DETERMINANTS OF ADOPTION OF IMPROVED WHEAT VARIETIES AND FERTILIZER USE BY SMALLHOLDER FARMERS IN NJORO AND KIENI WEST, DIVISIONS

BY

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DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this is my original work and has not been submitted in this or any other university for award of any degree.

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Recommendation

This thesis has been presented to the Graduate School of Egerton University with our approval as university supervisors.

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DEDICATION

This work is dedicated to my loving husband Mr. Francis Njane and to our children; Carren, Catherine, Sammy and Brian for their love, understanding and sacrifice throughout the study period. To my loving mother Jane Wanjiru, brothers and sisters for their encouragement.

ABSTRACT

Kenya has the potential to produce enough wheat for its domestic consumption, but over the years wheat consumption has continued to outstrip local production thus, making Kenya a perennial net importer of wheat. Current annual wheat consumption is estimated at 600,000 metric tonnes against a production of 365,696 metric tonnes. Though low wheat productivity can be attributed to many factors, little is known about the attitudes to and adoption of improved wheat production technologies at farm level. This study therefore, intended to bridge this information gap by determining socioeconomic factors that influence farmer's perception of technology-specific attributes of and response to wheat production technologies. A sample of 150 households from Njoro and Kieni divisions were sampled using multistage sampling procedure and a structured questionnaire was used for data collection.

Results of Kendall's Coefficient of Concordance (W) show education level, distance to seed market, access to extension services, number of livestock units and family size correlated significantly with farmer's perception of improved wheat varieties-specific attributes. Gender of household head, farmer's experience, farm size, education level, number of livestock units and a household head's affiliation to an organization correlated significantly with farmer's perception of fertilizer-specific attributes. Results of Tobit models shows that, farmer's Agro-Ecological Zone, farm size, farmer's experience and distance to seed market influenced adoption and intensity of use of improved wheat varieties significantly. Farmer's Agro-Ecological Zone, gender of household head and access to extension services influenced adoption and intensity of fertilizer use significantly. Decomposition of Tobit models revealed that marginal changes in an explanatory variable *ceteris paribus*, had higher effects on the probabilities of adoption than on intensity of adoption (use). Results of Spearman's Coefficient of Rank Correlation (r_s) show that, farmer's perception of improved wheat varieties-specific attributes correlated significantly with adoption and intensity of use of improved wheat varieties. Farmer's perception of fertilizer specific-attributes correlated significantly with adoption and intensity of fertilizer use. Results also showed that where the technology package is made up of separate components like seeds and fertilizer farmer's attitudes to and adoption of the components are not at the same level. The study findings are useful to researchers, extension agents and policy makers. The study findings bridged the information gap and added to the existing body of knowledge of Agricultural Economics.

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LIST OF ABBREVIATIONS

a.s.l	-	above sea level
BW	-	Bread Wheat
GoK	-	Government of Kenya
Ha	-	Hectares
KARI	-	Kenya Agricultural Research Institute
m	-	Meters
mm	-	Millimeter
MoA	-	Ministry of Agriculture
MoARD	-	Ministry of Agriculture and Rural Development
N	-	Nitrogen
NPBRC	-	National Plant Breeding Research Centre
P	-	Phosphorous

CHAPTER ONE: INTRODUCTION

1.1 Background Information

In terms of hectarage and contribution to food security, wheat ranks the second most important cereal crop in Kenya after maize (MoARD, 2002; GoK, 2004 and MoA, 2006). The current area under wheat is about 159,477 ha (MoA, 2006) and accounts for about 2.2 percent of the total area under crops and dairy pasture (GoK, 2004). Annual average wheat consumption is estimated at 600,000 metric tonnes against an annual average production of 365,696 metric tonnes (MoA, 2006).

Wheat has been grown in Kenya since the 1900s. Its early development was confined to large-scale farms in the Rift Valley and parts of Central and Eastern provinces. This pattern has, however, changed with subdivision of large-scale farms into smaller land holdings (MoARD, 2002). Today, a numerous number of small-scale farmers grow wheat in the Rift Valley and parts of Central and Eastern provinces.

The importance of smallholder farming is due to the number of farmers involved and their contribution to the economy. The smallholder sub-sector accounts for 75 percent of the total agricultural output and 70 percent of marketed agricultural produce (GoK, 2004). Production is carried out on farms averaging 2-3ha mainly for subsistence and commercial purposes. Increased wheat productivity, therefore, need to take place in the smallholder sub-sector and will involve enhanced efforts to encourage farmers to adopt modern farming practices. However, the sub-sector's current use of improved inputs such as improved seeds, fertilizers, and pesticides or machinery is very low (GoK, 2004).

Until 1974, Kenya was a net exporter of wheat to neighbouring countries and to Saudi Arabia, but since then the country has had to import wheat each year to meet a high and rising demand. According to FAOSTAT (2001) area under wheat increased from an annual average of about 118,552 ha in 1974-1990 period to an annual average of about 136,000 ha in 1990-2001. During the period 2001-2005, area under wheat increased to an annual average of 145,995 ha MoA (2006). However, increase in wheat production through area expansion has not kept pace with demand. Figure 1 shows wheat production and consumption for 1996-2006. From Figure 1 wheat consumption continues to outstrip local production. The result has been a wide gap between domestic production and consumption. The deficit in production is met through importation, which requires the use of scarce foreign exchange resources. This deficit in production indicates that production growth rate will have to more than double to keep pace with consumption growth rate.

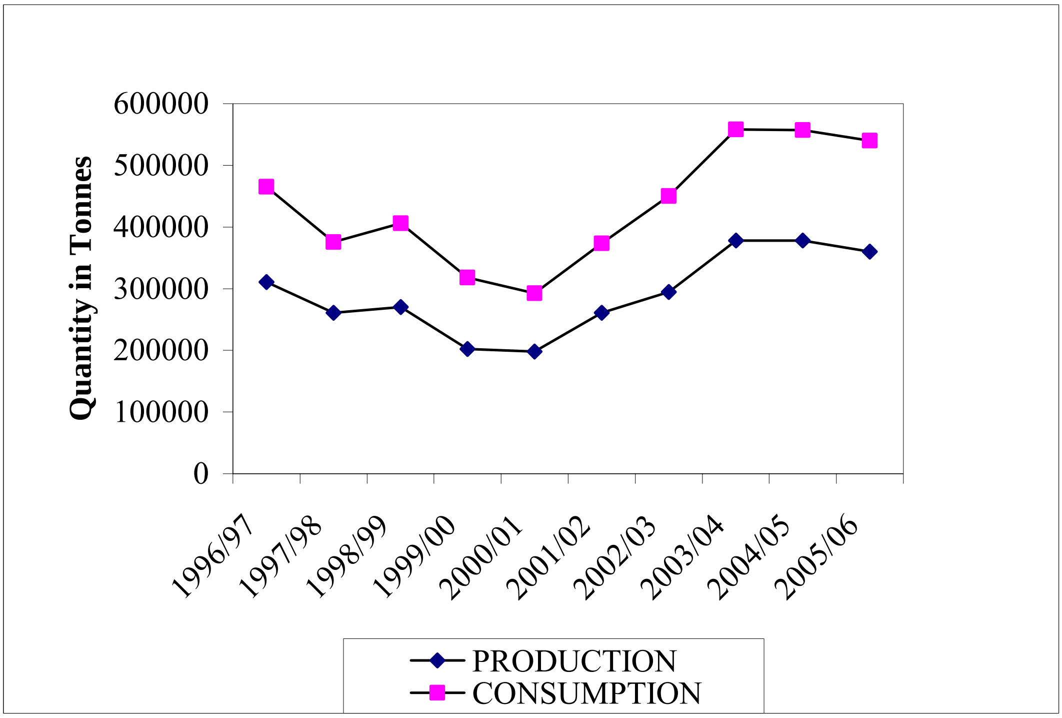

Figure 1: Wheat production and Consumption, 1996-2006
Source: MoA (2006)

Assessment of wheat production indicates that Kenya has the potential to produce enough wheat to meet its domestic consumption. This has been backed by FAO (2004) which has shown that, of all the rainfed wheat producing countries in Africa, Kenya has all the natural resources it needs to produce enough wheat to meet its consumption and hence increase its food security. According to GoK (1997a) increased wheat production will be achieved through intensification and increased productivity in high and medium potential areas and expansion of area under wheat in marginal areas. Increased production through area expansion in high and medium potential areas at macro-level is constrained by increased population pressure and stiff competition from maize, livestock production and high valued horticultural enterprises. The greatest competition, however, comes from livestock production, which occupies 47 percent of the land resources (GoK, 2004). The potential for increased production in high and medium potential areas is indicated by a productivity gap between research based-yield of 2.4 t/ha and 0.9t/ha obtained on farmer's field (Muasya and

Mwakha, 1996). Nevertheless the productivity gap in medium and high potential areas can be closed through the use of yield-enhancing technologies. The greatest potential for increased wheat production in Kenya is through expansion of area under wheat in marginal areas. According to MoA (2005b) the marginal districts in the Rift Valley province accounts for 77,866 ha (about 50 percent) of the current area under wheat though there is competition with wildlife and communal grazing.

Though wheat production is faced with many constraints, low and decline soil fertility and inappropriate seeds are the major constraining factors. This is because soil fertility and seeds are the factors that considerably determine wheat grain yields. Studies by KARI (2001), KARI (2000), and KARI (1992) have shown that low and declining soil fertility is one of the major constraints in wheat production, besides pest and diseases, poor farm management and lack of credit. According to KARI (2000) low wheat yields are as a result of low levels of Nitrogen (N) and Phosphorous (P) in the soil. Hassan, *et al.* (1993) showed that low soil fertility is one of the most serious problems affecting wheat production thus, threatening the wheat sub sector in Kenya. The constraint of low Nitrogen (N) and Phosphorous (P) is worsened by the decline in soil organic matter content resulting from continuous cropping of wheat with no or little replenishment of removed nutrients; overgrazing between cropping seasons; and removal of crop residues for ruminant feeds (MoA, 2005a and KARI, 2001). Furthermore, many smallholder farmers in Kenya have not fully appreciated the values of using green manure and compost to maintain and improve soil fertility (KARI, 2001). Nevertheless, practical means of replenishing nutrients to exhausted cropland exist, and direct use of inorganic fertilizers is often considered to be an immediate solution.

Use of inappropriate wheat varieties is also a constraint to increased wheat yields. A survey conducted in wheat growing areas in Kenya by Hassan, *et al.* (1993) found that, despite the release of new wheat varieties, farmers continued to use own seeds retained from year to year, and those supplied by seed merchants and other farmers without due regards to seed quality. According to Ndiema (2002) only about 10.0 percent of the farmers in Njoro and Rongai divisions of Nakuru district had adopted improved wheat varieties.

Ndiema (ibid) in her study in Njoro and Rongai divisions of Nakuru district and Karanja (1996), in Mai-Mahiu and Ngorengore showed adoption of improved wheat production technology to be only 20.02 and 24.0 percent respectively. Therefore, the productivity gap between research-based yield of 2.4 t/ha and 0.9t/ha obtained on the farmer's field cannot be attributed to management factors alone, but non-adoption or low adoption of wheat production technologies, among others, may be the critical impediments to productivity growth.

1.2 Problem Statement

The trends in wheat productivity have been noted to be on decline, especially in decades following the 1970s; farmers have not seen sustained growth in wheat yields. Nevertheless, a huge potential exist for increasing wheat production in Kenya through use of improved seeds, soil fertility management technologies and good practices of crop husbandry. Inorganic fertilizer usage as a strategy for soil management has been recognized as an immediate solution to soil fertility problems, while introduction of improved wheat varieties that are high-yielding, resistant to pests and diseases, drought tolerant and early maturing has been viewed as a strategy to increase and maintain wheat production in Kenya. Accordingly, the National Plant Breeding Research Centre, KARI-Njoro has since its inception focused on research programs for developing and disseminating improved wheat varieties for various agro ecological zones, fertilizer use recommendations for various soil types and appropriate agronomic practices through multi-locational, on-farm and adaptive trials. Since 1974, a total of 22 wheat varieties have been developed and released and they are still popular with the farmers. Of the 22 wheat varieties, 4 varieties have been bred for drought tolerance, 2 varieties for acid tolerance and 4 varieties have shown some resistance to wheat rust among other desirable characteristic like early maturing, quality, high yielding and lodging resistance. Current research programs are focused on developing wheat varieties that are rust resistant as wheat rust is a major challenge to wheat growing especially in high rainfall areas. Despite the obvious potential importance of these research programs in increasing wheat production, little is known about the attitudes to and adoption of these improved wheat production technologies at farm level.

1.3 Objectives of the study

The overall objective of the study was to determine the factors that influence adoption or non-adoption of wheat production technologies among small-scale wheat farmers. The specific objectives were:

- To establish the relationship between socioeconomic factors and farmer's perception of improved wheat varieties- specific attributes in wheat production.
- To establish the relationship between socioeconomic factors and farmer's perception of fertilizer-specific attributes in wheat production.
- To determine the socioeconomic factors that influence adoption and intensity of use of improved wheat varieties.
- To determine the socioeconomic factors that influence adoption and intensity of fertilizer use.
- To determine the relationship between farmer's perception of technology-specific attributes and adoption and intensity of use of improved wheat varieties.
- To determine the relationship between farmer's perception of technology-specific attributes and adoption and intensity of fertilizer use.

1.4 Hypotheses of the Study

To help follow up on the objectives of the study, the following hypotheses were formulated.

- Socioeconomic factors have no significant relationship with farmer's perception of improved wheat varieties- specific attributes.
- Socioeconomic factors have no significant relationship with farmer's perception of fertilizer-specific attributes.
- Socioeconomic factors have no significant effects on adoption and intensity of use of improved wheat varieties.
- Socioeconomic factors have no significant effects on adoption and intensity of fertilizer use.
- Farmer's perception of technology-specific attributes has no significant relationship with adoption and intensity of use of improved wheat varieties.
- Farmer's perception of technology-specific attributes has no significant relationship with adoption and intensity of fertilizer use.

1.5 Justification of the Study

Increase and sustainability in wheat productivity in Kenya, will need to take place in smallholder sub-sector. This is only achievable if enhanced efforts to encourage farmers to adopt improved wheat production technologies are undertaken. However, technology targeting requires detailed characterization and identification of variables that influence farmer's perception of technology-specific attributes of and response to different technologies. The current study aimed at determining socioeconomic factors influencing farmer's perception of improved wheat varieties- and fertilizer-specific attributes and adoption and intensity of use of improved wheat varieties and fertilizer.

1.6 Scope of the Study

The study focused only on adoption of improved wheat varieties and fertilizer use in wheat production. Socioeconomic factors influencing technology-specific attributes and adoption of improved wheat varieties and fertilizer use were considered. The study focused only on small-scale farmers (farmers growing wheat on < 20 ha), and only two wheat-growing divisions, Njoro and Kieni West were covered.

1.7 Limitation of the Study

Since it was not possible to study the factors that influence adoption of all improved wheat technologies, improved wheat varieties and fertilizer use are the only improved wheat technologies that were considered. The information was ex- post facto (reports of past events), and the farmers in the study sites may not have given accurate information due to memory lapse, since most of the small-scale farmers do not keep records of operations.

CHAPTER TWO: LITERATURE REVIEW

Adoption of technological innovations by farmers in developing countries has attracted considerable attention among development economists. This is because the majorities of less developed countries' population derive its livelihood from agricultural production and also because introduction of many new technologies in these countries has been met with only partial success as measured by rates of adoption (Feder, *et al.,* 1982). This chapter contains a review of literature on approaches to adoption of agricultural technologies, adoption related studies, farmer's perception related studies and methodologies used in adoption studies.

2.1 Approaches to Adoption of Agricultural Technologies

The literature on issues related to adoption of improved agricultural technologies in developing countries is voluminous. This is perhaps due to the conventional wisdom that improved agricultural technologies are very important in increasing productivity and welfare of resource poor farmers. The literature conventionally falls into three broad categories.

The first category brings together the literature on what is referred as the innovation-diffusion Theory. This theory assumes that the technology introduced to farmers is appropriate in its given form and that what determines the adoption decision is the effectiveness of communication to the targeted users (farmers). Communication to the targeted user is achieved through extension, media, opinion leaders, on-farm or on-station demonstration, farmers' fields, training, seminars, and workshops (Odera, *et al.,* 2000). Studies applying innovation-diffusion theory and found communication of technology to be important factor in adoption include works by Odera, *et al.* (2000), Nkonya, *et al.* (1997), Polson and Spencer, (1991) and Kebede, *et al.* (1990). This theory revolves on source–communication–user model. The theory has been criticized for prescribing a top–bottom approach.

The second category of literature is concerned with the level of resource endowment as it impacts on adoption behaviour. It is referred as resource constraint model. This category assumes that the technology being introduced to farmers is appropriate in its given form and that what mainly determines adoption decision is the farmer's level of resource endowment. Effects of factors such as farm size and liquidity constraint on decisions to adopt or not to adopt new technologies have been variously examined. Studies applying resource constraint model include works by Hwang, *et al.* (1994), Anderson and Thampapillai (1990) and

Kebede, et *al.* (1990). The resource constraint model assumes only farmers' resource level is important in adoption decision and that farmer's knowledge about the technology and farmer's perception it is not important.

The third category of adoption literature has been in focus in recent times. This category of literature is referred to as adopter perception model. This category deviates from the other two and instead, focuses on whether technology-specific attributes are satisfactory to the farmer and on the understanding of the degree to which the attributes encourage or discourage adoption decisions. The adopter perception model assumes that farmer's perception of a technology's attributes and the farmer's socioeconomic circumstances have an influence on adoption behavior. Studies that have used adopter perception model include works by Adesina and Baidu-forson (1995), Adesina and Zinnah (1993), Shiferaw and Holden (1998), Negatu and Parkh (1999), Makokha, *et al.* (1999) and Sall, *et al.* (2000). Sall, *et al.* (ibid) contends that by virtually ignoring technology-specific attributes and how farmers evaluate the appropriateness of the technologies, the literature on adoption has omitted major sets of critical factors determining farmer's adoption behavior. Therefore, current study employs adopter-perception model.

