to ensure that farmers grab the concepts a

Table 4.3 Summary of linkages between research objectives, concepts, questions, methods and data analysis.

Specific Objectives	Concepts	Research Questions	Method of data Collection	Data analysis
1To identify what farmers perceive as returns and risks of various cropping systems with particular attention to agroforestry cropping systems.		•What things do farmers perceive as enhancing risks and which do they perceive as reducing risks in production? • How do farmers perceive cropping systems especially with respect to yields/returns? • Are there variations in risk perception among farmers and between cropping systems? • How do the perceived cropping systems compare with the actual cropping systems? • What is the position of agroforestry in farmers' actual cropping systems • Are there any methods/techniques used by farmers to cope with these perceived risks in general and in agroforestry in particular? If yes what are the main methods used.	• Use of structured questionnaire • Eliciting subjective probability distributions of six cropping systems using strength of conviction method	• Cross tabulations • Estimate Weibull and Lognormal distribution functions for each farmer for six cropping systems. Calculate the moments of distribution (mean variance and skewness)
2 To establish farmers' risk attitude in wider context and under different situations facing them	• Risk attitude in wider context (incorporating both aspects of a positive and negative risk attitude)	• Are there different utility functional forms for different situations facing farmers in the real world? • Are there different risk attitudes in different situations facing the farmers? • What are the factors determining risk attitude in a wider context?	• Eliciting certainty equivalents of 50/50 lotteries to assess utility functions under four different farmers' situations • Use of attitudinal aspects included in the structured questionnaire	• Estimate different utility functional forms for each farmer for four situations and select the most suitable ones under the different situations. Estimate coefficients of absolute and relative risk aversions • Select items suitable in measuring various attitudinal concepts using factor analysis • Cross tabulate the responses • Use regression analysis to determine the factors affecting risk attitude in a wider context
3 To assess farmers' preference ranking and choice of cropping systems.	• Risk attitude - Risk preference and risk aversion • Risk perception • Preference ranking	• What is the position of agroforestry in farmers' preference ranking of cropping systems? • Is the choice of agroforestry in production systems related to risk?	• Ranking/ordering of cropping systems by farmers (elicitation of the preferences)	• Calculating measures of central tendency and dispersion of the preference ranking • Combining the results of risk attitude and risk perception measured by the utility theory category
4 To identify any relationship between risk attitude, risk perception and preference ranking of cropping systems with household resources and characteristics	• Choice behaviour	• Is there any relationship between risk attitude, risk perception and preference ranking of cropping systems with household resources and characteristics?	• Use relevant data sources described above	• Regression analysis

well as give out the desired responses. Farmers were first oriented to the measurement procedures to ensure that they had adequate understanding of the concepts.
A special focus was also placed on the description of the sampling stages and interviewing procedure. For the preliminary survey, 20 respondents from each sampled village were randomly selected among agroforestry farmers. This was an input in designing the subsequent questionnaire and the measurements. In the main survey 100 farmers were picked at random from a list of farmers in each village. Measurements of risk attitude, risk perception and preference ranking of cropping systems strategies were undertaken using a relatively small number of respondents. This was because of the requirements of in-depth interviewing and close monitoring. This could only be possible to a small sample of 30 farmers. The 30 farmers were selected based on farm size categorisation, to ensure that there was equal representation in each category. However, attention was also paid to the Agro-Ecological Zones (AEZ) (described in chapter 5) since farm size alone might be a misleading criterion

In the coming chapters extensive discussions of the results of the research are presented. Chapter 5 starts with the results emanating from the general household survey, giving the general description of the research area and farm households with particular attention to agroforestry and risk.

CHAPTER 5

GENERAL DESCRIPTION OF THE RESEARCH AREA AND FARM HOUSEHOLDS

Following the farmers' decision conceptual framework (Chapter 3), risk attitude and perception are closely linked with the decision environment and the household resources and characteristics. In order to operationalise the conceptual framework, there is a need for understanding the agro-ecological factors on the one hand and the household system on the other. This is supported by a recent seminar on risk management in agriculture (See Huirne *et al.*, 1997) which observed (among other things) that there are some aspects of household risks that have been ignored in literature, for example family sources of risk. As a result the suggestion was made that risk analysis at best be conducted in a combined farm-household context. Specifically for this study, there is a need for understanding the relationship between agroforestry and the components of the household system, namely the value system, the farming system and household needs as well as its interactions with factor, financial and insurance markets.

In an attempt to address the above-mentioned aspects, this chapter presents the general description of the study area and the sampled households. The first part gives the general description of the area, geographical location, climate, rainfall characteristics and agro-ecological zones. This is prompted by the fact that one of the major sources of risks in developing countries of the tropics is the variation in agro-ecological factors.

The second part describes the major findings of the socio-economic survey, such as general characteristics of the sampled households, production systems, technology and resources, crop, livestock and agroforestry production with their linkages. Finally, the chapter looks at production constraints and opportunities. The second and the last part aims at addressing the household resources and characteristics as well as the relationship with the markets.

5.1 Geographical location

Babati district is in the south-western corner of Arusha region in the northern part of Tanzania (Figure 5.1). Most of the district lies below the rift valley escarpment to the East. To the East, the Tarangire national park takes up a large part of the district. Bashinet division is in the southern part of the Iraqw highlands and the area below the escarpment in Dareda; and Gorowa division is situated south of Lake Babati including parts of Ufiome highlands and the Pinaar heights. The district consists of 21 wards and 81 villages.

5.1.1 Climate and rainfall characteristics

The climate varies in the different parts of the district, with higher altitude areas having lower temperatures but with more precipitation than the lower altitudes. The climatic conditions vary from semi-arid lowlands to humid highlands (See section 5.1.2).

Rainfall also varies throughout the district. Mean monthly rainfall, recorded from 1972/73 to 1995/96, indicated that the annual cycle consists of one long dry period between June and September and two rain periods, i.e. short and long periods (Figure 5.2 and appendix 3). The short rains occur most commonly from October to December and sometimes in January, and the long rains between February and May. The dry period between June and September is characterised by low temperatures in June and July. By mid August the temperature rises again. Sometimes a short dry spell is noted at the end of the short rains. However, this dry spell has no negative impact on crop production.

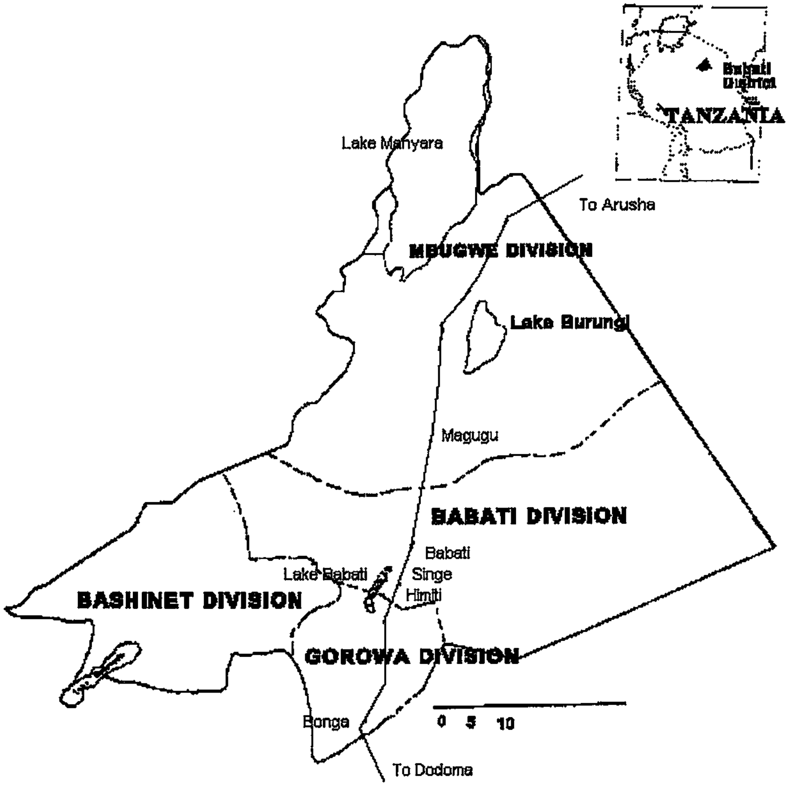

Figure 5.1 Location of Babati district, its administrative wards and the research villages

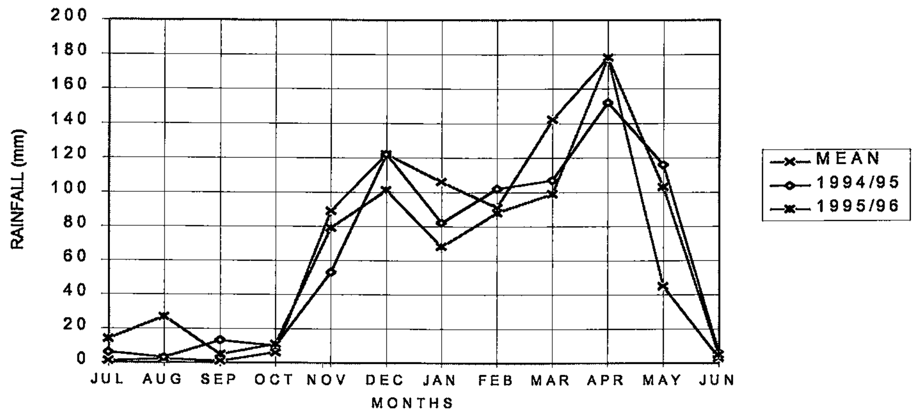

Figure 5.2 Average monthly rainfall distribution in Babati district in 1972/73 to 1995/96, and in 1994/95 and 1995/96.

We observe from figure 5.2 that the rainfall for the year 1994/95 and 1995/96 cropping seasons was more or less equal to the average amount for the entire period between 1972/73 and 1995/96. It implies that the study period represented normal years in terms of rainfall.

Analysis of the long-term annual rainfall in Babati district from 1972/73 to 1995/96 shows a long-term annual rainfall average of 801 mm. Annual rainfall variability in this period is rather moderate with a coefficient of variation of 33% (Appendix 3 and Figure 5.3). We also observe from figure 5.3 that good years in terms of rainfall occur approximately after every eight to nine years as noted in 1978/79 and 1986/87 seasons.

5.1.2 Agro-ecological zones

In describing the natural conditions of an area specifically for agricultural production, rainfall, temperature and soils are important. Based on this, a description on the essence of agro-ecological zones (AEZ) seems to be the best way to recapitulate the natural conditions of an area. AEZ is normally based on rainfall, temperature, altitude and evapotranspiration or the length of the growing period.

A survey of literature shows that several methods have been used to classify Tanzania into its agro-ecological zones. For example, Moris (1981) identified eight zones based on geographical divisions and constituent production systems. Samki and Harrop (1984) subdivided the country into 20 zones based on soil types, mean annual rainfall, rainfall patterns and the length of the growing period. A more recent revised version of AEZ's of Tanzania and the description of the farming systems is contained in Mowo *et al.* (1993). Despite the many attempts to identify agro-ecological zones of Tanzania, all arrive at similar classifications (World Bank, 1994).

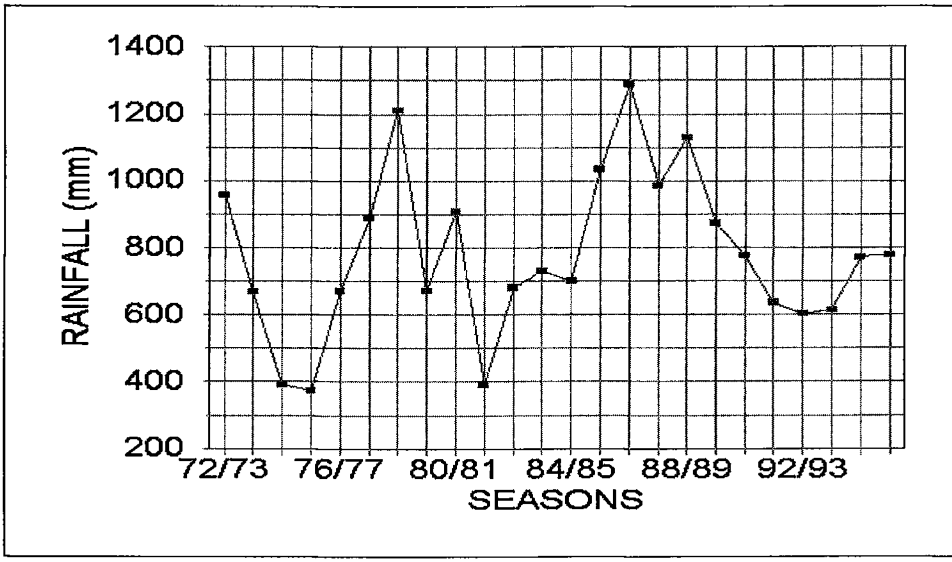

Figure 5.3 Total annual rainfall trend in Babati district 1972/73 to 1995/96

The most used classification, is that of the Land Resources Development Centre (LRDC). This centre gives six major zones, which can be sub-divided into 18 sub-zones according to soil types, altitude, mean annual rainfall and duration of the growing period (LRDC, 1987). The zones are (1) coast, (2) arid lands (3) semi-arid lands (4) plateaux (5) southern and western highlands and (6) northern highlands and isolated granitic mountains. According to FSG (1992), the classification by LRDC is more appropriate because of its comprehensiveness, ability to cover all geographical divisions and administrative regions and its consideration of the farming system as a consequence of the physical environment rather than one of its defining characteristics.

According to the classification by LRDC, Babati district falls under semi-arid lands. Although Babati district is generally classified as semi-arid land under the LRDC classification, five agro-ecological zones are identified (Macha, *et al.*, 1992) (Table 5.1 and figure 5.4), as follows:

I Humid highlands

This zone covers the highest part of the district above the Rift Valley. It is found mainly in Bashinet division and the north-western part of the Babati district. It is a high rainfall zone with low temperatures at night. Occasional frosts occur between June and July. The main vegetation is montane forest mostly contained in the Nou forest reserve.

II Sub-humid highlands

This zone is also a high rainfall area but with less rainfall as compared with the humid highlands. The original montane forests no longer exist due to increased human activities. The zone is found mainly in the Bashinet division and partly in the Ufiome highlands. The main production system is agropastoral.

III Semi-humid uplands

This zone is mainly found in the Gorowa division and the south-western part of the Babati and Bashinet divisions and around the Ufiome highlands. The climate is favourable and the soils are fertile. In this zone the population density is high and land holdings are small.

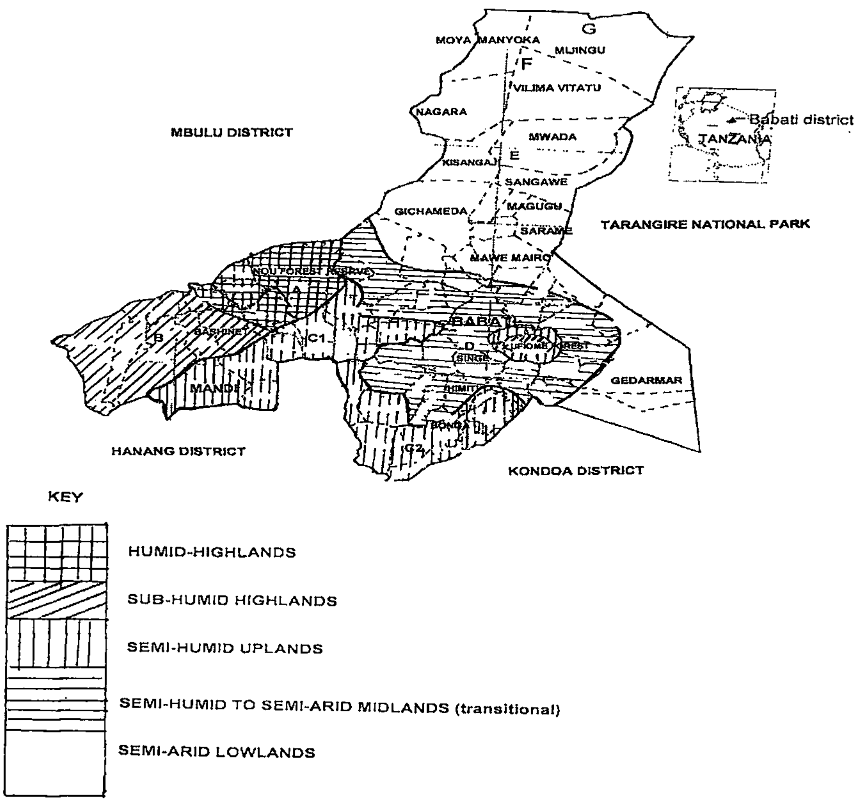

Figure 5.4 Agro-ecological zones of the Babati district
Source: Macha *et al.* (1992)

IV Semi-humid semi-arid midlands

This is an intermediate zone between the highlands and the lowlands. It is mainly found in the Babati and Gorowa division. It is characterised by high population density and land scarcity problems. Crop production is the dominant form of land use. Agroforestry systems are common here especially in the homestead plots.

Table 5.1 Agro-ecological zones and production systems in the Babati district

Agro-ecological zone	Altitude (Metres)	Rainfall (mm)	Tem-perature (°C)	Natural vegetation	Production system
I Humid Highlands	2150-2450	1200+	14-16	Montane forest. *Cassipourea, Casearia spp., Ekebergia capensis, Fagaropsis angolensis, Olea africana, O. capensis and Podocarpus latifolius*	Forest Reserve
II Sub-humid highlands	1850-2150	1100-1200	16-18	Short grass land, e.g. Star grass *Cynodon dactylon* Kikuyu grass *Pennisetum clandestinum, Themeda triandra, Chloris pythnotrox and Sporobulus africanus, Cyperus rigidifolius* and legumes such as *Rhyrrchosia nimena, Cassia mimosoides, Trifolium masaiense*	Wheat, Livestock-maize -potatoes-*Acacia mearnsii*, (Agropastoral)
III Semi-humid Uplands	1500-1850	900-1100	18-20	Dry forest/ woodland *Brachystegia microphylla, B. spiciformis, Albizia versicolor and Tubernadia globiflora*	Wheat- Barley, Maize- bananas-coffee- Grevillea and livestock (Agropastoral)
IV Semi-humid, semi-arid midlands (Transition)	1200-1500	750-900	20-22	Dry woodland/bushland *Acacia spp.*	Maize-Pigeon peas-beans-Livestock, Grevillea-Cassia (Agrosilvopastoral)
V Semi-arid lowlands	950-1200	500-750	22-28	Bushland/Bushed tree grassland *Acacia spp., Commifora spp., Combretum spp., Adansonia digitata.*	Livestock-maize-beans-cotton-Cassia-Grevillea (Agropastoral)
				Pennisetum spp., Panicum spp., Sporobolus and Digitaria spp.	Pastoral livestock-wildlife
				Open medium height grassland dominated by *Pennisetum spp., Digitaria spp., and Panicum spp.*	Pastoral livestock-wildlife

Source: Macha *et al.* (1992)

V Semi-arid lowlands

This is the driest part of the district with a low production potential. Soils are mainly alkaline with low fertility. During the rainfall period there is a high run-off. It is found mainly in the

Mbugwe division to the North of the district and in the south-eastern part of the Babati division. Production activities are mainly pastoral livestock, maize, beans and cotton with Cassia wood lots.

Based on the extent of agroforestry practices, the study has been concentrated in agro-ecological zones III, IV and V.

5.2 Overview of agroforestry practices in Tanzania

Tree growing by rural people in most developing countries is not new. In many parts it has been taking place since the beginning of settled agriculture. However, the extent to which these trees are grown, varies throughout the third world countries, depending on several factors like demand, factor endowment, institutional factors, local ecological patterns of agriculture and cultural practices and the extent of fuelwood and other tree products demand (See also Filius, 1997). In some parts of the third world countries, trees are a major element of the traditional farming systems. Good examples are the famous 'Chagga,' 'Pare' and 'Meru' home gardens of Northern Tanzania, where coffee is traditionally grown in combination with bananas, beans, timber species such as *Albizia* and *Grevillea* (Lundgren, 1992). In South-east Asia home gardens are also well integrated in the farming systems. These agroforestry systems have yielded positive results in some third world countries, such as Rwanda and the Philippines and Tanzania (Fernandes *et al.*, 1984).

Some agroforestry practices recorded in Tanzania are as described in sections 5.2.1 through 5.2.5 below.

5.2.1 Shifting cultivation

This is a system of land use that entails deliberate association of trees with herbaceous crops in time. According to Alriksson & Ohlsson (1990) shifting cultivation is one of the most ancient, but widespread and until recently, ecologically stable forms of agroforestry. This type of cultivation works well where population densities are low and fallow periods are long enough to allow soil fertility recovery. In this case, shifting cultivation becomes an ecologically viable and economically rational practice.

In Tanzania, shifting cultivation is still practised in its simplest form in Kondoa. Farmers clear the land, burn over and cultivate the plot until the soil productivity begins to decline, then they move to other areas (Nshubemuki & Mugasha, 1985 cited in Alriksson & Ohlsson 1990). In tobacco growing areas of Tabora and Iringa, farmers abandon cleared fields after two years. This is because of the build-up of pests in the soil. In doing so they move to another area, thus practising shifting cultivation (Sabuni, 1991).

However, as pointed out earlier, benefits of shifting cultivation are declining due to an increase in population in many parts of the country and increased land degradation. Population increase has the effect of shortening the fallow periods, thus interfering with the natural regeneration. The ultimate outcome is increased land degradation.

5.2.2 Home gardens

Home gardening refers to a land use system that involves deliberate management of multipurpose trees and shrubs in an intimate association with annual or perennial agricultural crops and livestock within the compound of the individual house (sometimes called compound farms). The various components of home gardens are normally managed by family labour.

In Tanzania, this type of agroforestry practice is common in most highland areas with land scarcity, for example on the foothills of Mount Kilimanjaro and Mount Meru, the Pare highlands and Southern highlands. This type of agroforestry practice is also noted in the study area. Coffee, banana, multipurpose trees and livestock are some major components. It is argued that with a minimum of external inputs, these farms can maintain sustainable production (Fernandes *et al.*, 1984).

5.2.3 Taungya system

This is a reforestation technique, which combines growing an annual crop with the young forest trees. The word taungya is of Burmese origin, which means "hillside agriculture". Regular tending and harvesting of the agricultural crops is beneficial to the trees, since at early stages they require careful weeding. In practical cases, farmers are given temporary access to state-owned land and sometimes modest wages in return for their labour in planting and caring for commercial forest seedlings (Raintree, 1987). According to Alriksson and Ohlsson (1990) this type of agroforestry is practised in Tanzania in the forest plantations on the slopes of Mount Meru. This system is also practised in North Kilimanjaro forest plantations (See for example, Hofstad, 1978; Chamshama *et al.*, 1992).

5.2.4 Inter-cropping trees with plantation crops

Plantation crops like coffee, tea and cocoa are traditionally grown under shade trees. This practice is common in most highlands of Tanzania where coffee or tea is grown. Most often, leguminous tree species are preferred as shade trees. Notable examples where trees are intercropped with plantation crops are the large-scale coffee plantations of the Moshi, Arusha and Mbeya regions.

Combe (1982) argues that the increasing use of chemical fertilizers and herbicides during the last decade has led to more intensive management of these plantation crops, where the shade has been gradually eliminated. However, the costs of chemical inputs still convince many farmers to maintain their plantations under natural shade.

In coffee plantations in the highlands of Tanzania timber species as shade trees have been included, for example *Grevillea robusta*.

5.2.5 Multipurpose trees mixed with crops or as part of pastoral systems

These are trees that provide several beneficial contributions to the satisfaction of the basic human needs. Some trees may for example contribute different products while playing an important role in maintaining soil fertility. In Tanzania, these include fruit trees, which have tree functions and at the same time provide income to the farmers as observed in the Uluguru Mountains, Babati (the study area), Kilimanjaro etc. Another example is cattle grazing under coconut trees along the coast. This practice is under development, and research is carried out in Tanga region (Coastal region bordering the Indian Ocean) on the way dairy farms can be combined with coconut production. Combe (1982) argues that, this agrosilvopastoral technique fits best the coastal areas with a monsoon rainfall climate.

5.3 Characteristics of the sampled households

The main features of our sampled households are presented in table 5.2. The average age of the head of the household worked out to be 46 years.

Table 5.2 Household characteristics by sampled village

Characteristic		Magugu	Bonga	Singe	Himiti
Sample size (No)	Male	14	21	27	12
	Female	5	7	4	10
	Total	19	28	31	22
Mean age of the household head (years)		47	48	44	46
Education (years)		10	8	7	8
Persons per household		7	6	8	8
Farm size (cultivated) (ha)		4.7	2.1	2.0	2.6
Mean household cash income ('000 TSH)		907	475	439	331
Number of trees planted (mean)		64	44	72	58
Asset ownership (Index)[a]		5.8	6.4	8.0	6.6

Source: Survey data, [a] for calculation see Appendix 2

Almost all the sampled households had literate respondents with the number of years in school ranging from 7 in Singe to about 10 in Magugu.

The average household size ranges from 6 in Bonga to 8 in Singe and Himiti villages (Table 5.2). The asset index in this study was a proxy for the household's asset ownership status. The higher the index the better off are the households. Singe had the highest asset index, and there were significant differences between Singe and Magugu ($p=0.021$). The rest did not have any significant differences with respect to asset index. This index together with the number of trees planted, household cash income and farm size were expected to have an impact on the risk taking capability of a household.

Household cash income consisted of cash incomes accrued from crop and livestock sales and the off-farm cash income. There were high variations in mean household cash income among the sampled villages. Magugu village had a significantly higher household income as compared to the rest of the villages. This high household cash income is attributed to the high income from paddy rice and livestock. A discussion of the relationship between risk attitudes, risk perceptions and preferences of cropping systems with household resources and characteristics is presented in chapter 6 and 8.

5. 4 Production systems and household resources

The production systems in the district vary with the agro-ecological zones (Section 5.1.2). Generally, production systems vary from natural forest in humid highlands to various crop-livestock-tree systems in semi-humid uplands, semi-arid midlands and semi-arid lowlands (agropastoral/ agrosilvopastoral).

Three main types of household resources and their characteristics are identified in the study area, namely land, labour and capital. These are presented below in sections 5.4.1 to 5.4.3.

5.4.1 Land and land tenure

Crop production is the most dominant form of land use in the study area. Estimates from this study show that about 75% of the land is used for crop production (including agroforestry), while the rest, 25%, is used for livestock grazing. These estimates do not differ much from those made by Kahuranaga (1992), namely 80% for crop production and 20% for livestock production. The picture is quite different when comparing land use in the study area with the whole district. According to the Babati District Council office, land use for the Babati district was estimated at agricultural area 30%, livestock grazing 35%, forest reserve 7% and others 28%.

A characteristic of the survey area, which is common in Tanzania's smallholder farming, is the ownership of different distinct farming plots. The average number of plots in the surveyed area worked out to be almost 3 plots per household (Table 5.3).

The motive of owning these different plots is mainly because of the desire to grow different types of crops on separate fields, diversifying against risk and the increasing pressure on fallow lands.

Despite the advantages of owning more than one plot, farmers have to travel long distances to the furthest plots and thus reduce the labour time committed to the plots. There are great

Table 5.3 Average number of plots owned by village

Village		Mean	Std Deviation
Magugu	(n=19)	3.0	0.7
Bonga	(n=28)	2.9	1.1
Singe	(n=31)	2.8	1.0
Himiti	(n=22)	2.7	1.2
Overall	(n=100)	2.8	1.0

Source: Survey data.

variations in the estimated times of travel to various plots due to the distances involved. Farmers at long distances require the availability of farm transport. Travel time on foot, ranged from 0.1 of an hour in the nearest plot to 0.7 hours in the other plots (Table 5.4). Table 5.4 also shows that Magugu villagers travel on average the longest time of 0.7 hours. This together with the time taken to do other activities, such as firewood collection, has an impact on the availability of labour for farm activities.

Table 5.4 Average time taken to various plots by village (in hours)

Village/Plots	Household plot		Distant plot		Overall by Villages	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
				Hours		
Magugu (n=19)	0.6	0.8	2.1	0.7	0.7	0.8
Bonga (n=28)	0.1	0.2	0.7	0.5	0.4	0.6
Singe (n=31)	0.0	0.0	0.4	0.2	0.1	0.4
Himiti (n=22)	0.02	0.1	1.0	0.3	0.3	0.6
Overall (n=100)	0.1	0.4	0.9	0.4	0.3	0.4???

Source: Survey data.

Generally, the different plots can be categorised into plots close to the homestead and plots far away from the homestead. As Alriksson and Ohlsson (1990) observed these plots have different crop preferences, crop diversity, land management, technology level and agroforestry practices. Plots close to the household tend to have many annual and perennial crops, few cash crops, good soil management, low external technology, many agroforestry practices, and production is done throughout the year. Plots farther away have many annual crops, few perennial crops, many cash crops, poor soil management, high external technology, few agroforestry practices and production is done only during the rainy seasons of the year.

Land ownership in the surveyed area is characterised by unrestricted cultivation rights over the land, which is essentially a government/public property. According to the Agricultural Policy of Tanzania (MOA,1983:10-11), all land in Tanzania is publicly owned and vested in the state. After the Arusha Declaration in the 1970s, land distribution in the villages became essentially the obligation of the village government. The distribution of land by the village government was mainly done for immediate use and not for long-term use. This led to insecurity of tenure in the long-term.

In practice, however, agricultural land can be owned in various ways as is evident in the surveyed area (Table 5.5). However, most agricultural land in the area is not properly surveyed or mapped, as a result no legal title deeds are available. Looking closely at the actual land ownership by households today, one finds out that a household excludes others from the land it is holding, pays no rent and possesses a full proprietorship without a limit, i.e. it can transfer land through selling, inheritance or lending (Table 5.5). However, the absence of legal tenure rights to land ownership has always been a major problem in agricultural production and environmental conservation in the study area. Farmers are cautious in long-term investments on the land, thereby affecting long-term investments such as tree planting and soil-water conservation structures. At the present state of ownership, the land is not accepted as a collateral asset for financing purposes. Recently, there have been changes in land use policy where individuals can have legal land occupancy. However, this is yet to be implemented as it requires a land survey and the process is long and expensive for smallholder farmers.

The main way of getting land in the survey area is through allocation by the village Government (Table 5.5). According to Alriksson and Ohlsson (1990), various factors are

Table 5.5 Way of land acquisition by village

Ownership/Villages	Magugu (n=25)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Given by village government	47	71	77	68	68
Purchased	63	46	52	45	51
Inherited	16	43	26	18	27
Hired	0	4	13	9	7.
Borrowed	0	11	6	5	6
Self bush clearing	21	7	3	5	5

Source: Survey data. More than one answer was possible

considered in allocating land by the village government in Babati. For example considerations are given to family size, families that have lived in the area for a long time are normally allocated more land than new settlers, and farmers who own tractors or could cultivate large areas can apply for more land. As noted above, however, this allocation is for immediate use and not for long-term use.

Land purchase is becoming an important way of obtaining land in the survey area. More than 50% of the respondents declared that they purchased land and over 60% of the respondents in Magugu purchased land (Table 5.5). Land purchase is becoming increasingly significant in Babati because of the high immigration rates from densely populated neighbouring areas such as Arusha and Moshi that incite lucrative prices for agricultural land.

Table 5.6 Average land purchase price and rent per hectare in the 1994/95 season by type of plot

Plots	Purchase Price ('000 TSH/ha)		Rent ('000 TSH/ha)	
	Mean (n=75)	Std Dev	Mean (n=11)	Std Dev
Household Plot	43	68	NH	NH
Distant Plots	34	45	11	7

Source: Survey data
NH means not rented out.

The price of land in the area depends on factors such as proximity to the household and road communication and fertility of the land. As a result the prices are highly variable (Table 5.6). Household plots normally fetched higher prices as compared to distant fields. This is because the household selling its plot has to vacate the area and settle elsewhere. As a result, the prospective buyer has to pay more for the immovable assets such as houses. In addition, household plots are often near a road. However, the purchase price was not statistically different between the two categories of plots. A small number of respondents hired out their distant plots and the prices ranged from TSH 6 000 to 24 000 per hectare. The household plot was not hired out throughout the study area. When asked why they did not hire out the household plot farmers pointed out that these plots are their major means of survival as production is undertaken throughout the year. In addition, it is difficult for the renter to maintain the required intensive management practices of the household plots.

Table 5.7 demonstrates that average farmland owned by sample households ranged between 2 hectares in Singe to almost 5 hectares in Magugu, with about 3 hectares being the mean farm size for all the sampled households (rounded off).

According to the SPSS PC+ percentiles (See chapter 4) the observed farm sizes were categorised into large (>7 ha), medium (3-6 ha) and small farms (0.1-2 ha). However, according to the classification by ICRISAT[15] (International Crops Research Institute for the Semi Arid Tropics) the mean farm sizes (Table 5.7) fall under a medium farm size category.

Table 5.7 Average farm size by village

Sample Villages	Cultivated land (ha)	Uncultivated (fallow) land (ha)
Magugu	4.7	1.8 (28%)
Bonga	2.1	1.2 (36%)
Singe	2.0	1.0 (33%)
Himiti	2.6	1.5 (37%)
Overall sample	Mean 2.8, min. 0.8 and max. 12	Mean 1, min. 0.1 and max. 6

Source: Survey data.

As pointed out in Feder *et al.* (1985:273) a wide variety of empirical results interpreted in the context of theoretical literature suggests that farm size is a proxy for a large number of potentially important factors. Among the factors, capacity to bear risks and access to both financing possibilities and scarce inputs are of interest to this study. The relationships between risk and household resources and characteristics are presented in chapters 7 and 8.

As far as agricultural land use is concerned, not all the land owned was cultivated in the1994/95 season, with Magugu and Bonga having the largest uncultivated areas (1.8 and 1.5 hectare respectively) (Table 5.7). Whereas only a small proportion of the household plots was not cultivated, a large proportion of distant plots was not cultivated. This observed trend is mainly because of the distance involved and other factors such as vermin and theft control.

Table 5.8 Average land area by type of plot

Plot	Cultivated land (ha)	Uncultivated land (ha)
Household plot	1.9	0.7 (27%)
Distant Plots	3.9	1.5 (39%)

Source: Survey data.

When asked the reasons for not cultivating all the land, the farmers indicated the major reasons as lack of capital, drought and hiring land out (Table 5.9). The problems of lack of capital are

[15] It is reported in Renkow (1990:670) that ICRISAT classifies land areas of between 0.21 to 2.50 ha, as small farms; between 2.50 to 5.25 ha as medium farms and above 5.25 ha as large farms.

also exacerbated by inadequate agricultural finance (See also chapter 7). As lack of capital was the major reason for not cultivating all the land in Bonga, Singe and Himiti, in Magugu the major reason was drought.

Table 5.9 Reasons for not cultivating all the land by village

Reasons	Magugu (n=13)	Bonga (n=3)	Singe (n=4)	Himiti (n=4)
		% of respondents		
Lack of capital	23	100	50	25
Drought	46	0	0	0
Hired out	15	0	50	25
Fallow land	15	0	0	50

Source: Survey data.

As pointed out above drought is a specific problem of Magugu village. This is because the village is located in semi-arid parts of the Babati district (Figure 5.4). The main problem is low, erratic and unevenly distributed rainfall. However, looking at the intensity of cultivation expressed as the proportion of the area not cultivated to the area cultivated shows that Magugu has the highest intensity (the lower the proportion the higher the intensity).

Land slope determines to a large extent the quality of farm land, as it is related to run-off as well as soil erosion, and therefore many conservation efforts are required. In the study area, farmers estimated that overall farming land slope range from steep slopes (2% of respondents) to flat land (70% of the respondents). However, responses of steep slope showed high variations within the villages making an average percent of 2 not representative of the area (Table 5.10). The land is predominantly flat to gently sloping, suggesting that erosion hazards are moderate (Tables 5.10 and 5.11).

Table 5.10 Land slopes by village

Slope/ Village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Flat Land	68	64	71	72	70
Gentle Slope	20	36	29	23	28
Steep Slope	11	0	0	5	2

Source: Survey data.

When land slopes are observed on land holding basis there are notable variations between the household plots and the distant plots in all slope categories. Generally more people indicated that distant plots are mainly flat (Table 5.11).

Table 5.11 Land slopes by land holding

Slope/Plots	Household Plot	Distant Plots
	% respondents	
Flat land	43	88
Gentle Slope	51	12
Steep Slope	6	0

Source: Survey data

5.4.2 Labour

(i) Family and hired labour

Whereas the mean percentage of hired labour is high, reliance on family labour for farm work still dominates for activities such as fertilizer application, planting, threshing and selling (Table 5.12). Table 5.12 shows that there is a high variation in percentage of hired labour among the villages and farm activity/operation. Section 5.4.3 shows that the ploughing activity is the most mechanised, while table 5.12 also points out that most of the hired labour was spent on ploughing. This is because many farmers referred to hiring of tractors and oxen for ploughing

Table 5.12 Proportion of the employed labour to total labour by activity

Activity/Village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)
		% of respondents		
Ploughing	33 (46)	66 (47)	72 (46)	68 (47)
Planting	21 (35)	38 (47)	44 (49)	34 (47)
Weeding	25 (36)	41 (48)	52(47)	45 (45)
Fertilizer application	0 (0)	20 (45)	23 (44)	25 (50)
Thinning/Pruning	0 (0)	67 (58)	100(0)	100 (0)
Harvesting	36 (43)	44 (47)	48 (47)	51 (46)
Threshing	8 (29)	29 (44)	44 (50)	26 (46)
Selling	22 (37)	0 (0)	30 (48)	29 (49)

Source: Survey data. Numbers in parentheses are standard deviations.

as labour hire. Magugu village, which had a relatively small proportion of its farmers hiring tractors, had most of its farming activities undertaken by family labour as compared to the rest of the villages. This may be partly due to high wage rates in Magugu (Table 5.13). The table shows that Magugu had a significantly higher wage rate as compared to the rest of the villages.

There are no significant differences in the proportion of hired labour between the household plots and the distant plots (for both cases the proportion is about 36%). It is worthwhile to mention that the labour hiring activity was common in both ways, i.e. labour in and out of the household. This was noted especially during high labour demand periods. Inter-household assistance in the form of work groups on a rotation basis was also not a rare activity. This implies that a farmer may enlist the aid of his fellow farmers for the accomplishment of a particular task

Table 5.13 Wage rates per day for hired labour by village

Village	Mean	Median
	TSH/day	
Magugu (n=11)	1 272 (1 057)	1000
Bonga (n=12)	375 (94)	325
Singe (n=12)	600 (762)	350
Himiti (n=7)	1 293 (1546)	350
Overall (n=42)	827 (973)	400

Highest rate 4,000, lowest 250 mode 300

Source: Survey data Numbers in parentheses are standard deviations

in exchange for grains, prepared food, local beer and/or his labour at a subsequent time.