2.2 Studies Related to Adoption of Agricultural Technologies

A review of past empirical studies on adoption reveals that, household attributes; resource endowment and institutional factors are important factors in explaining adoption behavior. Studies by Njue, *et al.* (1998) and Gamba, *et al.* (1998) have shown household attributes and resource endowment to be important factors influencing farmers' decision to adopt maize production technologies and improved wheat varieties respectively. Njue, e*t al.* (1998) further argued that when a package is made up of separate components, like maize variety, fertilizer and management practices, the components are not adopted to the same level. The study also found fertilizer availability to be important factor in explaining adoption of fertilizer use in maize production. The study by Gamba, *et al.* (1998) found household size to influence adoption of improved wheat varieties negatively and farm size and years in wheat farming to influence adoption of improved wheat varieties positively. Both studies investigated only the effects of household attributes and resource endowment on adoption decisions. Farmer's perception of technology-specific attributes and institutional factors such as access to extension, access to credit, access to input market and Agro-Ecological Zone of the farmer which may be important in explaining adoption behaviour were not addressed.

Tirunel, *et al.* (1998) in Ethiopia and Judicate, *et al.* (1998) in Tanzania found household characteristic, resource endowment, and institutional factors to be important factors in explaining farmer's adoption decisions of improved wheat production technologies. The study by Tirunel, *et al.* (1998) found gender of household head, access to extension services, radio ownership and farm size to influence adoption of improved wheat varieties in Ethiopia. Judicate, *et al.* (1998) found farm size, household size and level of education to be significant factors in explaining adoption of improved wheat varieties in Tanzania. The study also found farm size, access to extension services, hired labour, access to credit and number of livestock units owned to be significant factors in explaining adoption of fertilizer use. However, the two studies did not investigate factors influencing farmer's perception of technology–specific attributes and the influence of farmer's perception on adoption decision.

2.3 Studies Related to Farmer's Perception of Technology-specific Attributes

Perception is the process through which one gains an understanding of what is happening and forms an opinion/attitude/judgment about it. The way farmers perceive attributes of a given technology influences their adoption behaviour. However, the way potential adopters perceive the attributes of a technology may in fact be different from the actual or inherent attributes of a technology. It may also be different from the expert point of view. Therefore, technology-specific attributes of agricultural technologies are important as far as they are perceived by farmers favourably. A review of past empirical studies on adoption reveals that, farmer's perception of technology-specific attributes is an important factor in explaining farmer's adoption behavior. Studies by Odera, *et al.* (2000), Sall, *et al.* (2000), Wanyoike, *et al.* (2000), Makhoha, *et al.* (1999), Adesina and Baidu-forson (1995) and Adesina and Zinnah (1993) have shown that farmer's perception of technology-specific attributes of agricultural technologies influence his/her preferences and thus adoption decisions. The study by Odera, et *al.* (2000) focused only on effects of technology-specific attributes on adoption. The study did not consider resource endowment, household attributes and institutional factors, which are important in explaining adoption behavior. Studies by Adesina and Zinnah (1993), Adesina and Baidu-forson (1995) and Sall, *et al.* (2000) in West Africa studied effect of both farmer's perception of technology-specific attributes and socioeconomic factors on adoption decisions. The study by Makhoha, *et al.* (1999) focused only on effect of both technology-specific attributes and farmer's source of information variables on adoption decisions. However, studies by Odera, *et al.* (2000), Wanyoike, *et al.* (2000), Makhoha, *et al.* (1999), Adesina and Baidu-forson (1995) and Adesina and Zinnah

(1993) studied the effect of farmer's perception of technology-specific attributes on adoption decision using comparison of dichotomous preferences of each technology-specific attribute. They failed to take into account that farmers view agricultural technologies as complex embodiment of several attributes that interact to influence their subjective preferences and therefore, no single technology-specific attribute can be used to cover the dimensions of farmer's perception of technology-specific attributes (Sall, *et al.,* 2000). The study by Sall, *et al.* (ibid) used quasi-arbitrary index to measure farmer's perception of technology-specific attributes. The studies did not considered effect of socioeconomic factors on farmer's perception of technology-specific attributes.

A study by Ndiema (2002) in Njoro and Rongai divisions of Nakuru district found farmer's perception to be influenced by farm size. In her study large scale farmers were found to perceived profitability of improved wheat varieties and fertilizer use more favourably compared to small-scale farmers. The study did not consider effect of farmer's perception of technology-specific attributes on adoption decisions. Neither did it consider the effect socioeconomic factors on farmer's perception of technology-specific attributes.

Rogers (1983) observed that, the characteristics of innovations as perceived by the farmer influence adoption behavior. The author postulated that characteristics of an innovation as perceived by a farmer determine the rate at which it is adopted. Rogers presented five aspects of an innovation that have major influence on the rate of adoption.

(i) Relative advantage: the degree to which an innovation/idea is considered superior to Others.
(ii) Compatibility: the degree to which an innovation is seen as consistent with the existing values, past experiences and the needs of the recipients.
(iii) Triability: the degree to which trials can be conducted on a small scale.
(iv) Complexity: the extent to which an innovation is seen as relatively difficult to understand and use .
(v) Observability: the extent to which the results are visible.

He further argued that, apart from the characteristics of an innovation, characteristics of an adopter and his or her environment or situation are equally important. These aspects of technology are important as they can be applied to any agricultural technology.

2.4 Methodologies used in Adoption studies

Various models have been used to analyze socioeconomic factors affecting adoption decisions. Logit Regression model has been widely used in adoption studies and only determines the probability of a farmer to adopt a given technology. Studies that have used Logit Regression include works by Tirunel, *et al.* (1998), Judicate, *et al.* (1998), Njue, *et al.* (1998) and Gamba, *et al.* (1998) and Salasya, *et al.* (1997) among others. A study by Shiferaw and Holden (1998) used Ordinal Logit Regression model to investigate socioeconomic factors influencing adoption of soil conservation and farmer's perception of soil erosion in Ethiopia. Multinomial Logit Regression model was used by Oluoch-Kosura, *et al.* (2001) to analyze socioeconomic factors influencing choice of soil fertility management options. Multinomial Logit Regression model also determines the probability of a farmer to adopt to a given technology. Tobit model has also being widely used. The Tobit model measures not only the probability that a farmer will adopt a given technology but also measures the intensity of use of that particular technology, once adopted (Maddala, 1983 and Maddala, 1992). Studies that have used the Tobit Model include works by Odera, *et al.* (2000), Sall, *et al.* (2000), Wanyoike, *et al.* (2000), Oluoch-Kosura, *et al.* (2001), Makhoha, *et al.* (1999), Adesina and Baidu-forson (1995) and Adesina and Zinnah (1993) among others. A study by Odendo, *et al.* (2000) used Contingent Valuation Method (CVM) to assess household willingness to adopt, while a study by Ndiema (2002) used Chi-square to determine factors influencing adoption and farmer's perception of technology-specific attributes.

CHAPTER THREE: METHODOLOGY

This chapter discusses conceptual framework, test of data reliability and procedures that were used in data collection and analysis. These procedures, included research design and Instrument of data collection, sampling unit, sample size and sampling procedures, and data collection and analysis and procedures.

3.1 Conceptual Framework

From profit maximization theory, the firm's objective is to maximize profit (Hyman, 1989). However, small-scale farmers are both consumers and producers of goods and services. As producers, they still aspire to achieve various primary objectives and not necessarily profit maximization. Some of small-scale farmers' objectives include achievement of minimum subsistence requirements, maintenance of social status, leisure and better living standards among others. Therefore, a smallholder farmer would maximize his/her objectives by maximizing output. This is only achievable through the use of improved production technologies by the farmer. However, the farmer is faced with several technologies to choose from. Based on primary objective maximization, the probability of the farmer to choose an alternative technology is determined by how best that particular technology maximizes profits, minimizes cost per unit of production or ensures achievement of a threshold level of subsistence or any other objectives as the case may be, as compared to all other alternatives in the choice set. However, the farmer's decisions to choose a given alternative technology from the available choices is influenced by many and varied factors that are observable and non-observable.

The study conceptualized that farmer's decision to adopt improved wheat varieties and fertilizer use as being dependent on farmer's perception of technology-specific attributes. This is based on evidence from empirical works (Sall, *et al.* (2000), Makhoha, *et al.* (1999), Adesina and Baidu-forson (1995) and Adesina and Zinnah (1993)) that have shown farmer's perception of technology-specific attributes do significantly impact on farmer's adoption and intensity of use decisions. However, farmers view agricultural technologies as a complex embodiment of several attributes that interact to influence their subjective preference and therefore, no single technology-specific attribute can be used to cover the dimensions of farmer's perception of technology-specific attributes. However, farmer's perception (sum total of scores of farmer's opinion on each of improved wheat varieties and fertilizer attribute) would be influenced by farmer's resource endowment (land size and number of livestock units), institutional factors (access to extension, access to credit, affiliation to an organization, distance to input markets and Agro-Ecological Zone) and farmer's characteristics (farming experiences, family size, level of education, gender, age and access to off-farm income), among others. When the farmer has perceived technology-specific attributes to be positive and is convinced of the need to use improved wheat varieties and fertilizer, he/she makes a decision to adopt them. The decision to adopt or not to adopt improved wheat varieties and fertilizer use is also dependant on farmer's demographic and human capital variables (gender, age, education, experience, family size and access to off-farm income), resource endowment variables (farm size and number of livestock units) and social and institutional variables (access to credit, contact with extension services, access to input markets, affiliation to an organization and Agro-Ecological Zone) as shown in Figure 1.

From Figure 1 the dependent variables are farmer's perception of improved wheat varieties- and fertilizer-specific attributes and decision to adopt improved wheat varieties and fertilizer and the independent variables are institutional factors, resource endowment and farmer characteristics. The figure also shows that, farmer's perception of improved wheat varieties- and fertilizer-specific attributes are independent variables on adoption of improved wheat varieties and fertilizer respectively. The arrows in Figure 1 represent a cause-effect relationship.

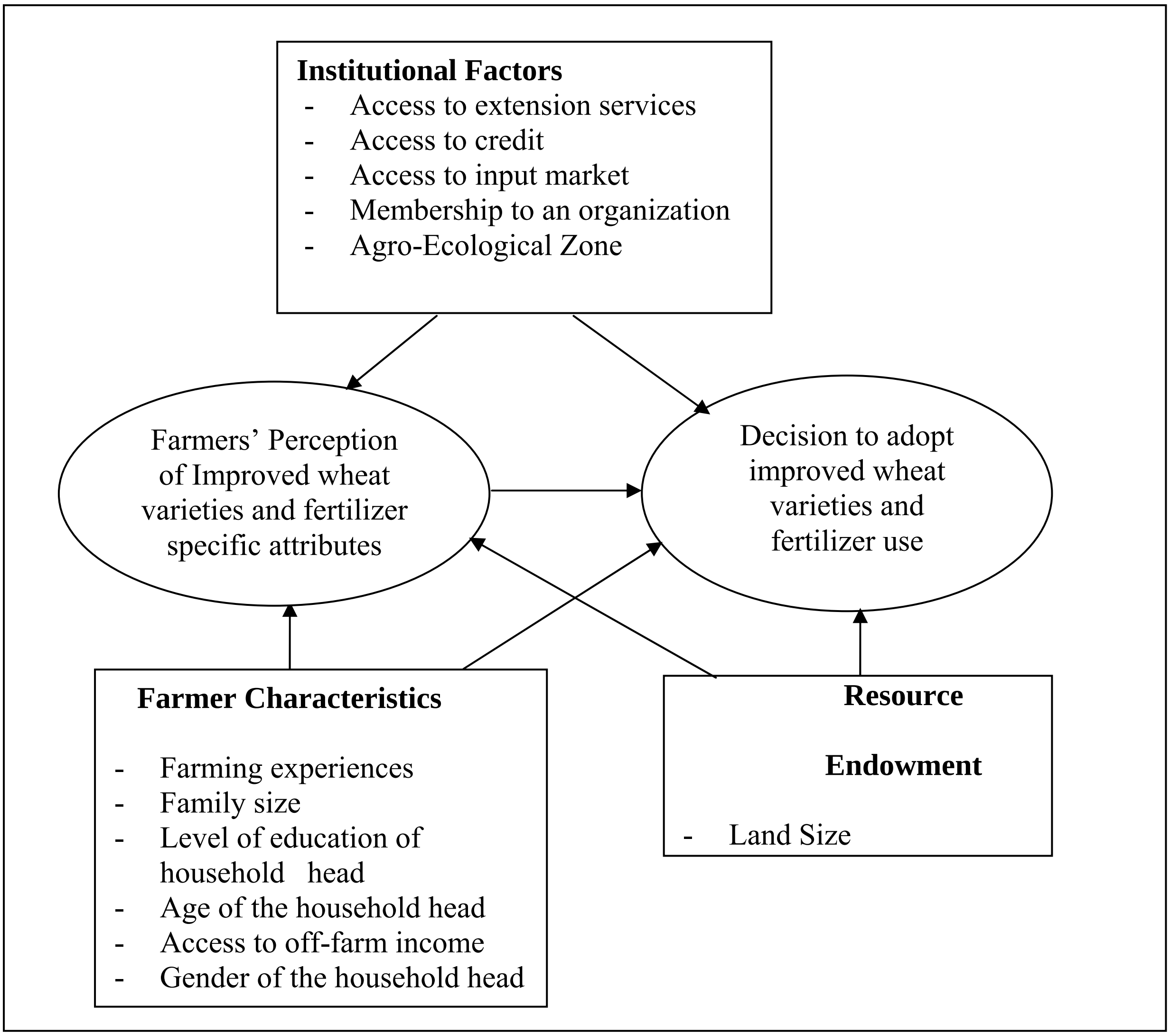

Figure 1: Improved Wheat Varieties and Fertilizer Use Adoption Model: A Framework.

Source: Author's Conceptual Framework

The inclusion of these variables was based on previous empirical work on adoption of agricultural technologies. Age was hypothesized to influence adoption decisions positively. Age could be an indication that older farmers have more resources compared to young farmers since they have worked for long and have accumulated enough resources. Therefore, older farmers could have more access and ability to purchase agricultural technologies and are more likely to adopt agricultural technologies. High resource base for older farmers would make them less risk averse as they have the capacity to cope with risk associated with use of technology. Studies by Wanyoike, *et al.* (2000) and Adesina and Zinnah (1993) have shown that age influences adoption decision positively. On the other hand, younger farmers may have a long planning horizon and/or may have more education compared to older farmers. In this case young farmers would have a higher probability of adopting improved agricultural technologies compared to old farmers. Therefore, age would influence adoption decisions negatively.

Farmers' education level was hypothesized to influence adoption decisions positively. Education is expected to increases the speed with which new skills and techniques can be learned and adopted (Oluoch-Kosura, *et al.,* 2001). This is because education enables farmers to decode technical information on new technology and it also enables farmers to source information about agricultural technologies from as many information pathways as possible. Therefore, better educated farmers are more likely to acquire, interpret and use technical advice from extension contact, research and other informants, allowing them to assess the relative benefits and risks from using alternative technologies (Nkonya, *et al.,* 1997).

Farmer's experience in farming was hypothesized to influence adoption decision positively. Experienced farmers are expected to have better technical knowledge, are able to assess the risks associated with use of new technology and are more likely to be getting highest possible returns from investments in new technology. Furthermore, farming experience implied that knowledge gained over time from working in uncertain production environment may help in evaluating information on agricultural technologies thereby, influencing their adoption decisions. Farmers in such situations continuously experiment and where results are promising if possible adopt the technology or if otherwise reject it (Sall, *et al.,* 2000).

Family size was hypothesized to influence adoption decisions positively. Larger household size may have more subsistence needs compared to smaller households. Therefore, larger households are expected to undertake intensification on crop and livestock production to mitigate food security in a land scarce situation, hence high probability of adopting new technologies. A study by Judicate, *et al.* (1998) found family size to influence adoption decisions positively. On the other hand large families have an effect on the household disposable income and resource allocation behaviour. Large families may have more subsistence needs leaving very few resources for purchasing external inputs like improved wheat varieties and fertilizer. Therefore, households with large families would be less likely to adopt agricultural technologies. This implies that, family size will influence adoption decision negatively. A study by Gamba, *et al.* (1998) found family size to influence adoption of improved wheat varieties negatively.

Farm size was hypothesized to influence adoption decisions positively. Land size determines the number of auxiliary enterprises to be undertaken by the farmers and this may influence farmers' adoption behavior. Large farm operators are also more likely to have more opportunities to learn about new technologies by first experimenting with innovations to see their result before adopting on large-scale. Or farmers with large landholding (proxy for wealth) could also be less risk averse as they have the capacity to cope with risks associated with new technologies. Studies by Gamba, *et al.* (1998), Tirunel, *et al.* (1998), Judicate, *et al.* (1998) among others, have found farm size to influence adoptions positively.

Access to off-farm income was hypothesized to influence adoption decisions positively. Household exogenous income plays an important role on adoption and intensity of use decisions. Access to off-farm income is expected to ease liquidity constraint at farm level thus, enabling farmers to access and purchase external inputs like improved wheat varieties and fertilizers. Mose (1999) and Ersado, *et al*. (2003) among other studies have found access to off-farm income to influence adoption of productivity and land-enhancing technologies positively. However, access to of-farm income may reduce household's subsistence needs, thus reducing the need for the household to rely on own-production for consumption. In this case households with access to off-farm income would be less likely to adopt agricultural technologies. Therefore, access to of-farm income would influence adoption decisions negatively.

Number of livestock units was hypothesized to influence adoption decisions positively. Livestock a proxy for wealth is expected to enable farmers to access and purchase agricultural technologies. Farmers with high livestock units are also expected to be less risk averse as they have the capacity to cope with risks associated with the use of a technology. Some crop residues are used as feeds for animals and farmers also use livestock manure for soil management, this make crop and livestock production to be complementary enterprises. Therefore, farmers who have more number of livestock units are more likely to adopt (Judicate, *et al.,* 1998 and Salasya, *et al.,* 1997). However, if high livestock units indicate specialization into livestock production, away from cropping, the economic significance of adopting yield–enhancing technologies like improved wheat varieties and fertilizer use may be lowered. Therefore, farmers with high livestock units would be less likely to adopt agricultural technologies and this would lead livestock units to influence adoption decisions negatively.

Farmer's affiliation to an organization was hypothesized to influence adoption decisions positively. Farmer's affiliation to an organization is regarded as a social capital as it enables farmers to source and access credit facilities. This enables farmers affiliated to an organization to access and purchase external inputs like improved wheat varieties and fertilizer. Farmer's affiliation to an organization is also an indication of the farmer's level of networks and contact with organized groups and informal groups. It provides an opportunity for the farmer to learn about agricultural technologies, a forum to share experiences and exchange opinions about agricultural technologies with other farmers. This enables farmers affiliated to an organization to be in a better position to assess and understand the risks associated with the use of an innovation thus high probability of adopting. A study by Sall, *et al.* (2000) found farmer's affiliation to an organization to influence adoption decisions positively.