Payment for labour hire is done by cash or in kind. In kind payments are made in a form of stored/harvested food and/or livestock. This was common among the poor families. Payment in kind has implications on household grain production, storage and utilisation and on livestock production. This is because the household that hire labour has to pay for the labour using the harvested grains or raised livestock.

For cash payment, the wage rate per day differed in the surveyed villages and was highly variable with respect to the rates paid by individual respondents (Table 5.13). Magugu village had its average affected by a few extreme values. The most frequent rate was TSH 300 (35.7% of the respondents). The median wage rate represented a fairly better measure of central tendency. Based on the median wage, Magugu still had higher rates as compared to the other villages. Discussion with the villagers in Magugu revealed that irrigated paddy production contributes to the high wage rates due to its high labour demands.

(ii) Gender division of labour and decision making

By holding discussions with key informants in the Babati district it was revealed that division of labour in the household follows, to a large extent, a long-standing tradition. It was reported for example, that some specific tasks as weeding, harvesting and threshing were predominantly womentasks, while men did jobs like land clearing and preparation, cultivation, thinning and pruning and selling activities. At present, however, some of this traditional division of labour has changed and the operations are almost equally shared as is evident in table 5.14. This table shows that ploughing, planting, weeding, harvesting and threshing which were gender specific, are now done jointly by men and women. It is only selling, thinning and pruning activities, which are male-dominated. The results cut across the sampled villages with some variations. Probably the reasons for this shift may have been attributed to area expansion, increase in the number of farming plots and increasing needs for selling surplus food crops. The first two reasons have also been reported for Sumbawanga (Tanzania) by Ashimogo (1994: 149), while the latter was also shared by Hyden (1990:304) in some villages in Tanzania where maize is produced both for food and for sale.

Table 5.14 Gender divisions of farm operations by village

Activity/gender	Magugu				Bonga				Singe				Himiti			
	% of respondents															
	M	F	M+F	n	M	F	M+F	n	M	F	M+F	n	M	F	M+F	n
Ploughing	35	0	65	23	27	6	67	33	19	7	74	42	16	12	72	25
Planting	4	9	87	23	8	8	84	49	14	8	77	62	10	8	82	38
Weeding	0	9	91	22	6	6	87	47	13	6	81	53	10	10	80	30
Fertilizer application	0	0	100	22	22	11	67	9	4	9	87	23	8	0	92	12
Thinning	0	0	100	3	83	0	17	6	100	0	0	2	100	0	0	1
Harvesting	0	0	100	19	7	6	87	54	7	10	83	60	5	8	87	39
Threshing	0	0	100	18	2	5	92	42	16	5	79	44	12	4	84	25
Selling	100	0	0	2	0	0	100	6	72	6	22	18	60	10	30	10

Source: Survey data

M = Male, F = Female, F+M= Male and Female together and n is the number of responses over different plots owned.

Apart from agricultural production work, noting that women also contribute to the household livelihood by participating in off-farm work is important. These activities are food processing and preparation, care for the children, the sick and elderly, fetching water and firewood, washing clothes, keeping the house clean, and off-farm cash income generating activities.

Decisions on what to produce, how to produce, what combinations of available resources to use to optimise household objectives and what type of market or disposal of the product should be is essential in determining the household livelihood security. It is documented that women contribute substantially in household food production and processing. To effectively undertake these tasks they also require having decision-making power regarding food production and processing. Identifying who decides in a household is also an important aspect in the dissemination of innovations. Targeting innovations to men while women do the decision making and implementation, the innovation is likely to be rejected.

Table 5.15 Decision making in agriculture by village

Village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
		% of respondents			
Decisions on which crops to grow					
Husband	58	21	26	41	35
Wife	16	4	7	9	7
Both	26	75	68	50	58
Decisions regarding labour use					
Husband	54	25	37	50	40
Wife	14	7	7	5	8
Both	32	68	56	45	52
Decisions on trees to be grown					
Husband	64	68	61	64	64
Wife	9	4	3	9	6
Both	27	29	36	27	30
Decisions regarding crops use					
Husband	38	21	19	23	26
Wife	6	4	5	9	5
Both	56	76	76	68	67
Decisions regarding the use of planted trees					
Husband	55	56	44	68	55
Wife	15	4	4	9	7
Both	30	40	52	23	38

Source: Survey data.

Who makes a decision in the study area depends on the type of decision to be made. For instance, the decision on which crop to grow is mainly done jointly, decision making regarding labour use is done jointly with much of influence from men, and decisions on trees to be grown are mainly done by men. Whereas the decision regarding the use of crops is done jointly, the decision regarding the use of planted trees is normally male-dominated. Generally, there are no major differences among the villages in decision making with respect to what type of tree species to be grown and their use (Table 5.15). However, on other decision options, it appears that Magugu village has more male-dominated decisions as compared to the other villages, thus rendering the overall figure to be interpreted with cautions.

Generally, the final decision making at the household level in Tanzania, has remained male-dominated, i.e. males make the final decisions, after consultation with the wife. Studies conducted in Tanzania, suggested that final agricultural decisions are male-dominated, although consultation with the wife is also common (Senkondo, 1992; Holmbie-Ottesen and Wandel, 1991).

Relevant to this study are decisions regarding the type of tree species to be grown in the farmland and decisions regarding the disposal of trees and tree products. The husband mainly takes these decisions with little support from the wife. An implication from these results is that women are less involved in decisions regarding tree growing and the use of trees and tree products. This seems to contradict with the highest role played by women in collecting firewood, some of which is derived from planted trees. Thus there is a need for striving for greater women involvement in these decisions.

5.4.3 Capital

Capital in this case is referred to as the stock of capital (often permanent) which is invested in agriculture. In Babati, capital was implied to items such as cash (on hand or credit) and equipment such as tractors, oxen plough, hoes, axe and machete. As noted earlier apart from ploughing and transport of produce, many agricultural activities are done manually. Whereas, very few people own tractors and oxen ploughs all the sampled respondents own at least a machete, hoe and axe (Table 5.16).

Table 5.16 Total agricultural assets owned by villagers

	Magugu		Bonga		Singe		Himiti	
Asset	No	Mean Price (TSH)	No.	Mean Price (TSH)	No.	Mean Price (TSH)	No.	Mean Price (TSH)
Tractor	1	7.5 Mil.	1	350,000	3	350,000	4	3.5 Mil
Ox plough	3	15 550	3	7 136	3	8 983	4	6 992
Hoes	133	1 400	112	3 570	124	4 114	110	4 915
Machete	19	1 600	56	1 300	31	1 064	22	1 500
Axe	38	1 725	28	728	31	710	22	1208

Source: Survey data.

Doing dual works is common for work with tractors and oxen i.e. they can be used for farm work and for transport of household utilities such as firewood or even doing off-farm businesses.

Credit is another source of financing capital goods to agricultural production. In Babati many farmers depend on informal credits, as obtaining credits from the formal source is difficult (See also chapter 7).

5.4.4 Crop production technology.

Farming practices are similar in the survey area and in the Babati district in general despite some observed differences. Crops are either grown in a pure stand or intercropped, and in homestead plots, integration of the tree component in the farming is very common. Fallow lands exist mainly in all the villages and they have been pointed out as one of the reasons for not cultivating all the land in Magugu and Singe (See tables 5.7 and 5.9).

Whereas the Babati district is mechanised largely in ploughing, crop production technology is generally underdeveloped especially in the use of agricultural inputs. Ploughing by tractor is the main method of land preparation, which is unique because many parts of Tanzania still use hand hoes. In the surveyed village, about 80% of the households used tractors in land preparation. Kahurananga (1992), Alriksson and Ohlsson (1990) and Lindstrom (1988) also reported this finding. The use of animal traction is also well developed in the district, and it formed the second main method of land preparation (about 10% of the respondents). The rest used hand hoes (10%). Hand hoes are also common in areas where perennial components such as trees, are mixed with other crops. Although the price of ploughing with a tractor was high (TSH 10,000 - 12,000 per ha), compared with that of oxen ploughing (TSH 5,000 to 6,000 per ha). Many farmers preferred tractor ploughing mainly because of the hard soils, and it makes weeding much easier. Both tractor and animal traction services are available, and some tractors come from as far as the Arusha and Moshi districts.

Other farm operations such as planting, weeding, fertilizer and manure applications etc. are done by hand. Motorised transport and/ or animal power is used to transport crops.

The use of chemical fertilizers is limited in the study area and generally there are variations in the use of manure and agricultural chemicals in the surveyed villages. Although farmers may suggest that they used fertilizers some used lower rates than the recommended ones. However, those participating in the Sasakawa Global 2000 project (Bonga, Singe and Himiti villages) use the recommended rates. Table 5.17 shows that only 40%, 21% and 20% of the respondents used farmyard manure, chemical fertilizers and pesticides/herbicides respectively. High use rates of farmyard manure and chemical fertilizers were recorded in Singe, Bonga and Himiti, where as pointed out above some farmers participate in Sasakawa Global 2000 project.

Table 5.17 Use of agricultural chemicals and manure by village

Villages/Type of chemical	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of *respondents*		
Farmyard Manure	40	43	45	45	40
Chemical Fertilizers	11	20	23	23	21
Pesticides and Herbicides	0	36	39	0	20

Source: Survey data.

Magugu village also reported a high percentage of respondents who use farmyard manure. This may be associated with the large numbers of livestock in Magugu as compared with other villages (See also table 5.22). Farmyard manure is more commonly used than chemical fertilizers

(Table 5.17). Although assessing the amount of manure used was difficult, the amount used was still low, and most of it was used in household plots due to its bulkiness. Other fertilizers used were
urea and sulphate of ammonia. Very few people used pesticides and herbicides (Table 5.17).

Table 5.18 Use of agricultural chemicals and manure by crop

Crop/ Chemical	Maize n=93	Coffee n=41	Tomatoes n=7	Paddy n=3	Sorghum n=2	Banana n=2	F/millet n=1	P/peas n=1
				% of respondents				
Farmyard Manure	62	34	14	33	50	100	0	0
Chemical Fertilizers	23	7	0	67	50	0	100	100
Herbicide and Pesticides	15	59	0	0	0	0	0	0

Source: Survey data

Table 5.18 demonstrates that most of the agricultural chemicals and manure were used for maize and coffee and to a lesser extent for tomatoes. This is mainly due to the importance of maize as the main staple and coffee and tomatoes as cash crops. Coffee and tomatoes are also highly susceptible to pests and diseases.

Various reasons were given about why fertilizers are not widely used, for example lack of means of transport for farmyard manure, expensive chemical fertilizers, lack of cash, and lack of retail stores in the villages.

5.4.5 Agricultural calendar and cropping patterns

Agricultural production in the surveyed area primarily depends on rainfall. Despite the fact that there is potential for irrigation district wise, it is still underdeveloped. Only a small proportion of land is under irrigation in Magugu village. As a result, the cropping seasons consist of different activities, which are very much dependent upon the distribution of rainfall. As already mentioned, Babati district receives a bimodal rainfall pattern consisting of short rains from October to December (sometimes January) and long rains between February and May (Section 5.1.1). Based on the rainfall distribution there are no marked differences in cropping patterns in the surveyed villages. The cropping calendar can be described in 3 periods for convenient purposes: The rainy season, which in Babati runs from December to May, is followed by the harvest period which runs from June to September and the post harvest period from October to November.

1. The rainy season (December to May)

Farming activities like planting, weeding, pruning and thinning are done in this period. An early bean crop can be harvested at this time and in May, a second crop of beans can be planted, depending on the rainfall pattern in that year. It is in this period that most households deplete their food reserves, primarily because of high cash demanding activities and because it was a long time since the last harvest.

2. The harvest period (June to September)

Depending on the planting date or onset of rains, most crops are harvested in this period. In this period harvesting crops, such as beans, maize, sorghum, millet, and pigeon peas are done.

3. The post harvest period (October to November)

In this period post harvest activities are carried out, including threshing, storage and ceremonies. This is normally the slack period of the season. Marketing activities and inter-household exchange of food is done. Land preparation starts to take place in this period up to December.

Maize is the dominant staple and a major cash crop through marketed surplus, followed by pigeon peas. Whereas, a larger number of people in Bonga, Singe and Himiti grow maize (more than 90% as compared to Magugu (63%), the opposite is true for pigeon peas (Table 5.19). The reason for this may be that pigeon peas which are more drought tolerant as compared to maize were more preferred for the semi-arid Magugu. Other important crops in the surveyed areas are cassava, bananas, sorghum, beans, coffee, paddy, millet, and groundnuts, lablab bean, green grams, cassava, sweet potatoes and a multitude of vegetables.

Table 5.19 Crops grown in the surveyed villages

Crop/Village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)
		% of respondents		
Maize	63	100	94	100
Pigeon peas	42	21	39	36
Cassava	27	26	31	36
Bananas	0	21	9	27
Sorghum	25	18	25	32
Beans	22	0	14	10
Coffee	0	28	6	0
Sweet Potatoes	17	9	9	9
Paddy	16	0	0	5
Millet	2	4	4	2
Sunflower	5	0	3	0
Groundnuts	11	0	0	0
Lablab beans	5	0	0	0
Tomatoes	0	4	3	0

Source: Survey data

Yields vary throughout the surveyed villages and among other factors it also depends on whether the crop is grown as a pure stand or in mixed cropping. However, it was not possible to have accurate figures of monocropping yields and mixed cropping yields, as farmers tend to mix their crops after harvest. Farmers pointed out that there are yield reductions of annual crops when mixed cropping is applied, but the combined return is higher than in monocropping. Table 5.20 shows the average estimated yields in the surveyed villages. Despite the effects on yield by the above-mentioned cropping pattern, the results suggest that agro-ecological conditions are important determinants of the yield. Magugu, which is situated in the semi arid area, recorded lower average yields as compared to the other villages. The only exception is on rice, which is grown under supplementary irrigation (Table 5.20).

Table 5.20 Farmers' estimates of yields of major crops grown in the surveyed villages (kg/ha)

Crop	Magugu	Bonga	Singe	Himiti	Overall
Maize	1 809	2 115	2 628	2 151	2 331
	(918)	(1 431)	(2 700)	(2 412)	(2 141)
Beans	549	387	711	639	576
	(459)	(297)	(522)	(549)	(477)
Pigeon peas	1 143	1 305	1 343	981	1 170
	(774)	(873)	(774)	(711)	(801)
Sorghum	-	2 000	4 000	200	1 660
		(2 600)	(0)	(0)	(1 800)
Coffee	-	1 215	621	-	1 053
		(1026)	(414)		(936)
Rice	1 640	-	-	880	1 488
	(638)			(366)	(662)
Lablab	225	-	300	150	225
beans	(156)		(71)	(141)	(131)

Source: Survey data. Numbers in parentheses are standard deviations.
Yields were reported in bags/ha and were converted to kg/ha.

Cropping systems

Earlier in this chapter, it was noted that farmers in the surveyed area own on average three different distinct farming plots. The motives of owning these separate plots are the desire to grow different types of crops/trees on separate fields, diversification against risk and the increasing pressure on fallow lands. Likewise, there are different cropping systems in the different plots with different kinds of crop/tree mixtures. Based on the mixtures and the plots, nine different cropping systems were identified and some were used as a basis for analysis in the subsequent chapters.

Table 5.21 shows the proportion of the respondents practising different cropping systems aggregated over all plots. The table shows that almost 80% of the respondents have 'Trees (timber/fuel wood all ages) + mixed food crops' (CS2). Other frequently practised cropping systems are 'Mixed food crops only' (CS3) and 'Mixed fruit trees (all ages) + mixed food crops' (CS1).

Due to time and resource constraints for both the researcher and farmers, it was not possible to subject all the above mentioned cropping systems to further analysis. As a result only six cropping systems were earmarked for further analysis. The main selection criterion was on frequency of application of the cropping systems. Based on this, CS1, CS2, CS3, CS4, CS5 and CS6 were included for further analysis. This does not, however, imply that the left out combinations are unimportant but it is rather due to the resources made available for this study. In subsequent chapters 6, 7 and 8 the six cropping systems selected are used to study in detail risk perceptions and preferences of farmers.

Table 5.21 Respondents practising different cropping systems (all land holdings aggregated)

Cropping system	% of respondents (n=100)
Trees(timber/fuel wood all ages) + mixed food crops (CS2)	89
Mixed food crops only (CS3)	60
Mixed fruit trees (all ages) + mixed food crops (CS1)	50
Mixed fruit trees (all ages) only (CS6)	36
Cash crops only (CS4)	33
Trees(timber/fuel wood all ages) only (CS5)	20
Mixed food crops +cash crops (CS9)	13
Cash crops + fruit trees (all ages) (CS8)	9
Cash crops + trees (timber/fuel wood all ages (CS7)	8

Source: Survey data

5.4.6 Livestock production

Livestock production in the research area forms the fourth main source of household cash income. Most of the farmers in the Babati district practise agro-pastoralism and agro-silvo-pastoralism. Cattle are the dominant species followed by goats, sheep and some zero grazed dairy cattle (Table 5.22). Magugu has significantly large herd sizes of cattle, goats and sheep as compared to the rest of the villages. It was pointed out earlier that Magugu village falls under the semi-arid area of the district where the main production activity is pastoral livestock. The main inhabitants are Maasai and Barbaig who are traditionally pastoralists. This explains why Magugu has a larger herd size as compared to the rest of the villages.

District wise there are large herds of livestock, estimated at 224,155 herd of cattle, 148,626 goats and 63,334 sheep (Tanzania, 1988).

Table 5.22 Average herd size per household with livestock

Livestock type	Magugu (n=10)	Bonga (n=20)	Singe (n=28)	Himiti (n=20)
Cattle	9	3	3	3
Goats	6	1	2	3
Sheep	3	1	1	1

Source: Survey data.

Two main types of physical production can be identified as a result of keeping livestock: The first one is recurrent production, with outputs in the form of manure, milk and draught power. These outputs depend on types and age of animals and they become available throughout the lifetime of the animals. The main cattle types kept in the survey areas especially in Magugu village are the local zebu. The second one is embodied production defined as meat production that is stored either in the form of an increase in herd size, or through a gain in liveweight of individual animals or through a combination of both. Apart from the outputs, cattle provide a number of services such as insurance against contingencies and display of status. The roles of these services are dependent on the access to and functioning of markets for saving and credit services, insurance and consumer goods. The role of cattle in financing and as prestige is important in areas where there are few other means of storing/displaying wealth, such as banks and durable consumer goods. The role of cattle as insurance results from the potential capability to sell animals in case of emergencies. In Babati and Tanzania as a whole, formal credit and insurance markets to farmers are not well developed, thus enhancing the above roles of cattle. This observation is also true to many parts of developing countries in general (Binswanger and Rosenzweig, 1986; Von Pischke *et al.*, 1983 and Bosman and Moll, 1995). As will be explained in chapter 7, cattle forms an important asset for liquidation in case of problems and as a form of storing wealth, making it an insurance against risks.

It is important to mention here that the roles of livestock described above have both advantages and setbacks compared to the situation when cash is kept/stored. Three advantages are identified. The first one is the absence for a need of safe keeping of cash, which is difficult in rural circumstances. The second is that inflation is avoided, as the value of cattle remains fairly stable and the third one relates to the avoidance of claims to smaller or large amounts of cash by relatives, which are difficult to turn down because of social reasons. Cattle keeping has some disadvantages such as risk of loss through theft or death and expenditures for herding. However, these problems are minimised by practising rotational grazing and distributing some of the animals to different clan members located in different locations.

It is pointed out in Moll and Heerink (1998) that the roles of cattle are affected by changes in domestic relative prices. For example an increase in meat prices may lead to more emphasis on embodied production and subsequent sale of the animals. An increase in crop prices would increase the value of output manure and draught power thus emphasising recurrent production. If the prices of imported luxury goods are increased, this will reinforce the role of cattle as the display of wealth etc. The effect of a price change on the roles of livestock is not presented in this research. Interested readers are referred to Moll and Heerink (1998).

It is worthwhile to note that the important roles of livestock described above cannot simply be added together because access to the respective outputs is partially mutually exclusive. One can either keep animals and get the recurrent output and thus recurrent production, security in emergencies and social prestige can be met, or one can dispose off some of the herd and use the money for other purposes. The decision to keep or dispose off the livestock is the responsibility of the owner and she or he may do that according to the relative importance attached to the various roles and to the expectation of future requirements.

Pasture is the most important feed resource in the area. In addition, there are also fodder trees that are used to feed the animals especially during the dry periods (Table 5.23). Cattle grazing is the next most important form of land use after cultivation. Whereas Bonga, Singe and Himiti are having rather smaller grazing areas, Magugu is having a relatively large area for grazing. Communal grazing is the most common way of grazing livestock, although some farmers have private pastures and fodder trees on their farming plots.

The combined individual decisions by cattle owners whether to keep or dispose off cattle have effects on the grazing lands. A shift in relative preferences for recurrent output and services derived from keeping cattle increases stocking rates. Whilst increased preference for income from meat leads to higher off-takes, preference in meat income, which is highly influenced by high relative beef prices, leads to a more sustainable use of rangelands (Moll and Heerink, 1998).

In Babati communal grazing and the lack of proper land tenure hamper good livestock management. They facilitate overgrazing which leads to serious land degradation, as well as poor animal nutrition. BDC (1992) points out that annual denudation rates on over-grazed slopes average around 10 mm of soil per year.

Table 5.23 Fodder trees and the type of livestock fed

Fodder tree	% of respondents using fodder trees (n=45)	Livestock type
Mgunga (S) (*Acacia spp.*)	69	Goat, cattle
Lucina (S) Leucaena (E) (*Leucaena spp*)	53	Cattle, goat, sheep
Grevillea (E) (*Grevillea robusta*)	20	Cattle, goat, sheep
Guava (E) Mpera (S) (*Psidium guajava*)	18	Goat, cattle
Mtopetope (S) Wild custard apple (E) (*Annona senegalensis*)	18	Goat
Mzambarau (S) Jambolan (E) (*Syzygium cuminii*)	13	Goat
Mkorosho (S) Cashewnut (E) (*Anarcadium occidentale*)	13	Goat, sheep
Marie (C) Bridelia (E) (*Bridelia micrantha*)	13	Goat, sheep
Mango (E) Mwembe (S) (*Mangifera indica*)	13	Goat, sheep
Mjohoro (S) Ironwood (E) (*Senna siamea*)	7	Goat, sheep, cattle

Source: Survey data
S = Swahili, E = English, C = Chaga

Based on the foregoing discussion it can be pointed out that various ways can be instituted to attain a more sustainable grazing. First, policies encouraging pasture management for example management of common property, encouraging land tenure (private property) and zero grazing will assist in good pasture management. Secondly, and as pointed out in Moll and Heerink (1998), policies that encourage acceptable institutional opportunities in financing and insurance to the rural people will enable the cattle sector to concentrate increasingly on directly productive roles, and thereby provide indirect support to the more sustainable use of rangelands.

About 45% of the respondents used fodder trees to feed their livestock, with the largest

Table 5.24 Average time spent on livestock per day

Livestock/village	Magugu	Bonga	Singe	Himiti
			hours/day	
Cattle	8 (1)	6 (2)	6 (3)	7 (2)
Goats	8 (1)	2 (0)	6 (2)	7 (2)
Sheep	8 (1)	6 (2)	4 (3)	5 (3)

Source: Survey data
Numbers in parentheses are standard deviations

number of respondents from Magugu (84%). The use of fodder trees was not very popular in

Bonga (22% of respondents) and Himiti (36% of the respondents) (See also table 5.29). Fodder from trees is normally fed during the dry periods between July and November to supplement the scarce pastures. Table 5.23 illustrates the type of fodder trees fed to specified types of animals.

Labour time involved in livestock grazing varies with the type of animal, availability of grazing pastures, feeding system and water sources. As a result there are variations in labour time spent on each type of livestock in the survey area (Table 5.24). Magugu village with grazing problems spends much more time on livestock rearing as compared to the rest of the villages. On average, each type of animal requires at least one person per day.

If a farmer is keeping more than one of the above types of livestock it is a common practice to mix and feed them together. Some farmers combine the animals in a group and graze them on a rotation basis. The number of days each household is required to graze the animals varies from three to seven days per rotation. This has the advantage of releasing family labour for other production activities. Cattle are important in spreading risk by the existence of various exchange systems, where a man's herd is distributed between family and clan members and friends in different locations.

Two main cost items in livestock production are also identified as cost of keeping animals i.e. shades and veterinary drugs. In the surveyed area, the average construction cost for a cow shade is estimated at TSH 48,137 and its useful life as six years. Goat stables are more expensive with average construction costs of TSH 88,236 and a useful life of 10 years. This is because extra work is involved in building stables as compared to the cow kraals.

Besides construction costs, cost of disease treatment and prevention are high. The most serious diseases are East Coast Fever (ECF), Babesiosis, Anaplasmosis, Pneumonia and Trypanosomiasis. Table 5.25 shows the distribution of respondents who managed to use livestock drugs.

Table 5.25 Livestock drugs used

Input type	Livestock type (n=100)	
	Cattle	Goat
	% of respondents	
Novidium (tds)	10	23
Milzan (cc)	23	7
Berenil (pct)	25	7
Dip (cc)	41	6
Samorine (pct)	7	6
Acaricide	7	0
Antray	10	0
Trodax (tds)	1	0

Source: Survey data

5.4.7 Linkages between livestock and crop production

There are strong linkages between crop production and livestock. These linkages stem mainly from the two main physical productions of livestock and the number of services provided. As already mentioned, animal power contributes to crop production through facilitating land preparation and transport of both agricultural products and other household utilities. Provision of manure to the agricultural plots is another important contribution of livestock.

Livestock production in the study area in addition to other uses is a store of wealth. As a result, proceeds from agricultural production are converted to livestock units for future use. Livestock plays an important role in the household food security as marketable wealth, which can be sold for cash or exchanged for grains or other types of food.

Besides the above positive interactions between livestock and crop/tree production there are also negative interactions. The most important one is the land use conflict between livestock and crop producers. Accidental grazing on fields during cropping seasons is common and is a source of conflicts. In addition, grazing on crop fields after harvesting is a big problem, leading to agricultural land degradation.

It was observed in the study area that there is continued encroachment of cultivation into grazing lands, pushing pastoralists to marginal lands. This increases environmental degradation in the marginal areas. As pointed out in Kahurananga (1992) the decline in crop production as well as saving wealth in the form of livestock is forcing many agro-silvo-pastoralists to turn more into livestock keeping for livelihood, thus putting more pressure on grazing resources.

5.4.8 Agroforestry

This sub-section presents the extent, role and functions of agroforestry/trees in the household. Specifically it gives the relationship between agroforestry/trees and the household systems.

As pointed out in Alriksson and Ohlsson (1990) the major forestry or agroforestry practices on the farmland were a mix of trees on farmland, woodlot, mix of trees on rangelands and home gardens. Trees on farmland are either naturally growing trees, planted trees or a mixture of both planted and naturally growing trees. Natural trees are those left by farmers during land preparation. They are either tended or used, or just left to grow. On average about 64% of the respondents have planted trees only, while very few farmers (2%) maintained naturally growing trees only. About 34% of the farmers have both a mix of planted trees and naturally growing trees (Table 5.26).

Table 5.26 Trees on farmland per village by way of regeneration

	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Planted only	11	86	84	55	64
Natural only	5	0	3	0	2
Both natural and planted	84	14	13	45	34

Source: Survey data

Bonga and Singe villages had the highest proportion of planted trees as compared to the other villages. Magugu and Himiti villages on the other hand have a high proportion of farmers mixing both naturally growing trees and planted trees on their farms. Climatic conditions in Magugu village might be the reason why a small proportion of farmers maintain only planted trees (11%) i.e. farmers do not take the risk of loss of planted trees due to grazing and drought conditions.

The criteria used by farmers in allowing natural trees to grow on their farms are mainly for their use.

Tree planting in Babati has most probably been influenced by the Forest Tree and People (FTP) programme, which was initiated in 1987. In 1990 its activities were transferred to the District Forestry office. The main incentives given to grow trees are free seedlings, training seminars, on-farm demonstrations and establishment of tree nurseries in the villages. There are several tree nurseries in the study area, including private individuals' nurseries, mainly because of the existing demand for seedlings.

Table 5.27 Mean number of trees planted per hectare and per household by village

Village	Mean per ha	Mean per household	Standard deviation trees per household
Magugu	14	64	59
Bonga	21	44	52
Singe	36	72	99
Himiti	22	58	90

Source: Survey data.

There were high variations in the number of trees planted by different households in the 1993/94 cropping season (Table 5.27). The highest number of planted trees was in Singe village (72 trees per household), the lowest was in Bonga (44 trees per household). The number of trees per hectare ranged from 14 in Magugu to 36 in Singe.

Table 5.28 illustrates that as one moves away from the household plot the percentage of farmers who planted trees decreases. The proportion of respondents who planted trees on a household plot was on average 61%, whereas in the most-distant plots the average was 39%.

Table 5.28 Planted trees by type of plot and village

Plot/Village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Household	44	62	71	65	61
Distant plots	56	38	29	35	39

Source: Survey data

The possible reason for the smaller percentage of respondents that planted trees on distant plots is that management of trees is easier if they are within the vicinity of the households. In addition trees grown near the households are easily controlled for example against theft in case of fruit trees. Grazing in the fields after harvest and fire incidents discourage farmers to plant trees at distant plots.

It seems that there are some problems of tree establishment/survival in the study area. About 53% said that nearly all the planted trees survived but 29% indicated that only about a half of the planted trees survived.

The use of tree species in the farmland of the surveyed villages is shown in table 5.29.

Table 5.29 Functions of trees on crop land by village

Village/use	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Timber	79	100	100	100	92
Fuel wood	84	86	90	95	89
Fruit	79	82	68	59	72
Fodder/Animal feed	84	22	48	36	45
Wind break	26	11	16	27	19
Field boundaries/ fencing	63	7	10	18	19
Shade	26	11	13	23	17
Soil fertility/ conservation	5	14	3	14	9
Storing wealth	0	0	3	5	3
Medicines	5	0	3	5	3

Source: Survey data. More than one answer possible

The table shows that the main use of trees is to produce timber. With exception of Magugu village (which indicated that fuelwood is the first use), all other villages pointed out that timber is the first use of trees on farmland followed closely by fuelwood. In Magugu shade is mainly for protecting people against sun-rays, while in Bonga and Himiti shade is common in coffee farms. Fruits, and animal feed are among the uses of trees that ranked relatively high. Trees for fencing and demarcating field boundaries were more common in Magugu as compared to other villages (Table 5.29). Grazing pressure in Magugu village may be the reason behind this. Table 5.30 gives the names of farm trees and their uses in Babati. The most popular timber species is *Grevillea robusta,* while famous firewood species are *Eucalyptus spp.* and *Senna siamea.*

Most of the trees planted or left on the farms are multipurpose trees, as is shown in table 5.30. Some indigenous tree species which are left on the farm during land clearing are managed, used or just left to grow. The most common indigenous species are *Ficus sycomorus, Kigelia africanum, Acacia spp., Pterocarpus angolensis* and *Adansonia digitata.*

Whereas one of the highly ranking uses of trees in the farmland is for firewood, households still said that their main source of firewood is from natural forests and open areas (Table 5.31). Planted trees do apparently not completely meet the peoples' fuelwood requirements.

We also observe from table 5.31 that planted trees have eased to a certain extent the pressure on natural forests for firewood as planted trees were indicated as the second main source of firewood.

The responsibility of firewood collection assists in deciding whom to target when disseminating firewood related technologies. Firewood collection in the survey area is mainly the responsibility of women and children. However, there are variations between females alone and females and children among the villages (Table 5.32). More respondents in Magugu indicated that firewood collection is the responsibility of females and children as compared to the other villages.

Table 5.30 Farm trees and their uses in Babati

Common/Local name	Scientific name	Uses
Cedrella (E)	*Cedrella odorata*	Field boundary
Mgivea (S) Grevillea (E)	*Grevillea robusta*	Soil conservation, firewood, timber, charcoal, wind break, field boundaries, shade, fodder, and wealth storage.
Guava (E) Mpera (S)	*Psidium guajava*	Fruit, firewood, fodder
Jakaranda (S) Jacaranda (E)	*Jacaranda mimosifolia*	Ornamental, firewood, shade, wind break
Limau (S), Lemon (E)	*Citrus limon*	Fruit, firewood (twigs and dead branches)
Lucina (S), Leucaena (E)	*Leucaena spp*	Fodder, fuel wood, soil conservation, hedge/fence
Marie (C) Mwaru (C) Bridelia (E)	*Bridelia micrantha*	Fodder, firewood, building poles, medicine, fruits
Mbuyu (S) Baobab (E) Gendaryandi (I)	*Adansonia digitata*	Fruits, drink, for putting bee hive, rope
Mchenza (S),	*Citrus reticulata*	Fruit, firewood (twigs & branches)
Mchongoma (S), Madras thorn (E)	*Pithecelobium dulce*	Fence, firewood, poles, fruit, drink
Mchungwa (S) Orange (E)	*Citrus sinensis*	Fruit, firewood
Mduguyu (G) Hawi (I) Mohoromo (C) Desert date (E)	*Balanites aegyptiaca*	Firewood, charcoal, poles, timber
Mforosadi (S), Mulberry (E)	*Morus alba*	Fruits, firewood, timber
Mgunga (S)	*Acacia spp.*	Fodder, nitrogen fixation, firewood, wind break, soil conservation
Mjohoro (S) Iron wood (E)	*Senna siamea*	Firewood, poles, windbreaks, shade, fodder, mulch, soil conservation, timber, medicine, field boundaries
Mkangazi(S) Mahogany (E)	*Khaya anthotheca*	Timber, firewood
Mkaratusi (S), Gum tree(E)	*Eucalyptus spp*	Firewood, poles, windbreaks, shade, charcoal, medicine, timber
Mkorosho (S) Cashewnut (E)	*Anacardium occidentale*	Nuts, oil, firewood, fodder and fruits
Mkungu (S), Bastard almond(E)	*Terminalia catappa*	Shade, soil conservation, fruit/seed, timber
Mkuyu (S) Sycome (E)	*Ficus sycomorus*	Shade, firewood, soil conservation, mulch
Mkwaju (S) Tamarind (E)	*Tamarindus indica*	Medicine, fruit, firewood, charcoal, drink
Mnazi (S) Coconut (E)	*Cocos nucifera*	Oil, nuts, beer, thatch, firewood
Mninga(S) African Teak (E)	*Pterocarpus angolensis*	Timber, firewood, charcoal, poles
Mparachichi (S) Mwembe mafuta (S) Avocado pear (E)	*Persea americana*	Fruit, firewood
Mregea/mwegea (S) Sausage tree (E) Mangafi (I)	*Kigelia africanum*	Shade
Mringamringa (S), East African Cordia (E)	*Cordia africana*	Firewood, timber, medicine, field boundaries, shade, soil conservation
Msesewe (C) Mkufi (S) Quinie tree (E)	*Rauvolfia caffra*	Brewing catalyst, medicine, timber, firewood ornamental
Mtarawanda (S) Golden bean tree (E)	*Markhamia spp.*	Firewood, poles, timber, medicine
Mtongoti (I) Mfu (C)	*Fagaropsis angolensis*	Firewood, timber
Mtopetope (S) Mrisirisi (C) Wild custard apple (E)	*Annona senegalensis*	Fruits medicine, fodder
Muarubaini (S) Neem (E)	*Azadirachta indica*	Medicine, firewood, fodder, soil conservation, insect repellent
Mwembe (S) Mango (E)	*Mangifera indica*	Fruit, shade, fodder, firewood (twigs and branches)
Mzambarau (S), Jambolan (E)	*Syzygium cuminii*	Fruit, firewood, shade, charcoals, fodder, soil conservation
Papai (S) Pawpaw (E)	*Carica papaya*	Fruit
Christmas, Flamboyant (E) Mkakaya (S)	*Delonix regia*	Firewood, field boundaries, shade, ornamental

Source: Survey data
S = Swahili; E = English; C = Chagga; G = Gogo; I = Iraqw
Local and Scientific names were verified from Mbuya *et al.* (1994)

Table 5.31 Sources of firewood in the surveyed villages

Source/Village	Magugu (n=17)	Bonga (=26)	Singe (n=30)	Himiti (n=20)	Overall (n=93)
			% of respondents		
Natural forests and open areas only	29	31	30	40	32
Planted trees only	12	4	30	10	15
Natural Forests, open areas and planted trees	5	23	17	5	14
Open areas and planted trees only	18	15	3	20	13
Natural forest only	18	8	7	20	12
Open areas only	18	12	7	0	9
Natural forests and planted trees only	0	8	7	5	5

Source: Survey data

Although firewood collection is most often done on multipurpose trips (e.g. travelling to distant plots for farming as well as collecting firewood), time taken to collect firewood affects time allocated for other productive activities.

Table 5.32 Firewood collection by household members per village

Village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)
		% of respondents		
Female	32	59	58	68
Female and children	65	30	30	30
Children	0	4	7	5
Female and male	0	4	7	0
Male and children	0	4	0	0
All	12	4	0	0

Source: Survey data

Table 5.33 shows that the mean number of hours spent on collecting firewood per year are 349. Magugu village had the highest frequency and time of collecting firewood as compared with the rest of the villages. This results from the easiness of obtaining firewood. The

Table 5.33 Frequency and time of collecting firewood per week and per year per village

Village	Mean time (hrs)	Frequency per week	Hours per year
Magugu	4.2 (2.5)	2.4 (0.6)	524
Bonga	3.0 (1.6)	1.8 (0.7)	281
Singe	2.6 (1.3)	2.0 (1.3)	270
Himiti	3.6 (2.2)	2.2 (1.4)	412
Overall	3.2 (1.9)	2.1 (1.0)	349

Source: Survey data Numbers in parentheses are standard deviations

largest part of Magugu village is semi-arid and natural trees and shrubs are not as prolific as in the other villages. In addition, Magugu is far away from natural forests.
About 74% of the respondents buy either firewood, charcoal or both. Few people do not purchase any of the two (23%). More people prefer buying firewood as compared to charcoal. This may be attributed to the higher price of charcoal as compared to firewood (Table 5.34). An implication of this finding is that fuelwood (in the form of firewood and charcoal) is traded in the survey area which as a result contributes to the household cash income. The incentive of growing trees for the above-mentioned uses is facilitated by the availability of a market for the products.

Table 5.34 Respondents buying charcoal or firewood by village

Villages	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)
		% of respondents		
Purchase firewood only	47	32	16	32
Purchase charcoal only	0	14	26	23
Purchase firewood and Charcoal	37	21	29	23
Do not purchase any	16	33	29	23

Source: Survey data

The price for charcoal and firewood depended on the relative demand for these commodities. Magugu having a low supply/difficult supply of firewood and charcoal had the highest price (Table 5.35). The high price in Magugu may also be attributed to the proximity to the Arusha markets as compared to the other villages. On the other hand prices in Singe and Himiti, which are relatively near to Babati town as compared to Bonga, are also high.

Given the price of firewood (Table 5.35), the amount of firewood collected per week, the time involved (Table 5.33), the wage rate per day (Table 5.13), and the finding that more than 30% of the villagers purchased firewood, it is possible to estimate the cash income (gross and net) from firewood collection. The analysis is based on the assumption that firewood collection

Table 5.35 Price of charcoal and firewood in the surveyed villages (TSH)

Item/village	Magugu	Bonga	Singe	Himiti	Overall
Charcoal/bag[16]	1,570 (888)	936 (526)	1,350 (463)	1,517 (434)	1,333 (610)
Firewood/bundle	400 (173)	171 (61)	182 (50)	195 (37)	198 (85)

Source: Survey data. Numbers in parentheses are standard deviations

by household members is a form of income that would have been foregone if firewood were purchased. However, two important findings need to be taken into consideration before

[16] Studies conducted at the Faculty of Forestry Sokoine University of Agriculture put estimates of a bag of charcoal to range from 0.2 to 0.7 cubic metres of solid wood with a weight of 28 kg. A big bundle of firewood was estimated to contain 11 pieces with 0.121 cubic metres (Okting'ati, 1984; Ishengoma *et al.*, 1990 and Ishengoma *et al.*, 1995).

deciding on the wage rate. First, firewood collection is normally done by women and children (Table 5.32) and secondly, in many cases firewood is collected during multipurpose trips. As a result, charging the full wage rate per day will be an overestimation of the returns to firewood collection. Based on the aforementioned, the wage for firewood collection was set at 75% of the actual reported wage rate. Net income from firewood collection is arrived at by assuming that labour is the only cost involved in firewood collection (other costs, such as implements used, are not considered).

Table 5.36 shows the annual household income emanating from firewood collection.

Table 5.36 Household's gross and net cash income (TSH) from firewood collection

	Gross Income			Labour costs			
Village	Bundles/ year	Price/bundle (median)	Annual Gross Income	Man-days/year [a]	Wage rate/man-day	Labour cost	Net income
Magugu	125	400	50,000	65	750	48,750	1,250
Bonga	94	171	16,074	39	244	9,516	6,558
Singe	104	182	18,928	39	263	10,257	8,671
Himiti	114	195	22,230	52	263	13,676	8,554
Overall	109	198	21,582	39	300	11,700	9,882

Source: Calculated from tables 5.13, 5.33 and 5.35.
[a] One man-day is equivalent to eight hours of a working day.

The table shows that the income ranges from TSH 16,074 in Bonga to TSH 50,000 in Magugu with an overall income of TSH 21,582. Based on the labour spent and 75% of the going wage rate, firewood income was found to be profitable in all the villages. Table 5.31 shows that slightly more than 15% of the respondents collected firewood from planted trees, which in most cases are within the household plot. This implies that for planted trees, the net income from firewood will be higher due to the little amount of time spent on collecting firewood.

5.4.9 Household's cash income

The main sources of cash income are through selling cash and food crops[17]. Off-farm cash incomes such as petty trade, local brewing, casual labour, remittances and employment are the third sources of household cash income (Tables 5.37 and 5.38).

Selling livestock and livestock products forms the fourth main source of cash income, giving an average of TSH 136,000 per annum. The average household cash income (combining both the on-farm and off-farm cash income generating activities) averaged TSH 488,000 per year (Table 5.38). Magugu village had the highest household cash income per year attributed to its high farm cash income (selling paddy and livestock). Its large farm size (Table 5.2) and high off-farm and livestock income might have also attributed to the high cash income in Magugu

[17] The distinction between cash and food crops follows the 'traditional' classification for example coffee is a cash crop while maize, pigeon peas, cassava etc. are food crops. As is apparent from above the distinction is not valid as all the crops can be regarded as cash crops.

(Tables 5.37 and 5.38). The variations in household cash income and their sources among the villages are high. Thus the overall figures in tables 5.37 and 5.38 should be interpreted with care as they are influenced by extreme values. One sampled farmer in Bonga village had a private tree nursery as a source of cash income. The annual average cash income from the private nursery worked out to be about TSH 400,000 per annum.

Table 5.37 Sources of cash income by village

Source/Village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Selling food crops	53	86	97	90	84
Selling cash crops	53	79	92	71	75
Off-farm cash income	79	14	14	28	33
Selling livestock	53	22	26	31	28
Selling trees and tree products	21	14	7	19	14

Source: Survey data

The contribution of off-farm income is substantial especially in Magugu, where almost 80% of the respondents derive incomes from this source. Off-farm income is one of the ways of diversifying income sources from agriculture, making households able to manage risks and uncertainties arising from agricultural production.

Table 5.38 Mean annual cash income per household in the surveyed villages

Source/Village	Magugu	Bonga	Singe	Himiti	Overall
			'000 TSH		
Food crops	520	70	51	131	179
Cash crops	255	228	96	113	150
Livestock and its by products	198	126	177	47	136
Farm cash income [a]	567	242	216	186	280
Income from firewood	50	16	19	22	22
Off-farm cash income	275	195	175	135	189
Household cash income [b]	689	346	295	253	488

Source: Survey data. The figures are rounded off.

[a] comprises food crops, cash crops and livestock income

[b] includes farm cash income, income from firewood and off-farm income

5.4.10 Production constraints

(a) Crop production constraints

Respondents were given a number of items (22 items) and were asked to suggest if the items were a constraint, by using the following key: Is not a problem = 1, Is a problem = 2 and Is a serious problem = 3. Responses 2 and 3 were recoded into 2 meaning it is a problem. The items were clustered into five major constraints (Table 5.39).

Climatic constraints

The main climatic constraint to agricultural production in the study area is related to rainfall. Delay in rainfall, low rainfall and unreliable rainfall was noted as the biggest problems in agriculture. As already pointed out, farming in the study area depends very much on rainfall. Irrigated agriculture forms a very small proportion of agricultural production. Although the rainfall data show that the district has a long-term average of 801 mm (Appendix 3), its poor distribution and uncertain onset makes it a problem. As a result drought was mentioned as a source of risk in crop production especially in semi-arid Magugu. Various solutions can be proposed such as improving irrigation, making use of rainwater harvesting techniques for crop production, use of soil and water conservation strategies and adopting quick maturing and drought tolerant varieties.

Insect pests and vermin attack

Insect pests and vermin attacks on crops were also seen as a problem in agricultural production. About 23.5% of the district is set aside as national parks or game reserves (BDC, 1992). The wildlife spills out into settled areas where besides destroying crops, they compete for grazing lands and water and they may transmit animal diseases. Post harvest losses due to insect attacks and poor storage structures were also noted.

Agricultural finance problems

Lack of formal credits, and poorly developed informal financing were also seen as problems in agricultural production (Table 5.39). As will be pointed out later, lack of credit is closely related to inability of farmers to take risks in terms of adoption of new technologies. Only 2% of the sampled farmers borrowed money from the banks. However 81% had credits from non-bank sources, i.e. 77% from informal sources and 4% from co-operative societies. In addition to other reasons for not borrowing money from banks, such as inadequate knowledge, difficult terms, bank bureaucracy and high interest rate, lack of security for example due to a lack of legal title deeds for their lands were mentioned as the reasons for not borrowing money from the banks.

In the current era of economic and political liberalisation, there is a vital need for promoting private initiatives and innovative self-help. Collective savings and wealth sharing are essential tools, which the poor can use to improve their socio-economic conditions and market bargaining power. Strengthening informal sources of savings and credits among farmers, private traders and consequently, forming an umbrella of informal savings and credits will help in solving the problem. Initially it was thought that subsidised formal credits which are cheap would lead to easy adoption of new technologies, and the assumed low interest would guarantee high repayment rates. However, this has not been the case as empirical evidence show that this has done more harm than good. For example, it has imparted a wrong notion among rural people that credit is a subsidy from the government and thus can as well be used for unintended purposes. Secondly, this type of financing has weakened the local capacity of rural people to mobilise and manage their own scarce resources and hampered the growth of strong and financially self-reliant small farmer organisations.

This does not exclude formal financing at all. For example, linkages between formal and informal lenders can lead to the development of the rural poor. Linkages between informal lenders and formal institutions in Babati are beginning to take root through formal lenders financing input stockists who in turn finance farmers. This has also been noted in other parts of the country (Kashuliza *et al.* 1998). However, this type of linkage can also act as a disincentive for farmers in forming, mobilising and managing their own savings and credit organisations.

Table 5.39 Agricultural production constraints by village

Constraint/Village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Climate	95	96	95	95	95
Insect pests and vermin	84	85	85	89	86
Agricultural finance	70	84	84	79	80
Soil fertility	44	78	77	76	75
Market and infrastructure	84	76	68	71	74

Source: Survey data

Soil fertility constraints

Soil fertility problems in the area are mainly associated with soil erosion, shortage of fertilizers and manure transportation problems. About 89% of the respondents agreed that soil erosion is a problem to agricultural production. Soil erosion and other problems such as deforestation and overgrazing are the main causes of low soil fertility in the study area. Clearing of forests and woodlands for agriculture in the area and increasing population growth (births and migrations), have led to encroachment of prime grazing lands thereby increasing pressure on the remaining grazing areas. This resulted in grazing and farming being pushed to marginal lands. All these processes promoted soil erosion and they are consequently leading to low soil fertility and poor land productivity. Improvement in soil-water conservation techniques, fodder production, production of feed concentrates and adoption of improved dairy herds will assist in alleviating these problems.

Market and infrastructure constraints

Problems on marketing, are not only that of the low market prices but rather those related to availability of markets for agricultural produce. This problem is also closely related to transport problems. Transport of agricultural produce to the household and markets was perceived as poor. This is attributed to poor road networks, especially during rainy seasons between Babati and its major marketing outlets such as Arusha, Dodoma and Singida. Poor road networks, and resulting high transportation costs also hinder procurement of agricultural inputs.

(b) Livestock production constraints

More than 70% of the respondents said that they were experiencing various livestock constraints. The most important limitation to livestock production is disease (37% of respondents) (Table 5.40). This constraint is related to other mentioned limitations as expensive drugs (26%) and unavailability of drugs (5%). Through discussions with farmers it was evident that disease problems are caused by the non-availability, insufficient, poor supply and distribution of drugs, vaccines, and acaricides. With a liberalization of agricultural input supply, together with the removal of subsidies the question of expensive drugs arises. Most private traders refrain from giving services to the rural areas, where milk production per livestock unit is low compared to dairy animals near urban areas.

Lack of grazing land and non-availability of pastures is another important limitation to livestock production (Table 5.40). The increasing number of livestock farmers coupled with the existing communal grazing land and lack of land tenure leads to the problems of insufficient and un-managed pastures, which in turn leads to overgrazing and land degradation.

Table 5.40 Constraints to livestock production by village

Constraint	Magugu (n=10)	Bonga (n=20)	Singe (n=28)	Himiti (n=20)	Overall (n=78)
			% of respondents		
Diseases	40	25	39	45	37
Expensive drugs	0	40	32	30	29
Lack of grazing land and non-availability of pastures	40	30	15	25	24
Non-availability of drugs	0	5	11	.0	5
Lack of water	20	0	3	0	4

Source: Survey data

Although not directly mentioned, discussions with farmers showed that there is a problem of low milk production per livestock unit. Milk production is constrained by the poor genetic potential of the livestock, and inadequate livestock feeds, grazing pasture and water. The latter as a result of broken down or lacking water infrastructures in the rural areas. A programme by Heifer International organisation has started improving the genetic potential of the livestock through a loaning system called Heifer In-trust Scheme. Under this programme a farmer is given an improved in-calf heifer in the understanding that if the calf is a heifer, it will be passed on to another farmer in the same understanding.

(c) Constraints to tree growing

Some of the constraints mentioned under (a) also apply to constraints in tree growing. Constraints such as climate, soil fertility, market and infrastructure are also true for tree growing. The diverse AEZ of Babati district indicate that different types of trees are needed to suit the diverse conditions, as different tree species are affected differently by the AEZ.

Accessibility to tractors during ploughing has been a constraint to tree growing in the survey area. Some farmers consider trees as obstacles to tractor ploughing because tractor ploughing has been associated with the disappearance of naturally growing trees on the farmlands. Alriksson and Ohlsson (1990) also reported similar observations in the northern part of Ufiome Mountains in the Babati district. Tractor owners and operators also view trees on farmland as reducing the effectiveness of ploughing. Planting trees in strips along contours with proper spacing can allow the use of tractors as well as reducing soil erosion. Planting deep-rooted trees can also avoid the damage of tree roots during tractor ploughing. These kinds of practices are undertaken by few farmers in the area (about 20%).

Burning over of agricultural land and pastures was also noted as a constraint to tree growing. Farmers pointed out that they burn the fields in order to get rid of notorious weeds, pests and diseases, and also to stimulate new growth in grazing lands. In doing so the farmers destroy planted trees, reduce the content of soil organic matter and they increase the possibility of erosion hazards. The use of fire therefore needs to be examined carefully before the decision is reached on whether to burn or not.

Grazing and browsing affect tree growth in farmland in the study area. This is almost common in all the villages in the surveyed area. However, it is more pronounced in Magugu as compared to the rest of the villages. Uncontrolled grazing, and grazing on the farmland hinders tree growing especially in early stages. In addition, trampling causes hard pans by compacting the soils. If farm manure is not spread on the farmland there are dangers of reducing the organic matter content of the soils.

The long time before benefits of trees and tree products become apparent holds back the efforts in tree planting in the surveyed villages. Although this was not perceived directly as a source of risk in agroforestry, discussion with farmers showed that they are worried about the long-term benefits. However, there were mixed feelings regarding this. Whereas some farmers were concerned with long-term benefits where prices of say timber is not known during planting, some farmers regarded it as a store of wealth for future generations. Looked differently, availability of trees and tree products in open and unprotected areas discourages tree planting on the farmland as farmers see no obvious advantages of planting trees on farmlands. However, not all the areas have these open areas. Good examples are Bonga and Magugu villages (the former is due to expanded farming lands, while the latter is the result of poor growth due to drought). For these areas the advantages of growing trees on farmland may be obvious.

Results of decision making in agriculture (Table 4.15) show that decisions regarding the type of trees to be grown and the use of trees and tree products rest on the husband. His choice of the tree species to be planted may conflict with the preference of his wife and hence discourage the whole exercise of tree growing. For example husbands may prefer timber species because of high returns but the wife may be interested in firewood species because it is her responsibility to collect them. Another factor, which was not explored by this study but related to tree growing, is the role of traditions and ethnic groups in tree growing (Alriksson and Ohlsson, 1990). Ethnic affiliations play a role in growing and managing trees. As pointed out in Alriksson and Ohlsson (1990), theoretically ethnic groups can have features that influence how well different agroforestry systems will be accepted when presented as an extension package. Pastoralists are more interested in livestock and would like to clear trees to reduce tsetse infestation (Otsyina, 1993). Even among farmers, paddy growers in Magugu would like to clear trees because they harbour birds, which destroy their crop.

5.5 Major findings and conclusions

This chapter has presented the general description of the research area and farm households. The aim was to generate background information from the area that will be useful in analysing risk attitudes, risk perceptions and preferences of cropping systems in the subsequent chapters. The following are the major linkages between this chapter and the subsequent chapters.

Geographical characteristics of the study area as presented in section 5.1, have implications to agroforestry and risk. As will be evident in chapter 7, one of the major sources of risk in agriculture in developing countries is related to the variations of the stochastic agro-ecological factors. For example rainfall and other climatic factors govern to a greater extent the type of crop and tree species to be grown in the area, the soil and water conservation efforts needed, and the type of livestock and the required management strategies etc. Among the sources of risk in agriculture, farmers in developing countries would first require to pay attention to stochastic agro-ecological factors as their immediate problems in agricultural production. The understanding of the geographical location, climate and rainfall characteristics therefore, link well with the subsequent chapters.

Attention was also paid to the overview of various agroforestry practices in Tanzania and Babati district in particular. Description of the agricultural production systems and the cropping calendar were also given attention. From the foregoing descriptions, the six frequently applied cropping systems were identified and used as a basis for studying risk attitudes, perceptions and preference ranking of cropping systems in the following chapters. In addition the actual ranking of the cropping systems, formed the basis for comparison with the rankings made by the use of risk attitudes, risk perceptions and preference ranking of cropping systems. Some important conclusions can be drawn from the characteristics of agricultural production in the area. The first one relates to the functions of the tree components on the farming system, which have effects on risk. Apart from providing products such as firewood, charcoal, fodder, shade regulation and fruits, trees can be liquidated in case of problems thus acting as savings, security and meeting contingencies. The second one concerns the potential for off-farm incomes in diversifying household cash income and thus improving risk management in agriculture. The third relates to capital access and ownership. Capital items owned by the farmers in the area are mainly hand tools, which implies that improvements in agricultural finance, market infrastructures, rural savings etc. can improve capital availability to farmers and hence improve their capabilities to take risks. The fourth conclusion is based on the cropping patterns. Crop production is organised in an average of three distinct plots. With regard to risk these plots allow spatial and crop diversification against risk. Finally livestock raising especially cattle has a crucial role to play in risk and risk management strategies through recurrent and/or embodied production. The roles played by cattle are dependent on the access to and functioning of markets for savings and credit services, insurance and consumer goods.

Attention in this chapter was also paid to household resources and characteristics. Household resources and characteristics such as age, education, capital, land, labour etc. are supposed to affect the risk attitudes, risk perceptions and preference ranking of cropping systems. Information on household resources and characteristics from this chapter is used in determining factors affecting risk attitudes in a wider context (Chapter 6) and risk attitudes, risk perceptions and preference ranking of cropping systems in chapter 8.

Finally, this chapter presented production constraints with respect to crop production, livestock production and tree growing. This chapter links with chapter 7 mainly because most of the identified constraints are also supposed to be the main sources of risk in agriculture and forms the basis for recommending risk management strategies to farmers. The crop production constraints related to risks are climatic, agricultural finance, problems of insect pests and vermin and problems related to soil fertility. In livestock production constraints identified include livestock diseases, expensive and unavailability of livestock drugs, lack of grazing land and unavailability of pastures and lack of water. Constraints to tree growing are also related to risk perception and risk attitude. The identified constraints are accessibility by tractors during ploughing, burning of agricultural land during land preparation, grazing on fields, the long-term benefits of trees and possible conflicts in household decisions regarding the type of tree species to grow.

CHAPTER 6

RISK ATTITUDE: EMPIRICAL RESULTS OF THE UTILITY AND LATENT VARIABLE CATEGORIES

Chapter 6 presents results of risk attitude measurements using the utility theory and latent variable categories. The procedures and basic assumptions are described in chapter 4.

The first part gives results and discussions of risk attitude measurements using the utility theory approach. The procedure in the utility theory approach was conducted using 30 case study farmers. The elicitation procedure of Certainty Equivalents (CEs) proved to be not an easy task, especially in terms of the farmers' time involved in both understanding the process and the elicitation exercise. On the other hand, farmers found the whole exercise interesting and surprisingly, they were very attentive. Most of them commented that the procedure is new and they had no experience with it. In this section the better-fitted utility functions were estimated for each farmer in each situation. The overall results of the estimated utility functions are also presented and discussed.

The second part presents the results of risk attitude measurement using the latent variable approach. The results of a set of items/statements included in the structured questionnaire that were used to study risk attitude are presented and discussed. This part includes data obtained from a sample of 100 farmers using the structured questionnaire (Appendix 1)

6.1 Results of the risk attitude analysis using the utility theory

Whereas there is empirical evidence on the magnitude and signs of the measures of risk aversion, there is little empirical evidence concerning the similarities/differences of these measures under different situations facing the farmers. In this section, the results of estimates of the magnitude of the measures of risk aversion under different situations that are typical for smallholder farmers (in this case smallholder agroforestry farmers) are presented.

Risk analysis using the utility theory involved eliciting farmers' certainty equivalents in four different situations (i.e. When the farmer has adequate food stocks, When the farmer has inadequate food stocks, When the farmer has adequate cash and When the farmer has inadequate cash) and fitting various utility function forms. As already pointed out above, the elicitation of farmer's CEs was done using a sample of 30 farmers. At least five points of CE were elicited per farmer in each situation (See also chapter 4). The aim of the analysis was twofold: First, to select the utility functional forms that fitted the data well under each situation and secondly to investigate whether farmers have different risk attitudes under different situations. The ultimate result is to come out with the farmers' risk attitude (risk preference/risk aversion) when faced by different situations.

6.1.1 Comparisons of certainty equivalents

Certainty equivalents obtained following the procedure described in chapter 4, under different situations were compared statistically (Tables 6.1 and 6.2). This was aimed at finding out if there are differences in CE between the different situations analysed. As explained in chapter 4, our expectations are that when farmers are faced with different situations they tend to have different CE and subsequently different risk attitudes. More specifically we expect farmers to be less averse to risk when they are in situations of adequate cash and food as compared to when they have inadequate cash and food situations.

Table 6.1 Statistics for certainty equivalents in different situations

	Mean	Median	Std. Deviation	Skewness
When the farmer has adequate food stocks (CE1)	40167	30000	32390	1.8
When the farmer has inadequate food stocks (CE2)	35000	30000	28738	2.6
When the farmer has adequate cash (CE3)	68333	60000	46169	0.2
When the farmer has inadequate cash (CE4)	32333	30000	24450	3.5

The results show that the situation when the farmer has adequate cash has the highest CE as compared to the others, followed by the situation when the farmer has adequate food stocks. The standard deviations are also higher, indicating that there are variations in CE among farmers. This is as pointed out in Hardaker *et al.* (1997) that generally, CE vary between people even for the same risky prospect because we seldom have identical attitudes to risk. The results are as expected because in wealthier situations (i.e. adequate cash and food situations) farmers are thought to be less averse to risk.

Pairwise comparison of certainty equivalents (Table 6.2) shows that there are significant differences in certainty equivalents between the situation when the farmer has adequate cash and the other three situations. The other pairs had non-significant differences in CE. This gives an indication that risk attitude of farmers differs with different kinds of 'wealth' the farmers are anticipating at the time they are making decisions.

It is easier for a farmer to take risks when having a higher level of 'wealth' or income. As a result most farmers will be decreasingly averse to risk the richer they are. Similarly, in situations of adequate food and adequate cash farmers are expected to have higher certainty equivalents compared to situations with inadequate cash or food. The pairwise comparison of certainty equivalents (Table 6.2) demonstrates this expected results more in situations with adequate cash than in adequate food stock situations. The results show that although the situation of adequate food stock is fairly better than inadequate food and inadequate cash (non-significant differences), farmers are less risk averse when they have adequate cash. An inadequate cash situation is the most severe one with lowest CE. This may be because for households with inadequate food stock there is a possibility of getting help from neighbours and from government food relief.

Table 6.2 Pairwise comparison of certainty equivalents (t-test)

Pair of CE	t-value	Probability
When the farmer has inadequate food (CE2) and when the farmer has adequate food (CE1)	-0.82	0.420
When the farmer has adequate food (CE1) and when the farmer has adequate cash (CE3)	-2.87*	0.008
When the farmer has inadequate cash (CE4) and when the farmer has adequate food (CE1)	-1.08	0.290
When the farmer has inadequate food (CE2) and when the farmer has adequate cash (CE3)	-3.49*	0.002
When the farmer has inadequate cash (CE4) and when the farmer has inadequate food (CE2)	-0.38	0.708
When the farmer has inadequate cash (CE4) and when the farmer has adequate cash (CE3)	-3.70*	0.001

* t significant at p=0.05

6.1.2 Fitting different utility functional forms

Zuhair *et al.* (1992) note a critical step on many applications of decision analysis under risk using the expected utility analysis as the specification and estimation of a suitable utility function. It is indeed important in this study because of the presence of different situations, which are analysed. As a result, six formulations of utility functional forms, which have been applied elsewhere (Smidts (1990); Clemen (1991); Zuhair *et al.* (1992) and Huirne *et al.* (1997) were tested for each situation. These are linear, logarithmic, negative exponential, power functions, quadratic and cubic formulations. In order to quickly test the fits of the various utility functions postulated, the curve fit procedure of SPSS PC+ was used for each farmer. The models/curves tested were in the following general utility function:

$u(x) = f(x_i)$,

Where:

$u(x)$ is the utility index calculated from the four situations using the CEs. (details are explained in Hardaker *et al.* 1997:90-91).

x_i is the scaled CE of each situation. Scaling[18] was such that utility of the highest income level of TSH 150,000 was scaled as 1 and the utility of the lowest income level of TSH 50,000 was scaled as 0. All utilities lie between 1 and 0 inclusive (See also (Hardaker *et al.*, 1997: 90-93)

However, as Hardaker *et al.* (1997:93) note, two main consequences of the utility index/scale are possible. First, it makes no sense to say one prospect is yielding twice as much utility as

[18] The scale is defined up to positive linear transformation. See also chapter 2.

another and secondly, it is not possible to have interpersonal comparison of utility although comparisons of risk aversion are possible as is evident in this chapter.

The evaluation criterion used in selecting the utility functional forms was on the basis of explanation, i.e. R-squared and the significance of the parameter estimates[19]. In addition, comparing the shape of the curve with the plotted points obtained during the elicitation was also considered i.e. 'judged by eye'. The purpose of curve fitting is to find the equation of a curve that is already partly defined by the elicited utility points, not to fit the curve to a scatter of points representing random deviations from some underlying but unknown relationship (Hardaker *et al.,* 1997) (See also figure 4.1 in chapter 4). Consequently, the statistical measures of goodness of fit such as R-squared, in most cases do not have their usual interpretation. Table 6.3 shows the chosen functional forms that fitted the data in each situation. Note that the evaluation of the functions that fitted the data was done using the overall sample and not the functions of individual farmers. This was mainly to simplify the process and save time.

Table 6.3 Models that fitted the data well in different situations

Situation	Model that fitted the data well	Form of the model tested[a]
Inadequate cash	Quadratic	$u(x) = a + bx + cx^2$
Inadequate food stocks	Cubic	$u(x) = a + bx + cx^2 + kx^3$
Adequate food stocks	Logarithm	$u(x) = b_0 + b_1 \ln(x)$
Adequate cash	Exponential	$u(x) = b_0 e^{-b1x}$

[a] Default SPSS formulations

The logarithm and exponential utility function formulations in table 6.3 are not the same as those postulated for this analysis (i.e. $u(x) = a + b\ln(x+c)$ for logarithm, and $u(x) = a_0 + be^{-cx}$ for negative exponential). As a result the two models were estimated by non-linear regression analysis using Levenberg-Marquardt algorithm[20] (SPSS PC+). The rest were estimated by curve fit (SPSS PC+). The results in this table suggest that there are different optimal functions for different situations facing the farmer.

[19] It is important to note that in addition to statistical tests above, the prediction power of the models is an important aspect of model selection. While we acknowledge this importance, it was unfortunately not done in this study given the time constraint. The use of multiple ways of evaluating the function was done deliberately because of the weaknesses of the different ways used. For example, the use of R^2 for exponential and quadratic utility functions which do not have the same dependent variable and are not nested to each other may be misleading. The appropriate way which was not used in this study could have been to construct non-nested hypotheses such as a J-test or a Cox test (See also Greene 1993:222-224)

[20] Levenberg-Marquardt is a method of iterative algorithm for computing parameter estimates. At each iteration, the estimates are evaluated against a set of control criteria. The iterative calculations continue until one of five cut off points is met, at which point the iterations stop and the solution is displayed (SPSS).

6.1.3 Results of Arrow-Pratt absolute coefficient of risk aversion (R_a)

The situation when the farmer has inadequate cash.
The quadratic utility function form was used to fit the data in inadequate cash situation for each farmer.

Arrow-Pratt's absolute coefficient of risk aversion was calculated for each farmer as $R_a = u''(x)/u'(x) = -2c/b+2cx$. The results are presented in appendix 7. The results show that R_a is positive for about 93% of the sample, indicating risk averse. The mean value of R_a for risk averse farmers is 0.00278.

The model identified only two farmers (7%) as risk takers (medium scale male farmers) with mean R_a of -0.00445. The results show that when farmers are constrained by cash (inadequate cash situation) the majority tends to become more risk averse while only a few are willing to take risks. R_a for the sample ranged from –0.00563 to 0.00547 with a standard deviation of 0.002 (Appendix 7). The expectation in this situation was that at least all farmers could have been risk averse because of the inadequate situation. However, as will be evident later in this section, the overall coefficient of risk aversion for all farmers is higher in this situation, indicating more risk averse behaviour.

The situation when the farmer has inadequate food stocks.
The utility functional form that fitted the data well was a cubic function (CUF).

The Arrow-Pratt absolute coefficient of risk aversion is given as: $R_a = - u''(x)/u'(x) = - (2c-6kx)/(b+2cx+3kx)$. The utility function classified 90% of the farmers as risk averse (mean R_a is 0.002496) and 10% of the farmers as risk seekers (mean R_a is -0.00146). The overall average R_a is 0.0021. R_a ranges from –0.00249 to 0.00431. Among the risk seekers are two male small and medium farmers and a small female farmer. The results show that when farmers are confronted with the situation of having inadequate food stocks the majority tends to be risk averters while very few of them are willing to take risks. The expected result in this situation is that at least all the farmers could be classified as risk averse because of the unfavourable situation of inadequate food stocks. The overall figure of the coefficient of risk aversion for all farmers in this situation is higher then in the situation of inadequate cash, indicating more risk averse behaviour (See pairwise comparisons of the coefficient of absolute risk aversion later in this section).

The situation when the farmer has adequate food stocks.
The utility functional form, which fitted the data well, was a logarithm. The model was estimated by non-linear regression analysis for each farmer using Levenberg-Marquardt algorithm (SPSS PC+). The estimated logarithm model was $u(x) = a + b\ln(x+c)$.

Arrow-Pratt's absolute coefficient of risk aversion was calculated as: $R_a = 1/x+c$. The results are presented in appendix 7. The R_a ranged from 0.00047 to 0.0050 with a mean of 0.0017 and a standard deviation of 0.001. The logarithm function classified all farmers as risk averters in a situation when they have adequate food stocks.

The situation when the farmer has adequate cash
The utility functional form that fitted the data well is negative exponential. A negative

exponential function of the form $u(x) = a_0 + be^{-cx}$ was estimated using non-linear regression by the Levenberg-Marquardt algorithm (SPSS). The value of R_a was given as the estimated coefficient *c*. R_a values range from 0.00006 to 0.00236 with a mean of 0.001. The results for each farmer are presented in appendix 7. All the farmers were classified as risk averse because the negative exponential function exhibited a constant positive R_a for each farmer. The latter is argued to be one of its major weaknesses.
Pairwise comparison of the Arrow-Pratt absolute coefficients of risk aversion is presented in table 6.4.

Table 6.4 Pairwise comparisons of the means of the Arrow-Pratt coefficient of absolute risk aversion (R_a) in different situations

Pair of R_a	t-value	Probability
When the farmer has inadequate cash (R_a1) and When the farmer has inadequate food (R_a2)	0.03	0.98
When the farmer has inadequate cash (R_a1) and When the farmer has adequate food (R_a3)	1.19	0.24
When the farmer has inadequate cash (R_a1) and When the farmer has adequate cash (R_a4)	4.26*	0.00
When the farmer has inadequate food (R_a2) and when the farmer has adequate food (R_a3)	1.39	0.18
When the farmer has inadequate food (R_a2) and When the farmer has adequate cash (R_a4)	4.71*	0.00
When the farmer has adequate food (R_a3) and when the farmer has adequate cash (R_a4)	2.93*	0.01

t significant at p=0.05

As pointed out earlier, farmers were expected to be less risk averse (lower coefficient of risk aversion) when anticipating a higher level of 'wealth' (food stock or cash). As a result most people will be decreasingly averse to risk if they are rich or earning higher in a particular undertaking. In the situation of adequate cash the calculated R_a is significantly smaller as compared to the other situations, supporting the proposition that farmers become decreasingly risk averse if they are rich or earning more. In the case of adequate food, the calculated R_a is smaller than in the situations of inadequate food and inadequate cash, implying that farmers are less risk averse in an adequate food situation as compared to inadequate food and inadequate cash situations. However, the differences were not significant (Table 6.4).

Comparing the worst situations (inadequate cash and inadequate food stock) farmers are slightly more risk averse in the situation of inadequate cash as compared to the situation of inadequate food. However, the differences were also not significant.

6.1.4 Results of Arrow-Pratt coefficient of relative risk aversion (R_i)

The situation when the farmer has inadequate cash

The Arrow-Pratt relative coefficient of risk aversion is given as $R_i = R_a x$. The results are presented in appendix 8. The calculated R_i ranges from -1.447 to 2.480, with a mean of 0.627 and a median of 0.573.

The high standard deviation of R_i of 0.783 indicates high variations in risk attitude under this situation.

The situation when the farmer has inadequate food stocks

The Arrow-Pratt relative coefficient of risk aversion R_i ranges form –0.98 to 2.64, with a mean of 0.674, standard deviation of 0.705 and median of 0.775.

The situation when the farmer has adequate food stocks

In this situation the R_i ranges from 0.18 to 1.50 with the farmers evenly distributed. The mean value of R_i is 0.383, a median of 0.326 and a standard deviation of 0.230. The statistics indicate high heterogeneity in R_i.

The situation when the farmer has adequate cash

The mean value of the coefficient of relative risk aversion R_i is 0.215 and a median value of 0.2. The value ranges from 0.134 to 0.875. The standard deviation is 0.165 and it shows that there is a high heterogeneity in relative risk attitudes among farmers.

Pairwise comparison of the R_i's is shown in table 6.5. The results are similar to those obtained while comparing the coefficient of absolute risk aversion. The situation with adequate cash has the lowest mean R_i as expected, implying that farmers are less risk averse in the situation with adequate cash as compared to all the other situations. In the situation with adequate food stocks R_i is significantly smaller as compared to the situations with inadequate cash and inadequate food, supporting the proposition that farmers are less risk averse when experiencing a 'wealth'

Table 6.5 Pairwise comparison of the means of the Arrow-Pratt coefficient of relative risk aversion (R_i) in different situations

Pair of R_i	t-value	Probability
When the farmer has inadequate cash ($R_i 1$) and When the farmer has inadequate food ($R_i 2$)	-0.67	0.51
When the farmer has inadequate cash ($R_i 1$) and When the farmer has adequate food ($R_i 3$)	2.10*	0.05
When the farmer has inadequate cash ($R_i 1$) and When the farmer has adequate cash ($R_i 4$)	2.57*	0.02
When the farmer has inadequate food ($R_i 2$) and when the farmer has adequate food ($R_i 3$)	3.87*	0.00
When the farmer has inadequate food ($R_i 2$) and When the farmer has adequate cash ($R_i 4$)	6.65*	0.00
When the farmer has adequate food ($R_i 3$) and when the farmer has adequate cash ($R_i 4$)	0.68	0.50

*Significant at $p \leq 0.05$.

situation. Although an adequate cash situation has a lower R_l as compared to the situation with adequate food, the differences in R_l were not significant.

Comparing the worst situations (i.e. inadequate cash and inadequate food stocks) R_l is lower in the situation of inadequate cash compared to the situation of inadequate food, but the differences were not significant.

6.1.5 Differences in indicators of risk attitude by farmer categories

The aim of this subsection is to investigate the differences in the indicators of risk attitude between male and female and between farmer categories[21] in each situation analysed. Where possible the reasons for the differences/similarities are presented.

Male and female farmers showed a significant difference in risk attitude measures only in the situation of inadequate food. In this situation, male farmers are significantly more risk averse as compared to female farmers (Table 6.6). This result was not expected because female farmers are traditionally concerned with food production while males focus more on cash-oriented undertakings. When faced with inadequate food, female farmers could have been more risk averse. Probably an explanation may be that male farmers are responsible for food purchase during difficult times, as a result they may be more cautious in inadequate food situations.

Table 6.6 Gender differences with respect to the risk attitude indicators R_a and R_l

Situation	Mean R_a		t-value	Mean R_l		t-value
	Men	Women		Men	Women	
Inadequate cash	0.0023	0.0026	0.35	0.609	0.740	-0.31
Inadequate food stocks	0.0025	0.0008	2.40*	0.378	-0.400	3.75*
Adequate food stocks	0.0048	0.0067	-0.94	2.114	2.623	-0.48
Adequate cash	0.0008	0.0010	-0.46	0.226	0.148	0.88

Source: Survey data, * indicates significant at ($p \leq 0.10$).

Pairwise comparison of risk attitude indicators between large, medium and small farmers shows that there are no significant differences in all measures between large and medium farmers (Table 6.7). Significant differences are observed between large and small farmers and between medium and small farmers. Table 6.7 shows that small farmers are more risk averse than large and medium farmers when they are faced with the situation of inadequate cash. Again this result is expected, as small farmers are adversely affected by risk factors as compared to large and medium farmers. This becomes worse when she/he faces the situation of inadequate cash.

In inadequate food stock and adequate food stock situations, large farmers are significantly more risk averse as compared to small farmers (coefficient of absolute risk aversion). In the

[21] For farmer categories see chapter 4

study area, most large and medium scale farmers are also having off-farm generating activities. They may be cautious in making farm production decisions when they are faced with these situations.

Table 6.7 Differences between farmer categories with respect to risk attitude indicators

Situation	Large and Medium		Large and Small		Medium and Small	
	R_a	R_i	R_a	R_i	R_a	R_i
	t-value		t-value		t-value	
Inadequate cash	0.96	0.25	-3.24*	-3.10*	-2.66*	-1.36
Inadequate food stocks	1.16	1.06	1.86*	1.45	-0.63	-0.60
Adequate food stocks	-0.08	0.10	2.90*	0.09	1.84*	0.24
Adequate cash	-0.21	-1.39	-0.10	0.02	0.14	0.92

Source: Survey data, * indicates significant at ($p \leq 0.10$).

6.1.6 Relationship of risk attitude indicators with household resources and characteristics

From the farmers' conceptual framework (Chapter 3), a relationship between risk attitude, risk perception and farmers' characteristics and resources was hypothesised. Initially, the following variables were assumed to be predicting/explaining the observed risk attitude of farmers. These are: age in years, years of education, family size (in number), farm size (in hectares), number of trees planted, asset index, household cash income and gender of the farmer (gender of the farmer was represented by a dummy variable =1 if male and 0 if otherwise). However, the inclusion of the above variables in a regression analysis (using Ordinary Least Squares (OLS) made the estimated relationship to be more insignificant in terms of parameters. As a result multicollinearity[22] was suspected. It was therefore decided to combine some variables, which were believed to be measuring/contributing to the same variable 'wealth', i.e. an aggregate of present and future income of the household. The variables farm size, number of trees planted, asset index, and household cash income were combined into a score using factor analysis. The items had a factor loading of >7.0 in a factor with a highest Eigen Value of 2.01. The items included explained about 50% of the variations in the 'wealth' factor. The items were therefore combined into a wealth score using SPSS PC+. The wealth score was used as an independent variable in a regression analysis. The predictors were therefore reduced into 5 namely education, age, gender, wealth and household size and they were applied in all the relationships postulated.