Agro-ecological Zone accounts for difference in rainfall, soil types and altitude which are site specific. Agro-ecological zone in terms of the farmer being in high potential or marginal area was hypothesized to influence adoption decisions. The coefficient on the dummy for a farmer being in high potential area was expected to influence adoption decisions positively. Agro-Ecological Zones are expected to influence productivity of a technology, therefore, where there is low production risks like Njoro (high potential areas) then the probability of adopting new technology would be higher and agricultural commercialization is possible. This implies that there are higher incentives to agricultural technologies in high potential areas compared to marginal areas (Salasya, *et al.,* 1997). Therefore, the coefficient on dummy for a farmer being in Njoro division was expected to be positive. Therefore, Njoro farmers are expected to have higher probability of adopting improved wheat varieties and fertilizer use compared to Kieni West farmers.

Distance to input markets were hypothesized to influence adoption of improved wheat varieties and fertilizer use negatively. It is expected that as distance to input markets increases transaction and information costs also increases, thus, reducing the likelihood of adoption (Ersado, *et al.,* 2003 and Lucila, *et al.,* 1999). Distance to input markets may provide the farmers with access to income-earning activities, which may reduce liquidity constraint on farm-level. This would enable farmers to access and purchase external inputs like improved wheat varieties and fertilizer. In this case distance to input markets would influence adoption decisions positively.

Gender of the household head was hypothesized to influence adoption decisions. The coefficient on the dummy for a farmer being a male household head was expected to be positive. This implies that male household heads are expected to have a high probability of adopting agricultural technologies compared to female household heads perhaps resulting from the role of male and female farmers at farm level. Male farmers are primarily the decision makers and as such control most resources at farm level, leaving female farmers to take a supportive and implementing role.

Access to extension services was hypothesized to influence adoption decisions positively. It is expected that households that have access to extension services are more likely to adopt agricultural technologies compared to households that have no access to extension services. This is because extension services are the means through which agricultural technologies are transferred from researchers to farmers. Therefore, access to extension services facilitates the up-take of technology. Studies by Adesina and Zinnah (1993), Nkonya, *et al.* (1997), Judicate, *et al.* (1998), Wanyoike, *et al.* (2000) and Sall, *et al*. (2000) among others have shown access to extension services to be a very important factor in adoption decisions.

Access to credit was hypothesized to influence adoption decisions positively. Credit availability is an important factor in adoption of agricultural technologies. Access to credit by the farmers is expected to ease liquidity constraint and enable them to finance/purchase external inputs such as improved wheat varieties and fertilizer. Credit availability for wheat farming is important given that wheat production technologies are very expensive. Therefore, to be effective in wheat production, high use of fertilizer and improved seed and proper management is desirable.

3.2 Study Area

The study covered two divisions in the republic of Kenya namely, Njoro division of Nakuru district in the Rift valley province and Kieni West of Nyeri district in Central

Province (Figure 2). The choice of Njoro division was based on a number of factors. First, Njoro division is one of the traditional and major wheat growing areas. Secondly, it hosts the National Plant Breeding Research Centre, KARI-Njoro that has the national mandate to develop and disseminate wheat production technologies. It is expected that farmers near the centre would have more access to information on wheat production technologies. Thirdly, majority of wheat farmers are smallholder. The choice of Kieni West division was based on the fact that most wheat is produced on small-scale due to small size and is a low potential area with annual rainfall of about 500mm.The choice of wheat crop as subject of study in Kieni West was based on the fact that wheat is more tolerant to drought and frost compared to other crops thus, many farmers have gone into growing it. Therefore, Njoro division represented high potential while Kieni West division represented the low potential area.

Nakuru district has a bimodal rainfall with long rains occurring in March-August and short rains occurring in October –December. Annual rainfall varies from 760mm in the floor of Rift Valley to 1270mm in high altitude areas where Njoro division falls (Jaetzold and Schmidt (1983). Nakuru district has a high agricultural potential. The main economic activities in the district are crop and livestock production. The main crops grown include pyrethrum, wheat, barley, maize, Irish potatoes, beans, coffee (in Bahati), millet, sorghum, sunflower, pigeon peas and horticultural crops. Livestock kept in the district include, dairy and beef cattle, goats, sheep, pigs and poultry. Much of Nakuru district was part of former white highlands. With the purchase of land from the settlers by various land buying companies, the white highlands were subdivided into small land holding leading to the emergence of smallholder sub-sector. This has influenced the production of both crops and livestock. Most of food crop production (maize, beans, wheat, potatoes, and various fruits and vegetables) and livestock production activities take place on smallholder farms (0.5-5ha). However, there are few medium and large-scale farmers growing wheat, barley, and to a lesser extent maize. Dairy and ranching is also practiced on large-scale farms. Njoro division falls in Zone II, which covers areas between 1800m-2400m above sea level (a.s.l) and receives 760mm-1270mm of rain annually. Figure 2 shows the position of Njoro division in Nakuru district.

Nyeri district experiences equatorial type of climate with two rain seasons. The long rains occur from March to May and the short rains from October to December. Annual rainfall varies from 500mm in the Kieni Plateau to 1500mm on the foothills of the Aberdares and Mt.

Kenya. The contrast in rainfall reliability is quite high, from 600mm–1500mm in the short rains and 1200mm – 1600mm in the long rains. The major reason is the rain shadow effects of these two mountains. Kieni West fall under Kieni Plateau where the average annual rainfall is as little as 500mm. Figure 2 shows the position of Kieni West division in Nyeri district. Main economic activities in the district are crop and livestock production. Crop production includes food, cash and horticultural crops. Food crops grown are maize, beans, Irish potatoes and wheat. Cash crops include coffee, tea and pyrethrum. Horticultural farming is also an important activity especially a long the river valleys in the district. Horticultural crops include cabbages, onions, Kales and tomatoes. Macadamia growing has gained popularity lately. However, the district is a net importer of food (maize, beans and Irish potatoes) since cash crops takes 65 percent of land. The types of livestock kept include dairy and beef cattle, sheep, goats, pigs and poultry. Average farm size is 0.78 ha per household in high potential area and 0.88 ha per in low potential areas.

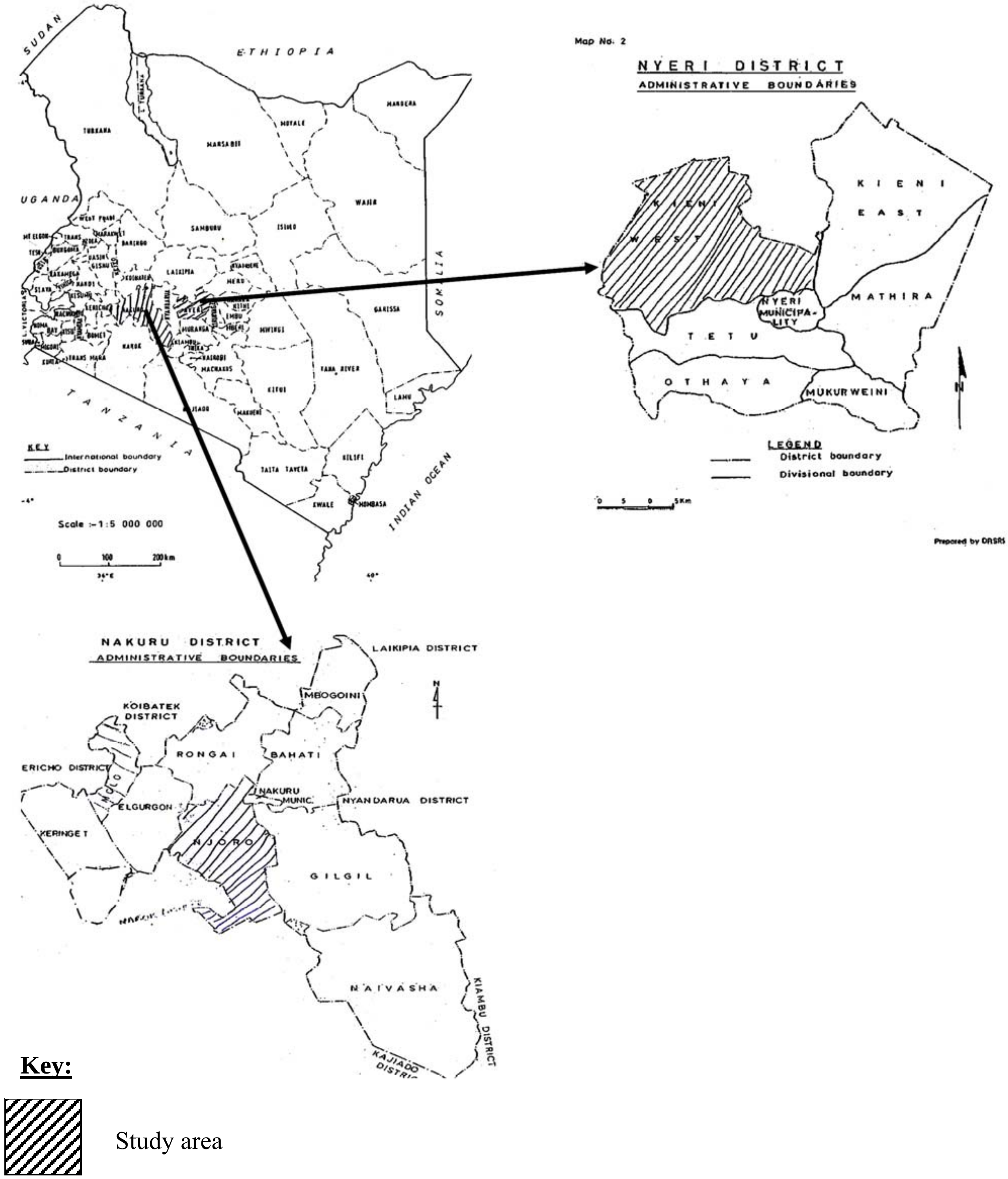

Figure 3: Map showing Position of Study Areas

Source: GoK 1997 b & c

3.3 Research Design and Instrument of Data Collection

A household survey was conducted and the instrument for data collection was a structured questionnaire (Appendix 1), which was pre-tested. Twenty (20) farmers from Rongai division of Nakuru district were used to pre-test the questionnaire. Rongai division was chosen in pre-testing the questionnaire because it has almost the same climatic conditions as Njoro division. Small-scale wheat producers dominate it and the two are neighbouring divisions.

3.4 Sampling Unit

The sampling unit of the study was the household and characteristic of the sampling unit was small-scale wheat farmers.

3.5 Sample Size and Sampling Procedure

Determination of sample size was done by estimating proportions of the population. That is determining the proportions of the population using and not using improved wheat production technologies. According to Kothari (2004) desired sample size is determined by the following formula.

$$n = \frac{z^2.p.q.N}{(N-1)(e)^2 + (z)^2.p.q} \quad \text{.......} \quad (1)$$

where; n = sample size, z = confidence level, p = proportion of the population, q = 1- p ,

e is the allowable error and N is the population size.

Since no prior research had been carried out in the area of study the proportions of population using improved wheat production technologies were not known. Even if a prior research had been carried out, such proportions could not have been relied on as farming is dynamic and such proportions could have changed due to farmers moving in and out of wheat farming. For the unknown population proportions, Kothari (2004) recommends p to take the value of 0.5 in which case 'n' will be the maximum and the sample will yield at least the desired precision. Therefore, $q = 1-0.5 = 0.5$, N =1547 and N -1= 1546, z = 2.576 at 99% confidence level and e = 10%.

Therefore, $n = \frac{(2.576)^2(0.5)(0.5).1547}{(0.1)^2(1546)+(2.576)^2(0.5)(0.5)} = \frac{2566.473}{15.46+1.659}$ = 149.914 which is about 150.0. Therefore, a sample of 150 farmers was required for the study.

Multistage sampling procedure combining both purposive and simple random sampling was used to identity farmers to include in the sample. First Nakuru and Nyeri districts were purposively selected. One division from each district was purposively selected. These were Kieni West division in Nyeri district and Njoro division in Nakuru district.

A list of all the small-scale wheat farmers was compiled with the assistance of Divisional Agricultural Officers in their respective divisions. The lists of farmers compiled formed the population (sampling frame) for each division. The sampling frame for Njoro division contained 384 households while that of Kieni West division contained 1163 Households. Then sampling of individual household was done in the divisional office by the researcher. Using a table of random numbers, a sample of 75 households was selected from the list of wheat farmers for each division.

3.6 Weighting of Means and Coefficients

The above sampling was not proportional to size. Consequently, one household in Njoro division represented less households compared to one household in Kieni West division. Thus, the households in Njoro division were overrepresented while, households in Kieni West division were underrepresented making the sample not be self-weighting. Therefore, estimating population parameters from such a sample would yield biased and inconsistent parameters.

To use such a sample to estimate population parameters, Deaton (1998) recommends the weighting of the sample data to ensure that each group of the households is properly represented. This would make sample parameters to be unbiased estimators of population parameters. The rule is to weight according to the reciprocal of sampling probabilities because households with low (high) probabilities of selection stand a proxy for large (small) number of households in the population. The weights are often referred to as 'raising' or 'inflation' factors. According to Deaton (1998) the probability of a household to be selected in a sample is calculated by dividing the required sample size by the sampling frame and is given by $n/_N$ and its reciprocal is given by $^N/_{n,}$ where n is the required sample size and N is the sampling frame. From this formula the probability of sampling a household in Njoro division where, n= 75 and N=384 is 75/384 = 0.20 and its reciprocal is 384/75 = 5.12. For Kieni West division the probability of sampling a household where, n=75 and N=1163 is $^n/_N = {}^{75}/_{1163}$ = 0.06 and its reciprocal is $^{1163}/_{75}$ = 15.51. Consequently, 5.12 and 15.51 are the inflation factors for Njoro and Kieni West divisions respectively. Thus, all the sample means and regression coefficients were weighted, so as to obtain unbiased and consistent estimators. Deaton (1998) gave the formula for estimating weighted means as:

$$X = \sum_{S=!}^{2} (N_S / N) X_s \text{ ...(2)}$$

where, X_S is the estimated mean for each division, N_S is the population of each division and N is the total population (combined for both division), which is 1547. s=1 and 2 since we have only two divisions. Including the inflation factors as part of the data did weighting of the coefficients.

Because the sampling of each division was independent, the variance of the estimate of population mean is as given below;

$$V(X) = \sum_{S=1}^{2} (N_S / N)^2 V(X_S) \text{ ... (3)}$$

where, $V(X_S)$ is the variance of the estimate of the division mean, $V(X)$ is variance of the estimated population means. N_S and N are as defined above.

3.7 Nature of the Data

Both primary and secondary data were used in this study. Secondary data was obtained by reviewing a number of relevant documents with a view to gathering information about the current wheat situation, wheat production technologies and adoption of agricultural innovations. These documents were obtained from institutional libraries and other sources. However, primary data was the core of the study.

3.8 Data Collection

A structured questionnaire was administered to 150 households selected randomly. Single visits personal interviews were conducted. Where the head of the household was found to be absent, the most responsible member of the household found in the homestead was interviewed on behalf of the household head. This person was mostly the household head‘s spouse. Where no responsible member of the household was found a second visit was made. Other members of the household were encouraged to participate where household head was required to recall some information. Face-to-face personal interview was used.

3.9 Test of Data Reliability

Reliability of the sample data was done by estimating a reliability coefficient according to Daniel, *et al.* (1995) as follows:

$t = \mu / (\sigma / \sqrt{\eta - 1})$……………………………………………………………………….(4)

where, μ = Sample mean, σ = sample std deviation, η = sample size and η-1 =149 is the degrees of freedom. Using the formula above to compute the students' t-statistics data reliability coefficient of this study is 183.22/ (46.69/√149) = 47.96. The value is greater than critical t-value of 2.576 at 99 percent, showing that the level of sample reliability is over 99 percent with degrees of freedom 149. The use of the sample means and standard deviations is due to the fact the population means and variance are not known.

3.10 Data Analysis and Procedure

The questionnaires were checked for clarity and consistency in answering questions. This was followed by coding of answers and data entry into the computer for analysis. Management and analysis of the data was done using Statistical Package for Social Scientists (SPSS) and Limited Dependent (LIMDEP) computer package respectively. Analyses done include; mean and standard deviation for continuous variables and percentages for categorical variables.

Independent two-sample *t*-tests were used to determine whether continuous variables on farm and farmer characteristics of adopters and non-adopters of improved wheat varieties and fertilizer use were homogenous or varied. It was also used determine whether continuous variable on farm and farmer characteristics of Njoro and Keini West farmers were homogenous or varied.

Chi-square was used to determine whether categorical variable on farm and farmer characteristics among the adopters and non-adopters were homogenous or varied. It was also used to determine whether categorical variable on farm and farmer characteristics among the Njoro and Kieni West Farmers were homogenous or varied.

Wilcoxon Rank-Sum test (W) was used to determine whether sum of ranks of farmer's perception of technology-specific attributes among adopters and non-adopters of improved wheat varieties and fertilizer use were equal or different. It was also used to determine whether the sum of ranks of farmer's perception of technology-specific attributes among Njoro and Kieni West farmers were equal or different and Pearson Product Moment Correlation (r) was used to test the independent variables for multicollinearity before entering them in the models.

Kendall's Coefficient of Concordance (W) was used to establish the correlation between socioeconomic factors and farmer's perception of technology-specific attributes. Tobit model was used to determine socioeconomic factors influencing adoption and intensity of use of improved wheat varieties and fertilizer use. Spearman's Coefficient of Rank Correlation (r_s) was used to determine the relationship between farmer's perception of technology-specific attributes and adoption and intensity of improved wheat varieties and fertilizer use.

3.10.1 Estimation of Correlation between Socioeconomic Factors and Farmer's Perception of Technology-Specific Attributes

Since farmers view agricultural technologies as a complex of embodiment of several attributes, no single technology-specific attribute can cover the dimension of farmer's perception of technology- specific attributes. Technology-specific attributes that were used in the current study were relative advantage, compartibility, triability, complexity and observability. The choice of these attributes was based on the fact that, they can be used to describe any agricultural technology as opposed to those technology-specific attributes that are very specific. For instance, taste, cooking quality, among others, which are only applicable to technologies whose end output, is directly consumable. Farmer's perception of technology-specific attributes were measured by asking a farmer to express his/her opinion as either strongly agree, agree, uncertain, disagree and strongly disagree on perception statements presented to the farmer. Using summated scale (Likert-type scale) each opinion was given a scale. Such that strongly agree took a scale of 5, agree a scale of 4, uncertain a scale of 3, disagree a scale of 2 and strongly disagree a scale of 1. The opinion of the farmer on each technology attribute is mutually exclusive while the technology attributes are not mutually exclusive. Then all the scores of farmer's opinion on each technology-specific attributes were summed up to give an index of farmer's perception of technology-specific attributes of that particular technology. The following perception indexes were revealed.

5*5=25 was the most favourable perception index

5*3=15 was a neutral perception index

5*1= 5 was the most unfavourable perception index attitude.

Therefore, farmer's perception of improved wheat varieties- or fertilizer-specific attributes index would fall between 5 and 25. If the perception index is above 15, it shows favourable perception to improved wheat varieties or fertilizer specific attributes. If it falls below 15 it shows unfavourable perception of improved wheat varieties or fertilizer specific attributes.

Since farmer's perception of technology-specific attributes index was of ordinal-level measurement, Multiple Linear Regression model was not the best model to estimate socioeconomic factors influencing farmer's perception of technology-specific attributes. Multiple Linear Regression model makes use of interval- and ratio-data levels and requires normality assumptions (Mukras, 1993). Therefore, only the degree of association between socioeconomic characteristics and farmer's perception of technology-specific attributes was studied and Kendall's Coefficient of Concordance analysis was used. The choice of Kendall's Coefficient of Concordance (W) was based on the fact that, it is an appropriate measure of studying the degree of association among three or more sets of ranking (Kothari, 2004).

Various socioeconomic factors were hypothesized to correlate with farmer's perception of improved wheat varieties- and fertilizer-specific attributes. This was in line with the first and second objectives of the study. To fully achieve the objective, two Kendall's Coefficient of Concordance analyses were carried out. The first analysis was to test the following null (H_0) and alternative (H_1) hypotheses which were stated as follows:

Ho: Socioeconomic factors have no significant correlation with farmer's perception of improved wheat varieties-specific attributes.

H_1: Socioeconomic factors have significant correlation with farmer's perception of improved wheat varieties-specific attributes.

The second analysis was to test the following null (H_0) and alternative (H_1) hypotheses which were stated as follows:

Ho: Socioeconomic factors have no significant correlation with farmer's perception of fertilizer-specific attributes.

H_1: Socioeconomic factors have significant correlation with farmer's perception of fertilizer-Specific attributes.

The hypotheses were tested at $P<0.05$ probability level and the significance of W was determined by calculating χ^2. The use of χ^2 to test significance of W was based on the fact that the number of rankings to be considered was more than 7. Kothari (2004) recommends the use of χ^2 for number of rankings greater than seven. The formula for calculating χ^2 was $\chi^2 = k(N-1)W$ with N-1 degrees of freedom, where, N is number of objects ranked, k is number of sets of rankings. The null hypotheses (Ho) were rejected if the calculated χ^2 was more than the critical (table) value and the alternative hypotheses was accepted at $P<0.05$ with N-1 degrees of freedom

3.10.2 Estimation of Socioeconomic Factors Influencing Adoption and Intensity of Technology Use

Various socioeconomic factors were hypothesized to influence adoption and intensity of use of improved wheat varieties and fertilizer. This was in line with the third and fourth objectives of the study. To fully achieve the objectives, two Tobit models were run. The first model was used to test the following null (H_0) and alternative (H_1) hypotheses which were stated as follows:

Ho: Socioeconomic factors have no significant effect on adoption and intensity of use of improved wheat varieties.

H_1: Socioeconomic factors have significant effect on adoption and intensity of use of improved wheat varieties.

The second analysis was to test the following null (H_0) and alternative (H_1) hypotheses which were stated as follows:

Ho: Socioeconomic factors have no significant effect on adoption and intensity of fertilizer use.

H_1: Socioeconomic factors have significant effect on adoption and intensity of fertilizer use.

The null hypotheses were accepted if β's (coefficients of the models) were less or equal to zero and rejected if β's (coefficients of the models) were significantly different from zero.

Adoption and adoption intensity was estimated using Tobit model. The Tobit model assumes a normal distribution with zero mean and constant variance. The model was specified as;

$$Y_i = \beta_o + \beta_I HH_{Age} + \beta_2 HH_{Educ} + \beta_3 EX_{Cont} + \beta_4 HH_{Size} + \beta_5 HH_{Exper} + \beta_6 HH_{Credit} + \beta_7 HH_{Organ} + \beta_8 FA_{Size} + \beta_9 HH_{Off\text{-}farm} + \beta_{10} TL_{Units} + \beta_{11} HH_{Male} + \beta_{12} HH_{Mktinput} + \beta_{13} HH_{Nakuru} + \nu_i \qquad (5)$$

where, Y_i (dependent variable) is probability of adopting (and intensity of use of) improved wheat varieties or fertilizer use and its either amount of improved wheat varieties (AMT_{Seed}) or amount of fertilizer used (AMT_{Fert}), β's are parameters of the model, and HH_{age}, HH_{educ},…….......HH_{Nakuru} are the explanatory variables as explained in Table 1.

ν_i is an error term

The choice of the model was based on the fact that Tobit model measures not only the probability that a farmer will adopt a given technology but also measures the intensity of use of that particular technology, once adopted (Maddala, 1983 and Maddala, 1992). Hence equation (5) is simultaneous and stochastic decision model. From a theoretical point of view, the application of Tobit model is also preferred because it uses data both at the limit (here the limit is zero for non-adopters) as well as those above the limit (here above the limit is more than zero for adopters) to estimate regressions (McDonald and Moffit, 1980). In the current study there is a group of households with zero adoption of improved wheat varieties and fertilizer, which is at the limit and the dependent variables specified in the model (amount of improved wheat varieties and fertilizer used by the farmer) were derived from field measurements. Therefore, a direct application of Tobit estimation sufficiently provides the needed information on adoption probability and intensity of use of improved wheat varieties and fertilizer.

Table 1. Definition of Variables Used in the Empirical Models.

Variable	Description	units	Priori Assumption
AMT_{Seed}	Dependent variable	Kg/acre	
AMT_{Fert}	Dependent variable	Kg/acre	
HH_{Age}	Age of the household head	Years	+ or-
HH_{Educ}	Number of years household head had in formal education	Years	+
EX_{Cont}	Whether household head had access to extension services	1 for Yes 0 for No	+
FA_{Size}	Farm size	Acres	+
HH_{Exper}	Household head's Years in wheat farming	Years	+
HH_{Credit}	Whether household head had obtained credit in 2004 cropping season	1 for Yes 0 for No	+
HH_{Organ}	Whether household head was affiliated to any organization	1 for Yes 0 for No	+ or-
HH_{Size}	Family size (Number of people living with household head as family i.e. own children + other dependants)	Number	+or -
$HH_{Off\text{-}farm}$	Whether household head had access to Off-Farm income	1 for Yes 0 for No	+ or-
TL_{Units}	Number of livestock units owned	Number	+
HH_{male}	Dummy for sex of household head	1 for male 0 for Female	+
$HH_{Mktinput}$	Distance to inputs markets and it Is either distance traveled to get Seeds (MKT_{Seed}) or Fertilizer (MKT_{Fert})	1 same village 2 < 5 km 3 5-10 km 4 >10 km	-
HH_{Nakuru}	Dummy for Agro-Ecological Zone	1 for Njoro division 0 for Kieni West division	+
$FP_{TchnSeed}$	Farmer's Perception of improved Wheat Varieties Specific attributes	Index	Favourable
$FP_{Tchnfert}$	Farmer's Perception of Fertilizer Specific Attributes Index	Index	Favourable

The coefficients in the Tobit model can further be decomposed to determine the effect of changes in probability of adopting improved wheat varieties or fertilizer use. Following McDonald and Moffit (1980) it can be shown that;

$$E(y) = X_i\beta F(z) + \sigma f(z) \qquad (6)$$

where, $z = X_i\beta/\sigma$, $f(z)$ is unit normal density and $F(z)$ is cumulative normal distribution function at z. Furthermore, the expected value for y for those farmers who have already made the adoption decision here denoted by y^* is simply $X_i\beta$ plus the expected value of the truncated error term. Therefore,

$$E(y^*) = X_i\beta + \sigma f(z)/F(z) \qquad (7)$$

Consequently the basic relationship between the expected value for all observations, E(y), the expected value for those farmers who have already made the adoption decision, $E(y^*)$, and probability of a farmer being an adopter is;

$$E(y_i) = F(z)\, E(y_i^*) \qquad (8)$$

Differentiating with any element of X gives:

$$\partial E(Y_i)/\partial X_i = F(z)\{\partial E(y_i^*)/\partial(X_i) + E(y_i^*)\{\partial F(z)/\partial X_i\} \qquad (9)$$

Change in Y_i has two effects (i) Change in probability of adoption of the technology and (ii) Change in intensity of use of the technology.

Since the model estimates β and σ, each of the terms in equation (9) can be calculated at some value of $X_i\beta$ usually at the mean of Xs. The value of $E(y^*)$ can be calculated from equation (7), and the value of F(z) can be obtained from the statistical tables. The two derivatives are also calculable:

$$\partial F(z)/\partial X_i = f(z)\beta i/\sigma \qquad (10)$$

and, from (8),

$\partial Ey^*/\partial X_i = \beta_i[1 - zf(z)/F(z) - f(z)^2/F(z)^2]$……………………………………………...(11)

using F'(z) =f(z) and $f'(z) = -zf(z)$ for unit normal density.

3.10.3 Estimation of Correlation between Farmer's Perception of Technology-specific Attributes and Adoption and Intensity of Technology Use

Farmer's perception of technology-specific attributes was hypothesized to correlate with adoption and intensity of use of improved wheat varieties- and fertilizer-specific attributes. This was in line with the fifth and sixth objectives. To fully achieve the objectives, two Rank-Order Correlation (r_s) analyses were carried out. The choice of the Rank-Order-Correlation was based on the fact that, farmer's perception of technology-specific attributes was of ordinal-data level and does not require the normality assumptions. It also requires two sets of ranking (Mason and Lind, 1996). The first analysis was to test the following null (H_0) and alternative (H_1) hypotheses which were stated as follows:

Ho: Farmers' perception of improved wheat varieties-specific attributes has no significant correlation with adoption and intensity of use of improved wheat varieties.

H_1: Farmer's perception of improved wheat varieties-specific attributes has a significant correlation with adoption and intensity of use of improved wheat varieties.

The second analysis was to test the following null (H_0) and alternative (H_1) hypotheses which were stated as follows:

Ho: Farmer's perception of fertilizer-specific attributes has no significant correlation with adoption and intensity of fertilizer use

H_1: Farmer's perception of fertilizer-specific attributes has a significant correlation with adoption and intensity of fertilizer use

The hypotheses were tested by finding whether the calculated r_s lies within or outside the acceptance region of the area under the normal curve. The hypotheses were tested at $P<0.05$ and the null hypotheses were rejected if the calculated r_s were found to be outside the acceptance region of the area under the normal curve. The null hypotheses were accepted if the calculated r_s was found to be within the acceptance region of the area under the normal curve. The use of area under the normal curve was due to the fact that the sample size was more than 30. According to Kothari (2004) a sample consisting of more than 30 items, the sampling distribution of r_s is approximately normal with a mean zero and a standard of $1/\sqrt{n-1}$ and thus, the standard error of r is: $\sigma_r = 1/\sqrt{n-1}$. Then the table of area under normal curve is used to determine the significance of r_s for testing hypotheses about the population rank correlation.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

This chapter covers results and discussions of the survey. The results were descriptive and inferential

4.1 Descriptive Results

4.1.1 Socioeconomic Characteristics of the Households

The socioeconomic characteristics of the households are summarized in Table 2a and b. It was found necessary to separate the continuous and categorical variables for clarity's sake. Continuous socioeconomic characteristics of the households are presented in Table 2a. Table 2a show that the differences in mean age, family size, farm size and experience in wheat farming between Njoro and Kieni West households were insignificant. The overall mean number of years the household head had in formal education was 8.11 years. This is an indication that, majority of the farmers had primary education since; duration of primary school is 7 or 8 years. Thus, majority of the household heads were considered literate and therefore, could access written agricultural information through print media. The mean number of years the household head had in formal education was more for Kieni West household heads (8.45 years) than for Njoro household heads (7.07 years) and the difference was significant at $P<0.05$ probability level. Therefore, likelihood of technology uptake would be higher for Kieni West farmers.

The overall mean total number of livestock units owned by the household head was 4.91 units and the majority of the farmers owned crossbreed cattle, goats and sheep-a picture typical of smallholder mixed farming. The mean total number of livestock units owned by the household heads was more in Kieni West division (5.35 units) than in Njoro division (3.59 units) and the difference was significant at $P<0.05$ probability level. These results could be explained from the point of the view that, Nyeri household heads had more land hence, more pasture that could accommodate more livestock units.

Table 2a. Continuous Socioeconomic Characteristics of the Farmers in Njoro and Kieni West, Divisions

Characteristics	Njoro Division (N=75)	Kieni West Division (N=75)	Overall (N=150)		Unweigh-ed t-ratios	Weight-ed t-ratios
	Mean	Mean	Unweight-ed Mean	Weight ed Mean		
Age	51.01 (12.45)	50.67 (11.87)	50.84 (12.64)	50.75 (9.45)	0.167	0.223
Family Size	9.19 (3.92)	8.49 (3.67)	8.84 (3.80)	8.67 (2.93)	1.142	1.482
Education Level	7.07 (4.51)	8.45 (3.58)	7.76 (4.11)	8.11 (2.92)	-2.087	-2.921**
Farm size	9.75 (6.78)	12.68 (18.51)	11.21 (13.97)	11.95 (14.02)	-1.300	-1.297
Farmer's Experience	6.64 (5.89)	8.50 (8.76)	7.57 (7.49)	8.04 (6.75)	-1.540	-1.710
Distance to Seed market	4.95 (1.31)	4.05 (3.44)	4.50 (2.60)	4.28 (2.64)	2.147	2.113**
Distance to Fertilizer market	11.20 (0.84)	9.95 (1.07)	10.55 (0.97)	10.26 (0.83)	7.992	9.326***
Total no. of Livestock Units	3.59 (2.99)	5.35 (5.53)	4.47 (4.52)	4.91 (4.22)	-2.574	-2.585**

Note: *** Significant at P<0.01 and ** Significant at P<0.05 probability level

Figures in parentheses are the standard deviation

Number of Livestock Units was calculated from Appendix 2

Source: Field Survey Data

The overall mean distance traveled by the household heads to get seeds was 4.28 km. The mean distance traveled by the household head to seed markets was longer in Njoro division (4.95 Km) than in Kieni West division (4.05 Km) and the difference was significant at P<0.05 probability level. The overall mean distance traveled by the household head to fertilizer markets was 10.26 Km. The mean distance traveled by the household head to fertilizer market was longer in Njoro division (11.20 Km) than in Kieni West (9.95 Km) and the difference were significant $P<0.05$ probability level. These results could mean that Njoro farmers find it cheaper to get inputs from major market centres, due to the fact that, village-level stockists could be selling inputs at high prices that can not be accounted for by the cost of transport or/and such stockists do not stock enough inputs to meet the farmers' demand. Or the transport system in Njoro division could be efficient and as such there are no much differences in terms of cost of the inputs from village-level stockist or from major centres.

Results of categorical socioeconomic characteristics of household heads are presented in Table 2b. Results indicate that the difference in percentage in terms of gender of household head, access to extension services, access to credit and access to off-farm income between Njoro and Kieni West households were insignificant.

Farmer's affiliation to an organization was reported by 64.0 percent of all the households interviewed. These could imply that household heads had good networks of information that could enable them to source for agricultural information from varied sources. Majority of Kieni West household heads (77.3 percent) were affiliated to organizations compared to Njoro household heads (50.7 percent) and the difference in terms of head's affiliation to an organization between Njoro and Kieni West divisions was significant at $P<0.01$ probability level. This could be explained by the fact that unlike Njoro division a number of farm produce cooperatives exist in Kieni West division, and most households are likely to members.

Table 2b. Categorical Socioeconomic Characteristics of the Farmers in Njoro and Kieni West, Divisions

Characteristics	Overall (N=150)	Njoro Division (N=75)	Kieni West Division (N=75)	χ^2
	Percentage of Farmers	Percentage of Farmers	Percentage of Farmers	
Dummy for household head's gender				
1 for Male	67.3	64.0	70.7	0.758
0 for Female	32.7	36.0	29.3	
Whether household head had Access to Extension				
Yes	49.3	45.3	53.3	0.960
No	50.7	54.7	46.7	
Whether household head had Access to Credit				
Yes	8.0	8.0	8.0	1.000
No	92.0	92.0	92.0	
Household head's affiliation to an Organization				
Yes	64.0	50.7	77.3	11.574***
No	36.0	49.3	22.7	
Whether household head had Access to Off-Farm Income				
Yes	51.3	61.3	41.3	0.111
No	48.7	38.7	58.7	

Note: *** Significant at P<0.01probability level

Source: Field Survey Data

4.1.2 Farmer's Perception of Improved Wheat Varieties- and Fertilizer-Specific Attributes.

Results of Wilcoxon Rank-Sum test (Z) of farmer's perception of improved wheat varieties- and fertilizer-specific attributes of the farmers in Njoro and Kieni West divsions are presented in Table 3. The results show that Njoro farmers had smaller sum of ranks of farmer's perception of improved wheat varieties-specific attributes (5362.50) compared to Kieni West farmers (5962.50) while Njoro farmers had a larger sum of ranks of farmer's perception of fertilizer-specific attributes (5898.50) compared to Kieni West farmers (5426.50). Large sum of ranks implies that distribution of higher ranks of farmer's perception of technology-specific attributes were more than the lower and medium ranks in one group therefore, large totals. Large sum of ranks is an indication of favourable farmer's perception of technology-specific attributes. Therefore, Kieni West farmers perceived improved wheat varieties-specific attributes favourably compared to Njoro farmers. While Njoro farmers perceived fertilizer-specific attributes more favourably compared to Kieni West farmers. The differences in sum of ranks of farmer's perception of improved wheat varieties- and fertilizer- specific attributes between household heads in Njoro and Kieni West divisions were not significant and therefore, the difference was due to sampling error.