Regression analysis (OLS) was applied as the method of analysing the postulated relationship for each situation of risk attitude measurements in the utility theory category. The dependent variable is the coefficient of absolute risk aversion[23] derived from the estimated

[22] It is pointed out in Koutsoyiannis (1977:238-239) that multicollinearity can be detected by standard errors, partial correlation and R-squared, but none alone is a satisfactory test. A procedure of testing suggested, of detecting useful, superfluous and detrimental variables was used. Interested readers are referred to Koutsoyiannis (1977).

[23] Due to time constraints only the coefficient of absolute risk aversion was used.

utility functions. If the estimated independent variable has a positive sign, it implies that with an increase in that variable, the risk attitude coefficient is also increased, resulting in more risk adverse behaviour of the farmer.

The results of regression analysis of risk attitude indicators are shown in table 6.8 and appendix 6. Very few variables were significant in explaining the variations in risk attitude indicators. The variables wealth, years of education, household size and the age of the respondent are significant in one or two situations, while the gender variable is not significant at all. The significant variables are negatively related to risk attitude measures indicating that as these variables are increased, the individuals become less risk averse and are consistent to the expected relationships. Education and age variables are related to the level of information processing and experience in farming, which improves decisions involving risk. The household size variable is often related to family labour availability. The bigger the household size the more family labour is available for farm work. This also contributes in making farmers less risk averse.

However, there was a low level of explanation of risk attitude indicators by the included variables in each analysed situation showing a weak explanation of the included predictor variables in each analysed situation (Table 6.8). However, when the risk coefficients are combined by means of factor scores (using factor analysis see section 4.5 for factor analysis) over all the situations, the explanation of the included variables improved and three out of five variables were significant and had expected negative signs (Table 6.8).

Table 6.8 Effects of household resources and characteristics on indicators of risk attitude (n=30)

Variable	Inadequate cash		Inadequate food		Adequate food		Adequate cash		Combined risk attitude coefficient	
	Sign	Significance	Sign	Signifi cance	Sign	Significance	Sign	Significance	Sign	Signifi cance
Education (years)	(-)	-	(+)	-	(-)	*	(+)	-	(-)	*
Age (years)	(-)	*	(-)	-	(-)	-	(+)	-	(+)	-
Gender (dummy: 1 if male, 0 if female)	(+)	-	(+)	-	(+)	-	(+)	-	(-)	-
Wealth (score)	(-)	*	(-)	-	(+)	-	(+)	-	(-)	*
Household size (number)	(-)	-	(-)	-	(-)	*	(-)	*	(-)	*
R-squared	0.49		0.22		0.42		0.30		0.63	

* Means the coefficient is significant ($p \leq 0.10$ two tailed)

\- Means not significant

If the number of years in education, household size and wealth variables are increased, holding other factors constant, there is a significant decrease in the magnitude of the coefficient of risk aversion.

6.2 Results of risk attitude measurement using the Latent Variable Approach

This section presents the results and discussion of risk attitude measurements using the latent variable approach (factor analysis). The 25-attitudinal items/statements included in the structured questionnaire (Appendix 1) were first clustered into three main research variables namely attitude towards risk, attitude towards commercialisation and attitude towards land resource conservation. Then, each set of items/statements in the research variables were subjected to factor analysis with the aim of identifying a relatively small number of factors that can be used to represent a relationship among sets of interrelated items/statements.

The factors/latent variables that have the highest Eigen Values in each case are used to develop factor scores for measuring the attitudinal variables. The factor loading of each item in each case contributes to the computed factor score (which is a type of risk attitude in a wider context). All these are done using SPSS PC+.

The attitudinal variables, together with household resources and characteristics were postulated to explain the risk attitude of the decision-makers, measured by the latent variable approach. Percentages were calculated and a regression analysis was used in summarising the results.

Table 6.9 Items/statements and their factor loadings, measuring attitude towards risk in the latent variable approach

Item	Researcher's hypothesis	Outcome from farmers	Factor loading [a]
T2 Without taking risk farming is not worthwhile	Agree	Agree	0.5000
T3 I believe that the best farmers take the most risks	Disagree	Disagree	-0.3457
T4 By always being cautious in farming I could not get ahead	Disagree	Disagree	-0.6279
T5 To have nice things in life I cannot be as cautious in farming as I should be	Disagree	Disagree	-0.5669
T9 I try new things on my farm even if I lose money on it	Disagree	Disagree	-0.7501
T10 We always try new things on our farms	Agree	Disagree*	-0.5840
T17 I believe that big farmers are not bothered by rainfall problems	Agree	Agree	0.6723
T24 If I had more labour I could get reliable crops, which do not fluctuate	Agree	Agree	0.5301
T25 If I had more capital to invest in my farm I could get reliable crops, which do not fluctuate	Agree	Not used	-

Source Survey data

* Means that there is a difference between researcher's expectations and farmers' actual answers.

[a] Un-rotated factor loading computed from factor analysis

6.2.1 Attitude towards risk

Items/statements measuring the risk attitude were postulated as shown in table 6.9.

The results of factor analysis indicated that 28.7% of the variations are explained by the included items/statements in the factor with the highest Eigen Value of 2.584. However, statement T25 (See table 6.9) had a very low factor loading (almost zero) as compared to the other items/statements, implying that the answers are almost not correlated with the answers in the other items/statements.

When item T25 was removed from the analysis, the explanation by the included factors rose to 32.5% and the items/statements included loaded highly (>3.0). Items/statements T2, T3, T4, T5, T9, T10, T17 and T24 were used to generate the factor scores for attitude towards risk (Table 6.10). Rotation of the factors using the varimax method did not produce better results as compared to the un-rotated solution.

Items/statements T3, T9 and T10 loaded negatively which means the respondents who scored 'agree' to items/statements T2, T4, T5, T24 also scored 'disagree' in items/statements T3, T9 and T10. The negative loading to item T10 is contrary to the researcher's expectation. Farmers disagree that they always try new things on their farms. The hypothesis was that farmers have a positive attitude towards risk by adopting new techniques on their farm. As a result they were expected to accept it, but instead they rejected the researcher's hypothesis. However, since adoption and trying new techniques on the farm is supporting risk taking behaviour, farmers who rejected it were taken as having a negative attitude towards risk.

Table 6.10 shows that for items/statements T2, T3, T4, T5 and T24 more than 90% of the respondents acknowledge a positive attitude towards risk. However, items/statements T9 and

Table 6.10 Respondents indicating a positive attitude towards risk[1)] by village

Village/Item	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
T2	95	96	90	100	95
T3	84	93	97	100	94
T4	95	100	90	95	95
T5	100	100	94	95	97
T9	53	14	6	18	20
T10	40	61	52	50	45
T17	68	4	6	22	20
T24	100	93	84	100	93
Overall	75	70	65	73	70

1) For a definition see section 2.2

Source: Survey data

T17 showed a high heterogeneity in responses making the overall figure to be interpreted with caution. Bonga, Singe and Himiti, showed low responses to items/statements T9 and T17, while Magugu village showed high responses.

On average, about 70 % of the respondents showed a positive attitude to risk. There were no significant gender differences in the responses. With respect to T9 and T17, Magugu village had significantly high responses as compared to the rest of the villages. On the other hand, Singe had significantly low responses to those items/statements as compared to the rest of the villages. This implies that farmers in Magugu have a more positive attitude to risk with respect to these items/statements as compared to the rest of the villages. The opposite is true for Singe village. This may be related to the drought sensitivity in Magugu village.

6.2.2 Attitude towards land resource conservation

Items/statements believed to be measuring the attitude towards land resource conservation and their hypothetical sign values were postulated as shown in table 6.11.

Results of factor analysis show that items/statements T6, and T13 had a very low factor loading on the factor with the highest Eigen Value. When these items/statements are removed, the factor loading of the items/statements improved (>3.0). Explanation by the included items/statements improved from 21.1% to 26.1%. As a result items/statements T7, T8, T11,

Table 6.11 Items/statements and their factor loadings, measuring attitude towards land resource conservation in the latent variable approach

Item	Researcher's hypothesis	Outcome from farmers	Factor loading [a]
T6 In order to make some money, I have to do some things that are not good for the soil	Disagree	Not used	-
T7 The way we are farming now is not good and cannot last forever	Disagree	Disagree	-0.4894
T8 If I keep farming like this I will exhaust the land	Agree	Agree	0.4138
T11 We need to preserve the way our parents farmed	Agree	Agree	0.6694
T12 I cannot afford to worry about preparing for the future	Disagree	Disagree	-0.5307
T13 I worry that the land will not produce much when our children will take over farming	Agree	Not used	-
T14 There will be plenty of opportunities for our children	Disagree	Disagree	-0.5189
T15 We are required to conserve our environment in order to have higher yields	Agree	Agree	0.3016
T16 Cropping systems that conserve soil and water are the only ones that will help us during low rainfall	Agree	Agree	0.5959
T18 We need to make changes in our farming practices for the benefit of the future	Agree	Agree	0.5248

[a] Un-rotated factor loading computed from factor analysis

T12, T14, T15, T16 and T18 were used to calculate factor scores in measuring the attitude towards land resource conservation (Table 6.11). All the items/statements included have the same sign as expected.

The results show that about 59% of the respondents in the survey area have a positive attitude towards land resource conservation (Table 6.12). Significant differences between male and female respondents as well as differences between villages were not evident.

Discussions with farmers in the study area showed that farmers together with the LAnd Management Project (LAMP) have developed soil and water conservation strategies in response to the changing socio-economic and environmental conditions. As will be pointed out in chapter 7 the main sources of risk are drought and poor soils. In response to those risks, soil and water management strategies are used, such as ridges, application of manure, bench terraces, deep ploughing using tractors and animal power and tree planting. These together with the perceived soil fertility decline prompt farmers to have a positive attitude towards land resource conservation. In addition, floods in the area make farmers to have a positive attitude towards land resource conservation.

Table 6.12 Respondents indicating a positive attitude towards land resource conservation

Village/Item	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
T7	16	25	26	18	22
T8	16	14	13	23	16
T11	95	93	94	96	94
T12	16	32	36	27	29
T14	37	21	26	27	27
T15	100	86	97	100	95
T16	95	93	100	86	94
T18	100	100	94	96	97
Overall	68	58	50	56	59

Source: Survey data

6.2.3 Attitude towards commercialisation

Six items/statements were considered in measuring the attitude towards commercialisation. These are presented in table 6.13.

The results of a factor analysis of the above items/statements showed that items/statements T20 and T21 loaded very low to the factor with the highest Eigen Value (1.86). When these items/statements are removed, the factor loading of the remaining items/statements is >6.0, showing a high loading i.e. a high correlation of responses among the items/statements included. The explanation of the variations in the factor improved from 31.3% to 46.5%. As a result items/statements T1, T19, T22 and T23 were used to explain the attitude

Table 6.13 Items/statements and their factor loadings, measuring the attitude towards commercialisation in the latent variable approach

Item	Researchers' Hypothesis	Outcome from farmers	Factor loading [a]
T1 if there is an opportunity to make money I will use it	Agree	Agree	0.6122
T19 growing as many crops for sale is the best I can do for this farm	Agree	Agree	0.6981
T20 frequent change in crop prices is the biggest problem for my income	Agree	Not used	-
T21 information on produce prices helps me to decide on what crops to produce for sale	Agree	Not used	-
T22 in the future we will grow more and more crops for sale	Agree	Agree	0.6716
T23 the most important thing for a farm household is to grow all its own food requirements	Disagree	Agree *	0.7308

* Means that there is a difference between researchers' expectations and farmers' actual answers
[a] Un-rotated factor loading computed from factor analysis

towards commercialisation. With the exception of T23, the signs of all the other items/ statements conform to the researchers' prior expectation implying that the researcher's assumption about those items/statements is accepted. Agreement with item T23 means that farmers attach more weight to the production of food for home consumption and therefore they have a low attitude towards commercialisation with respect to item T23.

However, items/statements related to products' prices loaded very low and were ultimately removed (T20 and T21). This means that the respondents' answers to these two items/statements are not very much related to the answers of the other items/statements and thus do not measure the same thing. Reflecting the results of chapter 5, changes in producer prices and price information were not perceived as a constraint. This and the finding that the main marketing problems in the surveyed area are non-availability of market outlets and

Table 6.14 Respondents indicating a positive attitude towards commercialisation

Village/Item	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
T1	100	78	87	86	87
T19	79	54	42	45	53
T22	11	43	36	32	32
T23	21	0	0	9	6
Overall	42	35	33	35	37

Source: Survey data

infrastructure problems rather than on problems related to the price, explain why T20 and T21 were left out.

Farmers' attitude towards commercialisation is rather low with an overall average of 37% of respondents showing a positive attitude towards commercialisation (Table 6.14). In a way the results were expected because the farmers' major objective in farming was indicated as to produce enough food for their family consumption and to sell only to a small extent cash crops and surplus food crops (this is supported by the small number of people agreeing to item T23 (Table 6.14). However, poor market outlets and road infrastructures exacerbate this situation, making villagers think more of the production for home consumption.

The respondents showed a rather low attitude towards commercial farming. Gender differences in the responses were not explicit. Magugu village had a significantly lower response in item T22 as compared to the rest of the villages. However, the overall responses were not significantly different among the villages.

The results of the attitudinal variables have shown that Magugu village and Singe have higher and lower non-significant differences to the attitudinal measures respectively. The reasons for this were not very apparent from the interviews. However, through observations and discussion with farmers, the higher response from Magugu might have been brought about by the sensitisation given by the Land Management Project which started its activities in the area just before the field work.

6.2.4 Relationship between risk attitude and household resources and characteristics

Following the conceptual framework in chapter 3, a relationship between risk attitude measured by the latent variable approach and household resources and characteristics was postulated. Two attitudinal measures emanating from the latent variable approach are also included. These are attitude towards land resource conservation and attitude towards commercialisation. It is expected that as the attitude towards commercialisation and land resource conservation increases, the attitude towards risk will also increase. An increase in attitude towards risk means that the farmers become less risk averse. An increase in attitude towards land resources conservation and consequently adopting measures to improve land resources is just like taking risk in an investment whose returns are expected in the future. Likewise, high scores on attitude towards commercialisation are postulated to have high scores on attitude towards risk, i.e. farmers are willing to take risks related to the markets.

As mentioned earlier in this chapter attitudinal variables are measured by the items/statements found to be reliable, obtained by means of factor analysis (items/statements in the factor with highest Eigen Value which have a factor loading of ≥ 3.0). The items/statements were combined into a factor score using SPSS PC+ for each attitudinal variable. Some of the items/statements were reversed so that they all measure a positive attitude towards a given concept, for example T10 and T23.

Household resources and characteristics were obtained from the questionnaire survey (Appendix 1). Items/statements measuring 'wealth' i.e. household income, number of trees planted, asset index and farm size, were combined into a score using factor analysis. These items/statements had a factor loading of >4.0, and explained 44.1% of the variations in the factor with the highest Eigen Value of 1.76.

A linear multiple regression analysis was used to show the relationship between attitude towards risk and the other attitudinal variables and selected household resources and characteristics. The included independent variables are the attitude towards land resource conservation (measured as a score), age (in years), gender (using dummy variable =1 if male and 0 if female), attitude towards commercialisation (measured as a score), education (in years), household size (in number) and wealth (measured as a score).

Considering the assumptions of both the linear multiple regression and that of the estimating technique (Ordinary Least Squares, see appendix 4) the results reported in table 6.15 were obtained.

Table 6.15 Results of multiple linear regression explaining attitude towards risk (in a wider context) (n=100)

Variable	Coefficient	t-statistic	Probability
Constant	0.906	1.751	
Age (years)	-0.006	0.919	0.360
Gender (dummy: 1 if male and 0 if female	-0.024	-0.719	0.474
Attitude towards land resource conservation (score)	0.212	2.271*	0.026
Attitude towards commercialisation (score)	0.270	3.081*	0.003
Education (years)	0.589	2.891*	0.005
Household size (number)	-0.013	-0.384	0.702
Wealth (score)	0.279	3.058*	0.003
R^2	0.74		

*Significant at $p < 0.05$

The results of the regression analysis suggest that the included variables account for more than 70% of the variation in positive attitude towards risk among the farmers in the study area. Four of the seven independent variables had significant partial regression coefficients implying that the variables' effect on risk attitude is not by chance. The attitude towards commercialisation was the biggest predictor of risk attitude. The positive regression coefficient indicates that high scores on attitude towards commercialisation lead to high levels of risk attitude. These results are as expected.

The wealth variable has a positive coefficient and is significant in explaining the variations in attitude towards risk. This was expected as the wealthier the individuals are, the more flexible they are in taking risks.

As expected, educated farmers as well as farmers with a positive attitude towards land resource conservation tended to take the most risks and their attitude towards risk increases as these variables are increased. This is shown by the positive and significant regression coefficients (Table 6.15).

6.3 Testing the reliability of risk attitude measures using correlation analysis

The aim of this analysis is to find out whether the different risk attitude coefficients measure the same thing (in this case risk attitude of the respondents using the utility theory category and using the latent variable category). According to Musser and Musser (1984), one way of testing reliability based on internal consistency is to compare every item to every other item in a correlation analysis.

Correlation analysis between risk attitude measures in the utility theory category and risk attitude score from the latent variable approach shows a negative correlation (Table 6.16).

Table 6.16 Correlation in each situation between risk attitude measures using the utility theory and risk attitude scores using the latent variable category

Situation	Pearson correlation Coefficient with R_a	Pearson correlation coefficient with R_i
Inadequate cash	-0.305*	-0.443*
Inadequate food	-0.304*	-0.077
Adequate food	-0.172*	-0.222
Adequate cash	-0.273*	-0.023

Source: Survey data

* Indicates that the coefficient is significant at P#0.10

Significance with respect to the absolute coefficient of risk aversion is found in the situations 'inadequate cash', 'inadequate food' and 'adequate cash'. The relative coefficient of risk aversion showed significance in the 'inadequate cash' situation only. Table 6.16 shows therefore that the latent variable measure of risk is more significantly correlated to the absolute coefficient of risk aversion as compared to the relative coefficient of risk aversion. The results show that the two approaches in risk analysis (latent variable and utility theory categories) measures more or less similar thing in an opposite direction. The differences in direction was expected because the measure of risk attitude using the latent variable approach was measuring positive attitude towards risk (willingness to take risk) (See section 6.2.4), while the coefficients obtained using the utility theory approach are showing that farmers are risk averse (unwilling to take risk), with exception of very few individuals

6.4 Major findings and conclusions

This chapter has presented the results of risk attitude. The summary of the major findings and conclusions are as given in sub-headings below.

Risk attitude using the utility theory category

Four farmers' situations were examined with respect to risk attitude measures. Two measures of risk attitude were calculated for each situation examined. These are Arrow-Pratt absolute and relative risk aversion coefficients.

The results indicate that there are differences in functional forms that fitted the data in each situation. In the situation with adequate food stock logarithm utility functional form was found desirable. In the situation of inadequate food stocks the cubic functional form fitted the data well as compared to other forms of utility function tested. Whereas the negative exponential function fitted the data well in the situation of adequate cash, quadratic utility functional form was found desirable in the situation with inadequate cash. The results emphasise the need for specification and selection of the most suitable functional forms.

Statistics of CE indicate that the situation when the farmer has adequate cash had the highest CE as compared to the others followed by the situation when the farmer has adequate food stocks. Pairwise comparison of CE shows that there are significant differences in CE between the situation when the farmers have adequate cash and the other situations. These differences give an indication that farmers have different risk attitudes under different situations.

The coefficients of risk aversion (Absolute R_a and relative R_i) were calculated and presented for each situation. Pairwise comparison of R_a, R_i and CE support the prior expectation that if farmers are rich or earning higher in a particular undertaking, they tend to be less risk averse. This was particularly supported by the situation when the farmers experience adequate cash. Among the worst situations, farmers are slightly more risk averse in the situation of inadequate cash as compared to the situation of inadequate food (the differences were not significant).

The results show further that there are significant differences in risk attitude indicators such as R_i and R_a, among categories of farmers. Male farmers are significantly more risk averse as compared to female farmers when faced by the situation of inadequate food stocks. Small farmers are more risk averse than large and medium farmers in the situation of inadequate cash, while the opposite is true when the farmers are facing the situation of inadequate food stocks and adequate food stocks.

In the relationship between risk attitude indicators and household resources and characteristics, wealth, years of education, household size and age of the respondents were found to be significant in explaining risk attitude in various situations. However, the predictor variables had low explanation as indicated by R-squared. Similar observations were also noted by Walker (1981) and Smidts (1990). When the coefficients of absolute risk attitude are combined together in a score, more explanation of the dependent variable is attained. In this case, significant predictor variables are education, wealth and household size. In the research by Walker (1981) the education variable, measured as years of schooling, was significant in explaining the variations in risk attitude as is the case in this research.

Based on the above four important conclusions can be drawn from this section. **First,** whereas there are many attempts in estimating measures of risk aversion, apparently very few have been tested in sub-Saharan Africa. Studies by Wolgin (1975) and Mtoi (1984) are among the few attempts and they used the normative approach (See chapter 2). This attempt using positive approach has provided similar observations as elsewhere (See chapter 9 for comparison between risk attitude measures from this study and other studies). **Secondly,** the results have supported various recommendations given by earlier studies such as specification and estimation of suitable utility functions as different farmers' situations showed different utility functional forms. The study has demonstrated that the choice of a utility function cannot be disregarded, as it is an important aspect of the methodology of applying the utility theory. Generally, the results of risk attitude measurements using utility theory category are as expected, where farmers are less risk averse when anticipating/experiencing a wealth situation.

Thirdly, CE and the measures of risk aversion varied between farmers and among the various situations analysed. However, the more favourable the situations the less risk averse are the farmers. It should be noted that since an individual's risk preference and utility function are unique to each individual, it is not expected that one utility function will be suitable for all individuals. **Fourthly,** this sub-section has demonstrated that categorising risk attitude studies into different situations facing the farmers and into farmer categories assists in unveiling the differences in risk attitude indicators such as R_i and R_a.

Risk attitude using the latent variable approach

The results of risk attitude using the latent variable approach were presented in two parts. The first part looked at the farmers' responses with respect to various attitudinal measurements using the structured questionnaire. Special attention was paid to whether there were gender differences in the responses or not. The second part looked at the relationship between positive risk attitude and the other attitudinal measurements as well as with selected household resources and characteristics.

The results have shown that the use of factor analysis can assist in selecting a number of items/statements that measure a certain construct which is reliable. In addition, the items/statements can be combined into a score for a particular factor/latent variable for inclusion in a regression analysis. The score for each set of items/statements measures the attitude towards that particular factor.

Based on the above results, it can be concluded that a substantial number of farmers have positive attitudes towards risk and land resource conservation. Because of their main objective in farming of producing mainly for subsistence consumption, lack of reliable market outlets and poor transport infrastructure, attitude towards commercialisation in farming was low. Generally, gender and village differences in responses were not evident.

Bearing in mind the limitation of the estimating technique, positive risk attitude was significantly explained by attitude towards land resource conservation, attitude towards commercialisation, wealth of the individuals and number of years in education. If these variables are increased there will be increases in positive risk attitude. Similar results are observed elsewhere. For example, Adubi and Daramola (1996) found in Nigerian smallholder agriculture that risk decreases with an increase in farm size (one of the items/statements included in the wealth score in this study).

Latent variable category versus utility theory category in risk attitude analysis

It was pointed out in chapter 2 that the application of the Subjective Expected Utility (SEU) model in agriculture has received several criticisms, ranging from low predictive validity, failure to recognize various psychological principles of judgment and choice to problems of subjective probability elicitation, encoding and analysis. The measurements in the utility theory category in this study, were designed in such a way as to avoid the above mentioned problems. Yet, it was found useful to conduct a parallel analysis of risk attitude using the latent variable category.

The latent variable category looks at the risk attitude in a wider perspective and measured it using various items/statements believed to be indicating/showing risk attitude from farmers' perspectives. Further, other attitudinal measures can be analyzed and compared with risk attitude measures. However, both categories produced results which are consistent to small-holders' conditions.

The application of the latent variable category avoided the difficult task of eliciting subjective probabilities as well as the difficulties of encoding and analysis. It involved a rather simple method of data collection which is time conscious. However, the method does not generate the Arrow-Pratt coefficients of risk aversion and thus, does not classify farmers into risk averse,-neutral and -seekers. It is therefore not useful for inter-personal comparisons of utilities. Both methods generate measures of risk attitude that can be used to analyze the relationship between risk attitude with household resources and characteristics.

The use of the utility theory category involved the time consuming elicitation process, probability encoding and analysis. The method is not suitable for a quick evaluation of risk attitude and needs rather more specialised persons to apply as compared to the latent variable approach. The utility theory category does not consider the fact that risk attitude can be measured by many but interrelated items/statements. Significant negative correlation between some measures of risk attitude derived from the latent variable category showed that they more or less measure the same thing in the opposite direction. Based on above and the results of correlation analysis, the latent variable approach can be proposed as a quicker way of getting insights to peoples' risk attitude. However, more research work is still needed to prove this.

CHAPTER 7

RISK PERCEPTION: EMPIRICAL RESULTS USING STRUCTURED QUESTIONNAIRE APPROACH AND STRENGTH OF CONVICTION METHOD

The first part of this chapter presents the results of risk perception measurement using the structured questionnaire. The second part gives the results of risk perception measurements using the strength of conviction method, which entails eliciting farmers' subjective probability distributions (as described in chapters 2 and 4).

7.1 Risk perception aspects in the structured questionnaire

To explore farmers' perceived risk, some risk perception items were included in the structured questionnaire (Appendix 1). The main concern in this section is how farmers (necessarily have to) deal with environmental variability (in the broadest sense), what can be learned from the farmers' risk management strategies and eventually how they can be better helped in making good decisions.

The first part of this section presents results of the perceived sources of risk in sole cropping and in agroforestry, risk perception/assessments of cropping systems and perception of trees in relation to annual crop yields. Measures to cope with the perceived risks are also presented. Emanating from the perceived risks is the problem of poor soils. This necessitated investigating in detail the perception of the respondents towards land productivity decline. Finally, perceived sources of information and their role in risk management are also briefly presented.

7.1.1 Risk perception in crop production

Farmers identified 8 sources of risk in sole cropping practices (Table 7.1). Drought, poor soils and insect and vermin attacks on crops were among the most pressing sources of risk to sole cropping.

There were differences in perceived sources of risk among the villages. Magugu villagers perceived drought and wind as the main source of risk, while in other villages poor soils were perceived as the main source of risk in sole cropping. Many respondents in Magugu mentioned drought as the main source of risk because Magugu is located in semi-arid areas of the district i.e. AEZ V (See chapter 5), where rainfall is low, erratic and poorly distributed. Bonga village, which is located in the semi humid uplands (AEZ III), has the highest and evenly distributed rainfall as compared to the other villages. Only 14% of the respondents indicated that drought is the source of risk to sole cropping. Himiti and Singe villages are located in a transition zone (AEZ IV) and had a relatively big proportion of the farmers indicating that drought is the main source of risk.

Table 7.1 Perceived sources of risk to sole cropping

Source/village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Drought	84	18	32	36	39
Poor soils	0	43	45	36	34
Insects and vermin attack	0	29	23	23	20
Late planting	0	14	26	18	16
Wind	58	0	3	9	14
Flood	5	11	13	14	11
Lack of capital	0	7	6	23	9
Delayed weeding	0	7	13	5	7

Source: Survey data

It follows therefore that drought risk perception follows the AEZ and is severe in semi-arid areas of Magugu. Likewise risk due to poor soils follow the AEZ. Zones with high rainfall as in Bonga, Himiti and Singe are subjected to soil erosion caused by water and to leaching of plant nutrients. As a result a bigger proportion of farmers indicated poor soils as a source of risk to sole cropping. Other sources of risk, which were perceived by farmers, are wind (predominantly in semi arid areas), flood (predominantly in high rainfall areas) and insect and vermin attack (predominantly in high rainfall areas).

Table 7.2 Perceived sources of risk in agroforestry

Source/Village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Competition	63	82	61	68	69
Insect and diseases	21	21	3	9	13
Difficult to plough	0	7	7	23	9
Drought	26	4	7	0	8
Poor soils	0	4	7	0	3

Source: Survey data

In agroforestry, farmers identified 5 sources of risk. In all the villages, competition with annual crops by trees was perceived as the first source of risk in agroforestry. The possibility of trees harbouring insect pests and promoting incidences of diseases were also seen as a main source of risk in agroforestry (Table 7.2). Drought, which was the first source of risk in sole cropping was the fourth source of risk in agroforestry. Generally, perceived sources of risk which were agroforestry-specific are competition for light and nutrients and problems of ploughing using tractors mainly due to close tree spacing and problems with tree roots.

Generally, very few respondents indicated that poor soils and drought are the source of risk in agroforestry (Table 7.2). Comparing this with the results of table 7.1, there is an indication that agroforestry diminishes risks of drought and poor soils.

The above mentioned types of risks, which were identified by farmers, are related to production and are generally falling under uncertainties concerning stochastic agro-ecological factors. Other sources of risk are as reflected by the production constraints described in chapter 5. Institutional risks related to unavailability of markets for agricultural produce, which is aggravated by poor road infrastructure, were indicated as a source of risk/constraint to agricultural/agroforestry production. Another source of risk that came out from the constraints is related to financial risks. According to Hardaker *et al.* (1997) financial risks may arise as a result of using borrowed funds (leverage effect) or as a result of an unexpected rise in the interest rate. However, in our case these risks are related to the unavailability of a reliable source of agricultural finance, leading to failure in adopting technologies and improving agricultural production. As pointed out in chapter 5 adequate financing and insurance to rural people encourages the cattle sub-sector to concentrate on directly productive roles which support the sustainable use of rangelands as opposed to embodied livestock production.

Discussions with farmers indicated that they recognise human or personal risks that are related to labour and management, for example poor health or death of members of the household, divorce and carelessness in handling machinery, trees or livestock.

Farmers were asked to asses different cropping systems with regard to risk by using the key: risky, moderately risky and not risky (Table 7.3). The respondents indicated that monocropping of maize and beans is less risky as compared to when they are mixed with trees. It seems therefore that farmers perceive specific agroforestry sources of risk (competition and problems of tractor ploughing) as more detrimental compared to the benefits of agroforestry. However, some positive aspects of agroforestry can be deducted from table 7.3 by ranking it as moderately risky (more than 48% of the respondents).

Trees and perception of crop yields

Farmers were asked to give their perception regarding the effects of tree growing together with other crops in a mixture. The aim of this question was to find out whether farmers perceive any beneficial effects of trees on soil fertility and thus improve other crop yields. Farmers perceived three effects of tree growing on the farmland as shown in table 7.4.

Table 7.3 Risk perception/ assessment of cropping systems by village

Cropping system/village		Magugu	Bonga	Singe	Himiti	Overall
		% of respondents				
Agroforestry (in general)	Risky	26	27	41	33	32
	Moderately risky	21	61	48	57	48
	Not risky	53	12	11	10	19
		n=19	n=26	n=27	n=21	n=93
Maize and trees	Risky	50	41	27	30	36
	Moderately risky	50	55	60	65	58
	Not risk	0	4	13	5	6
		n=18	n=27	n=30	n=21	n=95
Beans and trees	Risky	50	35	21	32	33
	Moderately risky	44	54	64	53	55
	Not risky	6	11	14	16	12
		n=18	n=26	n=28	n=19	n=98
Maize alone	Risky	0	0	0	0	0
	Moderately risky	32	0	0	0	6
	Not risky	68	100	100	100	94
		n=19	n=27	n= 31	n=21	n=98
Beans alone	Risky	5	0	0	0	1
	Moderately risky	32	0	0	0	6
	Not risky	63	100	100	100	93
		n=19	n=27	n=31	n=21	n=98
Mixture of food crops	Risky	5	7	3	10	7
	Moderately risky	32	4	0	5	10
	Not risky	63	89	97	85	83
		n=19	n=27	n=31	n=21	n=98

Source: Survey data. Data on other mixtures specified were not obtained (See appendix 1)

Table 7.4 Perceived effects of trees on yields of other crops (n=100)

Effect	% of respondents
Increase other crops' yield	5
Lower other crops' yield	52
Has no effect on other crops' yield	43

Source: Survey data

More than half of the respondents perceived trees as reducing other crops' yield (52%). Only 5% indicated that trees increase other crops' yield i.e. perceived beneficial effects of trees on soil fertility or soil conservation. A substantial number of respondents suggested that trees have no effect on other crops' yield (43%). These differences may be due to different arrangements and spacing of the tree components and the other components as well as the type of trees planted. Many farmers perceived *Grevillea robusta, Senna siamea* and *Acacia spp.* as reducing other crops' yields.

Table 7.5 Tree species reducing other crops' yields and average number of trees planted/retained per farmer in 1994/95 (n=100)

Tree species	% of respondents	Number planted/ retained in 1994/95
Mgrivea (S) Grevillea or Silky oak (E) *Grevillea robusta*	41	114
Mjohoro (S) iron wood (E) *Senna siamea*	30	75
Mgunga (S) Acacia (E) *Acacia spp.*	14	32
Mringaringa (S) East African Cordia (E) *Cordia africana*	4	5
Mzambarau (S) Jambolan (E) *Syzygium cuminii*	3	15
Mkorosho (S) Cashewnut (E) *Anarcadium occidentale*	3	3
Mwembe (S) Mango (E) *Mangifera indica*	3	24
Mbuyu (S) Baobab (E) Gendaryandi (I) *Adansonia digitata*	2	4
Msesewe (C) Mkufi (S) Quinie tree (E) *Rauvolfia caffra*	1	2
Mtarawanda (S) Golden bean tree (E) *Markhamia spp.*	1	2
Mkaratusi (S), Gum tree (E) *Eucalyptus spp*	1	13

Source: Survey data
S=Swahili, E= English I = Iraqw C=Chaga

However, it is surprising to note that the trees perceived as reducing other crops' yield are still preferred by farmers i.e. planted or retained on the farmland (Table 7.5). This implies that these trees have other benefits which make them preferred other than only reducing annual crop yield. It was noted in chapter 5 that *Grevillea robusta* is an important timber tree in the area while *Senna siamea* and *Acacia* are famous for quality firewood. The above uses may explain why these trees are still preferred despite the disadvantage of reducing other crops' yield.

There are different ways by which trees affect other crops. Table 7.6[24] shows that farmers perceive competition for nutrients and light, problems of using tractors and possibility of harbouring crop pests as the main problems caused by trees on the farm land. Table 7.2 also pointed out that these problems are the sources of risks in agroforestry.

Table 7.6 Problems of trees on the farmland (n=100)

Problem	% of respondents
Compete with other crops	63
Difficult to plough when using tractors	28
Harbour crop pests	19
Harbour livestock pests	12

Source: Survey data

7.1.2 Measures to cope with risks in crop production

The 'conventional' treatment of risk is that it lowers the effective rate of return (by the risk premium) which leads to lower work efforts in agriculture and through which in many cases farmers may decide to choose other activities within or outside agriculture which are less risky. Another consequence is, as has been pointed out by Newberry and Stiglitz (1981:81-82), that farmers work harder as a result of risk, attempting to provide a margin for error, i.e. improving their farming to avoid extreme consequences. All these arguments show that decision-makers do not remain silent in case of risky situations.

Sonka and Patrick (1984) distinguish two types of risk responses by farmers. The first one concerns actions for reducing the effects of risk and the second one involves changes in the decision process. The second response is the result of additional information that becomes available to the decision-maker about future events (attention on the roles of information in risk management is presented in section 7.1.5 while the actions to reduce risk are presented in this section).

In view of the above farmers try a variety of ways to cope with risks in crop production. Selecting crops, which have properties like drought tolerance, quick maturing and pest

[24] In this and some following tables more than one answer was possible

resistance as mitigation against drought and pests is done in the survey area. Tree pruning to reduce the effect of competition of trees with annual crops and reducing hiding places for insect pests are also practised. This was the second important measure of reducing risk in agroforestry. Pruning has the advantage that the pruned material can be used as firewood. The use of fertilisers and manure as well as applying various soil and water conservation techniques were also among the measures used against risk (Table 7.7). Tree planting was also seen as a measure against risk. This is mainly related to diversifying major sources of output to avoid total crop failure. Farmers were also aware of the wealth stored in trees for use during difficult times i.e. farmers realise direct uses of trees and tree products and also trees as savings for future use (See also table 7.10). Magugu village has high responses regarding tree planting and pruning (Table 7.7). This may be associated with the role of trees in reducing drought-related risks in the area as pointed out in the previous section. Table 7.10 also shows that Magugu village had more than 50% of its respondents selling/liquidating trees and their products during difficult times.

Table 7.7 Measures to reduce risk in crop production by village

Source/village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Drought resistant crops	84	71	58	91	74
Prune trees	42	75	58	73	63
Use fertiliser and manure	53	50	29	68	48
Soil and water conservation	37	43	52	45	45
Plant trees	40	11	19	27	22
Use proper spacing	0	7	6	18	12
Diversify crops	5	4	3	2	5

Source: Survey Data

Farmers plant specific crops as a measure against risk (Table 7.8). Cassava, sorghum, pigeon peas, quick maturing maize varieties and sweet potatoes are the main crops grown as a measure of risk reduction.

The main characteristics of special crops grown as a measure against risk are drought tolerant, quick maturing and storability of the produce (Table 7.9). Cassava and sweet potatoes have low yield risk since they are drought tolerant and provide a stock of food locked up in the soil, which can be used during shortages. Similar strategies have also been observed in Sukuma-land Tanzania (Dercon, 1993; Ruthenberg, 1976; Malcolm, 1953).

It is pointed out by Dercon (1993) that the disadvantage of these crops is their low protein content even though with high energy. The financial returns are also low because of high transportation costs due to its bulkiness. Cassava, however, has the advantage of easy storage. In the research area some people dry cassava and store it either in a form of flour or chips. Growing of pigeon peas in Babati is becoming popular because of its high market price. In addition to reducing drought risks, pigeon peas are also a measure of reducing income risk because it is mainly produced for the market.

Table 7.8: Production of crops with a low risk by village

Source/village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Pigeon peas	84	43	81	86	72
Cassava	84	54	65	86	70
Sorghum	79	36	52	77	58
Quick maturing maize	47	36	35	23	35
Sweet potatoes	53	18	19	23	26
Finger millet	5	7	10	5	7

Source: Survey data

In addition to planting special crops to avoid risks, farmers maintain some sort of liquid asset to buffer their consumption during bad years. The use of liquid household assets has attracted a considerable attention by researchers for example Dercon (1992), Paxson, (1992), Deaton (1990, 1997) and Kinsey *et al.* (1998). The households do not only build sufficient assets in good years to be used in bad years, but they are also investing in long term liquid assets such as trees. In the study area these assets are in the form of stored grains, livestock and planted trees (Table 7.10).