Table 3. Results of Wilcoxon Rank-Sum Test (Z) of Farmer's Perception of Improved Wheat Varieties and Fertilizer-Specific Attributes in Njoro and Kieni West, Divisions

Farmer's perception	Njoro Division (N=75)		Kieni West Division (N=75)		Wilcoxon (W)	Z
	Mean Rank	Sum of Ranks	Mean Rank	Sum of Ranks		
$FP_{TchnSeed}$	71.50	5362.50	79.50	5962.50	5362	-1.142
$FP_{TchnFert}$	77.69	5898.50	73.31	5426.50	5889.50	0.631

Note: $FP_{TchnSeed}$ is farmer's perception of improved wheat varieties specific attributes

$FP_{TchnFert}$ is farmer's perception of fertilizer specific attributes

Source: Field Survey Data

4.1.3 Wheat Varieties Grown by Farmers

The study shows that farmers used 20 varieties of wheat. Farmers in Njoro division grew more wheat varieties (19 wheat varieties) compared to those in Kieni West division (9 wheat varieties). These results were unexpected as Njoro farmers being close to the NPBRC, KARI-Njoro were expected to be more focused in their choice of wheat varieties due to being able to access information on right wheat varieties for the area. Therefore, Njoro farmers were expected to grow fewer wheat varieties compared to Kieni West farmers. These results could be explained from the point of that Njoro division having been a wheat growing area for along time farmers have many distribution channels for wheat varieties compared to Kieni division. In fact most farmers in Njoro division indicated that they sourced their seeds from large -scale farmers who may be growing different varieties and even imported ones.

Table 4 shows the wheat varieties grown by the farmers. “Unknown” wheat varieties were grown by majority of the farmers (36.0 percent). The unknown wheat variety was not a particular wheat variety since, any wheat variety whose name the farmers did not know was classified as unknown. Therefore, “Unknown” wheat variety was a collection of varieties. This situation of farmers growing unknown wheat varieties could be an indication of lack of awareness/knowledge about the available wheat varieties, perhaps resulting from poor research-extension-farmer linkages and/or poor information delivery systems. More Kieni West farmers (53.3 percent) grew unknown wheat varieties compared to Njoro farmers (18.7 percent). The results could be an indication of difference in access to information about available wheat varieties between Njoro and Kieni West farmers due to Kieni West farmers being far from the Wheat Research Centre. Results could also be explained by the fact that majority of Kieni West farmers (46.7 percent) use own seeds as opposed to purchased seeds and therefore, they do not source for information on varieties available in the market. The results are rather surprising given that, Kieni West farmers are relatively more educated than Njoro farmers (Table 2a). Though education was expected to increase farmer’s ability to source information from as many information sources as possible, the reality of this study was that, closeness to point of technology development seems to be an important factor in creating awareness of a given technology. This calls for the researchers to be setting on-farm trial demonstrations in every area where a particular wheat variety is suitable.

Short wheat varieties were preferred and the local name was “Gatumani”. This was particularly so in Kieni West division. That these varieties were preferred would be due to their non-lodging and early maturing characteristics. The most well-known wheat variety in this catergory was Duma wheat variety and was reported by 22.7 percent of the farmers. The popularity of Duma wheat variety by farmers was not by chance. The unpredictability of rainfall in study sites indicate Duma was the right variety, for it is early maturing and drought tolerant too (KARI, 2003). However, more Kieni West farmers (25.5 percent) used Duma wheat variety compared to Njoro farmers (18.7 percent). Use of Duma wheat variety by more farmers in Kieni West division compared those in Njoro division was logical as it is among the recommended wheat varieties for marginal areas. Use of Mbuni wheat variety by Kieni West (13.3) was unexpected as this variety is late maturing and is recommended for high potential areas (KARI, 2003). These results show lack of awareness/knowledge on recommended varieties for various Agro Ecological Zones on the part of farmers.

Table 4. Wheat Varieties grown by Farmers in Njoro and Kieni West, Divisions

Wheat variety	Year of Release	Percentage of farmers Growing the variety
Unknown	_	36.0
Duma	1993	22.7
Chiriku	1989	18.7
Kwale	1987	15.3
Mbuni	1987	9.3
Fahari	1977	3.3
Mwamba	2001	3.4
Pasa	1989	4.0
Ngamia	1993	2.7
Njoro BW2	2001	2.0
Njoro BW1	2001	1.3
Tembo	1975	1.3
Chozi	1999	2.0
Heroe	1999	0.7
Tausi	1989	0.7
Sungura	**	0.7
Mbega	1993	0.7
Popo	1982	0.7
Kongoni	1981	0.7

Note: ** Year of release is not known

Source: Field Survey Data and KARI, 2003

Kwale and Chiriku wheat varieties were important in Njoro division and were grown by 33.3 and 28.0 percent of the farmers respectively. This was not surprising, as these varieties are the recommended wheat varieties for high potential areas (KARI, 2003). The use of recently released wheat varieties like NJORO BW1 and NJORO BW2 was very low despite their high yield potential and good resistance to diseases and was reported by 1.3 and 2.0 percent of the farmers respectively. Mwamba wheat variety, which was released in the same year as NJORO BW1 and 2, was used by 3.4 percent of the farmers only. This could be an indication of low awareness/lack of knowledge concerning these varieties by farmers. The varieties could also have been unavailable and/or expensive to the farmers. More revealing about these results was that, none of the Kieni West farmers had adopted NJORO BW1 and 2, a fact that could be explained by inaccessibility of the seeds to Kieni West farmers. The seeds were only available at KARI – Njoro.

4.1.4 Reasons for the Preferred Wheat Varieties

Farmers gave various reasons for choosing the wheat varieties they were using. High yielding was the most important reason given by 70.0 percent of the farmers. From economic point of view, the farmers preferred high yielding varieties to achieve increased output and hence profits. The percentage of the farmers in Njoro division and Kieni West division that reported high yielding as a reason for choosing the varieties they were using was almost the same, 68.0 percent and 72.0 percent respectively.

Early maturing as a reason for the preferred wheat varieties was reported by 14.0 percent of the farmers. This was a logical decision given that, rainfall is unreliable in the study sites and therefore, farmers understand the need to grow wheat varieties that take short time to mature to take advantage of whatever rainfall that may be available. Though the percentage of the farmers reporting early maturing as a reason for the preferred varieties was almost the same for Njoro farmers (13.3 percent) compared to Kieni West farmers (19.0 percent), the farmers reason was real as Kieni West is a marginal area and Njoro division has been experiencing erratic rains during wheat growing seasons.

Pests and diseases resistance as a reason for the preferred wheat varieties was reported by 12.1 percent. From economic point of view, the aspect of wheat variety being pests and diseases resistant is important, as it cuts down on the cost of production. More Njoro farmers (14.7 percent) compared to Kieni West farmers (6.7 percent) choose the varieties they were using on the basis of the variety being resistant to pests and diseases. Perhaps Njoro farmers are more enlightened on the importance of wheat variety being pests and diseases resistant compared to those in Kieni West farmers. These could due be to the fact that, Njoro farmers are close to NPBRC KARI-Njoro and are able to access information on importance of wheat variety being resistance to pests and diseases. Other reasons for the preferred wheat variety were weight of the wheat grain, sprouting resistant, no criteria, drought resistant, lodging resistance, only available seed, uniformity of the crop in the field and right variety for the area.

4.1.5 Use of more than one Wheat Variety and Reasons

The survey revealed that 16.7 percent of the farmers used more than one wheat variety with 25.0 and 11.0 percent of the Njoro and Kieni West farmers respectively reporting use of more than one wheat variety. The most important reason for growing more than one wheat variety was to compare yields and was reported by 52.0 percent of farmers growing more than one wheat variety. This was supported by the fact that, 70.0 percent of the farmers indicated they preferred the varieties they were growing on the basis of yield. More Njoro farmers (80.0 percent) compared to Kieni West farmers (36.4 percent) grew more than one wheat variety to compare yields. The explanation could be that, Njoro farmers being aware of the many available wheat varieties compared to Kieni West farmers, they would like to do on-farm research to identify the best performing wheat variety under their own conditions. This would enable them to choose the best variety in terms of yields, drought tolerance among other aspects.

Spread of risk, as a reason for growing more than one wheat variety was reported by 36.0 percent of the farmers growing more than one variety. This was acceptable especially; if the farmer was growing wheat varieties that mature at different times during the growing season. MoARD (2002) recommends the use of more than one recommended varieties to spread risks resulting from weather variations. The percentage of the farmers in Njoro division and Kieni West division who reported the use of more than one wheat variety to spread risk was almost the same, Njoro farmers (16.0 percent) compared to Kieni West farmers (18.2 percent). The explanation could be due to the fact that, both divisions experience erratic rains. Other reasons for growing more than one wheat varieties were to have seeds, lack of seeds and to cut down on costs of seeds (seeds of some varieties are cheaper than others)

4.1.6 Constraints to Adoption of Improved Wheat Varieties

The biggest constraint to adoption of improved wheat varieties was lack of knowledge about improved wheat varieties and was reported by 42.0 percent of the farmers. Lack of knowledge about improved wheat varieties could precipitate a situation of ignorance, making non-adopters to make less informed adoption decisions. Indeed wheat researchers attributes lack of information about wheat production technologies as the most important factor limiting wide spread adoption (Ndiema, 2002). Lack of knowledge about improved wheat varieties by farmers could be an indication of poor research-extension-farmer linkages and/or poor information delivery system. In this study only 40.7 percent of the farmers sourced information about improved wheat from extension services compared to 90.0 percent who sourced information from other farmers. More Kieni West farmers (34.7 percent) reported lack of knowledge about improved wheat varieties compared to Njoro farmers (14.7 percent). These results could imply that, Njoro farmers have more access to information on improved wheat varieties due to them being near National Plant Breeding Research Centre, KARI-Njoro compared to Kieni West farmers. This view has being supported by the survey results that found more Kieni West farmers (53.3 percent) used unknown varieties compared to Njoro farmers (18.7 percent).

High cost of seeds was the second important constraint to adoption of improved wheat variety and was reported by 20.0 percent of the farmers. This was not surprising given that, wheat seeds are very costly and only 8.0 percent of the farmers had access to credit for wheat production during the 2004 cropping season. Smallholder farmers being resource poor, makes credit accessibility to be an important factor in wheat production. The use of improved seeds was further lowered by the fact that, alternative seed (local) was in many cases not purchased, but previous harvest was used for seed. Therefore, the farmer ends up choosing the cheaper option of using the local seeds. In addition, seeds were needed at a time when farmers were paying school fees and buying food for the family making money scarcer. More Kieni West farmers (21.3 percent) compared to Njoro farmers (14.7 percent) viewed high cost of wheat seeds as a constraint. This scenario was the reality, though Kieni West farmers had more resource base (farm size and livestock units) compared to Njoro farmers (Table 2a). These results could only be explained in terms of access to off-farm income. More Njoro farmers had access to off-farm income (61.3 percent) compared to Kieni West farmers (41.3 percent). However, more Kieni West farmers (46.5 percent) compared to Njoro farmers (35.6 percent) accessed off-farm income from off-farm businesses. Therefore, Kieni West farmers could be investing more resources in off-farm businesses at the expense of farming activities since wheat production and off-farm business are competing enterprises in terms of capital requirements. Twelve point three (12.3) percent of Kieni West farmers reported inaccessibility to improved wheat varieties as a constraint in adoption of improved wheat varieties but none of Njoro farmers report it as a constraint. This could be an indication of poor input delivery system, in Kieni West division. Other reasons for non-adoption of improved wheat varieties were own seed was good and lack of capital.

4.1.7 Seed Acquisition

Results show that seed acquisition by the farmers was either purchased or own seeds, and was reported by 66.7 and 37.3 percent of the farmers respectively. Among the 66.7 percent of the farmers who acquired seeds by purchasing, 50.0 percent of the farmers purchased seeds from other farmers. The high percentage of farmers using own seeds and purchasing seeds from other farmers shows that farmers are ignorant of the fact that continuous cropping of the same seed lowers the quality of seeds as a result of varietal mixing. Varietal mixing is more real at farm level as the hired combine harvesters the farmers use are never cleaned after harvesting one variety. The result is that, most varieties the farmers have are a mixture of wheat varieties plus barley and oats. This calls for the extension agents to include extension messages that explain the importance of using certified seeds. More Njoro farmers (78.7 percent) purchased their wheat seeds compared to Kieni West farmers (54.7 percent). The low percentage of farmers using purchased seeds in Kieni West division compared to farmers in Njoro division could be an indication that majority of Kieni West farmers lack awareness/ knowledge of the importance of using certified seed compared to Njoro farmers. Thus seed recycling.

Use of both purchased and own seeds was reported by 10.0 percent of the farmers. More Njoro farmers (14.7 percent) used both purchased and own seed compared to Kieni West farmers (5.3 percent). May be Njoro farmers used purchased seeds together with own seed to compare their performance. Indeed 25.0 percent of Njoro farmers indicated that they grew more than one wheat variety to compare yields.

Table 5 shows the major sources of wheat seeds for the farmers. The two major sources of wheat seed for the farmers were other farmers (50.0 percent) and own seed (37.3 percent). Of the farmers who purchased wheat seed from other farmers 25.0 percent said they purchased seeds from the farmers who were contracted to grow seeds by National Plant Breeding Centre (NPBRC), KARI-Njoro. While, 13.0 percent of the farmers who used their own seed indicated that, they were contracted to grow seeds by NPBRC. This was only the case for Njoro farmers. An informal seed market seems to be taking roots and it is detrimental to wheat production. This shows that farmers are oblivious of the importance of sourcing their seeds from registered and recommended sources to ensure high quality seeds and hence high wheat production. This could be explained from the point of view that, majority of the farmers do not understand the importance of using certified seeds and/or the input delivery system could be inefficient or farmers find it cheaper to buy seeds from other farmers. Source of wheat seeds could be an impediment to adoption of improved wheat varieties and this call for extension agents to educate farmers on the importance of sourcing their seeds from registered and recommended seed sources. It was expected that farmers should source their seeds from registered and recommended sources to ensure use of high quality seeds. However, the reality of this study was that, only 17.4 percent of the farmers sourced their seeds from recommended sources.

Table 5. Farmers' Sources of Seeds for Njoro and Kieni West, Divisions

Source of seeds	Percentage of the farmers
Other farmers	50.0
Own seeds	37.3
KARI	10.0
Kenya Seed Co.	6.0
Kenya Breweries Ltd stores	0.7
Stockists	0.7

Source: Field Survey Data

4.1.8 Constraint to Adoption of Fertilizer Use

High cost of fertilizer was the biggest constraint to adoption of fertilizer and was reported by 59.5 percent of the farmers. This situation was not surprising given that fertilizer is expensive and as mentioned earlier, only 8.0 percent of the farmers had access to credit. More Kieni West farmers (29.3 percent) compared to Njoro farmers (22.7 percent) perceived cost of fertilizer as a constraint. Again non-farm businesses could be clouding out investments in fertilizer use for Kieni West farmers as more Kieni West farmers (46.5 percent) had access to non-farm businesses compared to Njoro farmers (35.6 percent).

Use of farmyard manure as a constraint to adoption of fertilizers was reported by 29.1 percent of farmers who did not adopt fertilizer use. This was an indication that, farmyard manure though used below the recommended rates was used as a substitute for fertilizer and not as a supplement. This calls for extension agents, to educate farmers on nutrient status and mode of action of manure compared to fertilizer. They should advise farmers to use farmyard manure in combination with fertilizer and not manure alone. Of interest was the fact that, more Kieni West farmers (24.0 percent) compared to Njoro (4.0 percent) used manure. The results could be explained from the fact that, Kieni West farmers had more livestock unit compared to Njoro farmers hence more manure for Kieni West farmers (Table 2a).

Another constraint to fertilizer use was the perception by the farmers that fertilizer spoils the soils and was only important to Kieni West farmers (6.7 percent). This is a myth that needs to be eradicated and presents a challenge to extension agents to educate farmers on importance of fertilizer on wheat production. Fertilizers are quick acting and when used judiciously can increase yields and improve livelihood of rural population by offering good and reliable economic returns. Other constraints reported by the farmers who did not used fertilizers were: farm was fertile, lack of capital, lack of knowledge about fertilizer, land was fallow, land was new and wheat still does well without fertilizer.

4.1.9 Constraints to Wheat Production

Table 6 show constraints to wheat production. The results show that the biggest constraint to wheat production was damage by insects, animals, birds or diseases. This constraint was reported by 40.0 percent of the farmers. The effect of damage on wheat is undisputed given that when birds or animals eat wheat grain, there is physical reduction in yields thus an economic loss. Damage caused by insects and diseases on wheat crop calls for the farmer to use pesticides that cost money in terms of cost of the chemical and cost of labour to spray the chemical. The net effect is an increase in cost of production. More Njoro farmers (48.0 percent) compared to Kieni West farmers (34.7 percent) perceived damage of wheat by animals, birds and insects or diseases as a constraint to wheat production. This could be explained by the fact that, Njoro farmers are more aware of importance of damage of wheat by pests and diseases in wheat production compared to Kieni West farmers.

Drought was another constraint reported by 34.7 percent of the farmers. These results were not surprising for Njoro division, that has been experiencing unreliable rainfall and for Kieni West division which is a marginal area and droughts are very common. The importance of drought as a constraint was almost the same for Njoro farmers (38.7 percent) compared to Kieni West farmers (42.7 percent). This is because rainfall pattern in the two divisions are erratic.

Table 6. Constraint to Wheat Production Njoro and Kieni West, Divisions

Production Constraint	Percent of the Farmers
Damage by insects, animals or birds	40.0
Lack of water/drought	34.7
High Cost of inputs	29.3
Shortage of working capital	21.3
Lack of machineries	12.7
Low yields	8.0
Weed infestation problem	6.7
Difficult to obtain farm inputs	2.0
Late land preparation	2.0
Others	6.7

Source: Field Survey Data

High cost of inputs as a constraint to wheat production was reported by 29.3 percent of the farmers. This was expected, as cost of wheat inputs (seeds and fertilizers) and farm machineries to do farm operations are very high. High cost of inputs as a constraint in wheat production was reported by 29.3 percent of the farmers in both divisions.

Fourth important constraint to wheat production was shortage of working capital and was reported by 21.3 percent of the farmers. Since most of small-holder farmers are resource–poor, more often than not, they experience shortage in working capital and this has an effect on the type of inputs the farmer uses and also the appropriateness and timing of farm operations. Lack of capital as a constraint was reported by almost the same percentage of farmers in Njoro division (18.0 percent) compared to farmers in Kieni West division (20.0 percent).

Lack of machineries was reported by 12.7 percent of the farmers. This stems from the fact that majority of smallholder farmers does not own farm machineries. They have to contend with hiring farm machineries from business people or large-scale farmers. The result has been, farmers do not do farm operation on time and sometimes the business people do shoddy jobs for them resulting to reduction in wheat yields. The timeliness of operations depends on access to or ownership of machinery. Some small-scale farmers suffer greatly from delayed operation due to lack of machinery particularly combine harvesters. Lack of farm machineries was more important for Kieni West farmers (18.7 percent) compared to Njoro farmers (8.0 percent). These results could be due to the fact that, Kieni West farmers, though with more experience in wheat farming compared to those in Njoro farmers started growing wheat on commercial basis recently (MoA, 2003). Unlike Njoro division where growing of wheat has been on commercial basis since the time of white settlers, and there are large scale farmers and business people who own machineries and they usually hire them out to smallholder farmers. Other wheat production constraints were low yields, weed infestation problems, late land preparation, difficulty to obtain farm inputs, poor land preparation, water logging, unavailability of seeds and small farm size.

4.1.10 Marketing Constraints

The study revealed that major marketing constraints was lack of reliable market and was reported by 20.0 percent of the farmers. This was because smallholder wheat farmers sell their wheat produce to middlemen unlike the large-scale farmers who sell their wheat produce directly to the millers at negotiated prices. Furthermore, lack of reliable market is complicated by the fact that many smallholder farmers do not have on-farm storage facilities and therefore, they cannot store their wheat produce to allow them look for a better market later on.

Stealing of wheat by brokers was another marketing constraint and was reported by 16.7 percent of the farmers. This was a serious problem because middlemen use manipulated weighing scales, such that when they weigh 90kg bag of wheat, the actual weight is normally more than 90 kg. There is normally an economic loss to the farmers as they are paid less than what they deserve.

Low prices of wheat as a marketing constraint were reported by 7.0 percent of the farmers. The issue of low wheat prices can be attributed to the facts that, farmers practice distress sales since, they rely on wheat produce sales to meet their other financial needs like buying clothes, food and paying school fees for their children. This requires them to sell wheat produce when there is a glut hence low price. The story is even more complicated by the fact that most smallholder farmers as mentioned earlier lack on-farm storage facilities and therefore, they cannot hold wheat produce to await good prices.

4.1.11 Sources of Information of the Farmers for the Adopted Varieties and Fertilizer Use

Source of information on agricultural technology could influence farmer's adoption behaviour. Extension services are expected to be a linkage between the researchers and farmers, that is, extension agents are expected to deliver agricultural technologies from the researchers to the farmers and feedback from the farmers to the researchers. Table 7 shows farmers' sources of information for the adopted varieties and fertilizer use. The results show that 90.0 percent of the farmers sourced information on adopted varieties and fertilizer use from other farmers compared to 40.7 percent who got information from the extension services. The results could be an indication that the farmer-staff ratio is very high and therefore, only a few farmers are able to access extension services. Current extension agents' deployment by the Ministry of Agriculture is one extension staff per location. Another explanation could be that, even where extension services are available extension agents do not pass information on wheat varieties and fertilizer. It could also be explained from the fact that majority of the farmers sourced their seeds from other farmers (50.0 percent) and it is most likely that they got information on improved wheat varieties and fertilizer use from the sellers of the seeds. The results show that more Njoro farmers (86.7 percent) compared to Kieni West farmers (80.0 percent) sourced information on adopted varieties and fertilizer use from other farmers. However, more Kieni West farmers (52.0 percent) compared to Njoro farmers (29.3 percent) sourced information on adopted varieties and fertilizer use from extension services. These results could be an indication of difference in farmer staff ratio in the two districts, or extension agents in Kieni West division are more aggressive in their work compared to extension agents in Njoro division.

Table 7. Farmers' Sources of Information for Adopted Varieties and Fertilizer in Njoro and Kieni West, divisions

Source of Information	Percentage of the farmers
Other farmers	90.0
Extension	40.0
Field days	18.7
Research Centres	10.7
Seed Dealer	2.0
Radio	2.0
Demonstrations	3.3
Agricultural shows	5.3
Others	4.0

Source: Field Survey Data

Field day as a source of information for the farmers was reported by 18.7 percent of the farmers. This could be an indication that such events are not frequent or most farmers do not see the value of attending them when they are organized. Research centres as source of information was reported by 10.7 percent. These results could imply that, majority of the farmers do not know they can get information on wheat production from research centers or they live far from such centres. However, more Njoro farmers (17.3 percent) compared to those in Kieni West (4.0 percent) sourced information on adopted varieties and fertilizer use from research centres. These results were not surprising given that Njoro farmers are closer to NPBRC, KARI-Njoro compared to Kieni West farmers. Other sources of information for the farmers were agricultural shows, seed dealers, radio, demonstrations, farmer's field schools (FFS) seminar/workshop and farmers training centers (FTCs).

4.1.12 Socioeconomic Characteristics of the Adopters and Non-adopters of Fertilizer use

Results of independent two-sample *t*-test (test of equality mean) for continuous socioeconomic characteristics and Chi-square (test of equality of observed and expected frequencies) for categorical characteristics between adopters and non-adopters of fertilizer use are presented in Table 8a and b respectively. Table 8a shows that, adopters of fertilizer use scored higher over the non-adopters in all socioeconomic characteristics except family size and access to fertilizer market. However, the differences in mean age, family size, education level, farm size, distance to fertilizer markets and total number of livestock units between adopters and non-adopters were not significant.

The adopters with mean number of years the household head had in wheat farming of 9.52 years were more experienced in wheat farming than non-adopters (7.11 years) and the difference was significant at P<0.05 level. It is generally expected that farmers with more experience in wheat farming are more likely to adopt fertilizer use compared to less experienced farmers. This is as result of farming skills gained over time by the experienced farmers and also due to the fact that farmers who have used fertilizer for long understand better the risk associated with its use.

Table 8a. Results of Independent Two-sample *t*-Test for Socioeconomic Characteristics of the Adopters and Non-adopters of Fertilizer Use in Njoro and Kieni West, Divisions

Characteristics	Adopters (N=72)		Non-adoption (N=78)		Unweight-ed t-ratio	Weight-ed t-ratio
	Unweight-ed Mean	Weight-ed Mean	Unweight-ed Mean	Weight-ed Mean		
Age	51.72 (12.53)	51.42 (8.43)	50.02 (12.77)	50.03 (10.03)	0.820	0.854
Family Size	9.04 (3.82)	8.08 (2.43)	8.65 (3.80)	8.72 (3.08)	-0.623	-1.422
Education Level	8.15 (4.43)	9.18 (2.93)	7.39 (3.79)	7.52 (2.81)	1.125	0.532
Farm size	11.19 (7.98)	12.13 (7.68)	11.23 (17.86)	11.59 (16.18)	0.017	0.265
Farmer's Experience	8.31 (7.55)	9.52 (7.14)	6.89 (7.43)	7.11 (6.48)	1.156	2.152**
Distance to fertilizer market	10.15 (0.98)	9.75 (0.93)	10.95 (0.95)	10.80 (0.93)	-1.042	-1.541
Total No. of livestock units	4.58 (3.97)	5.49 (3.74)	4.47 (5.00)	4.55 (3.74)	0.280	1.489

Note: ** Significant at P<0.05 probability levels

Figures in parentheses are the standard deviation

Source: Field Survey Data

Table 8b shows the results of Chi-square (test of equality of expected and observed frequencies) for categorical characteristics between adopters and non-adopters of fertilizer use. Results show that the differences in percentage in terms of farmer's access to credit and access to off-farm income between adopters and non-adopters were insignificant.

Table 8b. Results of Chi-square for Socioeconomic Characteristics of the Adopters and Non-adopters of Fertilizer Use in Njoro and Kieni West, Divisions

Characteristics	Adopters (N=72)	Non-adopters (N=78)	χ^2
	Percentage of the farmers	Percentage of the farmers	
Dummy for Agro-Ecological Zone household head was in Nakuru			18.056***
1 for Njoro Division	68.1	33.3	
0 for Kieni West division	31.9	66.7	
Dummy for household head's gender			
1 for male	75.0	60.3	3.700*
0 for female	25.0	39.7	
Whether household head had Access to Extension Services			
Yes	61.1	38.5	7.684***
No	38.9	61.5	
Whether household head had Access to Credit			
Yes	9.7	6.4	0.558
No	90.3	93.6	
Household head's affiliation to an Organization			
Yes	56.9	70.5	2.992*
No	43.1	29.5	
Whether household head had Access to Off- Farm Income			
Yes	61.1	59.0	0.071
No	38.9	43.0	

Note: *** Significant at P<0.01 probability level and * Significant at P<0.1 probability level

Source: Field Survey Data

More Njoro farmers (68.1 percent) adopted fertilizer use compared to Kieni West farmers (31.9 percent) and difference was significant at P<0.01 probability level. This was an indication that the Agro-Ecological Zone of the household head in terms of the farmer being high potential or marginal area is an important factor in adoption decisions.

More male household heads (75.0 percent) adopted fertilizer use compared to female household heads (25.0 percent) and the difference was significant at $P<0.1$ probability level. These results could perhaps, be an indication that male household heads had more access to information on fertilizer compared to female household heads, or male household heads had access to more resources and therefore, able to purchase fertilizer compared to female household heads.

More adopters had access to extension services (61.0 percent) compared to non-adopters (38.5 percent) and the difference was significant at $P<0.01$ probability level. This was an indication that, access to extension services was an important factor on adoption of fertilizer use. Extension services are the means through which agricultural technologies are transferred from researchers to the farmers.

More non-adopters were affiliated to organizations (70.5 percent) compared to adopters (56.9 percent) and the difference was significant at $P<0.1$ level. The results were rather surprising as farmer's affiliation to an organization was expected to enhance farmer's ability to source for information on wheat production technologies and credit facilities.

4.1.13 Farmer's Perception of Fertilizer-Specific Attributes of the Adopters and Non-adopters of Fertilizer Use

Table 9 shows the results of Wilcoxon Rank-Sum test (Z) of farmer's perception of fertilizer-specific attributes among the adopters and non-adopters of fertilizer use. Results indicate that adopters of fertilizer use had larger sums of ranks of farmer's perception of fertilizer-specific attributes (6377.00) than non-adopters (4948) and the difference was significant at $P<0.01$ probability levels. This was an indication that distribution of higher ranks of farmer's perception of fertilizer-specific attributes was more than low and medium ranks among the adopters compared to non-adopters thus, large totals. These results implied that adopters of fertilizer use perceived fertilizer-specific attributes favourably. These results were not surprising, as agricultural technologies that are perceived favourably by the farmers are more likely to be adopted.

Table 9. Results of Wilcoxon Rank-Sum Test (Z) for Farmer's Perception of Fertilizer-Specific Attributes of the Adopters and Non-adopters of Fertilizer Use

Farmer's perception	Adopters (N=72)		Non-adopters (N=78)		Wilcoxon (W)	Z
	Mean Rank	Sum of Ranks	Mean Rank	Sum of Ranks		
$FP_{TchnFert}$	88.57	6377.00	63.44	4948.00	6377.00	3.625***

Note: *** significance at P<0.01probability levels

$FP_{TchnFert}$ is farmer's perception of fertilizer specific attributes

Source: Field Survey Data

4.1.14 Socioeconomic Characteristics of the Adopters and Non-adopters of Improved Wheat Varieties

Results of independent two-sample t-test (test of mean equality) for continuous characteristics and Chi-square (test of equality of observed and expected frequencies) for categorical characteristics analyses between adopters and non-adopters of improved wheat varieties are presented in Table 10a and b respectively. Table 10a revealed that adopters of improved wheat varieties scored higher over the non-adopters in all characteristics considered except age, family size and years in wheat farming.

The differences in mean family size, farm size, experience in wheat farming and total number of livestock units between adopters and non-adopters were not significant. Adopters with mean age of 49.06 years were younger in age than non-adopters (52.13 years) and the difference was significant at P<0.1 probability level. It is generally expected that younger farmers are more innovative than the older ones. Perhaps, the younger farmers have longer planning horizon than the older farmers, or younger farmers were more educated than the older farmers and were therefore, able to access information on improved wheat varieties compared to older farmers.

Adopters with mean number of years in formal education of 8.97 years were more educated than non-adopters (7.29 years) and the difference was significant at P<0.01 probability level. This is due to the fact that education enhances ones ability to assess risks associated with the use of a given technology.

Table 10a. Results of Independent Two-sample t-Test for Socioeconomic Characteristics of the Adopters and Non-adopters of Improved Wheat Varieties in Njoro and Kieni West, Divisions

Characteristics	Adopters (N=69)		Non-adopters (N=81)		Unweighted t-ratios	Weight-ed t-ratios
	Unweight-ed Mean	Weight-ed Mean	Unweight-ed Mean	Weight-ed Mean		
Age	48.90 (12.67)	49.06 (9.86)	52.49 (12.46)	52.13 (9.45)	-1.748	-1.943*
Family size	8.51 (4.02)	8.49 (2.54)	9.12 (3.61)	8.92 (2.65)	-0.989	-0.827
Education Level	8.77 (3.91)	8.97 (2.56)	6.90 (4.11)	7.29 (2.98)	2.835	3.733***
Farm size	11.51 (15.56)	14.15 (19.17)	10.96 (12.55)	11.07 (11.23)	0.234	1.176
Farmer's Experience	7.28 (6.89)	7.18 (6.45)	7.82 (8.00)	8.23 (6.88)	-0.443	-0.963
Distance to Seed Markets	8.40 (3.59)	9.70 (4.54)	1.15 (.78)	1.20 (0.61)	3.531	3.091***
No. of livestock units	4.25 (5.11)	5.83 (6.00)	4.66 (3.97)	4.68 (3.17)	0. 553	1.438

Note: *** Significant at P<0.01 probability level and * Significant at P<0.1 probability level

Figures in parentheses are the standard deviation

Source: Field Survey Data

The mean distance to seed markets was longer for adopters (9.70 Km) than for non-adopters (1.2 Km) and the difference was significant at P<0.01 probability level. These results were rather surprising as increase in distance traveled by the household heads to get seeds is expected to increase cost of seeds through transport and transaction cost.

Table 10b shows the results of chi-square analysis for categorical characteristics between adopters and non-adopters of improved wheat varieties. Results show that the differences in percentages in terms of gender of household head, access to extension services, access to credit, farmer's affiliation to an organization and access to off-farm income between the adopters and non-adopters were insignificant

More Njoro farmers (66.7 percent) adopted improved wheat varieties compared to Kieni West farmers (33.9 percent) and the difference was significant at P<0.01 probability level. This was an indication that Agro-Ecological Zones in terms if the farmer being in high or marginal areas is an important factor influencing adoption of improved wheat varieties decisions.

Table 10b. Results of Chi-square for Socioeconomic Characteristics of the Adopters and Non-adopters of Improved Wheat Varieties in Njoro and Keini West, Divisions

Characteristics	Adopters (N=69)	Non-adopters (N=81)	χ^2
	Percentage of the farmers	Percentage of the farmers	
Dummy for Agro-Ecological Zone household head was in Nakuru	66.7	39.3	14.198***
1 for Njoro Division	33.3	61.7	
0 for Kieni West			
Dummy for household head's gender	69.6	65.4	0.289
1 for male	30.4	34.6	
0 for female			
Whether household head had Access to Extension Services	53.6	45.7	0.941
Yes	46.4	54.3	
No			
Whether household heads had Access to Credit	8.7	7.4	0.084
Yes	91.3	91.3	
No			
Household head's affiliation to an organization	58.0	69.1	2.016
Yes	42.0	30.1	
No			
Whether household head had Access to Off-farm Income	66.7	54.3	2.366
Yes	33.3	45.7	
No			

Note: *** Significant at P<0.01 probability level

Source: Field Survey Data

4.1.15 Farmer's Perception of Improved Wheat Varieties-Specific Attributes of the Adopters and Non-adopters of Improved Wheat Varieties

Table 11 shows the results of Wilcoxon Rank-Sum test (Z) of farmer's perception of improved wheat varieties specific-attributes among the adopters and non-adopters of improved wheat varieties. Table 11 revealed that adopters of improved wheat varieties had larger sum of ranks of farmer's perception of improved wheat varieties-specific attributes (5797.00) compared to non-adopters (5528.00) and the difference was significant at $P<0.05$ probability level. These results indicate that distribution of higher ranks of farmer's perception of improved wheat varieties-specific attributes was more than low and medium ranks among the adopters compared to non-adopters thus, large totals. These results implied that adopters of improved wheat varieties perceived improved wheat varieties-specific attributes favourably. These results were expected, as agricultural technologies that are perceived favourably by the farmers are more likely to be adopted.

Table 11. Results of Wilcoxon Rank-Sun Test (Z) for Farmer's Perception of Improved Wheat Varieties-Specific Attributes of the Adopters and Non-adopters of Improved Wheat varieties

Farmer's perception	Adopters (N=69)		Non-adopters (N=81)		Wilcoxon (W)	Z
	Mean Ranks	Sum of Ranks	Mean Ranks	Sum of Ranks		
$FP_{TchnSeed}$	84.01	5797.00	68.25	5528.00	5797.00	2.243**

Note: ** significance at $P<0.05$ probability level

$FP_{TchnSeed}$ is farmer's perception of improved wheat varieties specific attributes

Source: Field Survey Data

4.2 Inferential Results

In this section the interest was to study the functional relationship between the dependent and the independent variables. A Pearson correlation analysis was used to test for multicollinearity among the independent variables before entering them in the Tobit models. Appendix 3 shows the Pearson's correlation matrix for independent variables. Correlation coefficients between independent variables were below 0.70, meaning there was no problem of multicollinearity between them. According to Mason and Lind (1996) a common rule of thumb is that correlation among dependent variables from -0.70 and +0.70 do not cause problems.

4.2.1 Correlation between Socioeconomic Factors and Farmer's Perception of Improved Wheat Varieties-Specific Attributes

The results of Kendall's Coefficient of Concordance (W) revealed that calculated $\chi 2$ = 1648 was greater than the critical (table) value, χ^2 =22.36 at P<0.05 probability level for degrees of freedom of 14-1=13. Therefore, null hypothesis (H_0) was rejected and alternative hypothesis (H_1) accepted at P<0.05 for degree of freedom 13. Therefore, W is significant and there is significant correlation between socioeconomic factors and farmer's perception of improved wheat varieties-specific attributes. The results differ with the findings reported in Sierra Leone where none of farm and farmer characteristics had any significant influence on farmer's perception of improved rice varieties (Adesina and Zinnah, 1993).