Table 7.9: Characteristics of special crops against risks by village

Characteristic	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=31)	Overall (n=100)
			% of *respondents*		
Drought tolerant	68	54	55	46	55
Quick maturing	63	43	32	32	42
Easily stored/reserved	16	18	23	27	21

Source: Survey data

Farmers store their wealth mainly by purchasing livestock (50%), investing in tree planting (30%), in banks (27%) and investing in off-farm income generating activities (23%). Most farmers suggested that they liquidate (in terms of priority) stored grains, livestock, and planted trees and their products during difficult times. Almost all the surveyed villages showed this trend of asset liquidation (Table 7.10). Similar observations

Table 7.10: Items sold/liquidated during difficult times by village

Item /village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Stored grain	74	82	84	82	81
Livestock	37	79	77	82	71
Planted trees and their products	58	43	26	45	41

Source: survey data

have been recorded in Zimbabwe, where the main ways of coping with drought risk are liquidation of livestock, resorting to off-farm activities and the use of cash balances and savings (Kinsey *et al.*, 1998). However, the use of trees as savings was not observed in that part of Zimbabwe.

The above mentioned items are therefore used as a store of wealth among smallholder farmers. There are, however, implications in stored grains regarding storage structures and storage pests. It was noted in chapter 5 under constraints to agriculture that storage losses are a constraint to agricultural production. Storage losses for maize were estimated to range between 1.6 to 3.9% for farmers who used pesticides and those who did not use pesticides respectively, in a storage period of 8 months (Ashimogo, 1995:247-248).

Other measures against risk are through the diversification[25] of income sources and they are mainly through adopting low risk off-farm income generating activities. Important off-farm income generating activities are petty trading, selling local brews and remittances. About 23% of the respondents indicated that they diversify their income sources by engaging in off-farm activities. The effectiveness of off-farm income as a strategy to reduce risk depends on the covariance of the income sources, the lower the covariance the lower the risk i.e. selection of off-farm income sources that have low or negative correlation. It is important to note that the variance of returns for two enterprises is the sum of the variances of each enterprise plus the covariance of the two. Thus adding enterprises that have less variance per unit of return or a negative correlation with the included enterprises can reduce variance. Including a sufficient number of activities will reduce risk considerably. Constraints to diversification mentioned above include the objective of farming, farm management skills, compatibility of the activities with the available resources and economies of scale (Backus, 1997).

Two other important types of farm diversification against risk that are practised in Babati are diversification of crops grown and spatial diversification of farming plots (Chapter 5).

[25] Diversification of crops usually takes many forms, for example growing different crops on the same plot with different temporal and spatial arrangements and diversification over different plots with either sole or mixed/inter-crop etc. These are, however, not detailed in this study.

For the farmers, diversification of crops and cropping patterns is just a way of ensuring that at least one output is realised. More scientifically, diversification means selecting crop activities that have yields with a low or negative correlation. As Hardaker *et al.* (1997:239) point out, many returns from different farm activities are typically strongly positively correlated thereby limiting the gains from diversification. Hardaker *et al.* (1997:239) point out further that a better opportunity for spreading risks may lie in spatial diversification as is being done in the survey area. Chapter 5 pointed out that farmers in the area own on average 3 different farming plots located in different areas with often different soil conditions and sometimes different AEZ. These are expected to reduce the positive correlation due to different weather and soil effects.

There is a general consensus that access to agricultural financial services by small farmers is beneficial to them as it increases their capabilities to manage risk and to increase production. Tanzania rural farming households do not rely on bank credits for reducing farming risks because both formal and informal credits are at the moment very limited. The formal credits are normally directed to the public and private commercial sectors, while informal credits, if available, are only from within villages (Amani *et al.*, 1987). Very few farmers borrowed from the banks (Table 7.11).

Table 7.11 Proportion of respondents who borrowed from banks by village

Village	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Yes	4	0	3	0	2
No	96	100	97	100	98

Source: Survey data

However, there is a strong informal credit practice where more than 90% (of the respondents who borrowed from informal sources) borrowed money (Table 7.12). With exception of Magugu village where a relatively small number of respondents borrowed from informal arrangements (50%), other villages had more than 80% of the respondents who received credit from informal arrangements. Informal credit in the survey area involves an agreement between the lender and the client where the client borrows money or inputs (such as animal traction, tractor, seed etc.) and pays in cash or in terms of harvested crops. However, this type of credit system requires strengthening as not all the people can easily have access to the credit facility, and repayment creates problems between the lender and the client.

Field results from Babati and elsewhere in Tanzania (Kashuliza *et al.*, 1998:44) have shown that informal lending has made positive contributions to both consumption and production activities of the rural people. However, the results suggest that informal lending is still far from being a specialised activity, but rather a side activity integrated into other enterprise undertakings of various farmers and businessmen. In addition, an organised informal lending in a form of traders or farmers' association was not observed in the study area, apart from the semi-formal co-operative society.

Organised crop and livestock insurance against risk is not well developed in Tanzania. It was only in 1996 when the National Insurance Company started livestock insurance. This is yet to benefit many rural farmers. On the other hand, there has been a low market response to livestock insurance, mainly because the insurance industry in Tanzania has mostly been urban oriented and has not focused on the rural areas. Insurance policies have in the past been concentrating on motor vehicle, life, building and industrial protection mainly in the urban areas.

Table 7.12 Sources of credit other than from banks by village

Village/source of credit	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Informal	53	86	83	81	77
Coop. Societies	5	4	7	5	5

Source: Survey data

Currently, there are major policy changes in the insurance market where the monopoly of the government-owned National Insurance Corporation has been dismantled to give way to private insurance companies. This move is expected to increase the efficiency of the insurance market in the country and there are high hopes that farmers may benefit from this move. However, to address the problem of the livestock insurance market there is a need for launching mobilisation and publicity programmes especially in the rural areas to educate the people about this type of insurance. This should be very tactical since rural people have low incomes and hence low capacity to raise the expected insurance premiums.

7.1.3 Role of trees in household risk management

Emanating from the measures to cope with risk in crop production is planting trees and liquidation of trees and tree products during difficult times/emergencies. This points out the role of trees as potential savings and security, meeting contingencies and as a food security measure.

Although stored grains and livestock are still the main assets kept to meet contingencies, trees are also gradually becoming important in this aspect. This is mainly due to the increased population of both human and livestock putting more pressure on available arable and grazing lands as well as pressures on the demand for fuelwood, poles and charcoal. Contingencies that can be met by stored grains, livestock and planted trees take many forms, they may be sudden and unexpected, slow in onset or may be large needs that can be foreseen. Chambers and Leach (1990) identify five categories of contingencies as follows. Social categories for example dowries, bride wealth weddings, funerals and other ceremonial and social needs. The second category of contingencies involves disasters such as theft, loss by fire, death of animals, floods, drought, epidemics, food shortage, war etc. Thirdly contingencies involve physical incapacity, such as disablement, sickness, old age etc. The fourth category of contingencies comprises unproductive expenditures, such as failures in small enterprises, litigation or gambling, school fees etc. Finally, contingencies take the form of exploitation including excessive demand and illegitimate acts by the powerful, such as exorbitant interest demand by moneylenders, expropriation of property, intimidation and blackmail. While the first three are observed in the study area, the last set of contingencies is not common in Babati district. However, we cannot comment on interest rates paid to moneylenders, as this was not explored in detail in this study.

The use of trees to meet contingencies can be classified into direct use, which is reflected in subsistence and consumption, and sale or mortgage for market relations (Chambers and Leach, 1990). In the study area direct use of trees in relation to contingencies is to provide resources to enable households to deal with seasonal shortages. For example trees provide fodder for livestock during dry seasons (See also chapter 5) and a recurrent flow of foods, such as fruits. These kinds of products help people and livestock to survive during the worse periods of the year. Sale or mortgage for the market occurs when the households require cash to meet costs such as medical treatment, funeral, rebuilding houses after fire incidences, to buy foods after drought or floods. Chapter 5 shows that trees and tree products such as firewood and charcoal can contribute substantially to the household income. This income can be used in filling deficits arising from drought. Chapter 5 also shows that the Babati district is vulnerable to both drought and floods.

An increasing number of studies have shown that trees planted in rural areas alone or in deliberate combinations with annual crops play an important role in household food security (See for example Arnold 1987, Falconer 1990, Belsky 1993 and see also table 7.10). Trees enhance food security directly by producing different foods and indirectly by providing inputs into other food producing parts of the farm system and by providing fuel for cooking.

Trees in their role in risk management have both advantages and disadvantages. An important disadvantage in the research area relates to tenure rights. Those who rent land are normally not allowed to plant long term crops, as they may later bring up the problems of land ownership. Planting long term crops has traditionally been associated with land ownership. This prevents the poor people without land to plant and own trees. However, for those who own land, tree planting was also seen as a means of land ownership, and the households are able to exclude others by planting trees. This is more common in distant plots and the plots allocated by village governments. In case a household has been allocated land, and it does not cultivate this for a long time, the land may be taken away by the village government if there are no permanent crops like trees. Other disadvantages are related to the constraints in tree growing presented in chapter 5, such as vulnerability to burning and grazing. Advantages include cheap establishment and maintenance, divisibility of tree products (i.e. divisibility of fuelwood and building poles to suit the needs closely), regeneration after pollarding or coppicing and they have a high appreciation rate through growth.

7.1.4 Perceived soil fertility decline

Poor soils were mentioned as a major source of risk to monocropping but to agroforestry it was a minor source of risk as depicted in tables 7.1 and 7.2. As a result it was necessary to investigate in detail issues related to soil fertility decline. In doing this some questions were included in the structured questionnaire presented in appendix 1. In the surveyed area decline in soil fertility was due to factors such as soil erosion, over-cultivation and overgrazing (Table 7.14).

With exception of Magugu village, the majority of the respondents in the other villages experienced soil fertility decline (Table 7.13). In Magugu only 22% of the respondents indicated that they experience soil fertility decline. More than 50% of the Magugu respondents showed that the soil fertility remained the same. The reasons may be attributed to the findings in chapter 5, which show that Magugu village made considerable efforts in applying farmyard manure and tree planting (Tables 5.17 and 5.27).

Table 7.13 Perceived change in soil fertility by village

Village	Magugu (n=18)	Bonga (n=28)	Singe (n=30)	Himiti (n=22)	Overall (n=98)
			% of respondents		
Declined	22	86	73	68	66
Remained the same	56	4	10	0	14
Increased	6	7	17	18	12
Do not know	17	4	0	14	7

Source: Survey data

The perceived reasons for decline in soil fertility were reported as soil erosion, over-cultivation[26] and over-grazing. Whereas, over-grazing and over-cultivation, were the major reasons in Magugu village, soil erosion and over-cultivation were the main reasons in Bonga, Singe and Himiti (Table 7.14). Overgrazing problems in Magugu are the result of high livestock numbers per household (See table 5.22) and drought, which leads to poor regeneration of pastures. Soil erosion problems in Bonga, Singe, and Himiti may be attributed to higher rainfall intensities as compared to Magugu village. Land slope may not be the main reason for soil erosion because in chapter 5 (Table 5.10) the slope of the land was mainly classified as flat (70% of the respondents) and gently sloping (28% of the respondents).

[26] Over-cultivation in this study was conceptualised as continuous cultivation on the same piece of land without fallow (or too short fallow periods), as well as crop production encroaching to other areas meant for other land use purposes.

Table 7.14 Reasons for the perceived decline in soil fertility by village

Reasons	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Soil erosion	5	39	64	54	44
Over-cultivation	37	39	32	32	30
Over-grazing	58	21	5	14	26

Source: Survey data

Through discussions with the villagers, it was noted that there were various combinations of the mentioned reasons for a decline in soil fertility in a given farm. Over-grazing, over-cultivation and encroaching to marginal lands were noted as factors facilitating soil erosion.

It is shown in table 7.13 that on average about 12% of the respondents experienced a soil fertility increase on their farms. The major reasons for the increase in soil fertility were through farmyard manure applications, planting trees, adopting soil and water conservation techniques and reducing the size of the livestock herds. About 51% of the respondents used various ways to increase soil fertility. Table 7.15 shows that for those who used various ways of improving soil fertility the outcome was promising (94% of those who used it).

Table 7.15 Effect of measures of improving soil fertility by village

	Magugu (n=8)	Bonga (n=14)	Singe (n=17)	Himiti (n=11)	Overall (n=51)
			% of respondents		
Good	88	93	94	100	94
Bad	12	7	0	0	4
Too early to say	0	0	6	0	2

Source: Survey data

Farmers were asked to comment on observed yield decline over time. The responses are presented in table 7.16. The majority of the respondents (80%) are experiencing yield decline over time and all the villages have more than 70% of the respondents indicating yield decline. It can be noted from table 7.14 and 7.16 that in Magugu village respondents reported a high yield decline over time (74%) but less soil fertility decline (22%). This in a

Table 7.16: Yield decline perception overtime by village

	Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
			% of respondents		
Experiencing	74	79	84	83	80
Not experiencing	26	21	16	18	20

Source: Survey data.

way shows that drought is an important factor in yield decline in Magugu.

It can be concluded that factors determining agricultural productivity in the survey area depend on the combination of agro-ecological factors, soil conservation measures, livestock numbers and grazing area. Among the agro-ecological factors, rainfall amount and distribution are important in the study area. In semi-arid Magugu for example, the main factor is drought, which is manifested by low and inadequate rainfall. Soil conservation measures such as tree planting and bench terraces are important in reducing the impact of soil erosion. High livestock numbers coupled with small grazing areas or drought leads to land degradation. Grazing in the fields as a result of inadequate grazing land compacts the soil and retards growth of trees and other perennial crops on the farmland.

7.1.5 Information and its role in risk management

Better decisions can be made in a risky world if information is available. Information is the most important ingredient in risk management. The greater the amount of valid and timely information one has, the more refined is the decision process. Information regarding more productive technology options, marketing opportunities, agricultural finance options, climate and soil and water conservation options etc., are crucial to a farmer. In eliciting subjective probabilities[27] of farmers regarding their risk attitude and risk perception (Chapter 6 and section 7.2) the dispersion of distribution will be reduced if there is adequate information (Hardaker *et al.*, 1997:235).

Backus *et al.* (1997) argue that effectiveness in risk management strategies by farmers depends on external orientation and the use of information sources. The use of information by farmers has a close relation to the survival of the farm business. It reduces farmers' aversion to uncertainties (See also chapter 1). As a result the focus on information as a risk response may contribute to improved farm decision making under risk. Risk perception depends to a large extent on the information available about a particular technology or practice. This information can be the result of experiences by the farmer himself or from external sources. The role of this information in risk management is to change the decision

[27] A discussion about information and subjective probability distribution is presented in Hardaker *et al.* (1997: 235).

process as a result of additional information that makes farmers to have a better anticipation about future events. Risk perception therefore can act as a striking out rule of not considering activities at all or it leads to a slowing down in the adoption process until more information is made available regarding the performance of the technology.

Table 7.17 Access to and importance of extension services by village

		Magugu (n=19)	Bonga (n=28)	Singe (n=31)	Himiti (n=22)	Overall (n=100)
				% of respondents		
Access	Easy	84	100	100	86	96
	Not easy	16	0	0	14	4
Importance	Important	100	100	100	82	97
	Not important	0	0	0	18	3

Source: Survey data

Extension workers are the major source of information to farmers regarding agricultural production and marketing in Tanzania. As pointed out earlier, farmers' perceived easiness of contacting an extension agent is a more reliable measure of extension contact, as it does not rely on memory. Table 7.17 shows the perceived importance of extension agents in the area. The table shows that contacting an extension agent in the survey area is relatively easy for a farmer. Most of the farmers perceive extension services as important. This finding is supported by the fact that in each of the surveyed villages there was a resident extension agent. However, transport for extension workers was noted as the main problem limiting the extension activities. How much information the extension workers provide and the extent of their training were beyond the scope of this study.

Regarding risk management strategies farmers were asked to mention the source of information about the various ways of increasing soil fertility, such as terracing, planting trees and various soil and water management strategies. The majority of the respondents (Table 7.18) pointed out that they received information from extension agents especially

Table 7.18 Source of information for undertaking soil conservation by village

	Magugu (n=8)	Bonga (n=14)	Singe (n=17)	Himiti (n=11)	Overall (n=51)
			% of respondents		
Extension advice	75	64	78	72	73
Own initiative	25	36	22	28	27

Source: Survey data

from those attached to the Land Management Project of Babati. Farmer to farmer information dissemination was not very apparent in the study area. However, discussions with farmers showed that what they call their own initiative (Table 7.18) has been learnt somewhere in seminars and visits to other farmers in different parts of the district. This shows that there are potentials for farmers learning from each other in the future if new productive information is acquired.

7.2 Risk perception using the strength of conviction method

This section implements the measurement of risk perception in the utility theory category. Elicitation of farmers' subjective probability distributions with respect to six cropping systems (30 farmers) was done, using the modified strength of conviction method described in chapter 4. As will be evident below, elicitation of probability distributions was not an easy task for both the respondents and the researcher. Sometimes the farmer had to answer unusual questions about the income she/he expects from a number of cropping systems. As pointed out in chapter 5, the six cropping systems were selected mainly based on the frequency at which they are practised in the study area. The use of six cropping systems out of the nine practised was mainly due to time constraints for both the researcher and farmers. This is because of the large number of data points that are elicited from farmers as is evident below. For each farmer a total of nine points were elicited per cropping system making a total of 270 points for each cropping system. Expected income and variance of the cropping systems were calculated based on the elicited points as follows:

Let the probability levels be represented by the suffix i $(i=1,2,3...9)$ and the farmers by j $(j= 1, 2, 3 ... 30)$. Using the procedure of strength of conviction outlined in section 2.3.2, farmers' personal beliefs about the income of the cropping systems were expressed as subjective probabilities p_i, where $\sum p_i = 1$. The income ranges YR_i were expressed as point estimates (pe_i). The expected income/return of a given cropping system was expressed as: $E_i = \sum(pe_i p_i)$, i.e. a weighted average of each point estimate multiplied by the subjective probability of the income/return range. The variance of the subjective probability distribution was calculated as $V_i = \sum (pe_I - E_i)^2 p_i$, i.e. a weighted average of the squared deviations of each point estimate from the expected income/return multiplied by the elicited subjective probability. The standard deviation was calculated as the square root of the variance. Other measures of variability were calculated using SPSS PC+ and from the estimated Weibull and lognormal distributions.

7.2.1 Weibull and lognormal distributions

Data obtained from the strength of conviction method was used to fit two distribution functions specified in chapter 2, section 2.3.2. The two distribution functions were fitted to each cropping system for each farmer and the parameters estimated were used to calculate the moments of the subjective probability distributions. The two cumulative distribution functions are:

Lognormal

$$Ln\ (x_i) = \mu + \sigma w_i + U_i$$

Weibull

$$Ln\ (x_i) = \alpha + \beta Ln\ Ln\ (1/1\text{-}z_i) + U_i$$

Where:
x = aggregated income of the cropping system based on the elicited points from the respondents
w = are points on the standard normal distribution with probability levels calculated
z = elicited probabilities from the respondents for the cropping system and
α, β, μ, and σ are parameters to be estimated and i is the number of the point elicited from the respondents.

Initially, it was proposed that the two cumulative distribution functions be estimated using OLS method. However, OLS poorly fitted the models as evaluated by their respective adjusted R-squared. As proposed by Aitchison and Brown (1957:38) and Greene (1993:719), Maximum Likelihood (ML) methods normally give a better fit of lognormal distributions[28]. The main assumptions of ML methods as outlined in Koutsoyiannis (1977:442) permit the use of the method, i.e. the distribution of the parent population assumed to be known and normal. The estimators of ML are described as sufficient and consistent especially for a large sample (Aitchison and Brown, 1957:53, Koutsoyiannis, 1977:442). According to Greene (1993:10) the principal of ML provides a means of choosing an asymptotically efficient estimator for a parameter or set of parameters. A discussion on ML estimation is presented by Aldrich and Nelson (1984) (See also appendix 4).

The test of goodness of fit that can be applied to all lognormal distributions is the Pearson chi-square test (Aitchison and Brown, 1957:53). Ungrouped probit analysis (which gives ML estimators) was used to estimate the parameters of both Weibull and lognormal distributions using SPSS PC+. The overall results for the whole sample are presented in tables 7.19 and 7.20.

he results show that the lognormal cumulative distribution had much better fits for all the cropping systems as compared with the Weibull cumulative distribution. The parameter estimates of the lognormal distribution were all significant, the Pearson chi-square was significant in each cropping system and the ML converged (Table 7.19).

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[28] The use of @risk best fit programme from Palisade Corporation provides a wide range of distributions that can be fitted, giving a number of statistics of goodness of fit such as chi-square, Anderson-Darling and Kolmogorov-Simirnov. However, this programme was not available during data analysis.

Table 7.19 Estimation of risk perception of income of cropping systems with a lognormal cumulative distribution using the maximum likelihood method (overall sample)

Cropping System	μ	σ	Pearson chi-square	ML convergence
Mixed fruit trees + mixed food crops (CS1)	3.79 t=204.7*	0.0298 t =5.52*	2721.4*	4 (0.0054)
Trees (timber/fuelwood) + mixed food crops (CS2)	3.61 t = 208.6*	0.2929 t =4.99*	2728.5*	5(0.0001
Mixed food crops only (CS3)	3.6 t = 218.8*	0.021 t =3.82*	2730.7*	4(0.00036)
Cash crops only (CS4)	3.6 t = 228.2*	0.049 t =8.08*	2640.3*	5 (0.0004)
Trees (timber and fuel-wood) only (CS5)	3.58 t = 208.7*	0.017 t=3.9*	2751.0*	5 (0.00001)
Mixed fruit trees only (CS6)	3.6 t =203.0*	0.027 t =4.4*	2735.8*	4 (0.0004)

* Means the coefficient t-test/Pearson chi-square is significant. ($p \leq 0.05$).

The Weibull distribution showed a significant Pearson chi-square, but the parameter estimates were significant in only two cropping systems namely 'Trees (timber/fuel wood) + mixed food crops only' (CS2) and 'Trees (timber/fuel wood) only' (CS5). In 'Mixed fruit trees + mixed food crops only' (CS1) cropping system, the ML did not converge at all when using Weibull specifications (Table 7.20).

Table 7.20 Estimation of risk perception of income of cropping systems with a cumulative Weibull distribution using the maximum likelihood method (overall sample)

Cropping System	α	σ	Pearson chi-square	ML convergence
Mixed fruit trees + mixed food crops (CS1)	3.52 t=176.8*	-0.01 t =-1.4	838.7*	Did not converge
Trees (timber/fuelwood) + mixed food crops (CS2)	3.4 t = 112.6*	-0.097 t =-4.4*	768.2*	4(0.00013)
Mixed food crops only (CS3)	3.55 t = 113.1*	-0.023 t =-1.0	955.7*	4(0.00027)
Cash crops only (CS4)	3.38 t = 96.4*	-0.049 t =-4.6*	855.2*	4 (0.0007)
Trees (timber and fuelwood) only (CS5)	3.6 t = 107.6*	-0.031 t=-1.4	1473.2*	4 (0.00001)
Mixed fruit trees only (CS6)	3.5 t =116.1*	-0.038 t =-1.5	732.0*	4 (0.00026)

* Means the coefficient (t-test)/Pearson chi-square is significant ($p \leq 0.05$).

The results compare favourably with those of Smidts (1990:112)[29] who found that Lognormal distributions gave large fits as compared with Weibull distributions when assessing risk perception of different marketing strategies of farmers in the Netherlands. Following Aitchison and Brown (1957), the parameters of the lognormal distribution function can be used to calculate the expected income (mean), median income, standard deviation and skewness of the subjective distribution function as illustrated in appendix 5. However, the use of SPSS PC+ calculates the moments of distribution much faster than using the procedures described in appendix 5. It is important to note that appendix 5 is essential for the purpose of showing how the results are arrived at and not only understanding the routine computations using software.

Table 7.21: Descriptive statistics of the lognormal distribution/Strength of Conviction Method

Cropping system	Mean (Expected income in TSH)	Median income (TSH)	Standard deviation (TSH)	Skew-ness
Mixed fruit trees + mixed food crops (CS1)	91 433	89 350	5 896	0.7
Trees (timber/fuelwood) + mixed food crops (CS2)	93 054	98 305	6 991	-0.2
Mixed food crops only (CS3)	80 389	75 027	5 738	0.2
Cash crops only (CS4)	92 153	94 553	9 113	-0.5
Trees (timber and fuelwood) only (CS5)	89 297	88 803	7 094	-0.3
Mixed fruit trees only (CS6)	91 094	86 750	8 883	0.7

Table 7.21 shows the expected income (Mean), standard deviation (Risk) and the skewness of the probability distribution function for each cropping system. The cropping system involving 'Cash crops only' (CS4) was perceived as the most risky system followed by 'Mixed fruit trees only' (CS6). Based on standard deviation the less risk cropping system was perceived as 'Mixed food crops only' (CS3) followed by 'Mixed fruit trees + mixed food crops' (CS1) cropping system. However, comparing the two, i.e. 'Mixed food crops only' (CS3) and 'Mixed fruit trees + mixed food crops' (CS1) it can be observed that although the former cropping system had the lowest risk, it also had the lowest expected income.

The results show that the cropping system that fulfils the objective in farming with the highest priority, namely to meet the food requirements had the lowest expected income.

For a risk averse farmer he or she might be interested in 'Mixed food crops only' (CS3) cropping system since it has a lower risk. However, a risk seeking individual might choose a 'Trees (timber fuelwood) + mixed food crops' (CS2) cropping system because it is perceived as having a much higher mean and only a little bit more variance. When

[29] Smidts (1990) estimated the functions using OLS, while this research used ML method of estimation.

comparing the cropping systems 'Mixed fruit trees + mixed food crops' (CS1) and 'Mixed food crops only' (CS3) one might be more interested in the former because the expected income is higher by Tshs 11 044 as compared with the extra risk (standard deviation) of only Tshs 158. However, the decision on which cropping system to choose will depend on the level of risk aversion and the rate of substitution between mean and variance.

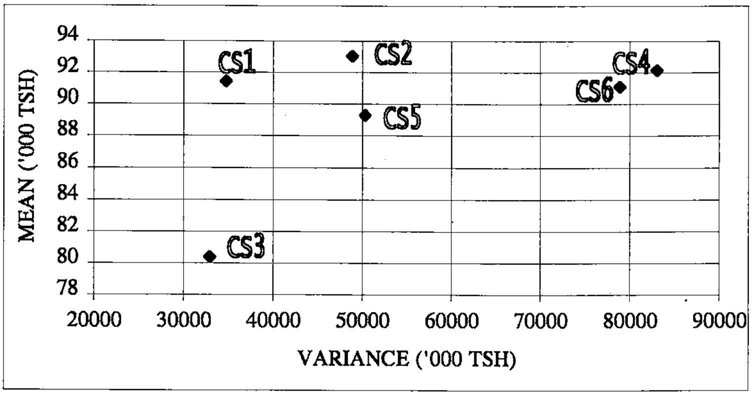

Figure 7.1 Relationship between expected mean return and variance of cropping systems
Key: CS1 = Mixed fruit trees + mixed food crops
CS2 = Trees (Timber, fuelwood) + mixed food crops
CS3 = Mixed food crops only
CS4 = Cash crops only
CS5 = Trees (timber, fuelwood) only
CS6 = Mixed fruit trees only

Figure 7.1 illustrates the six cropping systems in a mean-variance space. According to Hardaker *et al.* (1997) the mean-variance rule can be applied to identify the most efficient cropping system (i.e. a cropping system is in the mean-variance efficient set if no other cropping system lies in its north-western quadrant). The mean-variance rule is based, according to Hardaker *et al.* (1997:141), on the proposition that if the expected value of choice A is greater than or equal to the expected value of choice B and the variance of A is less than or equal to the variance of B, with at least one strict inequality, then A is preferred to B by all decision makers whose preference meet certain conditions. The requirements are that decision makers always prefer more to less and are risk averse, have an outcome distribution that is normal and have a quadratic utility function (See also section 2.3.3). The cropping system 'Mixed fruit trees + mixed food crops only' (CS1) is the most efficient cropping system, followed by cropping system 'Trees (timber/fuel wood) + mixed food crops only' (CS2). However, table 7.23 shows that cropping systems 'Mixed fruit trees + mixed food crops only' (CS1) and 'Mixed food crops only' (CS3) do not differ significantly in both mean and risk. Generally and invoking the mean-variance rule (as the example in Hardaker *et al.,* 1997: 143 adapted) the efficient cropping systems can be identified from the figure as CS1, CS2 and CS3[30].

Based on these results, the cropping systems can also be classified as highly risky, moderately risky and less risky as presented in table 7.22.

Table 7.22 Classification of cropping systems based on risk

High risk	Moderate risk	Low risk
1. Mixed fruit trees only (CS6)	1. Trees (Timber/fuelwood) + mixed food crops (CS2)	1. Mixed food crops only (CS3)
2. Cash crops only (CS4)	2. Trees (Timber and fuelwood) only (CS5)	2. Mixed fruit trees + mixed food crops (CS1)

Among the two agroforestry systems included, i.e. 'Mixed fruit trees + mixed food crops' (CS1) and 'Trees (timber/fuel wood) + mixed food crops' (CS2), the former was perceived as less risky as compared to the other. Although the 'Trees (timber/fuel wood) + mixed food crops' (CS2) cropping system had a higher expected income by Tshs 1 621, it also had a higher risk by Tshs 1 095 when compared to 'Mixed fruit trees + mixed food crops' cropping system (CS1). However, they are among the most efficient cropping systems.

The results compare favourably with those obtained using the questionnaire (section 7.1 above). In both cases farmers showed low perceived risk in the production of food crops. In the structured questionnaire the results indicated that sole cropping of food crops and mixture of food crops are less risky as compared to the mixture of food crops and trees (section 7.1). However, the mixtures of trees and annual food crops were on average perceived as moderately risky. Similar results are obtained in the strength of conviction method where a mixture of annual food crops and the mixture of trees and food crops were judged as less risky. The differences in the two types of analysis are that section 7.2 gives the magnitude of the perceived risks and expected income while section 7.1 relied only on the percentage of the respondents. The latter may be subject to farmers' memories while the former, being somehow a hypothetical game, does not depend much on the memories of respondents.

Average skewness for the sample is varying (Table 7.21). Three cropping systems, i.e. 'Mixed fruit trees + mixed food crops' (CS1), 'Mixed food crops only' (CS3) and 'Mixed fruit trees only' (CS3) have their subjective probability distribution skewed to the right, implying that farmers perceive a positive chance of higher income/returns in these cropping systems compared with the others. The other three cropping systems, i.e. 'Trees (timber/fuelwood) + mixed food crops' (CS2), 'Trees (timber and fuelwood) only' (CS5) and 'Cash crops only' (CS4) have their subjective probability distributions skewed to the left. This implies that farmers anticipate high chances of getting a lower income with these systems compared with the others. This outcome depended very much on the nature of the probability distribution of the expected income of the cropping systems, which in turn depends on farmers' expectation about the future earnings of the cropping systems. From the results it seems that there are expectations of high income from food crops and mixed

[30] The results give the opinions of the farmers. They might have overestimated the risk reducing capabilities of the cropping mixtures because they are familiar with them

fruit trees and low income is expected mainly from trees (timber/fuel wood) and cash crops. The reasons for this were not very apparent from the research results mainly because respondents were not asked the reasons behind their strength of conviction about the expected outcome of the cropping systems. Maybe the role of food crops in subsistence consumption and the increased dual role of food crops as cash generating crops are the main reasons.

So far only the average risk perception for all the respondents has been presented. Risk perception per farmer shows great heterogeneity when compared with the average one presented above.

Given the nature of assessing risk perception, it is clear that there is no single factor that can be attributed to risk perception. Many factors are expected to contribute to a difference in risk perception among farmers. For example, as pointed out in Huijsman (1986: 279), farmers may face different production risks to the same production activity due to differences in risk control capacity i.e. control over risk causing factors. Farmers' risk perception may differ due to differences in financial risk taking capacity and the need to secure the financial viability of the household unit. Other factors that account for differences in risk perception are differences in resource ownership, for example land, level of off-farm activities, proximity to better transport infrastructures etc.

It is expected that there are differences in risk perception and expected income between farmer categories. In order to find out whether there are differences among the farmers, the sample was categorised into female and male respondents, and into small, medium and large farmers[31]. The exact direction of the differences is not known in prior, mainly because perceived risk depends much on factors such as the level of information available and on experience with particular cropping systems. The results are presented in terms of the expected income (mean) and standard deviation (risk) (Figures 7.2, 7.3, 7.4 and 7.5).

Women respondents perceived cropping system 'Mixed fruit trees only' (CS6), followed by 'Trees (timber/fuelwood)+mixed food crops' (CS2) as the most risky cropping systems (Figure 7.2). In these two cropping systems, female farmers perceived significantly higher risk than male farmers ($p \leq 0.10$). There were no significant differences between male and female in risk perception in the other cropping systems. On the other hand male respondents showed that 'Cash crops only' (CS4) followed by 'Mixed fruit trees only' (CS6) as the most risky cropping systems. The cropping system perceived by female respondents as having lowest risk is 'Mixed fruit trees + mixed food crops (CS1) while male respondents suggested that it is 'Mixed food crops only' (CS3) that is less risky. With the exception of the 'Trees (timber and fuelwood) only' (CS5) cropping system, the results show that female respondents had higher expected income compared with men in all the other cropping systems. However, only in the cropping system 'Cash crops only' (CS4) the difference in expected income is significant ($p \leq 0.10$) (Figure 7.3).

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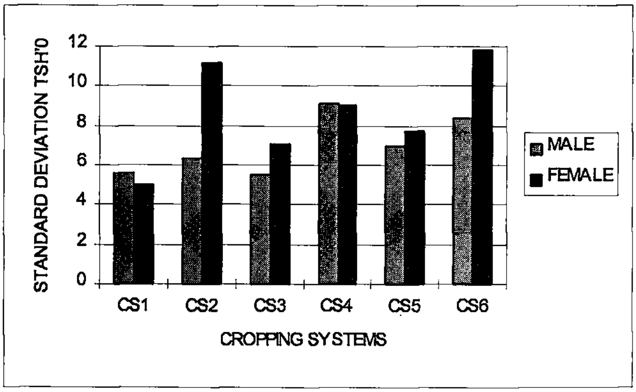
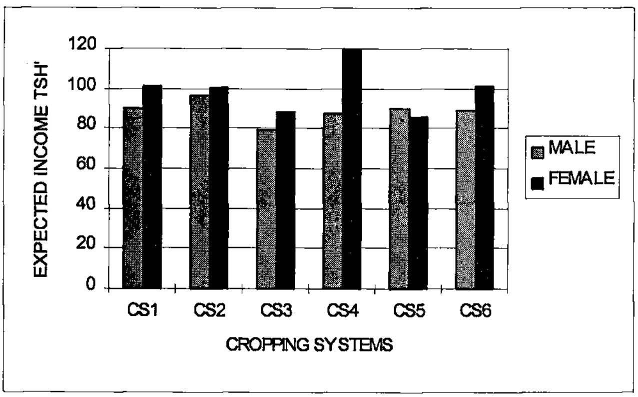
[31] The categories of farmers are those generated by the SPSS percentiles and may differ with other categorisation. For example according CYMMITY all the farmers fall only in the medium category.



Key:
CS1 = Mixed fruit trees + mixed food crops
CS2 = Trees (Timber, fuelwood) + mixed food crops
CS3 = Mixed food crops only
CS4 = Cash crops only
CS5 = Trees (timber, fuelwood) only
CS6 = Mixed fruit trees only

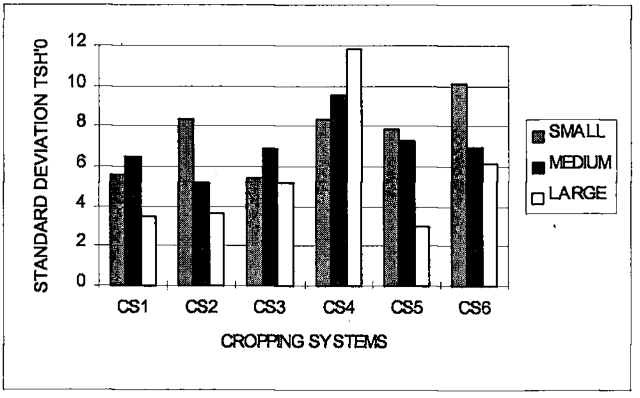
Figure 7.2 Risk perception (standard deviation) by gender (Male n=18, female, n=12)



Key:
CS1 = Mixed fruit trees + mixed food crops
CS2 = Trees (Timber, fuelwood) + mixed food crops
CS3 = Mixed food crops only
CS4 = Cash crops only
CS5 = Trees (timber, fuelwood) only
CS6 = Mixed fruit trees only

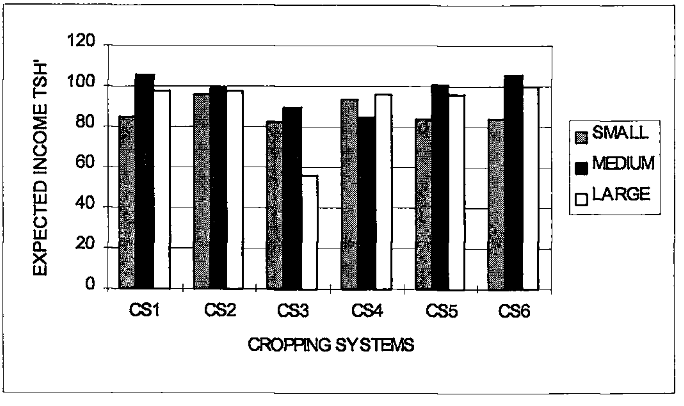
Figure 7.3 Expected income/return of cropping systems by gender

Large and medium farmers perceived 'Cash crops only' (CS4) as the most risky cropping system, while small farmers suggested that 'Mixed fruit trees only' (CS6) is the most risky cropping system. Large farmers perceived 'Trees (timber and fuelwood only) (CS5) as the lowest risk cropping system (Figure 7.4), whereas the medium scale farmers considered 'Trees (Timber and fuelwood) + mixed food crops' (CS2) as the lowest risk cropping system. Small farmers on the other hand perceived 'Mixed food crops only' (CS3) as the lowest risk cropping system. The results show that there are differences in risk perception among the above mentioned farmer categories. Pairwise comparison of risk perception by farmers in terms of farm size categorisation shows that medium farmers perceived significantly high risks in 'Mixed food crops only' (CS3) compared to large farmers.