Table 12 shows the results of Kendall's Coefficient of Concordance (W) between socioeconomic factors and farmer's perception of improved wheat varieties-specific attributes. Farmer's Agro-Ecological Zone, household head's gender, age, farm size, experience in wheat farming, access to credit, affiliation to an organization and off-farm income were insignificant.

Family size correlated negatively with farmer's perception of improved wheat varieties-specific attributes and was significant at P<0.05 probability level. These results implied that, households with small family size perceived improved wheat varieties specific-attributes favourably compared to households with large family size. These results may arise from the effect of household size on household disposable income and resource allocation behaviour. Larger households may have more subsistence needs leaving proportionally fewer resources to finance the adoption of improved technologies (Oluoch-Kosura, *et al.*, 2001). This makes households with large family size to be unable to access improved wheat varieties thus, affecting the need for them to look for information on improved wheat varieties. Therefore, households with large family size may not be in a position to assess and understand the improved wheat varieties-specific attributes.

The household head's education level correlated positively with farmer's perception of improved wheat varieties-specific attributes and was significant at P<0.01 probability level. These results could be explained in terms of differentials in ability to access information on improved wheat varieties from print media and other informants and ability to assess and understand the improved wheat varieties and fertilizer specific-attributes among more and less educated farmers. More educated farmers are able to access information on a given technology and assess and understand the attributes of that technology. Theses results were in agreement with the findings reported by Shiferaw and Holden (1998) that found education to have a positive relationship with farmer's perception level of erosion problem in Ethiopia.

Table 12. Results of Kendall's Coefficient of Concordance (W) between Farmer's Perception of Improved Wheat Varieties- Specific Attributes and Socioeconomics factors in Njoro and Kieni West, Divisions (Dependent Variable=$FP_{TchSeed}$)

Independent Variables	Coefficients
HH_{Nakuru}	-0.008
HH_{Male}	0.040
HH_{Age}	-0.061
HH_{Size}	-0.133**
HH_{Educ}	0.169***
FA_{Size}	0.060
HH_{Exper}	-0.006
Mkt_{Seed}	0.135**
Ex_{Cont}	0.147**
HH_{Credit}	0.032
TL_{Units}	0.085*
HH_{Organ}	0.025
$HH_{Off\text{-}farm}$	0.037

Note: *** Significant at P<0.01 probability level, ** Significant at P<0.05 probability level and * Significant at P<0.1 probability level

Source: Field Survey Data

Distance to seed markets was found to correlate positively with farmer's perception of improved wheat varieties-specific was significant at P<0.05 probability level. The positive sign on the distance to seed markets was rather surprising given that farmers living far from markets are expected to face high transaction and information costs and these costs may influence farmer's perception of the technology-specific. This is because farmer's perception of profitability of technologies is influenced by costs of inputs (Ersado, *et al.,* 2003).

Access to extension services was found to correlate positively with farmer's perception of improved wheat varieties-specific attributes and was significant at $P<0.05$ probability level. This means, households that had access to extension services had a higher probability of perceiving improved wheat varieties-specific attributes favourably than households that had no access to extension services. These results were expected, as extension services are the means through which farmers get information of agricultural technology from researchers. The results were consistent with the findings reported by Shiferaw and Holden (1998) and Makhoha, *et al.* (1999) which found access to extension services to be positive and significant in explaining farmer's perception of technology-specific attributes.

Total livestock units correlated positively with farmer's perception of improved wheat varieties-specific attributes and was significant at $P<0.1$ probability level. These results could be explained from the point of view that most farmers feed wheat straw (a joint product of wheat grains) to their ruminants animals and this makes wheat production to be a complementary enterprise to livestock production. Therefore, more wheat straw resulting in use of improved wheat varieties could make a farmer with more livestock units to look for information on improved wheat varieties, making the farmer to be in a better position to assess and understand improved wheat varieties-specific attributes. This could increase farmer's probability of perceiving improved wheat varieties-specific attributes favourably. These results differs with the findings reported by Shiferaw and Holden (1998) which found number of livestock owned by the farmer to negatively influence farmer's perception.

4.2.2 Correlation between Socioeconomic Factors and Farmer's Perception of Fertilizer-Specific Attributes

The results of Kendall's Coefficient of Concordance (W) revealed that calculated χ^2 = 1667 was greater than the critical (table) value χ^2 =22.36 at $P<0.05$ probability level for degrees of freedom of 14-1=13. Therefore, null hypothesis (H_0) was rejected and alternative hypothesis (H_1) at $P<0.05$ for degree of freedom 13. Therefore, W is significant and there is significant correlation between socioeconomic factors and farmer's perception of fertilizer specific-attributes. The results differ with the findings reported in Sierra Leone where none of farm and farmer characteristics had any significant influence on farmer's perception of improved rice varieties (Adesina and Zinnah, 1993).

Table 13 shows the results of Kendall's Coefficient of Concordance (W) between socioeconomic factors and farmer's perception of fertilizer specific-attributes. Farmer's Agro-Ecologic Zone, age, family size, distance to fertilizer market, access to extension services, access to credit, access to off-farm income were insignificant.

Table 13. Results of Kendall's Coefficient of Concordance (W) between Farmer's Perception of Fertilizer-Specific Attributes and Socioeconomics Factors in Njoro and Kieni West, Divisions (Dependent Variable=$FP_{Tchfert}$**)**

Independent Variables	Coefficients
HH_{Nakuru}	0.046
HH_{Male}	0.190***
HH_{Age}	0.041
HH_{Size}	0.052
HH_{Educ}	0.092*
FA_{Size}	0.128**
HH_{Exper}	0.140**
Mkt_{Seed}	-0.014
Ex_{Cont}	0.056
HH_{Credit}	0.055
TL_{Units}	0.150***
HH_{Organ}	-0.111*
$HH_{Off\text{-}farm}$	0.033

Note: *** Significant at P<0.01 probability level, ** Significant at P<0.05 probability level and * Significant at P<0.1 probability level

Source: Field Survey Data

The coefficient for being a male household head correlated positively with fertilizer-specific attributes and was significant at P<0.01 probability level. These implied that, male household heads perceived fertilizer-specific attributes favourably compared to female household heads. Perhaps male household heads could have been more educated compared to female household heads. Or male household heads could have had more access to information on fertilizer, making them to be in a better position to assess and understand fertilizer-specific attributes compared to female household heads.

Education level of the household head correlated positively with farmer's perception of fertilizer-specific attributes and was significant at P<0.1 probability level. These results could be explained in terms of differentials in ability to access information on fertilizer from print media and other informants and ability to assess and understand the fertilizer-specific attributes among more and less educated farmers. More educated farmers are able to access information on a given technology and understand and asses the attributes of that technology compared to less educated farmers. These results were consistent with the findings reported by Shiferaw and Holden (1998) which found education to have a positive relationship with farmer's perception level of erosion problem in Ethiopia.

Farm size was found to correlate positively with farmer's perception of fertilizer-specific attributes and was significant at P<0.05 probability level. These results were expected, as farmers with big farm sizes are expected to be able to access external inputs like fertilizers and therefore, they may be able to access information on fertilizer from extension services and other informants. This makes them to be in a better position to assess and understand fertilizer-specific attributes thus, favourable perception.

Farmer's experience correlated with farmer's perception of fertilizer-specific attributes positively and was significant at P<0.05 probability level. These results indicate that farmers who had grown wheat for long had a higher probability of perceiving fertilizer-specific attributes favourably compared to the farmers who had not. Such a pattern was expected, as more experienced farmers may have used fertilizer for a long time and had more access to information about fertilizer-specific attributes through extension services and other informants. Therefore, they were in a better position to understand and assess fertilizer-specific attributes hence high probability of perceiving fertilizer-specific attributes.

The correlation between total number of livestock units and farmer's perception of fertilizer-specific attributes was positive and significant at $P<0.01$ probability level. The explanation could be that farmers who owned higher livestock units and therefore, had more manure did not use manure as substitute but used it as supplement for fertilizer. Or results could be explained from the point of view that most smallholder farmers feed wheat straw (a joint product of wheat grains) to their ruminant animals and this makes wheat production to be a complementary enterprise to livestock production. Therefore, more wheat straw resulting from use of fertilizer is important to the farmer since, fertilizer makes wheat crop to be taller and more robust leading to increased yield of wheat straw. Therefore, more wheat straw resulting from fertilizer use could make a farmer with more livestock units to look for information on fertilizer, making the farmer to be in a better position to assess and understand fertilize-specific attributes. This could increase farmer's probability of perceiving fertilizer- specific attributes favourably. The results differs with the findings reported by Shiferaw and Holden (1998) which found number of livestock owned by the farmer to negatively relate with farmer's perception level of erosion problem in Ethiopia.

A farmer's affiliation to an organization correlated with farmer's perception of fertilizer-specific attributes negatively and was significant at $P<0.1$ probability level. These results were rather surprising. Farmer's affiliation to an organization is an indication of farmer's level of networks and contact with organized groups and informed groups. It provides an opportunity to the farmer to learn about agricultural technologies, a forum to share experiences and exchange opinions about agricultural technologies with other farmers. This enables the farmers affiliated to an organization to be in a better position to assess and understand the attributes of agricultural technologies. Therefore, organizations in the study sites were dealing with other issues rather wheat and were not good forums for gathering information on wheat production technologies.

4.2.3 Socioeconomic Factors Influencing Adoption and Intensity of Use of Improved Wheat Varieties

Table 14 shows the results of socioeconomic factors influencing adoption and intensity of use of improved wheat varieties. The results of Tobit model show that socioeconomic factors have significant effect on adoption and intensity of use of improved wheat varieties. Therefore, the null hypothesis (H_0) was rejected and alternative hypothesis (H_1) accepted. The model was good fit as indicated by the low negative log likelihood (NLL) value of

-357.65. It is known that NLL is always positive and measures lack of fit between data and model; the smaller the value, the better the model fits the data (Darlinton, 1990).

Table 14. Estimation Results of Tobit Model for Socioeconomic Factors Influencing Adoption and Intensity of Use of Improved Wheat Varieties in Njoro and Kieni West, Divsions

Variables	Coefficients	Total change δEY/δX	Change in intensity of use δEY*/ δX	Change in probability of adoption δF(z)/ δX
Constant	-51.274 (-0.689)			
HH_{Nakuru}	48.352*** (13.341)	22.242	7.585	14.657
HH_{Male}	1.260 (0.086)	0.580	0.198	0.382
HH_{Age}	-1.074 (-1.408)	-0.494	-0.168	-0.326
HH_{Size}	2.031 (0.859)	0.934	0.318	0.616
HH_{Educ}	0.760 (0.350)	0.350	0.119	0.231
FA_{Size}	1.093** (2.261)	0.503	0.172	0.331
HH_{Exper}	-2.868** (-2.558)	-1.319	-0.450	-0.869
Mkt_{Seed}	7.297*** (3.405)	3.357	1.145	2.212
Ex_{Cont}	15.559 (1.096)	7.157	2.441	4.716
HH_{Credit}	10.829 (0.483)	4.981	1.699	3.282
TL_{Units}	0.052 (0.038)	0.024	0.008	0.016
HH_{Organ}	-16.303 (-1.073)	-7.499	-2.557	-4.942
$HH_{Off\text{-}farm}$	12.663 (0.935)	5.825	1.986	3.839
SIGMA	62.662*** (9.051)			
Log likelihood Function	-357.652	z= -0.10	F(z)= 0.46	f(z)= 0.3970

Note: *** Significance at P<0.0 1 probability level, ** Significance at P<0.05 probability level

Figures in parentheses are t-ratios

Source: Field Survey Data

Household head's gender, age, family size, household head's education level, access to extension services, access to credit, total number of livestock units, household head's affiliation to an organization and access to off-farm income were insignificant. The results of insignificant influence of the household head's education level on adoption and intensity of use of improved wheat varieties were not surprising. Education increases the speed with which new skills and techniques can be learned and adopted (Oluoch-Kosura, *et al.,* 2001) and enables farmers to source information about agricultural technologies from as many information pathways as possible. In the current study, average number of years the household head had in formal education was 8.11years. This conformed well to a primary level of education, which is considered adequate for the farmer to be able to understand and interpret the technical information of improved wheat varieties from print media, extension contact and other informants. This means that, education beyond primary level is not an important factor on adoption and intensity of use of improved wheat varieties.

Agro-Ecological Zone of farmer in terms of a farmer being in high potential or marginal area influenced adoption and intensity of use of improved wheat varieties. The coefficient on the dummy for a farmer being in Njoro division was positive and significantly at $P<0.01$ probability level. This implied that Njoro (high potential areas) farmers had a higher probability of adopting and using more of improved wheat varieties compared to Kieni West (low potential areas) farmers. Low probability of adoption and intensity of use of improved wheat varieties by Kieni West farmers could be explained by harsh environmental conditions and therefore, high risks in wheat production. Where there are high production risks like Kieni West division, farmers are unlikely to adopt improved wheat varieties. These results were inconsistent with the findings reported by Shiferaw and Holden (1998) which found location of a farmer in terms of a farmer being in a high rainfall area to negatively and significantly influence the decisions to retain conservation structures in Ethiopia. However, these results concur with findings reported by Salasya, *et al.,* (1997) which found location of a farmer in terms of the farmer being in high rainfall area terms to positively and significantly influence adoption of improved maize seeds and fertilizer.

The effect of farm size on adoption and intensity of use of improved wheat varieties was positive and significant at $P<0.05$ probability level. The relationship is plausible because adoption costs, when considered as fixed expenses, may tend to discourage adoption by small holders who are likely to face more severe resource constraints (Oluoch – Kosura, *et al.,* 2001). Another explanation could be that large farm operators are likely to have more opportunities to learn about new technologies by first experimenting with innovations to see their result before adopting on large scale. Or farmers with large land holding (proxy for wealth) could be less risk averse and have the capacity to cope with risks associated with use of new technologies compared to farmers with small farm holdings. The results were consistent with findings reported by Ersado, *et al.* (2003), Obare, *et al.* (2000), Judicate, *et al.* (1998), and Gamba, *et al.* (1998) among others.

The experience of household head in wheat farming had unexpected negative sign but was significant at $P<0.05$ probability level in influencing adoption and intensity of use of improved wheat varieties. These results were contrary to the belief that experienced farmers have better technical knowledge, are able to asses the risks associated with use of improved wheat varieties and were likely to be getting the highest possible returns from investments in improved wheat varieties. Further, farming experience implied that knowledge gained overtime from working in uncertain production environment may help in evaluating information on agricultural technologies thereby, influencing their adoption decisions. Farmers in such situations continuously experiment and where results are promising if possible adopt the technology or if otherwise reject it Sall, *et al.* (2000). The negative and significant effect of farmer's experience on adoption and intensity of use of improved wheat varieties could mean that, farmers with experience had used improved wheat varieties and had proved they were not meeting their expectation resulting to farmer's rejecting the same. Alternatively, farmers could still be producing wheat at subsistence level despite their experience in wheat farming. The results were inconsistent with the belief that as farmers gain experience, it is expected to positively influence their decision– making skills (Adesina and Zinnah (1993) and Adesina and Seidi (1995)).

Distance to seed markets had unexpected positive sign and was significant at $P<0.01$ probability level. These results were unexpected, as farmers living far from the market face high transaction and information costs and this may influence adoption and intensity of use decisions. The significant influence of distance to seed market on adoption and intensity of use of improved wheat varieties could mean farmers value the use of improved wheat seeds and they can go to any length to get the seeds and this makes transport costs to be unimportant to them. The results differs with findings reported Ersado, *et al.* (2003) and Lucila, *et al.* (1999) which found distance to inputs markets to negatively relate with adoption decisions. However, these results were consistent with the findings reported by Mose (1999) which found distance to input markets to positively influence adoption and intensity of fertilizer use.

From the decomposition of Tobit model in Table 14, results show that, marginal changes in an explanatory variable *ceteris paribus,* had higher effects on probabilities of adoption than on intensity of adoption. This means marginal changes in an explanatory variable would cause higher changes in probability of adoption of a given technology than it would cause on intensity of its use. For instance, Table 14 shows that, an increase in farm size by an extra acre ceteris *paribus* would increase the probability of adopting improved wheat varieties by 0.331 percent while increasing its use by 0.172Kg/acre among adopters and by 0.503kg/acre for all the farmers. Similarly, an increase in household head's experience in wheat farming by an extra year *ceteris paribus*, would decrease the probability of adoption of improved wheat varieties by 0.869 percent while reducing its use by 0.450Kg/acre among adopters and by 1.3191kg/acre for all the farmers. These results were consistent with the findings reported by Sall, *et al.* (2000) and Wanyoike, *et al.* (2000) which found marginal changes in an explanatory variable to cause higher changes in probability of adoption than it causes on its intensity of use.

4.2.4 Socioeconomic Factors Influencing Adoption and Intensity of Fertilizer Use

Table 15 shows the results of Tobit model for socioeconomic factor influencing adoption and intensity of fertilizer use. The results of Table 15 revealed that that socioeconomic factors have significant effect on adoption and intensity of fertilizer use. Therefore, the null hypothesis (H_0) was rejected and alternative hypothesis (H_1) accepted. The model was good fit as indicated by the low negative log likelihood (NLL) value of -351.71. Table 15 shows that age, family size, education level, farm size, experience in wheat farming, distance to fertilizer markets, access to credit, total number of livestock units, farmer's affiliation to an organization and access to off-farm income were insignificant.

The insignificant results of access to credit were not surprising. Access to credit by the farmers is expected to ease liquidity constraint and enable them to finance/purchase external inputs such as improved wheat varieties and fertilizer. Credit availability for wheat farming is important given that wheat production technologies are very expensive. Though to be effective in wheat production, high use of fertilizer and improved seed and proper management is desirable, only 8.0 percent of the farmers had accessed credit for wheat growing in 2004 cropping season.