Key:
CS1 = Mixed fruit trees + mixed food crops
CS2 = Trees (Timber, fuelwood) + mixed food crops
CS3 = Mixed food crops only
CS4 = Cash crops only
CS5 = Trees (timber, fuelwood) only
CS6 = Mixed fruit trees only

Figure 7.4 Risk perception (standard deviation) of cropping systems by farmer category (Small n= 19, medium n=7, large n =4)



Key:
CS1 = Mixed fruit trees + mixed food crops
CS2 = Trees (Timber, fuelwood) + mixed food crops
CS3 = Mixed food crops only
CS4 = Cash crops only
CS5 = Trees (timber, fuelwood) only
CS6 = Mixed fruit trees only

Figure 7.5 Expected income/return (means) of cropping systems by farmer category (Small n= 19, medium n=7, large n =4)

The same comparison in terms of expected income showed that the medium farmer expects significantly higher income compared to large farmers in 'Mixed food crops only' (CS3). Small farmers also perceived significantly higher expected income as compared to large farmers in 'Mixed food crops only' (CS3) (significant at ($p \leq 0.10$) (Figure 7.5). As noted above, these differences may be varying with the level of information and experience in cropping systems and therefore needs to be interpreted carefully in case of extrapolating to other areas.

7.2.2 Pairwise comparison of cropping systems with respect to expected income and risk perception.

To find out whether there are differences in expected income and risk between cropping systems, a pairwise t-test was used. The aim of this analysis was to find out whether there are significant differences between the cropping systems with regard to risk perception and expected income and in which direction these differences are. The results can assist in identifying which cropping systems require attention with respect to risk and expected income. For instance how and in which direction appropriate information can be disseminated. Fifteen pairs of the six cropping systems were compared (Table 7.23).

Table 7.23 Pairwise comparison of expected income and risk perception of cropping systems

Pair	Expected income		Risk (standard deviation)	
	t-value	Probability level	t-value	Probability level
CS1,CS2	-1.12	0.270	-1.27	0.213
CS1,CS3	1.82	0.079	0.26	0.800
CS1,CS4	-0.09	0.926	-3.93	0.000*
CS1,CS5	0.30	0.768	-1.43	0.165
CS1,CS6	0.51	0.615	-2.40	0.023*
CS2,CS3	2.36	0.025*	1.29	0.206
CS2,CS4	0.55	0.585	-1.89	0.069
CS2,CS5	1.01	0.320	-0.13	0.890
CS2,CS6	1.18	0.246	-1.56	0.129
CS3,CS4	-1.57	0.127	-3.31	0.003*
CS3,CS5	-1.54	0.135	-2.01	0.050*
CS3,CS6	-1.75	0.090	-2.72	0.011*
CS4,CS5	0.33	0.745	1.75	0.091
CS4,CS6	0.14	0.890	0.15	0.879
CS5,CS6	-0.25	0.803	-1.49	0.146

Source: Computed from survey data. * Means significant at the specified probability levels ($p \leq 0.05$)

Key: CS1 = Mixed fruit trees + mixed food crops
CS2 = Trees (Timber, fuelwood) + mixed food crops
CS3 = Mixed food crops only
CS4 = Cash crops only
CS5 = Trees (timber, fuelwood) only
CS6 = Mixed fruit trees only

In the expected income of cropping systems, only 'Trees (Timber, fuelwood) + mixed food crops' (CS2) and 'Mixed food crops only' (CS3) showed significant differences.

Farmers perceived significantly higher income/return from 'Tree (Timber, fuelwood) + mixed food crops' (CS2) as compared with 'Mixed food crops only' (CS3). Figure 7.1 also depicts this. However, the perceived risk between the two cropping systems did not differ significantly. The rest of the combinations did not show any significant differences in expected income (Table 7.23). With respect to perceived risk five combinations out of fifteen showed significant differences.

Only two cropping systems with extreme low and high expected income differ significantly, and two systems with a high variance differ significantly from two systems with a low variance.

7.3 Relationship between risk perception with household resources and characteristics

Farmers differ in their risk perception of cropping systems (See section 7.2). There was a high heterogeneity in risk perception measurements among farmers of different sex and farm sizes. The main question is whether there are factors that can explain these differences. Regression analysis has been used to derive the relationship between risk perception of cropping systems with household resources and characteristics. The analysis gives the information regarding farmers' characteristics and resources that determine their evaluation of cropping systems. The same independent variables as postulated in the risk attitude research (See chapter 6) were used. The dependent variable is risk perception (standard deviation of expected income) measured using the strength of convection. A positive regression coefficient implies that an increase of one of the independent variables, the perceived risk of the decision-maker also increases. A negative regression coefficient means that a reduction of that particular variable lowers the risk perception of that individual.

The results are summarised in table 7.24 and presented in detail in appendix 6. The variable wealth is negative and significant in all the cropping systems. The variable age of the respondents, household size and years of education are also negative and significant for most but not all the cropping systems. The variable representing the gender of the respondent is negative in all the cropping systems but only significant in 'Mixed fruit trees only' (CS3). The value of R-squared ranged from 0.57 in the cropping system 'Mixed fruit trees only' (CS3) to 0.80 in the cropping system 'Cash crops only' (CS4). The degree of explanation is rather high, indicating that the included variables explain to a large extent, the variations in respondents' risk perception. Education is negatively related to the respondents' perceived risks of cropping systems. This implies that larger the number of years of education, the lower the respondents' perceived risks of the cropping systems. It was pointed out earlier in this chapter that information plays a crucial role in farmers' risk management strategies. This finding confirms the definition of risk perception given in chapter 2, which among other things points out that perception is not permanent and is shaped as new information is made available. Availability and use of relevant information is an ingredient in risk management strategies. A high level of education of an individual enhances information use. The higher the education the better the information processing ability of the farmers. Therefore availability of information alone is a necessary but may not be a sufficient condition for better risk management strategies. Education of the respondents is an additional condition.

The wealthier the respondent is in terms of the asset index, income, farm size and trees planted the lower are the perceived risks of cropping systems, i.e. wealthier respondents have a lower risk perception of cropping systems.

Household size, which is a determining factor for household labour availability, was negative and significant in four of the six cropping systems. This implies that the bigger the family size the less the perceived risk in production as could be expected. Age of the respondent, which is assumed to be closely related to experience in farming, was negative and significant in two out of six cropping systems. The older the respondents, the less the perceived risks in production i.e. it can be assumed that the older the respondent the more information/experience she/he possesses regarding the cropping systems, the decision environment and the risk management strategies, and thus low risk perception of the cropping systems.

Table 7.24 Effects of household resources and characteristics on risk perception of cropping systems (n=30)

Variable/Cropping system	Mixed fruit trees + food crops		Trees (timber/fuel wood) + food crops		Mixed food crops only		Cash crops only		Trees (timber/fuel wood) only		Mixed fruit trees only	
	Sign	Significance.	Sign	Significance	Sign	Significance	Sign	Significance.	Sign	Significance.	Sign	Significance.
Education (years)	(-)	*	(-)	*	(-)	-	(-)	*	(-)	*	(-)	-
Age (years)	(-)	*	(-)	*	(-)	-	(-)	-	(-)	-	(-)	-
Gender (dummy: 1 if male, 0 if female))	(+)	-	(+)	-	(+)	-	(+)	-	(+)	-	(-)	*
Wealth (score)	(-)	*	(-)	*	(-)	*	(-)	*	(-)	*	(-)	*
Household size (number)	(-)	*	(-)	-	(-)	*	(-)	*	(-)	-	(-)	*
R-squared	0.78		0.68		0.57		0.80		0.76		0.58	

* Means the coefficient is significant (p≤0.10 two tailed)

\- Means not significant

Gender of the respondent was found to be significant only in the cropping system 'Mixed fruit trees only' (CS6). The coefficient is negative implying that increases in this variable result in low risk perception i.e. male respondents perceive this cropping system as less risky. In this chapter we also observed that female respondents have a significantly higher perceived risk in this cropping system as compared to males, thus supporting this finding. However, the cropping system 'Trees (timber/fuel wood) + food crops' (CS2) that showed significance (See section 7.2.1) between male and female, does not show significance in explaining risk perception.

Based on the above we can conclude that risk perception showed a more strong and consistent relationship with household resources and characteristics as compared to the relationship between risk attitude and household resources and characteristics. In this relationship (Risk perception and household resources and characteristics) the explanation by the included variables in each cropping system is high (More than 50%).

7.4 Major findings and conclusions

The main findings and conclusions from this chapter can be summarised as follows:

Structured questionnaire approach

Assessment of cropping systems with regard to risk showed that sole cropping of maize and beans are considered by the farmers as less risky as compared to when they are mixed with trees. However, some positive aspects with respect to risk in agroforestry were shown.

Six main risk management strategies are applied in the study area. The first one is crop selection where properties, such as drought tolerance, quick maturity and resistance against pests and disease, are preferred. Secondly, pruning trees to reduce the effect of competition and minimise hiding places for insect pests is practised. Thirdly, the use of fertilisers and manure as well as applying soil and water conservation techniques (such as terraces and tree planting) is undertaken. The fourth risk management strategy in the area is to maintain liquid assets that can be sold or liquidated to buffer consumption during bad years.

Diversification of income sources, such as adopting low risk off-farm incomes, is the fifth risk management strategy in the area. In addition, diversification of crops grown and spatial diversification of farming plots are also important in the area as means of mitigating the consequences of risk. Finally, the use of an informal lending system is another way of sharing risks with others. This is mainly due to the absence of a well functioning formal agricultural finance and insurance systems for rural people in the area.

It can be concluded that risk considerations in farmers' decision making in the area is important due to the diversified sources of risk facing them. Although risk is everywhere and essentially unavoidable, there are decisions that strongly require more risk considerations than others. In the research area, decisions such as including trees in the farming system, decisions on how many livestock to keep and how much grain to store or sell need risk considerations, given the existing agro-ecological and institutional factors in the area. As far as agroforestry is concerned, the need for proper tree spacing and pruning techniques seems to be important in reducing/managing risks.

Risk perception in the utility theory approach

A total of nine points of subjective probabilities were elicited from each farmer. Of the two distribution functions evaluated, the lognormal fitted the data well, when estimated using the ML method. The criteria for fit were based ón three items. First is the significance of the parameter estimates (t-value). The second one, as suggested by Aitchison and Brown (1957), is the significance of the chi-square test and the third is on the basis of the convergence of the ML in the estimation of the parameters.

Following the lognormal distribution, mean (expected income), variance (risk) and skewness were calculated both for each farmer and to all farmers aggregated for all the cropping systems. This enabled the ranking of cropping systems based on variance (risk) and mean (expected income). Using individual farmers' results, pairwise analyses with respect to gender and farm size were done.

Cropping systems 'Mixed food crops only' (CS3) and 'Mixed fruit trees + mixed food crops' (CS1) were perceived as having the lowest risk as compared to the others. Among the two agroforestry systems included in the analysis, i.e. 'Mixed fruit trees + mixed food crops' (CS1) and 'Trees (timber/fuelwood) + mixed food crops' (CS2), the former was perceived as less risky compared with the other. Pure tree woodlots of mixed timber and fuelwood species (CS5) were perceived as moderately risky. Farmers perceive a positive chance of getting higher incomes in 'Mixed fruit trees + mixed food crops' (CS1), 'Mixed fruit trees only' (CS6) and 'Mixed food crops only' (CS3) cropping systems as indicated by the positive skewness of their distribution functions.

Depicting the cropping systems in a mean-variance space, cropping system 'Mixed fruit trees + mixed food crops' (CS1) was the most efficient, followed by cropping systems 'Trees (timber/fuelwood) + mixed food crops' (CS2).

There were differences in risk perception of the cropping systems when evaluated on gender basis. Whereas men respondents perceived 'Mixed food crops only' (CS3) as less risky, women respondents showed that 'Mixed fruit trees + mixed food crops' (CS1) was less risky. Large farmers perceived 'Trees (timber/fuel wood) only' (CS5) as the lowest risk cropping system. Whereas, medium farmers showed that 'Trees (timber/fuel wood) + mixed food crops' (CS2) is the lowest risk system, small farmers perceived, 'Mixed crops only' (CS3) as the lowest risky cropping systems. Generally, there is heterogeneity of risk perception among farmers.

Pairwise comparison of risk perception by farmers in terms of farm size categorisation shows that medium farmers perceived significantly high risks in 'Mixed food crops only' (CS3) as compared to large farmers. The same comparison in terms of expected income showed that medium farmers expect significantly higher income as compared to large farmers in 'Mixed food crops only' (CS3). Small farmers also perceived significantly high expected income as compared to large farmers in 'Mixed food crops only' (CS3), (significant at ($p \leq 0.10$)).

Four pairs of cropping systems had significant differences in perceived risk, while only one pair had significant differences in expected income.

In the relationship between risk perception and household resources and characteristics, the predictors explained a substantial amount of the variations in risk perception of the cropping systems, thus showing strong and consistent relationship. Most of the findings are more or less consistent with earlier findings of this chapter. Important predictor variables are education, wealth, family size, age and gender. If these variables change, risk perception of farmers can also change. In particular, risk perception decreases with education, age and richness of the respondents.

Structured questionnaire approach versus utility theory approach in analysing risk perception

When the results of the utility theory category are compared with the results of perceived risk using the questions included in the questionnaire, there are some similarities. In both cases farmers perceived that production of food crops is less risky. In the structured questionnaire the results indicated that sole cropping of food crops is less risky compared to the mixture of food crops and trees. However, the mixture of trees and annual food crops is on average perceived as moderately risky. Similar results are obtained in the strength of conviction method where a mixture of annual food crops and the mixture of trees and food crops were judged as less risky. The difference between the two types of analysis is that in the utility theory category the farmers' responses can be used to derive the magnitude of the perceived risk and expected income/return while the structured questionnaire approach does not give such magnitudes but only percentage of respondents.

The strength of conviction uses subjective probabilities, and it is possible to rank the cropping systems in a quantitative way. The structured questionnaire approach does not use subjective probability and ranking of cropping system is more qualitative. As a result the use of a questionnaire limits the application of risk perception elicited. For example, the use of subjective distribution models and easiness of determining the relationship between risk perception and household characteristics and resources are restrained (See also chapter 8).

The use of a questionnaire is simple, quick and does not involve the elicitation of subjective probability distributions, and therefore has no estimation problems as in the use of strength of conviction (utility category). If well designed and applied the use of a questionnaire addresses the problems involved in probability elicitation, encoding and estimation.

Chapter 8 explores further on the risk perception measurements derived from the strength of conviction.

CHAPTER 8

IMPLICATIONS OF PREFERENCE RANKING, RISK ATTITUDE AND RISK PERCEPTION RESULTS

This chapter presents two main issues for discussion. First, the relationship has been studied between on the one hand various measures of risk attitude, risk perception and background socio-economic variables of smallholder agroforestry farmers and on the other hand preference ranking of cropping systems. Secondly, risk attitude and risk perception results have been combined in an attempt to determine the optimal/best decision of smallholders with respect to cropping strategies. Before presenting the above-mentioned issues for discussion, the chapter briefly presents the results of preference ranking of cropping systems strategies.

8.1 Results of preference ranking of cropping systems strategies.

In this section, following the procedure described in chapter 4, the preference ranking of the cropping systems is presented. The data was derived from a sample of 30 farmers who were also used in studying risk perception in chapter 7 and risk attitude using the utility theory approach in chapter 6. Unlike in risk perception and risk attitude, preference ranking of cropping systems took a relatively short time during data collection (about 20-30 minutes per respondent).

Mean, median and standard deviation of the ranking/ordering of cropping systems are presented in table 8.1. The preference ranking is such that the bigger the number the higher the preference rank.

The variation in rank is moderate as shown by the standard deviations and the differences between mean and median values are not substantial. As a result the mean values were used

Table 8.1 Statistics of preference ranking of cropping systems strategies

Cropping Systems	Assigned preference rank		
	Mean	Median	Std. Dev.
Mixed fruit trees (all ages) + food crops (CS1)	3.3	3.0	1.4
Trees (timber/fuelwood all ages) + food crops (CS2)	3.9	4.0	1.3
Mixed food crops only (CS3)	3.5	3.5	1.2
Cash crops only (CS4)	2.8	3.0	1.4
Trees (timber/fuelwood all ages) only (CS5)	3.3	3.0	1.1
Mixed fruit trees (all ages) only (CS6)	2.0	3.5	1.3

Source: Computed from survey data.

in ranking the cropping systems strategies. The results show that the most preferred cropping system is 'Trees (timber/fuel wood)+ food crops' (CS2) followed by 'Mixed food crops only' (CS3) (Table 8.1). The cropping system involving production of cash crops only was the least preferred system.

Pairwise comparison of the ranks of cropping systems did not show, however, any significant differences, indicating that there are no major differences between the preferences for the cropping systems.

The choice reflects the desire by farmers to meet their subsistence food requirements (each highly preferred combination includes food crops). The choice of the cropping systems also reflects one of the farmers' major ways of managing risks and uncertainty in agricultural production, namely diversification of crops grown mainly because the highly preferred cropping systems mostly contain mixtures of different crops and tree species.

Farmer categories showed differences in the preference ranking of cropping systems. Large farmers preferred the cropping system 'Trees (timber/fuelwood all ages) only (CS5)', while medium farmers ranked positively, cropping system 'Mixed fruit trees (all ages) + Food crops (CS1)'. Small farmers on the other hand ranked 'Trees (timber/fuelwood all ages) + Food crops (CS2)' as their priority number one (Table 8.2).

Table 8.2 Statistics of preference ranking of cropping systems strategies by farmer categories

Cropping systems	Large			Medium			Small		
	Assigned preference rank								
	Mean	Median	Std. Dev	Mean	Median	Std. Dev.	Mean	Median	Std. Dev
Mixed fruit trees (all ages) + food crops (CS1)	2.7	2.0	1.2	4.2	5.0	1.1	3.0	3.0	1.4
Trees (timber/fuel wood all ages) + food crops (CS2)	3.3	4.0	2.1	3.8	4.0	1.3	4.0	4.0	1.2
Mixed food crops only (CS3)	3.0	3.5	0.1	4.0	3.5	1.4	3.3	3.5	1.4
Cash crops only (CS4)	2.7	3.0	1.5	2.2	2.0	0.8	2.9	3.0	1.5
Trees (timber/ fuel wood all ages) only (CS5)	3.7	4.0	1.5	3.3	3.0	0.8	3.3	3.0	1.1
Mixed fruit trees (all ages) only (CS6)	3.0	3.0	1.1	1.7	1.0	1.6	1.8	1.0	1.2

Source: Computed from survey data.

The results indicate that large farmers perceive the importance of trees and tree products as a source of cash, thus preferring to grow woodlots alone. Small and medium scale farmers on the other hand prefer the availability of food crops alongside the production of trees and tree products (including fruit trees). However, these differences among large, medium and small farmers, are not significant when compared pairwise.

Table 8.3 Statistics of preference ranking of cropping systems by gender

Cropping systems	Male			Female			
	Assigned preference rank						
	Mean	Median	Std. Dev	Mean	Median	Std. Dev.	Significance.
Mixed fruit trees (all ages) + food crops (CS1)	3.2	3.0	1.4	4.0	4.0	1.4	NS
Trees (timber/fuelwood all ages) + food crops (CS2)	4.1	4.0	1.2	2.8	2.5	1.4	SG
Mixed food crops only (CS3)	3.5	3.0	1.3	3.3	3.0	1.5	NS
Cash crops only (CS4)	2.8	3.5	1.3	2.7	3.0	1.2	NS
Trees (timber/ fuel-wood all ages) only (CS5)	3.4	3.0	1.1	3.0	3.0	0.8	NS
Mixed fruit trees (all ages) only (CS6)	1.5	1.0	0.9	2.7	2.0	1.6	SG

Source: Computed from survey data. SG and NS means significant and not significant respectively in a pairwise comparison.

When the results are categorised into male and female respondents (Table 8.3), male respondents indicated the cropping system 'Trees (timber/fuelwood all ages) + Food crops' (CS2) as the first preferred strategy, while female respondents preferred 'Mixed fruit trees (all ages)+ food crops' (CS1). This ranking shows the importance attached to agroforestry systems that include food crops. The preference shown by men for 'Trees (timber/fuel wood all ages) + food crops' (CS2) may be attributed to the cash obtained from timber. Both male and female farmers indicated 'Mixed food crops only' (CS3) as the second most preferred system. This shows that there is also a high preference for growing mixed food crops (Table 8.3).

There was no significant difference between male and female in the preference ranking of 'Cash crops only (CS4)'. As far as the preference of cropping systems is concerned, the results generally show that the most preferred cropping strategies are those involving diversification of the cropping systems and the desire to meet subsistence food requirements is there in both sexes. As a result agroforestry involving production of food crops is highly preferred.

Significant differences between male and female respondents regarding cropping systems preference ranking can be observed in the cropping systems 'Mixed fruit trees (all ages) only '(CS6) and 'Trees (timber/fuel wood all ages) + food crops' (CS2). Male respondents have a significantly higher preference to 'Trees (timber/fuel wood all ages) + food crops' (CS2) as compared with female respondents, while female respondents showed a high significant difference in cropping systems 'Mixed fruit trees (all ages) only '(CS6) (Table 8.3). This supports the observation that female farmers are much more concerned with selling fruits, while male farmers preferred selling timber.

8.2 Relationship between preference ranking of cropping systems and risk attitude, risk perception, household resources and characteristics

The conceptual framework (chapter 3) postulates that there is a relationship between risk attitude, risk perception, household resources and characteristics, and the preference ranking and choice of cropping systems.

The relationship was investigated using linear regression analysis. The dependent variable is the rank of cropping systems. The predictor variables are years of education, age in years, gender (dummy variable =1 if male and 0 if otherwise), household size and wealth (score), risk attitude (score), risk perception (standard deviation) and the expected income (mean). If a variable has a negative coefficient, it implies that the rank of that cropping system will be lowered and vice versa.

Generally, a negative relationship between the rank of a cropping system and risk attitude and risk perception of the farmers is expected. The higher the perceived risks of a given cropping system given the farmers' risk attitude the lower the rank of a cropping system. However, the extent of this relationship is dependent upon the risk associated with each cropping system. As already shown in chapter 7, cropping systems are perceived differently with respect to risk and expected income. More risk averse farmers are expected to rank low, more risky cropping systems (i.e. cropping systems with perceived high variance) and likewise, the more the perceived risks of a particular cropping system, the lower the rank of that cropping system.

However, the influence of risk attitude may be complex. Risk attitude and risk perceptions are factors that are not independent in influencing the preference rank of cropping systems.

The results are presented in table 8.4 and are detailed in appendix 6. With exception of household size, other variables are significant in at least one of the cropping systems.

With the exception of cropping system 'Mixed food crops only' (CS3), risk attitude showed the expected negative relationship with preference ranking of the rest of the cropping systems. However, significant effects were observed only in cropping systems 'Mixed fruit trees + food crops' (CS1) and 'Cash crops only' (CS4). Risk perception showed a consistent negative relationship with preference ranking of cropping systems. A significant relationship was observed in cropping systems 'Trees (timber/fuelwood +food crops' (CS2) and 'Cash crops only' (CS4).

The gender variable is significant and positive in preference ranking of the cropping systems 'Mixed fruit trees + mixed food crops' (CS1), 'Trees (timber/fuel wood) + mixed food crops' (CS2), and 'Mixed fruit trees only' (CS6). Gender therefore plays a role in the preference ranking of these cropping systems. In particular male respondents are responsible for the high ranking of these cropping systems. Earlier in this chapter we observed that in the cropping systems 'Trees (timber/fuel wood) + mixed food crops' (CS2), and 'Mixed fruit trees only' (CS6) males had a significantly higher preference ranking as compared to female respondents and thus showing support to this finding.

Table 8.4 Effects of risk attitude, risk perception, household resources and characteristics on preference ranking of cropping systems (n=30)

Variable/ Cropping system	Mixed fruit trees + food crops (CS1)		Trees (timber/fuel - wood) + food crops (CS2)		Mixed food crops only (CS3)		Cash crops only (CS4)		Trees (timber/fuel wood) only (CS5)		Mixed fruit trees only (CS6)	
	Sign	Significance.	Sign	Significance	Sign	Significance	Sign	Significance	Sign	Significance	Sign	Significance
Education (years)	(+)	*	(+)	-	(+)	-	(-)	-	(+)	-	(-)	-
Age (years)	(+)	*	(+)	-	(+)	-	(+)	*	(-)	-	(+)	*
Gender (dummy)	(+)	*	(+)	*	(+)	-	(-)	-	(-)	-	(+)	*
Risk attitude (score)	(-)	*	(-)	-	(+)	-	(-)	*	(-)	-	(-)	-
Risk perception (std. Dev.)	(-)	-	(-)	*	(-)	-	(-)	*	(-)	-	(-)	-
Expected Income (Mean)	(+)	*	(+)	-	(+)	*	(+)	-	(+)	-	(+)	-
Wealth (score)	(+)	-	(-)	-	(+)	-	(-)	-	(+)	*	(+)	-
Household size(number)	(-)	-	(-)	-	(-)	-	(-)	-	(+)	-	(-)	-
R squared	0.88		0.62		0.46		0.40		0.43		0.81	

* Means the coefficient is significant (p≤0.10 two tailed)
\- Means not significant

Age of the respondent is positive and significant in explaining the variations in the preference rank of the cropping systems 'Mixed fruit trees + mixed food crops only'

(CS1), 'Mixed fruit trees only' (CS6) and 'Cash crops only' (CS4). This shows that the older the respondents the higher the preference rank of these crops. This may be among other factors explained by experience gained in farming. The education variable is significantly and positively related to the preference rank of the cropping system 'Mixed fruit trees + mixed food crops' (CS1). The wealth variable showed a positive and significant effect in explaining preference ranking of the cropping system 'Trees (timber/fuel wood) only (CS5). The wealth variable typically was not expected to have a significant relationship with preference ranking. However, this significance may have been attributed by the fact that this cropping system is market oriented, as a result wealthier individuals may show preference.

The expected income (mean) variable was postulated to have a positive relationship with preference ranking of cropping systems. The results show that the variable has the expected sign. However, it is only in cropping system 'Mixed fruit trees + mixed food crops only' (CS1) and 'Mixed food crops only' (CS3) where the variable is significant in explaining preference ranking of cropping systems.

8.3 Summary of major findings and conclusions

A summary of the major findings and conclusions emanating form chapter 8 are presented in the subheadings below.

Preference rankings of cropping systems

The aim of preference ranking of cropping systems is two folds. The first one is to determine the most preferred cropping systems by farmers and relate the preference ranks with the household resources and characteristics. The second is to determine the differences in crop preference rankings among the farmer categories and gender.

In general farmers indicated high preferences to agroforestry cropping systems namely 'Trees (timber/fuel wood all ages) + food crops' (CS2) followed by preference to food crop production system namely 'Mixed food crops only' (CS3). The cropping system involving 'Cash crops only' (CS4) was the least preferred. This shows that farmers put more emphasis on food crop production as well as on integrating trees in their farming systems. It was mentioned in chapter 5 that some food crops like maize and beans are also produced for the market, reducing the dependence of farmers on 'traditional' cash crops like coffee and cotton. The desire of the farmers to diversify their crops and cropping systems is also observed from these results. This is one of the ways farmers use to cope with risk in agriculture (see also chapter 5 and 6). However, it is important to note from the results that there were no major significant differences in the ranking of the cropping systems.

The results show that large farmers prefer growing 'woodlots' i.e. 'Trees (timber/ fuel wood all ages) only' (CS5), while small and medium farmers prefer growing food crops mixed with trees i.e. cropping systems 'Trees (timber/fuel wood all ages) + food crops' (CS2) and 'Mixed fruit trees (all ages) + food crops' (CS1) respectively. The two agroforestry systems i.e. CS1 and CS2 were also ranked as the first option by male and female respondents respectively.

The general conclusion from the results of farmers' preference ranking is that high priority is attached mostly to food production and agroforestry (mixture of food crops with timber/fuel wood species and fruit species) on the one hand and diversification of crops (food and tree crops) on the other.

Relationship between preference ranking of cropping systems, risk attitude, risk perception and household resources and characteristics

Risk perception and risk attitude variables were negative and significant in two out of the six cropping systems, indicating that risk attitude and risk perception are important in explaining farmers' preference ranking of those cropping systems.

Included household resources and characteristics showed a strong relationship with preference ranking of cropping systems. The findings are also consistent to some of the earlier findings in section 8.1. With the exception of household size, which was not significant, the included variables are positive and significantly influencing the variations in the observed preference ranking of the cropping systems. Negative relationships were noted between preference ranking and some variables but were not significant. Expected income (mean) was significant in explaining preference ranking in cropping systems 'Mixed fruit trees + food crops (CS1) and 'Mixed food crops only (CS3).

From the above relationships we can conclude that preference ranking, is influenced by risk attitudes, risk perceptions, expected income and household resources and characteristics. Policies aimed at changing/influencing these household resources and characteristics are likely to have an impact in risk taking capabilities of the households. As was noted above and in chapter 2, influencing risk attitude is not easy as it is related to permanence or long term clusters of feelings, beliefs and behavioural tendencies. But since attitude has evaluative, belief and behavioural components, it is still possible to change some of the components. For example improvement in information people have, can improve the belief component which depends on the information available and its processing capabilities. Improving long-term crop yields can also influence the evaluative component (see also definitions of major concepts in chapter 2 and Musser and Musser (1984)).

On the other hand risk perception is not permanent and is easily influenced by factors such as household resources and characteristics.

Implications of the results on the choice of cropping systems

The main aim of this research is to establish an understanding of farmers' risk attitude and risk perception towards risk in making agroforestry production decisions. In the hierarchy of systems (Fresco *et al.*, 1989), the emphasis was placed on cropping systems at the level of analysis on farmers' individual plots. The purpose of considering the cropping systems approach was to be able to identify the position of agroforestry cropping systems in the whole production system, since as is evident from previous chapters, farmers own more than one agricultural plot and more than one cropping system (Chapter 5). Risk attitude, risk perception and preference ranking are assumed to have an impact on the choice of cropping systems (See the conceptual framework in Chapter 3).

So far the cropping systems proposed in this research have undergone different analyses namely risk perception of the cropping systems (including efficiency of cropping systems in terms of mean-variance) and preference ranking. All the above analyses provided a ranking of cropping systems according to a pre-set criterion. The aim is to compare the rankings emanating from the above analysis with the actual cropping systems practised. Table 8.5 presents the ranking of the cropping systems emanating from this research. If a boundary is drawn at the centre of this table, the two halves are showing more or less similar rankings of the cropping systems. CS1 CS2 and CS3 dominate the upper portion, while the lower portion consists of CS4, CS5 and CS6. Cropping system CS4 was ranked higher when the ranking is based on expected income (mean).

Table 8.5 Comparison of the rankings of the cropping systems by different analyses

Analysis /Ranking	Actual Cropping systems[1]	Risk Perception[2]	E-V efficiency[3]	Ranking based on expected Income[4]	Preference Ranking [5]
1	CS2	CS3	CS1	CS2	CS2
2	CS3	CS1	CS2	CS4	CS3
3	CS1	CS2	CS3	CS1	CS1
4	CS6	CS5	CS5	CS6	CS5
5	CS4	CS6	CS6	CS5	CS4
6	CS5	CS4	CS4	CS3	CS6

[1] Actual cropping systems: The ranking was obtained from the data collected using the structured questionnaire analysed using cross tabulation (See chapter 5)

[2] Risk Perception: Cropping systems were ranked based on the perceived risk/standard deviation (See chapter 7)

[3] E-V efficiency: The ranking was done by plotting the mean against the standard deviation of the cropping systems, making use of the E-V rule (See chapters 7)

[4] Ranking based on expected Income: Cropping systems were ranked based on the perceived mean income (See chapter 7)

[5] Preference Ranking: Ranking was done by using data from farmers' preference ranking of cropping systems (See chapter 8)

Based on this, almost all the analyses produced a similar ranking of cropping systems. The analyses more or less conform to the actual cropping systems practised. The most highly ranked and most practised three cropping systems are CS3, CS2 and CS1. However, CS4 "Cash crops only" was ranked higher when the ranking criterion is expected income, but ranked lower when the other ranking criteria are used. This result was expected.

Some important conclusions can be drawn from the above comparisons. **First** the analyses show a similar ranking of the cropping systems as the actual cropping systems practised, indicating that farmers consider risks in selecting their cropping strategies and in making production decisions. This is supported by the diversified components of the first three highly ranking cropping systems. In addition, farmers make a rational choice under risk when selecting their cropping systems because their choices are consistent with their strength of conviction (subjective probabilities) about the occurrence of risk prospects (i.e.

cropping systems). **Secondly**, production of food crops is emphasised, because each of the highly ranking cropping systems involves a mixture of different food crops, either grown with or without trees. In a way farmers put more emphasis on growing crops and trees that will meet their immediate subsistence consumption of food, fuelwood and other tree products needs. The inclusion of trees (timber/fuelwood/fruit trees) in the highly ranked cropping systems confirms that farmers consider agroforestry as a measure against risk as indicated in chapter 7. **Thirdly,** farmers' actual cropping systems show that they are consistent in their risk attitude, risk perception and preference ranking of their cropping systems. This is mainly because of the similarities shown along the rankings that involved independent methodology of eliciting information from the farmers.

CHAPTER 9

GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents reflections on the research approaches and assumptions, conceptual framework, research methodology and the results of this research. The discussion centres on specific limitations and strengths of the research in trying to validate the results.

9.1 Reflections

This section looks at the research methodologies and the hypothesised relationships in order to find out if they are in line with the actual observations. The section also reflects on the results of the research, the extent to which they meet the research objectives and how they compare with the outcome of the results of researches in the literature.

9.1.1 Reflections on the research approaches and assumptions

The research approach was mainly based on gathering information about risk attitude and risk perception from the decision-makers, i.e. direct use of decision-makers to generate information about risk attitude and risk perception, rather than making prior assumptions and deliver recommendations regarding decision making to the farmers (Positive approach). As pointed out earlier, this approach is appealing because one gets the firsthand information on the way farmers perceive and react to risk from their own point of view. However, several limitations are also observed in this type of approach. The first one concerns the need to have the presence of the decision-maker, especially his time, in order to elicit the information. Sometimes the farmers are not available and/or only they allocate a short time to the elicitation process that is long and tiresome. Farmers showed interest in the process of elicitation. This was only fortunate because they perceived the interview and questions quite differently from the normal questionnaires they were used to. Kajembe (1994:152) notes that there is a tendency among farmers to give 'conditioned' responses to questionnaires they are often used to, in trying to impress the researchers. However, this was not the case here because the farmers are not used to the elicitation procedures applied in this research. However, our structured questionnaire (Appendix 1), involving 100 farmers did not avoid the so-called 'conditioned' answers. Informal discussion with farmers and observations assisted in reducing the possible biases in the questionnaire used. Secondly, as pointed out in chapter 1, farmers are not always seeing risk in the way the analysts do and therefore more time was needed to translate the technical concepts of risk to farmers in order to have a common understanding, especially from English to the local 'Kiswahili' language. This had implications on the time and cost of the research.

Closely related to the research approach are the criticisms that are placed on the use of elicitation and the application of the utility theory approach (See chapter 2). Although much support exists for the use of the utility theory approach, this research attempted also another approach of examining risk attitude (the latent variable approach) based on factor analysis. This method is based on the fact that things like risk, altruism, love etc. cannot be measured by a single item/statement, but rather a group of items/statements. However, the method has the limitation that farmers were not classified using the risk aversion measures as is the case in the utility theory category. The strength of this method is that only items that are found to be reliable are used or given more weight in factor scores. In addition, like in the use of the utility theory approach, this approach also allows the use of regression analysis to explore the relationship between the risk attitude measured and the household resources and characteristics. Furthermore, it avoids the use of the highly criticised elicitation and utility theory assumptions.

The main assumption of this research on the decision-makers is that they act rationally and choose the 'best' alternatives available to them. However, in practice non-rational acts are not ruled out completely. The results in a way supported this assumption of the farmers when making their choices under risk because the farmers' actual choices of cropping systems were more or less consistent with their strength of conviction (subjective probabilities) about the occurrence of the uncertain prospects. This was made evident by comparing the rankings made using the strength of conviction method and the actual cropping systems. These were more or less similar.

In the elicitation of utility under different situations, a restrictive assumption was made regarding the occurrence of the situations. If the respondent is assuming a situation of adequate cash, the other situations are assumed to be constant or not specified. This assumption though restricting, was made in order to interpret the results given that the farmer faces the assumed situation. However, in reality farmers may be experiencing for example, inadequate cash as well as inadequate food. The possible combinations of different situations were not tested. Further research is required to make assumptions that are more explicit in real world situations. However, the finding that farmers may have different risk attitudes when faced by different combinations of situations is important to support such further research.

9.1.2 Reflections on the conceptual framework

Smallholder farmers are assumed to be making their production decisions in a complex decision environment that influences their decisions (Chapter 3). The research, however, did not pay much attention to the complex set of elements constituting the decision environment. As pointed out in chapter 3, the decision environment is expected to have influence on risk attitude and risk perception, preference ranking and choice of the cropping systems. The nature, direction and extent of the influence of these elements of the decision environment were not studied i.e. the elements of the decision environment, were assumed to be the same for all the farmers. This is in a way a valid assumption because the research was undertaken in the same geographical region where farmers have a more or less similar decision environment. To take into account the differences in the decision environment the research could have been extended to geographical regions with a different decision environment. In reality, the scope of the research was deliberately limited, largely due to time and resource constraints for the research. As a result only household resources and characteristics were singled out as crucial elements influencing risk attitude, risk perception and preference ranking of cropping systems.

Household objectives/criteria (e.g. productivity, profitability, security, sustainability etc.) may be important in explaining the differences in decisions among smallholder farmers (Chapter 3). No explicit attention was paid to these objectives/criteria in this research. For example, the postulated relationship between risk attitude and risk perception with the household objectives/criteria and the effect of household objectives/criteria on the preference ranking and choice of cropping systems were not explicitly studied. But implicitly, the household objectives were taken into account at least partly, via the household resources and characteristics. Despite all the limitations above, the results are still expected to be valid. The postulated relationship between household resources and characteristics and risk attitude, risk perception and preference rankings of the cropping systems was found to exist and some of the household resources and characteristics are significant in explaining the variations in risk attitude, risk perception and preference ranking of cropping systems.

9.1.3 Reflections on the research methodology

The choice of a single research area, Babati District, was justified based on the efforts made in agroforestry development on the one hand and the resources that were available for this research on the other. However, there are areas in Tanzania where such efforts are also present, for example SECAP in Lushoto, TFAP in north Pare and DOVAP in Dodoma etc. (See chapter 1). We do not know yet to what extent the results obtained in this research can be transferred to other areas such as those mentioned above. In this regard more research efforts are needed to complement or extend this research.

Another important limitation of this research is that it did not follow a comparative approach by including agroforestry and non-agroforestry farmers. This would have allowed the comparison of the various measures of risk attitude and risk perception among the farming community in Babati district. Initially it was planned to categorise the sample into the above propositions. However, the following reasons made it difficult to do so. The first, and foremost were financial and time resources constraints. This would have entailed another sample of say 30 farmers who are not practising agroforestry, making the elicited data points to almost double if six cropping systems were to be adopted for non-agroforestry farmers. Secondly, the nature of farming plots in the surveyed villages made it difficult to conclude that a particular farmer is an agroforestry farmer per se. A farmer may have four or five plots located in different areas with only one of the plots with agroforestry. In other words it was difficult to single out a pure non-agroforestry farmer in the sampled villages which is also one of the limitations of the choice of the research area. Due to the above reasons, the fact that the cropping systems could not be directly compared (i.e. agroforesters and non-agroforesters will have incomparable cropping systems) and the desire to have information from agroforestry necessitated the sampling approach used. However, the cropping systems' approach made it possible to have comparative analysis of different cropping systems ranging from a mix of food crops, cash crops, fruit trees, pure woodlots and agroforestry cropping systems.

Taking into consideration that farmers' decisions, especially on perennial crops, are highly dynamic and are influenced by changing socio-economic, institutional and natural factors, it was decided during the design of this research to collect information for two consecutive seasons. However, due to time and financial resources constraints, the measurement procedures were only taken once, using cross-sectional data (static decision process). We cannot therefore predict with certainty how stable our results will be over time and we do not know how long the results obtained in this research will be valid.

The elicitation process of risk perception (nine points per farmer per cropping system) and that of certainty equivalents (at least five points per farmer per situation) proved to be a long and a tiring process. This necessitated limiting the sample of farmers to only 30 (for detailed research approach). Small sample sizes are usually associated with sampling errors and the problems of statistical inferences. However, a trade-off was made between the foregoing statistical advantages and the level of in depth information required for the research. This was mainly due to the long procedure of obtaining the elicited points and the farmers' time involved. Further, due to the relatively large number of points elicited for each farmer the overall data points were 270 for the risk perception study for each of the six cropping systems and at least 150 points for the risk attitude study for each of the four situations. More time and financial resources are needed in the future if the full advantages of a large sample size are desired.

Most decision problems involve more than one uncertain quantity. In our example of the choice of cropping systems, returns to cropping systems may depend on many uncertain factors including yields, prices, agro-ecological conditions, soils etc. In other words the choice of a risky prospect most often is not stochastically independent (See Hardaker *et al.*, 1997). Two variables are stochastically independent if the probability distribution of one does not depend on the value of the other. We cannot strongly argue that the probability distribution of returns of cropping systems is not influenced by the distributions of other factors, making our assumption of stochastic independence not holding. The assumption was therefore made to simplify the process of elicitation, assuming that all other factors are constant; what determines risk perception is return to cropping systems. Otherwise the research could have involved a rather difficult task of eliciting joint probabilities. Other methods that could have been used as discussed in Hardaker *et al.* (1997:47-48) are the use of historical data alone or in combination with elicitation and the use of a 'hierarchy of variables' approach.

9.1.4 Reflections on results

Reflections on the results are presented, based on the extent to which the results achieve the objectives of the research and how they compare with previous research conducted elsewhere.

Extent of achieving the objectives of the research

The main objective of the research is to set an understanding of the farmers' attitude and perception towards risk in making agroforestry decisions as well as its relationship with the social and economic environment.

Based on the objectives, a series of specific objectives and research questions were formulated (Chapter 3). A schematic representation of the linkages between research objectives, concepts, questions, methods and data analysis has also been outlined in chapter 4. The results, which are presented in chapter 5 up to chapter 8, indicate that the objectives of the research are more or less achieved and the research questions are answered.

The broad and specific objectives of the research were achieved by answering the research questions presented in chapter 3 as shown below:

Research questions one to five (See chapter 3) relate to farmers' risk perception of cropping systems, how their risk perception compares with the actual cropping systems and the position of agroforestry in farmers' actual cropping systems. In answering these questions sources of risk in agroforestry and in sole cropping were identified (See chapter 7). Farmers' risk perception of cropping systems with respect to returns of the cropping systems were derived from the strength of conviction method (Chapter 7).

Research question six inquires about the farmers' risk management strategies. In the research area farmers apply six main risk management strategies. These are crop selection, pruning trees, use of fertilisers and manure, maintenance of liquid assets, diversification of income sources and the use of formal and informal lending systems (Chapter 7)

Research questions seven up to nine (Chapter 3) relate to the choice of utility functional forms in different farmers' situations, differences in risk attitude among farmers in different situations and the factors affecting risk attitude in a wider context. These were answered and presented in chapter 6. Prior testing and evaluation of different utility functions under different situations was found useful. This also supports the recommendations made by Zuhair *et al.* (1992).

Research questions ten and eleven were concerned with the position of agroforestry in farmers' preference ranking of cropping systems and whether the choice of agroforestry is related to risk. The results of ranking cropping systems (Chapter 8) show that almost all the analyses produced a similar ranking of the cropping systems, which compares well with the actual cropping systems practised in the surveyed villages. Based on the rankings and the actual choices, farmers' actual choices of cropping systems are consistent to their risk attitude, risk perception and preference ranking of cropping systems, and they depend on risk and returns of the cropping systems.

Research question twelve (Chapter 3) inquires about the existence of a relationship between risk attitude, risk perception and preference ranking of cropping systems with household resources and characteristics. Using regression analysis, some relationship has been found between risk attitude, risk perception and preference ranking of cropping systems with selected household resources and characteristics. The relationship between preference ranking of cropping systems with risk attitude, risk perception and household resources and characteristics was also found. The analysis, however, showed a low level of explanation of risk attitude indicators by the included household resources and characteristics with respect to risk attitude indicators. Other analyses i.e. with risk perception and preference rankings of cropping systems showed a high explanation level.

Comparison of measures of risk aversion with previous studies

Various attempts have been made in estimating measures of risk aversion among farmers, especially the absolute and relative coefficients of risk aversion. As pointed out in Bar-Shira *et al.* (1997) there exists some empirical evidence on the signs and magnitudes of these measures. There is little evidence of these measures in sub-Saharan Africa and even less in agroforestry and in different situations facing the farmer. Table 9.1 shows the measures of risk aversion emanating from this research while table 2.2 gives a summary of previous studies (not exhaustive), for comparison purposes. None of the cited studies is from sub-Saharan Africa.

The tables 9.1 and 2.2 show that there are variations in the magnitude of the estimated risk attitude coefficients depending on the method of analysis employed. With the exception of the studies by Simon and Pomareda (1975), Wolf and Pohlman (1983); Antle (1987) and Chavas and Holt (1993) who had larger coefficients as compared to those of this research, all other researches (Table 2.2) show more or less a similar magnitude of the coefficient of absolute risk aversion (R_a) as reported in this research (Table 9.1)[32] Studies by Buccolla (1982) and Huirne *et al.* (1997), which used an exponential utility function, have R_a values comparing favourably with the situation of adequate cash and used the same utility functional form.

Table 9.1 Summary of results of measures of risk aversion in this research

Situation	Utility function used	Coefficient of absolute risk aversion (R_a)	Coefficient of relative risk aversion (R_l)
Inadequate cash	Quadratic	-0.00563 to 0.00547 (0.0023)	-1.447 to 2.48 (0.627)
Inadequate food stock	Cubic	-0.00249 to 0.00431 (0.0021)	-0.98 to 2.64 (0.674)
Adequate food stocks	Logarithm	0.00047 to 0.0050 (0.0017)	0.180 to 1.500 (0.383)
Adequate cash	Exponential	0.00006 to 0.00236 (0.00106)	0.134 to 0.875 (0.215)

Numbers in parenthesis are mean values

Regarding the coefficient of relative risk aversion (R_l) the ranges are more or less similar to those obtained from previous studies (Table 2.2). For example the situation of inadequate cash has similar ranges of R_l as those recorded in Freund and Blume (1975), Hansen and Singleton (1982), Szpiro (1986) and Bar-Shira (1997).

Results from Zuhair *et al.* (1992) show great similarities in the classification of farmers. Both cases have, as expected, all farmers classified as risk averse by the negative exponential function. The quadratic utility function has 10% and 7% of the farmers as risk takers/preferring in Zuhair *et al.* (1992) and this research respectively. However, in Zuhair *et al.* (1992), the cubic utility functional form had more risk seekers (50% of the respondents) as compared to this research (10% of the respondents). These two researches

[32] R_a is sensitive to the scale of measurement, i.c. the scale of X. This may be a source of differences with coefficients reported

are comparable mainly because both of them elicited information from farmers (positive approach) and applied similar utility functional forms. The research by Smidts (1990) also gave a similar classification of decision-makers. In 1984 and 1985, 6% and 9% respectively were risk preferring individuals, indicating that the majority of farmers are risk averters as is the case in the present research.

It can therefore be concluded that the present research in the order of magnitude of the coefficients of risk aversion compares favourably with those of research conducted elsewhere.

9.2 Conclusions

The research has made an attempt to give an understanding of risk attitude and risk perception in agroforestry with particular emphasis on decision making regarding the choice of cropping systems. The research also made a particular attempt to apply the expected utility model in agroforestry using elicitation of farmers' certainty equivalents.

A general conclusion from this research is that the approach of studying risk attitude and risk perception separately is useful in drawing meaningful conclusions regarding farmers' risks and uncertainties in making production decisions. In addition the research has demonstrated the use of positive approach in understanding farmers' risk attitude and risk perception based on direct contact with them. The following are the main conclusions with respect to the specific objectives (in bold face and italic).

To establish what farmers perceive as returns and risk of various cropping systems with particular attention to agroforestry.

- In sole cropping the main perceived sources of risk are drought, poor soils, and insect and vermin attack to crops. In agroforestry, perceived problems are competition of trees with annual crops, labouring of insect pest by trees and problems related to accessibility by tractor.
- Farmers give priority to production of food crops as well as agroforestry systems that involve a mixture with food crops. The preferred food cropping system based on returns and risk is 'Mixed food crops only' (CS3) which was classified as low risk. The agroforestry systems preferred under the same criteria are 'Mixed fruit trees + mixed food crops (CS1) and 'Trees (timber/fuelwood) + mixed food crops only' (CS2), which were classified as low risk and moderately risk respectively.
- Farmers therefore strive first to meet their household requirements of food and tree products (i.e. firewood, poles, fodder and fruits). This shows that agroforestry systems play important roles in the household economy and as a measure against risk. With regard to risk management strategies, agroforestry products are maintained as liquid assets that can be sold or liquidated to buffer consumption during bad years. Provision of fodder for livestock during dry seasons by the tree component is a measure against drought related sources of risk.
- The most preferred cropping systems based on returns and risk always involve a mixture of food and/or tree species. This implies that the cropping systems are

highly diversified (in terms of species and plots). This is one way of managing risk in the research area.

- Males dominate decision making in households regarding the tree species to be grown and utilised/sold. Since the responsibility of collecting firewood is by women and children, there is a danger of growing preference conflicts in the household. Males may be interested in high valued timber species as compared to females' interest in growing firewood species.

To establish farmers' risk attitude in a wider context and under different situations facing the farmers.

- The research showed the need for looking at the selection and specification of the utility and the probability distribution functional forms mainly because individuals have a unique risk attitude and it is unlikely that one form of utility function can correctly predict behaviour of all individuals. The research does not suggest that the selected functional forms are appropriate in those situations, rather suggesting that several utility functional forms should be evaluated.
- The use of the expected utility model through elicitation needs to be taken with great care. The use of multiple approaches including non-utility methods can complement the results of the utility approach if not confirming it.
- The use of the latent variable approach in risk attitude analysis explains risk in a wider context, by taking into considerations various items that jointly explain risk attitude more widely. The method also allows the comparison of other attitudinal measures with risk attitude.
- A relatively large number of respondents have a positive attitude towards risk and land resource conservation as analysis with the latent variable category shows. The attitude towards commercialisation was low, maybe because of poor transport and road infrastructure.
- Risk attitude in a wider context (using the latent variable approach and regression analysis) is significantly influenced by the attitude towards land resource conservation (measured as a score), attitude towards commercialisation (measured as a score), education of the respondents (in years) and the wealth index (measured as a score).

To assess farmers' preference ranking and choice of cropping systems.

- Comparison of different rankings of the cropping systems applied in this research (Chapter 8) showed similarities with the actual cropping systems practised by farmers. The highly ranked and frequently practised cropping systems are 'Mixed food crops only' (CS3) 'Mixed fruit trees + mixed food crops (CS1) and 'Trees (timber/fuelwood) + mixed food crops only' (CS2).
- The choices of the cropping systems by farmers (agroforestry cropping systems in particular) are based on risk and returns. This has been made evident by the observed relationship between preference ranking of cropping systems with risk attitude and risk perception.

- Based on the above mentioned, farmers make a rational choice under risk when selecting cropping systems in that way their actual choice is consistent with their strength of conviction (subjective probabilities) about the occurrence of uncertain prospects.

To identify any relationship between risk attitude, risk perception, expected income and preference ranking of cropping systems

- Using regression analysis, there is a relationship between risk attitude, risk perception and preference ranking of cropping systems with selected household resources and characteristics.
- Risk attitude and risk perception are significant in influencing farmers' preference ranking of some cropping systems. Expected income (mean) was also significant in explaining preference ranking of some cropping systems.
- The role of household resources and characteristics in influencing risk attitude, risk perception and preference ranking of cropping systems allows for policy recommendations to be made which will influence the choice of cropping systems and manage risk.

9.3 Recommendations

Based on the conclusions derived above, recommendations regarding the method of analysis, areas for further research and policy implications are made in the following section.

Recommendations on methods of analysis

Some important lessons emanating from this research concern the application of the utility and the strength of conviction methods in studying risk attitude and risk perception using the positive approach. The approaches produced results that are generally consistent with other studies carried out elsewhere. Experiences gained, showed that the difficulty in the elicitation process and the time taken for the respondents was enormous. The time taken is aggravated by the need for setting a common understanding between the respondents regarding the technical concepts involved in risk analysis. Educational surveys are necessary before the actual elicitation. However, as pointed out in section 9.1.1 above, the problem of 'conditioned' answers was not apparent because farmers were not familiar with the elicitation procedure beforehand. With the emergence of user-friendly packages, data analysis is made simpler and a wide range of distributions and utility functional forms can be estimated. An example of a user friendly and practical oriented package is '@risk' from Palisade Corporation. The packages could also be useful for extension workers, researchers and policy makers in educating and assisting farmers in decision making. However, the first and foremost thing is to ensure that the elicitation processes give reliable data.

Experience from this research shows that the latent variable approach is a quick way of understanding risk attitude and other attitudinal measures from the respondents. The relationship between risk attitude measured using latent variable approach with other attitudinal measures and household resources and characteristics can be investigated using multiple regression analyses.

Areas for further research

As pointed out in section 9.1.3, there is a need for extending this research to other areas in order to ascertain the extent to which results obtained in this research are applicable in other areas with or without similar conditions as in the research area. In addition, the time frame needs to be considered to know whether the results will change over time. However, it is important to note that as time passes by there may be changes in the decision environment as well. Various ways are available in considering time in risk analysis. The method suggested by Backus *et al.* (1997:321) needs to be considered in further research. This involves characterising the long-run uncertainties by developing a set of scenarjos that captures the range in uncertainties facing the firm's or farmer's external environment. A detailed review is contained in Backus *et al.* (1997).

Risk sharing through the use of insurance has a role to play in farmers' risk management strategies. Taking into consideration that its application to Tanzania's agriculture is still underdeveloped, there is a need for carrying out research and get more information on the structure, conduct and performance of markets with respect to risk especially markets for land, finance and insurance for agricultural activities.

Perception of the main sources of risk in the surveyed areas by farmers show that risks related to stochastic agro-ecological factors are important. As a result there is a need for putting more research efforts on different agro-ecological zones and how risk perceptions differ with agro-ecological zones which are mostly having different agroforestry systems.

Although the research used agroforestry as a case study, still more treatment/research is needed on the impact of farm level risk behaviour and/or decisions versus the possible consequences on the environment. These areas are closely related because consequences of risk behaviour may adversely affect the environment, which is a potential source of risks.

The approach raised by Schmeidler (1982, 1989) and Gilboa (1987) and applied by Aizenman (1997) on uncertainty aversion and the use of subjective non-additive probability distributions needs to be further explored especially in agricultural applications, (Schmeidler-Gilboa - SG approach). This enables the distinction between risk and uncertainty aversions.

The latent variable approach used in this research need to be further explored and used in measuring attitude towards risk. As is evident from the application, this approach can be a relatively quick way of getting an insight into farmers' risk attitude without involving the use of subjective probability distributions. Also extension personnel, policy makers and agricultural researchers can use it. However, more use and wider applications and refinements need to be carried out.

More work is needed in measures to combat variability in the stochastic agro-ecological conditions affecting agroforestry and in the development of techniques that are affordable by smallholder farmers. Research in rainwater harvesting which explores methods required to optimise the use of soil moisture could be one of such areas where research efforts can be directed.

Further research is required in determining the optimal choice of cropping systems based on risk attitude and perception i.e. developing the efficient frontier and indifference curves. Given the time and resource constraints this analysis was not undertaken in this study.

Policy implications and recommendations

Adopting agroforestry can both reduce and increase risk to the security of a household's livelihood. Income diversification is a strong positive benefit to the household with respect to risk. However, there are risks associated with cultivating trees as with any other crop, for example unusual droughts, poor seedlings, uncertain markets, lack of factors of production such as land, labour and capital etc.

However, the results of the research show that farmers use agroforestry as part of their risk management strategies. To support the role of agroforestry in fulfilling its role in risk management, various policy interventions are possible. The first category is the development of infrastructure and institutional support in roads, extension, legal land tenure and to a certain extent in agricultural finance especially credits and saving schemes by the farmers. Improvement in information dissemination (extension and training) regarding agroforestry technologies is advocated. For example information related to proper spacing of trees, which will optimise the benefits from agroforestry and reduce competition for nutrients, light and water and information regarding deep-rooted tree species, which will reduce impediment to tractor operations, is necessary. Information on better use of fire and improvement of pasture and grazing lands will enhance establishment of tree seedlings on the farmlands. These measures/interventions will enhance the capabilities of the rural communities to take risk. Although the main driving force for agroforestry in the research area is to meet household needs, development of marketing institutions and infrastructures will gradually encourage the sale of surplus agroforestry products (Filius, 1997).

The second category of policy interventions are those related to minimising the impacts of risks and uncertainties as a result of stochastic agro-ecological factors. Important measures are those related to the control of environmental variability i.e. minimising the adverse effects of stochastic agro-ecological factors. Notable examples are the use of irrigation/supplementary irrigation against drought risks, soil conservation measures, tillage practices and the uses of rainwater harvesting for crop, trees and livestock production.

Interventions towards technology development in agroforestry will have an impact on farmers' risk control capacity. Such interventions are for example breeding and selection techniques for drought and short maturity, breeding varieties for pest and diseases resistance, agroforestry tree species selection which are more suited to drought are among the measures. Integrated pests and diseases control measures are also long-term options of dealing with environmental variability.

Based on the above mentioned there is a need for strengthening research in tree species suitable for minimising risk incidences when mixed with annual crops. The choice of tree species should consider among others good economic properties, meeting farmers' subsistence need for fuel, fruits etc, allow the use of tractors e.g. deep rooted, fast growing tree species and species that improve soil fertility and conservation.

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SUMMARY

Agriculture in most of the developing countries, especially those of sub-Saharan Africa is underdeveloped. Risks and uncertainties related to stochastic agro-ecological and institutional factors are rampant. On the other hand land degradation caused mainly by unsustainable farming is also a constraint to agriculture. Yet, many people have to derive their basic necessities of food, fibre, shelter and fuelwood predominantly from the land holdings they own. As a result, agroforestry as a land use option is proposed as a measure to reduce the above problems.

However, farmers are also expected to take into consideration risks and uncertainties in decision-making, where the difference between the good and the bad consequences of the decisions are significant.

The main objective of the research was to set an understanding of farmers' attitude and perception towards risk in making agroforestry production decisions. The main premise of the research is that farmers' risk attitude and risk perception play an important role in the choice of cropping systems. As a result the research wants to establish to what extent farmers use/consider risk in agroforestry decision making.

A review of the literature in risk analysis and decision making shows that four major ways are available in dealing with farmers' decision making. The first is assuming risk indifference and therefore the goal is to maximise or minimise the expected monetary gains and losses respectively. The second one is specifying utility functions based on previous studies and using methods such as observed economic behaviour to arrive at measures of risk. The third one is risk analysis when the risk preferences are unknown. An example is Stochastic Dominance (SD) analysis, which does not require the specification of a particular utility function. The fourth one is the direct elicitation of subjective probability distributions. Direct elicitation of the Subjective Expected Utility (SEU) was adopted mainly because of the need for getting information about decision making from the farmers. Due to criticisms on the SEU model, the latent variable approach was also used to study risk.

The research was conducted in Babati district located in the south-western part of Arusha region in the northern part of Tanzania. The research villages were Magugu, Bonga, Singe and Himiti. Several factors were considered in choosing Babati district, including the efforts that have been put in the management and utilisation of trees by the Forest Trees and People (FTP) project which has now shifted emphasis to land management issues i.e. the LAnd Management Project (LAMP). The climate varies in different parts of the district, with higher altitudes having lower temperature but with more precipitation than lower altitudes. The rainfall periods follow a bi-modal pattern of short and long rainfall seasons. Short rainfall occurs most commonly from October to December and sometimes January, and long rains between February and May. The agro-ecological zones (AEZ) of the district range from semi-arid lowlands to humid highlands.

The data collection procedure involved three major surveys: a preliminary survey of 20 farmers, a single visit general household questionnaire survey with a sample of 100 farmers and a detailed research approach involving 30 farmers. The first two surveys provided information used in the description of the research area, and measurement of risk attitude using the latent variable category. The sample of 30 farmers has involved a series of measurement

procedures to elicit farmers' risk perception (strength of conviction method in the utility theory category), risk attitude using utility theory analysis and preference ranking of cropping systems. In studying risk attitude in the utility category, four situations were used, namely inadequate food, inadequate cash, adequate food and adequate cash.

Two main approaches in studying risk emanating from the research are positive and normative analyses. This research followed the positive analysis rather than the normative analysis that has received a lot of attention in research as compared to positive analysis. The analysis of risk attitude and risk perception in this research was done separately rather than putting them together under the title of risk. Whereas risk attitude are more related to permanence, risk perception is continually changing and is a necessary condition for the emergence of risk attitude. This emphasises the need for repeating this research in subsequent times to accommodate the changes in perceptions as new technology and information unfold.

In order to address the main objective effectively, a functional conceptual framework was devised and a series of specific objectives and research questions were formulated. The conceptual framework, the specific objectives and the research questions provided the core issues and directions of this research.

The data obtained from the methodology and approaches described above were analysed using the utility theory and the latent variable categories. In addition, the estimation of probability distribution functions was done using the maximum likelihood technique, the utility functions through linear/non-linear regression analysis and the relationship between risk attitude, risk perception and preference ranking of cropping systems with household resources and characteristics was done using linear regression analysis. Factor analysis was employed in analysing risk attitude in a wider context using the latent variable approach. The latent variable category in risk attitude analysis was used because the concept of risk can be measured by a number of items, which together give an indication of the factor/latent variable. The main results are as outlined in the subheadings below.

Sources of risk and risk management strategies

In sole cropping the major sources of risk were identified as drought, poor soils and insect and vermin attack. In agroforestry, the main sources of risk are competition with other crops, insects and diseases and problems related to tractor ploughing. Other perceived sources of risk are institutional, financial and human or personal risks.

Among the villages sampled, there are similarities in perceived risk and risk management strategies. Magugu villagers perceived drought as the major source of risk while the other villages indicated poor soils as the major source of risk. This is attributed to differences in AEZ.

In the research area, farmers apply six main risk management strategies. These are crop selection, pruning trees, use of fertilisers and manure, maintenance of liquid assets, diversification of income sources and the use of formal and informal lending systems.

Risk perception using the strength of conviction method

The cropping systems 'Mixed food crops only' (CS3) and 'Mixed fruit trees + mixed food crops' (CS1) are perceived as being low risk as compared to other cropping systems included in the analysis. The cropping systems 'Trees (timber/fuelwood) +mixed food crops only'

(CS2) and 'Trees (timber and fuelwood) only' (CS5) were perceived as moderate risky. High-risky cropping systems were 'Mixed fruit trees only' (CS6) and 'Cash crops only' (CS4). Differences in perceived risk were noted in the sample, among male and female respondents and among farmer categories i.e. high, low and medium.

There is a general indication that production of food crops and a mixture of food crops and trees are perceived as less risky as compared to the others.

Risk attitude using the utility theory approach

The four situations analysed (i.e. inadequate food, inadequate cash, adequate food and adequate cash) showed differences in utility functional forms that fitted the data well.

The results of certainty equivalents and the measures of risk aversion support the prior expectation that if farmers earn higher or are rich, they tend to be less risk averse, especially in the situation of adequate cash. Generally, there were variations in risk attitude measures among the farmers and the situations analysed. The measures of risk aversion of this research compare well with measures obtained from other studies, with only minor deviations.

Risk attitude using the latent variable category

The results show that the use of factor analysis can assist in selecting a number of items that measure a certain construct, which is reliable. In addition, the items can be combined into a score for the factor/latent variable.

The results show further that a substantial number of farmers have a positive attitude towards risk and land resource conservation. However, the attitude towards commercialisation was low, maybe due to poor transport and infrastructure in the area. As a result farmers are mainly producing for home consumption.

The attitude towards land resource conservation, the attitude towards commercialisation, the wealth of the respondents and their education significantly explain the positive attitude towards risk. The degree of explanation was high (70%) and if the above mentioned independent variables are increased, there will be an increase in positive attitude towards risk.

Preference ranking of cropping systems

In preference ranking of cropping systems, farmers showed a high preference for agroforestry systems namely 'Trees (timber/fuelwood) + mixed food crops' (CS2), followed by food crop systems 'Mixed food crops only' (CS3).

Preference ranking of cropping systems is influenced by risk attitude, risk perception, expected income (mean) and household resources and characteristics.

Overall results

Risk attitude is influenced by wealth of the farmer, years of education, household size and the age of the respondent. A change in these variables, for example an increase (*ceteris paribus*), will decrease the level of risk aversion of the individuals. However, the estimated relationship was not as strong as that obtained using latent variable approach. A strong and consistent relationship was obtained when the measures of risk aversion are combined into a score. A strong relationship between risk perception and household resources and characteristics was also observed. Education, wealth, family size, age and gender of the respondent were significant in explaining variations in the observed risk perception of the respondents.

Risk attitude and risk perception were also found to be significant influencing farmers' preference ranking of some cropping systems.

Combining the measurements of risk perception and risk attitude in a mean-variance analysis using a quadratic utility function, shows that the most preferred cropping systems are 'Mixed food crops only' (CS3), 'Mixed fruit trees + mixed food crops' (CS1) and 'Trees (timber/fuelwood) + mixed food crops' (CS2). Rankings based on different criteria are more or less conforming to the actual cropping systems of the farmers. The low ranking cropping systems 'Trees (timber/fuelwood species) only' (CS5), 'Mixed fruit tree species only (CS6) and 'cash crops only' (CS4) are also more or less similar to the actual cropping systems of the farmers.

The following main conclusions are drawn from this research:

• Separating risk attitude and risk perception analysis is useful in understanding farmers' decision making under risk.

• Farmers use a variety of ways in the management of risk and uncertainty. However, their efforts are constrained by many factors including agricultural finance problems and market and infrastructure problems.

• Farmers' actual choices of cropping systems are generally consistent to their risk attitude, risk perception and preference ranking of cropping systems. Farmers make a rational choice under risk when selecting their cropping systems because their choices are consistent with their strength of conviction (subjective probabilities) about the occurrence of risk prospects (i.e. cropping systems).

• Before applying different utility functional forms, prior testing and evaluation under different situations were found useful.

• The coefficients of risk aversion emanating from this research with farmers in Tanzania are more or less similar to those obtained in researches with farmers from other parts of the world.

• The use of the latent variable approach and factor analysis is a useful way of analysis risk attitudes in a wider context. It has advantages of avoiding the tedious process of eliciting and encoding certainty equivalents used in the utility theory category.

• Household resources and characteristics are factors that were found influencing risk attitude, risk perception and preference ranking of cropping systems.

Finally some recommendations that are emanating from this research are highlighted. The following are the major areas of these recommendations:

• The use of the utility theory category in a positive analysis framework is supported and has produced results, which are comparable with other studies. However, the difficulty of the elicitation process can be avoided by using the latent variable approach. The results of risk measures using the utility theory and the latent variable categories were positively correlated but not significant.

• Areas for further research were recommended. These are:
  - Further testing and use of the latent variable approach in risk analysis.
  - Consideration of different time frames in risk analysis.
  - Structure, conduct and performance of markets with respect to risk .
  - Risk and environmental consequences.
  - Uncertainty aversions versus risk aversions.
  - Measures to combat the adverse effects of stochastic agro-ecological factors.

- Determination of optimal choices/best alternatives in terms of the calculated mean and variance along the indifferent curves.

• Policy recommendations were made based on the finding that farmers use agroforestry as part of their risk management strategies. Policy recommendations were made towards the role of agroforestry in risk management strategies such as improvement in infrastructure and socio-economic environment (roads, extension and land tenure). Recommendations on technology development in agroforestry through breeding and selection of crops and tree species for specific suitable characteristics (such as drought tolerant, short maturity, disease resistance etc.) were also made.

SAMENVATTING

Titel: Risico-attitude en risicoperceptie in beslissingen over agroforestry: een case studie in Babati, Tanzania.

In de meeste ontwikkelingslanden, in het bijzonder in die van sub-Sahara Afrika, is de landbouw onderontwikkeld. Risico en onzekerheid als gevolg van stochastisch agro-ecologische en institutionele factoren zijn algemeen. Land degradatie, als gevolg van het toepassen van niet-duurzame landbouw, is evenwel ook een beperking voor de landbouw. Vooralsnog moeten veel mensen hun basisbehoeften, zoals voedsel, vezels, onderdak en brandhout, grotendeels halen van het landbouwbedrijf dat ze bezitten. Zodoende is agroforestry voorgesteld als een grondgebruiksoptie die bovengenoemde problemen vermindert.

Verwacht wordt echter dat boeren ook rekening houden met risico's en onzekerheden bij het nemen van beslissingen waarbij het verschil tussen goede en slechte resultaten significant is.

Het hoofddoel van dit onderzoek is meer inzicht te krijgen in de rol die houding tegenover en perceptie van risico speelt bij het nemen van productiebeslissingen betreffende agroforestry. Het belangrijkste uitgangspunt in dit onderzoek is dat risico-attitude en risicoperceptie van boeren een belangrijke rol spelen in de keuze van teeltsystemen. Daarom wordt in dit onderzoek nagegaan in welke mate boeren rekening houden met risico in hun agroforestry-beslissingen.

Een literatuurstudie van risico-analyse en beslissingen toont aan dat er vier belangrijke benaderingen beschikbaar zijn betreffende het nemen van beslissingen door boeren. De eerste veronderstelt dat boeren onverschillig staan ten opzichte van risico en dat hun doel daarom is het maximaliseren of minimaliseren van respectievelijk de verwachte monetaire winst en het verwachte verlies. De tweede specificeert nutsfuncties gebaseerd op eerder uitgevoerde studies en gebruikt methoden, zoals waargenomen economisch gedrag, om risico te meten. De derde is risico-analyse waarbij wordt verondersteld dat preferenties betreffende risico onbekend zijn. Een voorbeeld van deze benadering is Stochastisch Dominantie (SD) analyse. Deze benadering vereist geen specificatie van een bepaalde nutsfunctie. Bij de vierde benadering worden de subjectieve kansverdelingen direct gemeten. Direct meten van het subjectieve verwachte nut (*Subjective Expected Utility* (SEU)) is in dit onderzoek vooral toegepast om informatie te krijgen over het beslissingsgedrag van boeren. In verband met de kritiek op het SEU-model is ook de latente variabele methode gebruikt om risico te bestuderen.

Het onderzoek werd uitgevoerd in het Babati district. Dit is gelegen in het zuidwestelijk deel van de Arusha regio in het noordelijk deel van Tanzania. De dorpen van onderzoek waren Magugu, Bonga, Singe en Himiti. Met verschillende factoren is rekening gehouden bij de keuze van het Babati district, waaronder de inspanningen op het gebied van beheer en gebruik van bomen door het *Forest Trees and People* (FTP) project. Dit project heeft nu de nadruk van haar inspanningen verlegd naar grondgebruikszaken binnen het *LAnd Management Project* (LAMP). Het klimaat varieert tussen de verschillende delen van het district, waarbij de hogere delen een lagere gemiddelde temperatuur en een hogere neerslaghoeveelheid hebben dan de lager gelegen delen. De regenperioden volgen het bi-modale patroon van korte en lange regentijden. De korte regentijd valt gewoonlijk tussen october en december, soms januari, en de lange regentijd tussen februari en mei. De Agro-Ecologische Zones (AEZ) van het district varieren van semi-aride laagland tot vochtig hoogland.

Voor het verzamelen van de data zijn drie surveys uitgevoerd: een inleidende survey onder 20 boeren, een algemene huishoudsurvey met een steekproef van 100 boeren en een gedetailleerde survey onder 30 boeren. De eerste twee surveys gaven informatie voor een beschrijving van het onderzoeksgebied, en voor het meten van de risico-attitude gebaseerd op de latente variabele methode. De steekproef van 30 boeren werd benut om door middel van een aantal procedures risicoperceptie (de *strenght of conviction* methode) en risico-attitude binnen de nutstheorie te meten en om de voorkeuren voor teeltsystemen van boeren aan het licht te brengen. Bij het bestuderen van risico-attitude in de nutscategorie zijn vier situaties onderscheiden, te weten onvoldoende voedsel, onvoldoende kasmiddelen, voldoende voedsel en voldoende kasmiddelen.

Twee belangrijke benaderingen die worden gebruikt bij het bestuderen van risico worden beschreven, namelijk de positieve en normatieve analyse. Dit onderzoek volgt de positieve analyse in plaats van de normatieve analyse die in het algemeen relatief veel aandacht heeft gekregen in het onderzoek. Risico-attitude en risicoperceptie zijn in dit onderzoek afzonderlijk bestudeerd in plaats van tezamen onder de titel risico. Risico-attitude is van duurzamer aard dan risicoperceptie; risicoperceptie verandert voordurend en is een noodzakelijke voorwaarde voor het ontstaan van risico-attitude. Dit benadrukt de noodzaak dit onderzoek later in de tijd te herhalen om verandering in perceptie op te sporen als nieuwe technologie en informatie beschikbaar komt.

Om het hoofddoel van het onderzoek op effectieve manier aan te pakken, zijn een aantal specifieke onderzoeksdoelen en onderzoeksvragen geformuleerd. Het conceptuele kader, de specifieke onderzoeksdoelen en -vragen verschaften de centrale aspecten en de richting van dit onderzoek.

De data verkregen volgens deze methodologie en deze benaderingen zijn geanalyseerd met behulp van de nutstheorie en de latente variabele benadering. Bij schattingen van kansverdelingsfuncties is gebruik gemaakt van de *maximum likelyhood* techniek, bij die van nutsfuncties van lineaire en niet-lineaire regressie analyse en bij die van de relatie tussen risico-attitude, risicoperceptie en voorkeur voor teeltsystemen met resources en kenmerken van de huishouding werd gebruik gemaakt van lineaire regressie. Factoranalyse werd gebruikt bij de analyse van risico-attitude in een bredere context, dat wil zeggen waarbij de latente variabele benadering is gebruikt. Bij de latente variabele benadering voor de analyse van de risico-attitude wordt het risicoconcept gemeten aan de hand van de antwoorden op een aantal vragen die te maken hebben met risico. De belangrijkste resultaten van het onderzoek worden in het onderstaande vermeld.

Bronnen van risico en risico-management strategie.n

Als belangrijkste bronnen van risico bij toepassing van monocultuur werden ge|dentificeerd droogte, arme grond en aantastingen door insecten en ongedierte. In agroforestry zijn de belangrijkste bronnen van risico concurrentie tussen gewassen, insecten en ziekten en problemen die te maken hebben met ploegen met een tractor. Andere bronnen van risico zijn van institutionele, financiële en personele aard.

Er zijn overeenkomsten tussen de onderzochte dorpen in risicoperceptie en management-strategieën. In Magugu is droogte de belangrijkste bron van risico terwijl in de andere dorpen arme grond als de belangrijkste bron van risico wordt aangewezen. Deze verschillen kunnen worden toegeschreven aan verschillen in AEZ.

In het onderzoeksgebied passen boeren zes risico-managementstrategie.n toe. Deze zijn keuze van gewassen, snoeien van bomen, gebruik van kunstmest en mest, het aanhouden van liquide middelen, diversificatie van inkomensbronnen en het gebruik van een formeel of informeel kredietsysteem.

Risicoperceptie: gebruik van de strenght of conviction methode

De teeltsystemen 'Alleen voedselgewassen gemengd' (CS3) en 'Fruitbomen gemengd + voedselgewassen gemengd' (CS1) worden gezien als teeltsystemen met gering risico ten opzichte van andere teeltsystemen betrokken in het onderzoek. De teeltsystemen 'Alleen bomen (zaag/brandhout)' (CS5) en 'Bomen (zaag/brandhout) + voedselgewassen gemengd' (CS2) worden gezien als systemen met matig risico. Als teeltsystemen met hoog risico worden beschouwd 'Alleen fruitbomen gemengd' (CS6) en 'Alleen handelsgewassen' (CS4). Verschillen in risicoperceptie werden in de steekproef geconstateerd tussen mannelijke en vrouwelijke respondenten en tussen grote, middelgrote en kleine boeren.

In het algemeen wordt geconstateerd dat gemengde voedselgewassen en menging van voedselgewassen met bomen als minder riskant worden gezien.

Risico-attitude: de nutstheorie benadering

De vier geanalyseerde situaties (te weten onvoldoende voedsel, onvoldoende kasmiddelen, voldoende voedsel en voldoende kasmiddelen) vertoonden verschillen in de vorm van de nutsfuncties die het beste pasten bij de data.

De resultaten van meting van *certainty equivalents* en de mate van risicomijding ondersteunen de verwachting dat boeren minder risicomijdend zijn naarmate ze meer verdienen of rijker zijn, in het bijzonder in de situatie van voldoende kasmiddelen. Er waren in het algemeen verschillen in risico-attitude tussen de boeren en tussen de geanalyseerde situaties. De mate van risicomijding in dit onderzoek is goed vergelijkbaar met die verkregen in andere studies, met slechts kleine verschillen.

Risico-attitude: de latente variabele methode benadering

De resultaten geven aan dat het gebruik van factoranalyse van dienst kan zijn bij het selecteren van een aantal items die een bepaalde betrouwbare constructie meten. De items kunnen bovendien worden gecombineerd in een score voor de factor/latente variabele.

De resultaten geven verder aan dat een aanzienlijk aantal boeren een positieve houding hebben tegenover risico en bodemconservering. De houding tegenover commercialisering is daarentegen laag en is wellicht toe te schrijven aan gebrekkige transportmiddelen en infrastructuur in het gebied. Boeren produceren dientengevolge voornamelijk voor eigen huishoudelijk gebruik.

De houding tegenover bodemconservering en commercialisering, de grootte van het bezit en de opleiding zijn significante variabelen voor de verklaring van de positieve risico-attitude. De mate van verklaring was hoog (70 %) en het verband houdt in dat een grotere waarde van deze variabelen een hogere positieve risico-attitude met zich meebrengt.

Voorkeuren voor teeltsystemen

Bij de vraag naar voorkeur voor teeltsystemen toonden de boeren een sterke voorkeur voor agroforestrysystemen, namelijk 'Bomen (zaag/brandhout) + voedselgewassen gemengd' (CS2) gevolgd door 'Alleen voedselgewassen gemengd' (CS3).

De voorkeur voor teeltsystemen wordt beïnvloed door risico-attitude, risicoperceptie, verwachte inkomen alsmede door resources en kenmerken van de huishouding.

Algemene resultaten

Risico-attitude wordt beïnvloed door de grootte van het bezit, de opleiding, de grootte van de huishouding en de leeftijd van de respondent. Een verandering in deze variabelen, bijvoorbeeld een toename, zal (*ceteris paribus*) de mate van risicomijding doen afnemen. De geschatte relatie was evenwel niet zo sterk als die verkregen met de latente variabele benadering. Een sterke en consistente relatie werd verkregen wanneer de verschillende risico-attitude metingen worden gecombineerd in één score. Een sterke relatie werd ook gevonden tussen risicoperceptie enerzijds en resources en kenmerken van de huishouding anderzijds. De opleiding, de grootte van het bezit, de grootte van de huishouding, de leeftijd en het geslacht van de respondent zijn significante variabelen bij de verklaring van de gemeten risicoperceptie van de respondenten.

Combinatie van risicoperceptie en risico-attitude gebaseerd op een kwadratische nutsfunctie in een gemiddelde/variantie-analyse toont aan dat de meest geprefereerde teeltsystemen zijn 'Alleen voedselgewassen gemengd' (CS3), 'Fruitbomen gemengd + voedselgewassen gemengd' (CS1) en 'Bomen (zaag/brandhout) + voedselgewassen gemengd' (CS2). De rangorde van teeltsystemen die op basis van verschillende criteria worden verkregen zijn min of meer conform de actuele keuze van teeltsystemen van de boeren. De teeltsystemen die laag scoren 'Alleen bomen (zaag/brandhout)' (CS5), 'Alleen fruitbomen gemengd' (CS6) en 'Alleen handelsgewassen' (CS4), scoren als regel ook laag bij de actuele teeltsystemen van de boeren.

De volgende hoofdconclusies zijn getrokken uit het onderzoek:

- Om beslissingen van boeren onder risico te begrijpen, is het nuttig onderscheid te maken tussen risico-attitude en risicoperceptie.
- Boeren gebruiken verschillende manieren om risico en onzekerheid te beheersen. Hun inspanningen worden echter beperkt door verschillende factoren waaronder financiële, marktkundige en infrastructurele problemen.
- De actuele keuze van teeltsystemen van boeren is in het algemeen consistent met hun risico-attitude, risicoperceptie en geuitte voorkeur voor teeltsystemen. Boeren maken een rationele keuze onder risico bij het selecteren van teeltsystemen omdat hun keuzes consistent zijn met hun *strength of conviction* (subjectieve kansverdelingen) ten aanzien van risicoverwachtingen (van teeltsystemen).
- Het is nuttig vóór het toepassen van verschillende vormen van nutsfuncties deze te testen en te evalueren onder verschillende omstandigheden.
- De orde van grootte van de coëfficiënten van risicomijding die zijn gevonden in dit onderzoek onder boeren in Tanzania komt overeen met die gevonden in onderzoek onder boeren in andere delen van de wereld.
- De latente variabele methode met factoranalyse is een bruikbare wijze van analyse van

risico-attitude in ruimere context. Het voordeel van toepassing ervan is dat het moeizame proces van het verkrijgen en coderen van zekerheidscoëfficiënten die worden gebruikt in de nutstheorie wordt vermeden.

- Resources en kenmerken van de huishouding zijn factoren die risico-attitude en riscoperceptie en voorkeur voor teeltsystemen beïnvloeden.

Tenslotte worden enkele aanbevelingen die voortvloeien uit dit onderzoek belicht. Het volgende geeft de belangrijkste categorieën aanbevelingen:

- Het gebruik van nutsfunctie in het kader van een positieve analyse wordt ondersteund en heeft in dit onderzoek resultaten opgeleverd die vergelijkbaar zijn met die van andere onderzoeken. De moeilijkheid van het verkrijgen van gegevens voor het opstellen van nutsfuncties kan worden vermeden door toepassing van de latente variabele methode. De resultaten van metingen van risico met nutsfuncties en met de latente variabele methode waren positief gecorreleerd maar niet significant samenhangend.
- Verder onderzoek op de volgende onderwerpen wordt aanbevolen:
  - Verder testen en gebruiken van de latente variabele benadering in risico-analyse.
  - Introduceren van het aspect tijd in risico-analyse.
  - Structuur, werking en functionering van markten met betrekking tot risico.
  - Risico en gevolgen voor de omgeving.
  - Vermijding van onzekerheid versus risicomijding.
  - Maatregelen ter bestrijding van ongunstige gevolgen van stochastisch agro-ecologische factoren.
  - Bepaling van optimale keuze/beste alternatieven in termen van berekende gemiddelden en varianties langs de indifferentiecurven.
- Aanbevelingen voor het beleid zijn gebaseerd op de conclusie dat boeren agroforestry gebruiken als onderdeel van hun risico-managementstrategiën. De aanbevelingen voor het beleid betreffen de rol van agroforestry in risico-managementstrategiën zoals verbetering van infrastructuur en de sociaal-economische omgeving (wegen, voorlichting en grondbezit). Ook zijn aanbevelingen geformuleerd betreffende technologie-ontwikkeling met betrekking tot agroforestry door veredeling en selectie van gewassen en boomsoorten gericht op specifieke kenmerken (zoals droogtetolerantie, snelle productie, resistentie tegen ziekten etc.).

APPENDIX 1

Questionnaire for Smallholder Agroforestry Farmers

A General characteristics

A1 Name of the respondent________________ Sex_____________
Age______________ years
Male =1 Female =2
A2 Role in the household______________________________
Head of the household =1
House wife = 2
Son/daughter of the head of household
Others (Specify)
A3 Name of the head of household if not the respondent ____________________
Sex ________________________Male =1 Female =2
A4 Date of interview______________19___ Time________________________
A5 Village____________________ Division_____________ Ward___________

B Land use and Ownership

B1 What were your main sources of income in the last season (arrange in order of priority)

Key:
Sale of food crops=1
Sale of cash crops=2
Sale of livestock and its products =3
Wage employment =4
Off farm income generating activities (not employment) =5
Remittance =6
Others (specify)

B2 Total agricultural lands owned and state if you own different plots

Name of land or plot	Time taken to walk to the farm (hours/min)	Slope of the land(to be verified by the interviewer	Crops grown	Total area (acres)	Ownership	Uncultivated area	Reason for not cultivating all the area

Key for slope: 1=flat, 2= moderate sloping land and 3 =steep slope
Ownership Bought =1, Rented =2, Inherited =3, allocated by the village government=4 others (specify)

B3 If the land was bought, how much did you pay per acre/plot

Name of the plot/number	Price (TSH)

B4 If is a rented one how much did you pay per plot

Name of the plot/number	Price (TSH)

B5 What type of trees did you plant in your farm in 1994/95 season?

Name of plot or number	Tree species (swahili or local name accepted)	Planted or retained	Total number	Arrange ment	Uses
1					
2					

Key for uses (more than one entry can be done): Firewood =1, fodder trees =2 Fruits =3, Timber =4 Poles=5, fence =6, Field boundary =7, Soil fertility and conservation =8, wind break =9 shade =10 store of wealth =10 religious or taboo =11 Others specify and give number

Key for arrangement: Mixed = 1, Zoned =2, Zoned and mixed =3
Put 1 if planted and 2 if retained a naturally growing tree

B6 Source of seeds and seedlings

Plot number/name	Crops/trees	Source	Amount/number used	Price/Kg or seedling

Key for source of seeds: Own seed =1, Tanseed =2 Cargil =3 Village nursery =4 Others (specify)

B7 Of the planted seedlings last year how many survived
Almost all =1, About a half =2, Less than a half =3 Others (specify)
If less than a half explain the reasons

C Labour for farm work

C1 People residing in this house (including the respondent)

Name	Relations to head of household	Age	Sex	Years of education	Work done last season	Months worked	Income earned (TSH)
Total*							

* Total where applicable

Key Work done: works in family farm =1, employed elsewhere =2, self employed =3, Sick or old =4 Others (specify)

C2 Did you employ labour in your farm last season YES =1 No =2
C3 If yes how long did they work____________________ Months/days
C4 If yes how many were women____________________
C5Farm operations

Plot name or number	Work done	Month	Days performed	Man-days	Man/wife/both	% employed
	Ploughing					
	Planting					
	Weeding					
	Fert. Appl.					
	Thinning/pruning					
	Harvesting					
	Threshing					
	Selling					

Key if done by men =1 women=2 both=3 Put 1 if done by hired labour and 2 if family labour

C6 how much did you pay your labourers TSH_______________ per day
C7 If you pay them in kind explain___________________________________
C7 Do you have shortages of hired labourers: Yes =1 No =2
If yes what are the problems?
Use key: Unavailability =1, Inability to pay =2 Others (specify)
Which months do you have labour shortages? ______________________.

D. Capital

D1 Do you keep livestock Yes =1 No = 2

If yes answer the following questions

Type	Number	Improved	Uses	Feeding system	Value TSH
Bulls					
Cows					
Heifer					
Steers					
Calves					
Oxen					
Cattle sub-total					
Donkeys					
Goats					
Sheep					
Piglets					
Weaners					
Sows					
Boars					
Chicken					
Total					

Key for uses: Sell animals =1, Store of wealth for emergencies =2 For milk and manure =3 Social prestige=4 Others (specify)

Key for feeding system: Zero grazing =1 Tethering =2 Paddocks =3 Grazing in communal area =4 Free grazing =5 Others (specify)

D2 How much did you spend in the following

	TSH	Year constructed	Useful life
Goat house			
Pig house			
Cattle shade			

D3 Assets

Please indicate the assets you have

Asset	Numbers	Year bought	Price/Value	Useful life
1 Tractor				
2 Oxen plough				
3 Bicycle				
4 Car				
5 Radio				
6 Radio cassette				
7 Spongy mattress				
8 House with corrugated iron sheet				
9 Cement floor				
10 Burnt bricks or cement				

11 Hurricane lamp				
12 Charcoal stove				
13 Kerosene stove				
14 Torch				
15 Hoe				
16 Panga				
17 Axe				

Agricultural Finance

D4 Did you borrow money from banks Yes = 1 No =2
D5 If yes please explain the following

Year borrowed	Amount	Reasons	Repayment including interest
1			
2			
3			

D6 If not what are the reasons for not borrowing from the banks?

D7 Do you have any other source of finance for Yes = 1 No =2
If yes explain

D8 Do you save your wealth for future use Yes =1 No = 2
If yes mention in order of priority

Key: In banks =1, Planting trees =2, in livestock =3 Petty trading =4 Education of children =5 others (specify)

E Activities of the farm

E1 What are your objectives in farming put in priority

Key: To get more food for self sufficiency =1, Money =2, Stable output =3, Prestige/respect from other villagers =4, Livestock = 5 Others (specify)

E2 who makes the following decisions?

Plot name/number	Labour input	Crops grown	Trees planted	Use of annual crops	Use of trees/ tree products
1					
2					
3					
4					

Key: Husband =1 Wife =2 Joint decision =3 Children =4 Others (specify)

Agroforestry

E3 Who fetches firewood (prioritise)

Key Women = 1, Men =2, Children =3, Women and children =4, Women and men =5,Men and children, Others (specify)

E4 Where do you collect firewood? Prioritise

Key: Farmland (planted trees) =1, Natural forests =2, open areas =3, farmland Others (specify)

E5 How long does it take to collect firewood ________________ hours

E6 What is the frequency of collecting firewood per week________________

E7 Do you buy firewood Yes =1 No =2 and or charcoal Yes =1 No =2

E8 If so, what is the price THS____________ per bundle TSH___________ per bag of charcoal

E9 What is your feelings about tree planting in your farm? Use the following key to specify tree species. Key: compete with annual crops = 1, Is obstacle in ploughing with tractors =2 Hide crop pests =3, Hide livestock pests =4 Others (specify)

Tree species	Feeling
1_______________	____________________
2_______________	____________________

E 10 What are the effects of trees in your farm? Use the following key

Key: Increase other crops yield =1, Reduce other crops yield =2, Has no effect on other crops yield=3

Plot number/name	Tree species	Effects

Livestock

E11 Please indicate the number of livestock you have

Do you get problems in feeding/grazing your livestock Yes =1 No=2

If yes, in which months do you get problems ____________________________________

E12 Do you use fodder trees in feeding your livestock Yes =1 No =2

E13 If yes which months do you feed your livestock______________________________

E14 Please name tree species you use in feeding your livestock

Tress species	Type of livestock

E15 Please explain to us the time you used to feed/graze your animals

Type of livestock	Time taken	Number of people involved
Cattle		
Donkey		
Goats		
Sheep		
Pig		

Note: Please indicate whether you feed them together

E16 Do you experience any problems in livestock production Yes = 1 No = 2
If yes state the problems in order of priority

Agricultural inputs

E17 Did you use fertiliser/farm yard manure and other agricultural chemicals in 1994/94? Yes =1 No =2

E18 If yes please give the following information

Plot number/name	Type of fertiliser/chemical	Amount used	Crop type	Price/unit

E19 please explain why you are using fertiliser and other agricultural chemicals
To get more crops____________________
To avoid the probability of no harvest at all____________________
Because of poor soil fertility____________________
Others (Specify)____________________

E20 If you did not use fertilisers/agricultural chemical explain why
E21 Do you have any problems in getting fertilisers/ Yes = 1 No =2

E22 If yes please give the problems in getting fertilisers

E23. Please indicate inputs purchased for livestock

Type of livestock	Inputs	Amount used	Price/unit

E24 Please explain the output from crops in 1994/95 season

Plot number/Name	Crops/trees/tree products	Amount	Price/unit	Comments on yields/output

E25 What things do you consider/perceive as source of risk of loss of your crops if planted in pure stand

____

____

____

____

E26 What things do you consider/perceive as source of risk of loss of your crops if mixed with trees (agroforestry)

____

____

____

____

E27 In the following crop mixtures which poses risk of annual crop loss/
Use the following key
Risky = 1, Moderately risky = 2 and not risky = 3

Agroforestry in general ____________________
Maize and tree____________________
Beans and trees____________________
Sole crop maize____________________
Sole crop beans____________________
Mixture of food crops____________________
Cash crops and trees____________________
Cash and food crops____________________
Others (explain)____________________

____

E28 How do you cope with risk in crop production?

____

____

____

E29 Do you plant special crops in coping with risk: Yes =1 No =2
If yes please mention the crops/cropping strategy

Crop/strategy	Characteristics of the crop/cropping strategy

E 30 When you get problems of money due to unforeseen/foreseen incidence what things do you liquidate? Mention them in order of priority
Use the following key. Livestock =1, Fruits =2, Firewood form the planted trees = 3 Stored grains = 4 (Others specify and give number)

Off farm Incomes

E 31 Do you sell firewood or tree products from open forest which is not protected? Yes = 1 No =2
If yes give the following information

Product	Source forest	Amount sold	Price/unit

E32 Mention other sources, which are off-farm and which give income including remittances
Type Amount (TSH) per year

____________________ ______________________________
____________________ ______________________________
____________________ ______________________________

Output

E33 Production and disposal of the products in 1994/95 season

Plot name or number	Products	Amount sold	Amount consumed	Amount sold	Price/ unit
1					
2					
3					
Livestock and livestock products					
Trees and tree products					

F Extension Services and Information

F1 how easy is it for you to contact an extension worker when you need him
Is easy = 1, Fairly easy = 2 Not easy =3

F2 Please comment on agricultural advice and information
Is very important____________________
Is fairly important____________________
Not important____________________
I do not know____________________

F3 Please tell as if you get the following problems as years pass by

Problem	Explanation

Use the following key: I have it = 1, I have never got it =2

F4 Do you think soil fertility in your farm has changed and in which direction?
Use the following key: Decreased a lot = 1, little decrease = 2, remained the same =3, Little increase = 4, increase a lot = 5, I don't know =6

F5 If fertility decreased what are the main reasons for this decrease? Use the following key: Soil erosion = 1, absence of fallow =2, over-cultivation = 3 Overgrazing =4 Others (specify)

F6 If there are increases in soil fertility what are the main reasons

____

____

____

F7 Have you used measures of improving the soil fertility of your farm? Yes = 1 No = 2.
If yes please give the following information

Type of measure	Results	reasons
________	________	________
________	________	________
________	________	________

Use the following key: For measures Contour ploughing =1, Tree planting =2, reduce livestock = 3, Soil and water conservation measures = 4 Others (specify)
For results Good =1 Bad =2 no results = 3, Is too early to say =4
For reasons which made you undertake the measures: Extension advice =1, Advice from fellow farmers =2, my own decisions=3, poor soil fertility and erosion =4 Others (specify)

F8 Please indicate if the following is not a problem = 1, is a small problem = 2, is a big problem =3

	Response
Problems of land acquisition	
Pests and vermin attack	
Poor soil fertility	
Soil erosion	
Lack of extension advise	
Lack of credits	
Lack of labour	
Post harvest losses	
Low crop prices	
Poor transport	
Lack of farm implements	
Lack of pesticides	

High input prices	
Too much rain	
Too low rainfall	
Unreliable rainfall	
Late rainfall	
Lack of off-farm works	
Lack of title deed	
Lack of fertilisers	

F10 Please indicate whether you strongly agree =1, Agree =2, not decided =3, disagree =4 and strongly disagree =5 to the following statements

Item/statement	Response
If there is an opportunity to make money I will use it	T1
Without taking risk farming is not worthwhile	T2
I believe best farmers take the most risks	T3
By always being cautious in farming I could not get ahead	T4
To have nice things in life I cannot be as cautious in farming as I should be	T5
In order to make money I have to do some things that are not good for the soil	T6
The way we are farming now is good and will last for ever	T7
If I keep farming like this I will exhaust the soil	T8
I try now things in farm even if I lose money	T9
We always try new things in our farm	T10
We need to preserve the way our parents farmed	T11
I cannot afford to worry about the future	T12
I worry that land will not produce much when our children will be farming	T13
There will be plenty opportunities for our children	T14
We are required to conserve our environment in order to have higher yields	T15
Cropping system that conserves soil and water is the only one that will help us during low rainfall	T16
I believe that big farmers are not bothered by rainfall problems	T17
We need to make changes in our farming practices for the benefit of the future generation	T18
Growing as many crops for sale is the best I can do for this farm	T19
Frequent change in crop prices is the biggest problem of my income	T20
Information on producer prices helps me decide on what crops to produce for sale	T21
In the future we will grow more and more crops for sale	T22
The most important thing for a farm household is to grow its own food requirements	T23
If I had more labour in my family I could get reliable crops which do not fluctuate	T24
If I had capital I could get reliable crops which do not fluctuate	T25

Interviewer's comments on the way the interview proceeded:
Was the respondent comprehensive?
Do you think he/she was honest?
Are the answers precise or rough etc.?

APPENDIX 2

Calculation of the asset index

Seventeen items of durable assets were included in the questionnaire (Appendix 1). The respondents were asked to indicate the number of durable items they owned, the initial value and the expected useful life. The information in this question was combined into an index (Asset) which gives an indication of the wealth status of the households. The asset index was calculated as follows

$$AI = \sum_{n=1}^{n=17} k\,[(OV-D)/UL]$$

Where n = number of assets/items owned by a farmer where n = 1,...,17
k = the number of a particular asset owned by the farmer .
AI= Asset Index
OV = Original Value
D = Depreciation (straight line depreciation method was used)
UL = Useful Life

The asset index is the proportion of the remaining value of the assets summed over all the assets owned. Assumptions were made regarding the nature of the depreciation and the salvage value of the assets. For simplicity, the assets were assumed to depreciate at a straight-line method and the assets are used until they do not have any value (Salvage value =0). In practice however, some of the assets may not be depreciating at a straight-line method and may also have some value at the end of the useful life. Appreciation of the assets in the course of use was also not considered.

APPENDIX 3
Rainfall Distribution in Babati 1972/73 to 1995/96 Seasons

Season/				SHORT RAINS				LONG RAINS					
Month	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
72/73	0	0	0	0	184	208	173	151	59	168	15	0	957
73/74	0	0	0	0	140	71	36	31	93	287	11	0	669
74/75	0	0	0	0	38	35	9	16	145	125	22	8	390
75/76	6	0	1	0	0	94	52	106	82	14	17	1	373
76/77	0	10	0	0	138	106	108	144	6	75	83	0	670
77/78	0	0	0	0	104	192	236	120	120	104	9	3	888
78/79	0	0	0	0	240	274	153	223	119	136	46	20	1211
79/80	0	0	0	0	38	115	90	37	236	121	34	0	671
80/81	0	2	0	0	77	129	91	139	201	217	52	0	909
81/82	0	1	10	18	23	115	38	52	44	75	4	9	391
82/83	0	0	0	53	206	64	64	61	180	35	20	1	683
83/84	0	0	0	8	101	181	151	16	99	160	16	0	731
84/85	1	0	0	7	133	83	3	189	49	163	69	3	700
85/86	0	0	0	2	173	80	121	59	172	274	155	0	1033
86/87	0	0	0	16	90	204	186	142	236	241	145	29	1288
87/88	0	0	0	0	34	32	334	28	294	261	2	0	985
88/89	0	0	0	0	47	43	221	134	160	480	44	0	1128
89/90	0	0	0	2	107	43	56	77	257	307	23	0	872
90/91	0	0	0	8	18	229	140	35	169	156	20	0	774
91/92	0	0	0	1	29	196	1	66	78	222	43	0	635
92/93	0	0	0	14	61	208	134	33	120	20	13	0	601
93/94	0	0	0	0	25	12	49	105	231	88	99	4	613
94/95	6	3	13	10	53	122	82	102	107	152	116	6	772
95/96	14	27	5	11	79	101	68	88	99	178	103	5	778
Mean	1	2	1	6	89	122	106	91	142	178	45	3	801

APPENDIX 4

MAXIMUM LIKELIHOOD VERSUS LEAST SQUARES ESTIMATION

[derived from Aldrich and Nelson (1984:49-52)]

Estimation of a Lognormal and Weibull distribution was carried out using Tobit parameter estimation. Tobit and logit parameters are typically estimated using Maximum Likelihood (ML). Least squares (LS) (or OLS if the ordinary Gauss-Markov assumptions are made) methods try to find parameter estimates that make the predicted values of Y (in our Weibull and lognormal the dependent variable is X) based on the parameter estimates (β_i's) and the assumed relationship between Y and X, as close as possible to the actual observed values of Y. This closeness in LS estimate is measured by the sum of the squared deviations between the observed and predicated value of Y, i.e. as possible values of β are tried out, there is an error for each set of values in every observation. The estimated β is that which minimizes the error sum of squares.

ML produces estimates like OLS, but whereas OLS is concerned with picking parameter estimates that yield the smallest sum of squared errors in the fit between the model and data, ML is concerned with picking parameter estimates that imply the highest probability or likelihood of having obtained the observed sample Y.

Assuming a standard linear model of the form

$$Y_i = \Sigma b_k X_{ik} + u$$

The OLS normal equations are

$$\Sigma[Y_i\text{-}(\Sigma b_k X_{ik})]\, X_{ij} = 0 \quad j = 1,\ldots,k$$

In ML we proceed to find b so as to maximise the probit likelihood,

$$L(Y/X,b) = \Pi\,[\phi(\Sigma b_k X_{ik})^{Yi}\,]\,[1\text{-}\phi(\Sigma b_k X_{ik})]^{1\text{-}Yi} \qquad j = 1,\ldots,k$$

or logit likelihood,

$$L(Y/X,b) = \Pi[exp(\Sigma b_k X_{ik})/\,1 + exp(\Sigma b_k X_{ik})]^{Yi}\,[1/\,exp(\Sigma b_k X_{ik})]^{1\text{-}Yi} \qquad j = 1,\ldots,k$$

Taking logs and noting that if b maximizes $L(Y/X,b)$ also maximizes log $L(Y/X,b)$ then

$$log\, L(Y/X,b) = \Sigma[Y_i\, logP_i + (1\text{-}Y_i)\, log1\text{-}P_i)]$$

Computing the derivatives of the above logarithm with respect to each of the k coefficients b_k and set equal to zero. Solutions of these ML equations will yield the ML estimators.

For probit, the equations are:

$\{[Y_i\ \phi(\Sigma b_k X_{ik})]\ \phi(\ \Sigma b_k X_{ik})\}X_{ij}\ /\phi(\Sigma b_k X_{ik})[1\text{-}\phi(\Sigma b_k X_{ik})]$ (summed over the sample size N)

Where $\phi(.)$ is the probability density function for the standard normal distribution, i.e. the derivative of the cumulative normal distribution function.

For logit the equations are:

$\Sigma[Y_i - \{exp(\Sigma b_k X_{ik})/1 + exp\Sigma b_k X_{ik})\}]X_{ij}$ (Summed over the sample size N)

The probit and logit equations can be written as:

$\Sigma[Y_i - P(Y_i = 1/X_i, b)] A_i X_{ij} = 0$

where $A_i = \phi/\phi(1-\phi)$ for probit and $A_i = 1$ for logit.
It can be concluded that both OLS and ML take as estimates those values of b which make the weighted sum of deviations between Y_i and its expected value equal zero. The difference is in the definition of the expected values, i.e.

$Y_i\ \Sigma b_k X_{ik}$ in LSE and $P\ (Y_i = 1/X_i, b)$ in logit and probit.

APPENDIX 5

Moments of the Lognormal Distribution

The lognormal distribution in its simplest form may be defined as the distribution of a variate whose logarithm obeys the normal law of probability (Aitchson and Brown, 1957)
Consider any positive variate $X(0<x>\infty)$ such that $Y=logX$ normally distributed with mean μ and variance σ^2. It can be said that X is lognormally distributed or that X is a Λ-variate i.e. $\Lambda(\mu,\sigma^2)$ and correspondingly Y is $N(\mu,\sigma^2)$.
The distribution of X is completely specified by two parameters μ, and σ^2
Thus we have two distribution functions denoted by X and Y as $\Lambda(x|\mu,\sigma^2)$ and $N(y|\mu,\sigma^2)$ respectively.
Since X and Y are related through $Y=logX$, their distribution functions are also related.

The two distributions possess moments of any order; the j^{th} moment about the origin is given and denoted as

$$\lambda_j = \int x^j \, d\Lambda(x) \; j=0,..\infty$$
$$=\int e^{jy}N(y) \;\; j=-\infty,..\infty$$
$$=e^{j\mu}+\tfrac{1}{2}j^2\,\sigma^2$$

From the properties of the moment generating functions of the normal distribution the mean and variance can be obtained as

$$\alpha = e^{\mu}+\tfrac{1}{2}\sigma^2 \tag{1}$$
$$\beta^2 = e^{2\mu+\sigma 2}\,(e^{\sigma 2\text{-}1}) \tag{2}$$
$$= \alpha^2\eta^2 \tag{3}$$

Where $\eta^2 = e^{\sigma 2\text{-}1}$ and η is coefficient of variation μ and σ are the parameters of the estimated lognormal distribution and a tabulation of η and σ is available in statistical tables (Aitchkson and Brown, 1957)

Other moments about the mean for example the third moment is given as

$$\lambda_3 = \alpha^3(\eta^6\,3\eta^4) \tag{4}$$

The measure of departure from normality namely the coefficient of skewness is given as

$$\lambda_3/\beta^3=\eta^3 3\eta \tag{5}$$

It follows therefore that from the tabulated values, the mean, variance and skewness can be approximated or calculated directly from the above equations. Equation 1 for the mean, 2 and 3 for variance and skewness and its coefficient by equations 4 and 5 respectively.

APPENDIX 6
Regression Results between Risk Attitudes and Perceptions with Household Resources and Characteristics

(a)Results of regression analysis between risk attitude measures and household characteristics and resources (n=30)

Variable	Inadequate cash		Inadequate food stocks		Adequate food		Adequate cash		Combined risk attitude coefficient	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Constant	-0.17	-0.21	0.506	0.98	4.42	2.10	-0.0029	-0.16	3.038	2.82
Education (years)	-0.03	-0.05	0.008	0.21	-1.133	-1.75*	0.01	0.43	-0.149	-1.78*
Age (years)	-0.02	-1.80*	-0.002	-0.30	-0.02	-0.47	0.001	0.36	1.184	0.25
Wealth(scale)	-0.14	-2.18*	-0.008	-0.19	0.151	0.909	0.001	0.08	-1.705	-3.29*
Gender (dummy)	0.62	1.50	0.187	0.68	0.10	0.74	0.02	0.16	-0.00008	-0.163
Hh size (number)	-0.04	-0.71	-0.038	-0.96	-0.17	-1.72*	-0.02	2.22*	-0.173	-2.391*
R squared	0.49		0.22		0.42		0.30		0.63	

* Means the coefficient is significant (p≤0.10 two tailed)

(b) Results of regression analysis between risk perception of cropping systems and household characteristics and resources (n=30)

Variable/crop-Ping system	Mixed fruit trees +food crops		Tree (timber/fuel wood)+ food crops		Mixed food crops only		Cash crops only		Trees (timber and fuel wood) only		Mixed fruit trees only	
	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
Constant	8357.91	5.51	9519.99	3.53	4980.68	2.29	14547.95	6.98	8822.06	4.24	11337.91	2.05
Education (years)	-72.55	-3.01*	-204.24	-1.77*	-123.11	-0.80	-79.216	-2.390*	-37.25	-2.33*	-69.34	-0.79
Age (years)	-230.88	-2.15*	-47.41	-1.79*	-0.62	-0.02	-94.90	-0.644	-1.10	-.007	-204.47	-0.52
Gender(dummy)	636.10	0.78	31.20	0.151	149.23	0.13	947.91	0.849	270.33	0.24	4716.83	1.85*
Wealth (scale)	-547.06	-4.33*	-794.88	-3.53*	-553.49	-2.51*	-899.50	-5.17*	-887.25	-5.11*	-1361.14	-2.95*
Hhsize (number)	-202.51	-1.75*	-86.26	-0.06	-51.29	-1.72*	468.19	-2.935*	1.66	0.10	-455.64	-1.80*
R squared	0.78		0.68		0.57		0.80		0.76		0.58	

* Means the coefficient is significant (p≤0.10 two tailed)

(c) Results of regression analysis between preference ranking of cropping systems and risk attitude, risk perception and household characteristics and resources (n=30)

Variable/crop-ping system	Mixed fruit trees +food crops		Tree (timber/fuel wood)+ food crops)		Mixed food crops only		Cash crops only		Trees (timber and fuel wood only)		Mixed fruit trees only	
	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
Constant	5.04	2.78	2.64	1.5	2.74	0.68	3.79	2.23	2.82	2.29	-20.85	-2.19
Education (years)	0.23	1.92*	0.11	1.18	0.07	0.28	-0.07	-0.68	0.06	0.52	-0.33	-0.66
Age (years)	-0.09	-3.76*	0.01	0.59	0.002	0.04	0.04	1.88*	-0.009	-0.42	0.36	2.36*
Gender(dummy)	2.72	2.52*	1.58	1.98*	0.2	0.13	-0.62	-1.08	-0.01	-0.02	12.66	2.34*
Risk attitude (score)	-0.19	-4.07*	-0.02	-0.26	0.16	1.20	-0.53	-1.92*	-0.24	-0.87	-0.06	-0.91
Risk perception (std. Dev.)	-2.01	-1.31	-0.38	-1.81*	-0.65	-0.74	-0.001	-1.70*	-0.005	-0.38	-0.02	-0.63
Expected Income (Mean)	0.00003	2.5*	0.00001	0.23	0.00002	1.67*	0.00005	0.057	0.00001	0.23	0.00004	0.38
Wealth (scale)	0.006	0.04	-0.001	-1.46	0.001	1.35	-0.0003	-0.38	0.001	1.73*	0.006	0.46
Hhsize (number)	-0.09	-0.66	-0.11	-0.94	-0.08	-0.58	-0.13	-1.37	0.02	0.20	-0.13	-0.53
R squared	0.88		0.62		0.46		0.40		0.43		0.81	

* Means the coefficient is significant (p≤0.10 two tailed)

Appendix 7
Arrow-Pratt absolute risk aversion coefficients for each farmer under different situations

Farmer	Inadequate Cash	Inadequate food	Adequate food	Adequate cash
1	0.00247	0.00329	0.00068	0.00082
2	0.00235	0.00228	0.00047	0.00067
3	0.00263	0.00318	0.00054	0.00095
4	0.00232	0.00340	0.00082	0.00092
5	0.00267	0.00258	0.00079	0.00090
6	0.00249	0.00217	0.00212	0.00131
7	-0.00327	0.00143	0.00051	0.00086
8	0.00095	0.00400	0.00050	0.00011
9	0.00096	0.00143	0.00126	0.00215
10	0.00349	-0.00249	0.00120	0.00082
11	-0.00563	0.00238	0.00362	0.00020
12	0.00265	0.00420	0.00067	0.00006
13	0.00465	0.00239	0.00072	0.00055
14	0.00127	0.00217	0.00073	0.00044
15	0.00264	0.00277	0.00053	0.00200
16	0.00249	-0.00093	0.00324	0.00069
17	0.00407	0.00233	0.00076	0.00047
18	0.00405	0.00198	0.00500	0.00046
19	0.00131	0.00258	0.00471	0.00236
20	0.00238	0.00359	0.00442	0.00021
21	0.00401	0.00299	0.00362	0.00020
22	0.00132	0.00172	0.00083	0.00082
23	0.00401	0.00284	0.00151	0.00035
24	0.00260	0.00431	0.00057	0.00071
25	0.00249	0.00297	0.00079	0.00056
26	0.00450	0.00385	0.00418	0.00035
27	0.00146	0.00180	0.00151	0.00126
28	0.00510	0.00276	0.00167	0.00081
29	0.00536	-0.00097	0.00117	0.00136
30	0.00547	0.00185	0.00418	0.00126
Overall	0.0023	0.0021	0.00170	0.00106

Appendix 8

Arrow-Pratt relative risk aversion coefficients for each farmer under different situations

Farmer	Inadequate Cash	Inadequate food	Adequate food	Adequate cash
1	0.320	0.950	0.312	0.13
2	0.480	0.350	0.320	0.137
3	0.280	0.830	0.311	0.136
4	0.380	0.520	0.313	0.135
5	0.380	1.390	0.314	0.200
6	0.160	1.620	0.340	0.139
7	-0.630	1.380	0.360	0.875
8	0.570	0.990	0.200	0.212
9	2.290	0.320	0.270	0.236
10	0.160	-0.850	1.500	0.134
11	-1.450	0.470	0.440	0.740
12	0.510	0.870	0.180	0.189
13	0.630	2.640	0.332	0.311
14	0.410	1.310	0.342	0.197
15	0.730	0.600	0.321	0.134
16	0.320	-0.210	0.600	0.139
17	0.720	1.110	0.330	0.207
18	0.430	0.380	0.220	0.194
19	0.710	0.980	0.500	0.206
20	0.490	0.990	0.480	0.134
21	0.480	0.290	0.320	0.190
22	0.760	0.210	0.250	0.210
23	0.380	0.110	0.430	0.146
24	1.910	1.070	0.190	0.137
25	1.720	0.060	0.490	0.134
26	0.480	0.440	0.320	0.254
27	0.690	0.810	0.240	0.157
28	1.910	1.050	0.441	0.243
29	0.180	-0.980	0.710	0.199
30	2.480	0.470	0.330	0.431
Overall	0.627	0.674	0.383	0.215

About the Author

Ephraim M.M. Senkondo was born on the 16th May 1956 in Vumari, Same district in Tanzania. He studied diploma in Agriculture at Uyole Agricultural Center and graduated in 1980. He worked briefly with Kilombero Sugar Company and later with Tanzania Seed Company. Between 1982 and 1984 he studied at Sokoine University of Agriculture and graduated in 1984 with BSc Agriculture (Hons). Sokoine University of Agriculture then employed him as an academic member of staff. Between 1985 and 1988 he was registered at the University of Nairobi, Kenya, where he graduated in 1988 in MSc Agricultural Economics. In 1990 he reoriented himself in environment and sustainable agriculture studies at the Agricultural University of Norway, where he graduated in 1992 in MSc Management of Natural Resources and Sustainable Agriculture. He returned to Sokoine University of Agriculture and worked in the Department of Agricultural Economics and Agribusiness as a Lecturer.

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As a researcher the author has worked with a number of research projects in Tanzania, including the Soil-Water Management Research Project at Sokoine University of Agriculture and he is a member of the Soil and Water Management Research Network. He has done a lot of consultancy work including:

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- Participatory Rural Appraisal (PRA) of Refugee affected West Lake Region-Bukoba Tanzania funded by CARE International,
- Farming Systems Study of Western Pare Lowlands funded by the Department for International Development (UK)
- Review of The Kikafu Chini Irrigation Project in Tanzania, funded by the Norwegian Agency for Development Cooperation (NORAD) and
- People Participation in Natural Resource Management: The case of Zaraninge Proposed Forest Reserve-Bagamoyo Tanzania, funded by the World Wide Fund for Nature (WWF).

The author has authored and co-authored various publications including the following:

- Factor Substitution and Wage Employment in Agriculture in Tanzania Beitr. Trop. Landwirtsch. Vet. Med. 29(3): 259-266 (1991);
- Are Smallholder Agroforestry Systems Profitable? A case study of Uluguru Mountains area, Tanzania Agricultural Economics Analysis and Rural Development 4(1):7-17 (1994);
- The Use of Linear Programming in Planning Optimal Agroforestry Strategies Eastern Africa Social Science Research Review 12(2): 25-36 (1996);
- Privatization of Veterinary Services in Tanzania: The role of Government Interventions Tanzania Veterinary Journal -The Tropical Veterinarian 14(3-4): 181-187 (1994);
- Factors Affecting the Adoption of Rain Water Harvesting Technologies in Western Pare Lowlands of Tanzania. Tanzania Journal of Agricultural Sciences 1(1): 81-89(1998).