Table 15. Estimation Results of Tobit Model for Socioeconomic Factors influencing Adoption and Intensity of Fertilizer Use in Njoro and Kieni West, Divisions

Variables	Coefficients	Total change δEY/δX	Change in intensity of use δEY*/ δX	Change in probability of adoption δF(z)/ δX
Constant	-195.073*** (-2.965)			
HH_{Nakuru}	47.774*** (4.258)	22.932	8.095	14.837
HH_{Male}	25.152** (2.237)	12.073	4.262	7.811
HH_{Age}	0.461 (0.873)	0.221	0.078	0.143
HH_{Size}	- 2.282 (-1.310)	-1.095	-0.387	-0.708
HH_{Educ}	1.011 (0.700)	0.485	0.171	0.314
FA_{Size}	-0.497 (-1.180)	-0.239	-0.084	-0.155
HH_{Exper}	0.437 (0.649)	0.210	0.074	0.136
Mkt_{Fert}	-5.956 (-1.297)	-2.859	-1.009	-1.850
Ex_{Cont}	26.129*** (2.667)	12.542	4.427	8.115
HH_{Credit}	-5.037 (-0.310)	-2.418	-0.854	-1.564
TL_{Units}	-0.577 (-0.005)	-0.277	-0.098	-0.179
HH_{Organ}	2.331 (0.208)	1.119	0.395	0.724
$HH_{Off\text{-}farm}$	5.699 (0.599)	2.736	0.966	1.770
SIGMA	44.466** (9.396)			
Log likelihood Function	-351.708	z= -0.05	F(z)= 0.48	F(z)= 0.3984

Note: *** Significance at P<0.01Probability level and ** Significance at P<0.05 Probability level

Figures in parentheses are t-ratios

Source: Field Survey Data

The significant impact of the constant at P<0.01 probability level on adoption and intensity of fertilizer use imply that, there are other factors rather than those specified in the model that are important. Agro-Ecological Zone of a farmer in terms of the farmer being in a high potential or marginal arear influenced adoption and intensity of fertilizer use. The coefficient on the dummy for a farmer being in Njoro division was positive and significantly at P<0.01 probability level. These results imply that farmers in Njoro division (high potential areas) had a higher probability of adopting and using more of fertilizer compared to farmers in Kieni West (low potential areas). Low probability of adoption and intensity of fertilizer use by Kieni West farmers again, could be explained by harsh environmental conditions and therefore, high risks in wheat production. Where there are high production risks like Kieni West division, farmers are unlikely to apply fertilizer. These results are inconsistent with the findings reported by Shiferaw and Holden (1998) which found location of a farmer in terms of a farmer being in high rainfall area to negatively and significantly influence decision to retain conservation structures in Ethiopia. However, these results concur with findings reported by Salasya, *et al.* (1997), which found location of a farmer in terms of a farmer being in high rainfall area to positively and significantly influence adoption of improved maize seeds and fertilizer.

Gender of household head influenced adoption and intensity of fertilizer use significantly at P<0.05 probability level. The positive sign on the dummy for a farmer being a male household head show that, male household heads had a higher probability of adopting and using more fertilizer compared to female household heads. The explanation could be that male household heads could have had more education and therefore, had more access to information on fertilizer and/or male household heads could have had higher resource base than female household heads, thus higher probability of adoption and intensity of fertilizer use. The results were inconsistent with findings reported by Wanyoike, *et al.* (2000) and Mose, *et al.* (2000) but consistent with findings reported by Njue, *et al.* (1998).

Extension services are the link between the researchers and the farmers. That is, extension agents get technologies from researchers and disseminate the same to the farmers. So access to extension services is an important factor in adoption and intensity of use of a given technology. The results reveal that contact with extension services impacted on adoption and intensity of fertilizer use positively and was significant at P<0.01 probability level. These results are in agreement with adoption-diffusion theory and implied that households that were in contact with extension services were more likely to adopt fertilizer use compared to households that were not. Many adoption studies have found the same results. Studies by Nkonya, *et al.* (1997), Judicate, *et al.* (1998), Wanyoike, *et al.* (2000) and Sall, *et al.* (2000) among others have shown access to extension services to be an important factor in influencing adoption decisions.

Decomposition of Tobit model in Table 15 shows that, marginal changes in an explanatory variable *ceteris paribus*, had higher effects on probabilities of adoption than on intensity of adoption. This means marginal changes in an explanatory variable would cause high changes in probability of adoption of a given technology than it would cause on intensity of its use. For instance, a positive unit change in contact with extension services *ceteris paribus,* would increase the probability of fertilizer use by 8.115 percent while increasing its application by 4.427kg/acre among adopters and by 12.542kg/acre for all the farmers. Likewise, an increase in family size by an extra member *ceteris paribus*, would decrease the probability of adoption of fertilizer use by 0.708 percent while reducing its application by 0.387Kg /acre among the adopters and 1.095Kg/acre for all the farmers. These results are consistent with the findings reported by Sall, *et al.* (2000) and Wanyoike, *et al.* (2000) which found marginal changes in an explanatory variable to cause higher changes in probability of adoption than it causes on its intensity of use.

4.2.5 Correlation between Farmer's Perception of Technology-Specific and Adoption and Intensity of Use of Improved Wheat Varieties

Spearman's Coefficient of Rank Correlation (r_s) results, revealed that correlation between farmer's perception of improved wheat varieties specific-attributes and adoption and intensity of use of improved wheat varieties was 0.133 and significant at P<0.05 probability level. The calculated r_s=0.133 is more than the critical r_s=0.028 meaning that the calculated r_s lies out side the acceptance region. Therefore, the null hypothesis was rejected and the alternative hypothesis accepted at P<0.05 probability level. Hence, we conclude that there is a positive correlation between farmer's perception of improved wheat varieties-specific attributes and adoption and intensity of use of improved wheat varieties. The results were not surprising given that technologies that are favourably perceived by the farmers have a high probability of being adopted. These results are consistent with findings reported by Wanyoike, *et al.* (2000), Shiferaw and Holden (1998), Adesina and Zinnah, (1993), Makokha, *et al.* (1999) and Adesina and Baidu-Forsen (1995) which found farmer's perception of technology-specific attributes to positively and significantly influence adoption decisions.

4.2.6 Correlation between Farmer's Perception of Technology-Specific and Adoption and Intensity of Fertilizer Use

Spearman's Coefficient of Rank Correlation (r_s) results revealed that correlation between farmer's perception of fertilizer-specific attributes and adoption and intensity of fertilizer use was found to be 0.251 and significant at $P<0.01$ probability level. The calculated $r_s=0.251$ is more than the critical $r_s=0.056$ meaning that the calculated r_s lies out side the acceptance region. Therefore, the null hypothesis was rejected and the alternative hypothesis accepted at $P<0.05$ probability level. Hence, we conclude that there is a positive correlation between farmer's perception of fertilizer-specific attributes and adoption and intensity of fertilizer use. The results were not surprising given that technologies that are favourably perceived by the farmers have a high probability of being adopted. These results are consistent with findings reported by Wanyoike, *et al.* (2000), Shiferaw and Holden (1998), Adesina and Zinnah (1993), Makhoha, *et al.* (1999) and Adesina and Baidu-Forsen (1995) which found farmer's perception of technology-specific attributes to be positive and significant in influencing adoption decisions.

CHAPTER FIVE: CONCLUSION AND POLICY IMPLICATIONS

5.1. Conclusions

The study has examined the socioeconomic factors that influence farmer's perception of improved wheat varieties and fertilizer-specific attributes and socioeconomic factors influencing farmers' decision to adopt and the use intensity of improved wheat varieties and fertilizer. Also examined was the correlation between farmer's perception of technology-specific attributes and adoption and intensity of use of improved wheat varieties and fertilizer.

From the results of the study, it can be concluded that education level, distance to seed markets, access to extension services, household size and total number of livestock units correlated with farmer's perception improved varieties-specific attributes significantly. Gender of household head, farmer's experience in wheat farming, farm size, education level, household head's affiliation to an organization and number of livestock units correlated with farmer's perception of fertilizer-specific attributes significantly.

Agro-Ecological Zone in terms of the farmer being in high potential or marginal area, farm size, farmer's experience and distance to seed market influenced adoption and intensity of use of improved wheat varieties significantly. However, in terms of the farmer being in high potential or marginal area, gender of the household head and access to extension services influenced adoption and intensity of fertilizer use significantly.

Farmers' perception of improved wheat varieties-specific attributes correlated with the adoption and intensity of use of improved wheat varieties significantly. In addition, farmer's perception of fertilizer-specific attributes correlated with the adoption and intensity of fertilizer use significantly. The study also revealed that farmer's perception of technology-specific attributes and adoption and intensity of use of agricultural technologies patterns are technology-specific. The study also revealed that marginal changes in an explanatory variable *ceteris paribus,* had higher effects on probabilities of adoption than on the intensity of adoption (use).

Majority of farmers (36 percent) did not know the varieties they grew. The popular known wheat varieties were Duma and Chiriku reported by 22 and 18.7 percent of the farmers. The major sources of wheat seed for the farmers were found to be other farmers and own seeds reported by 50.0 and 37.3 percent of the farmers respectively. Major reason given for choice of preferred varieties was high yielding as reported by 70 percent of sampled farmers.

Major constraints to adoption of fertilizer were reported as high cost of fertilizer, use of manure and perception by the farmers that fertilizer spoils the soils. Similarly, constraints to adoption of improved wheat varieties were cited as lack of knowledge about improved wheat varieties and high cost of improved wheat varieties (seeds). Major constraint in wheat production were cited as damage by insect, animal/ birds, drought, and high cost of inputs and shortages of working capital. Farmers cited marketing problems as lack of reliable markets and stealing of wheat by brokers.

5.2. Policy Implications

Based on the findings and conclusions of the study extension services was found to be essential in disseminating improved methods of farming which are important in increasing agricultural productivity. Therefore, lack of the same implies depressed agricultural production. Thus, there is need to strengthen information delivery services.

The study revealed that marginal changes in an explanatory variable *ceteris paribus*, had a higher effect on probabilities of adoption than on intensity of adoption. This shows that extension agents need target the farmers who have not adopted the technology rather than try to increase the intensity of use of the technology by the farmers who have already adopted.

The study has also revealed that, socioeconomic factors influencing farmer's perception of technology-specific attributes and adoption and intensity of use are specific to a given technology. This implies that for every technology developed a study of factors influencing farmer's perception of technology-specific attributes and adoption and intensity of adoption of the technology need to be carried out. Where the technology is made up of several separate components like improved seed, fertilizer use and crop husbandry, a study on factors influencing adoption of each component should be carried out, since the components are not adapted to the same level by the farmers (Njue, *et al.,* 1998).

The farmer-extension-research linkages need to be strengthened. The study revealed that 36.0 percent of the farmers used unknown wheat varieties and only 7.3 percent of the farmers used the recently released varieties like Njoro BW1, Njoro BW2 and Mamba. This could be an indication of poor technology transfer from the researchers to the farmers. Mwangi (1998) contended that no matter how well new technologies work, if farmers do not use them their development is in vain.

Agricultural productivity growth requires development and delivery of productivity enhancing-technologies and appropriate incentives and enabling mechanisms for the farmers to adopt such technologies. Therefore, input delivery systems and promotion of private sector participation in inputs and product markets need to be improved. This calls for the government to improve the infrastructure and rural road networks to help in reduction of the transportation and transactions costs for the farmers and inputs suppliers. Improvement of rural road networks has both inputs and output price effects on agricultural development.

5.3 Area for Further Research

This study was a static analysis, and the results were based on stated preferences. Therefore, dynamic analysis using panel data to get revealed preferences over time should be investigated.

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APPENDIX 1

SURVEY QUESTIONNAIRE

The purpose of this exercise is to identify reasons for adoption and non-adoption of improved wheat varieties and fertilizer use in wheat production. The farmers have been randomly selected in Nakuru and Nyeri districts. The information gathered through this questionnaire is confidential and is only meant for use in this study.

Section A: Information on farm and farm operator characteristics

1.Name of the interviewee / household head…………………………...............

2.Date of the interview………………………………………………………………..

3.District…………………………………………………………………………………

4.Division………………………………………………………………………………..

5.Sex of the head of the household……………………. (1) Male (0) Female

6.Age of the head of household………………………………Years

7.If female, married? (1)…Yes (2)………No

8.If female and married, where is the husband?

Dead……………………………………..(1)

Divorced…………………………………(2)

Working outside…………………………(3)

Other (Specify)……………………………(4)

9.Household head's and spouse's number of children

……………………………………………..

10.Any other dependants that are not household head's children or spouse?………………

11.Household head's major occupation.

(1). Farming

(2). Business

(3). Civil servant

(4). Domestic house wife

(5). Non-full time employee

(6). Unemployed

(7). Others (specify)……………………..

12.Who make decisions on the type of practices to be adopted on this farm?

(1)…. Wife (2)……… Husband.

13. Do you have formal education? 1 Yes 0 No

If yes, how many years were you in school?.......Years.

14.What is the highest level of formal education that the household head have attained?

(0) No formal education

(1). Primary

(2). Secondary

(3). Tertiary

(4). University

(5). Others (specify)………………………….

15. Total farm size……………acres

16. Land under wheat……………………………………...acres in 2004-cropping season.

17. How many 90Kgs bag did you harvest during the 2004-cropping season?……bags.

18.Land tenure of the farmer

(1)……….Own (2)………Family (3)……….Rented (4) ....own/family

19.If renting,, area…………….. acres

20.Land rented for wheat growing…………..acres

21.Since you acquired the land you are using has land size (1) remained the same (2) Increased (3) decreased

22.How long have you been farming wheat? ……………Years

23.What distance do you travel to get seeds?

1. Same village
2. < 5 Km
3. 5 – 10 Km
4. > 10 Km

24.What distance do you travel to get fertilizers?

1. Same village
2. < 5 Km
3. 5 – 10 Km
4. > 10 Km

25.What distance do you travel to sell your wheat produce?

1. Same village
2. <5 Km
3. 5-10Km
4. >10 Km

26.What are sources of your information for adopted varieties and fertilizer?

1. Extension 5. Radio 8. Other farmers

2. Field day
3. Research Centres
4. Seed dealers
6. Demonstrations
7. F.T.CS
9. Agricultural shows
10. Seminar / workshops

27.Did an extension Officer visit you 2004-cropping year?

1. …… Yes 2. ……… No

28.If yes what time of the year or during which operations.

1.Ploughing. No. of visits …………………………

2.Planting No. of visits …………………………

3.Weeding No. of visits …………………………

4.Harvesting No. of visits …………………………

29. Did you obtain credit during 2004-cropping season? (1)……… Yes (2.) …… No

30.If yes, what kind of credit did you receive?

1. Money 2. Fertilizer 3. Seed 4. Others (specific)

If no, give reasons

1.Lack of collaterals

2.Credit conditions difficult to meet.

3.High cost of credit.

4.No banking institution nearby

5.Others (specify).

31.What number of livestock did you have on the farm during 2004-cropping season as per categories listed below.

Categories	Breed	Number
Mature cows (over 2 years)	…………	…………………
Heifers (1-2 years)	………..	…………………
Calves	………..	…………………
Sheep / Goat		…………………
Others		…………………

32.Are you a member of an organization?

1..........Yes 0............No

If yes which one?

(1). Self help group …………………………………………………………

(2). Co-operative ……………………………………………………………

(3). Others (specify)……………………………………………………....

If No give reasons.……………………………………………………………

33. A part from farm income did you have another source of income during 2004-cropping season?

1 Yes 0 No

If yes, from which source

1 Business

2 from employed children

3 Interest from shares/savings

4 Other sources (specify)

34. Did you use hired labour during the 2004-cropping season? 1 Yes 0 No

If yes,

(i) How many permanent laborers did you have?

(ii) How many casual .... and for how many mandays?

Section B. Technology Adoption

35.Are you aware of any wheat production technology? (1)….. Yes (2)….. No

If yes, which technology are you aware of?

(1). High yielding wheat varieties.

(2). Fertilizer rate application.

(3). Pest and disease control.

(4). Weed control.

(5). All of them.

36.Do you use fertilizer?

(1)…….. Yes (2)………No

If yes, what quantity per acre? ………. Kgs

If no, give reasons

Expensive………………………………………………..(1)

Not accessible……………………………………………(2)

Lack of knowledge………………………………………(3)

Others (specify)…………………………………………….(4)

37.Which type of wheat varieties do you use?

Chozi, Mbuni, Mbega, Kwale, Pasa, Popo,Chiriku, Duma Ngamia, Heroe and others (specify)………………………

38. If more than one variety, give reasons

(1).. (2)............................ (3).................................

39. How many years have you used the mentioned improved wheat varieties?.........Years.

40. Where do you obtain your seeds from?

(1) Own seeds

(2) Kenya seed Company

(3) Other farmers

(4) Stockiest

(5) Others (Specify)

40. What quantity of seed do you use per acre?.............................Kgs

41. Did you plant new varieties in the 2004-cropping season?

1....yes 2.......No

If you did not use new wheat varieties, give reasons

(1) Expensive

(2) Not accessible

(3) Lack of knowledge

(4) Others (specify)

42. If used new varieties, what quantity of seed did you use per acre?.............................Kgs

43.Why did you choose the seeds you used?

(1) High yielding

(2) Early maturity

(3) Pest and diseases resistance

(4) Sprouting resistance

(5) Lodging resistance

(6) Others (specify)......................................

44. What was the source of your new wheat varieties?

(1) Own seeds

(2) Kenya seed Company

(3) Other farmers

(4) Stockiest

(5) Others (Specify)

45.To what extent have improved wheat varieties been available at your nearest stockiest whenever you need them for the last two years?

1.Always available

2.Sometimes available

3.Rarely available

4.Never available

46.To what extent have fertilizer been available at your nearest stoctists whenever you need it for the last tow years?

(1). Always available

(2). Sometimes available

(3). Rarely available

(4). Never available

47. How did you plough your land during the 2004-cropping season? 1 Tractor 2 hand

48. How did you plant your wheat during 2004-cropping season? 1 machine 2 manual (broadcasting)

49. How many times did you plough your land during 2004-cropping season?.......times

50. How many times did you harrow your land during 200-4 cropping season? ...... times.

51. What constraints did you facing in wheat production during the 2004-cropping season?

1. High cost of inputs
2. Lack of water / drought
3. Difficult to obtain farm inputs
4. Damages by insects, animals or diseases
5. Technical matters (specify them)
6. Lack of reliable market
7. Low yields
8. Lack of machineries
9. Shortage of working capital
10. Others (Specify)

Section C

The following questions will be used to measure farmer perception of improved wheat varieties and fertilizer specific attributes. Please answer all questions by ticking the appropriate box and scale them. Strongly agree is given a scale of 5 and strongly disagree a scale of 1.

1. Use of improved wheat varieties is a technology that is profitable.

Strongly agree ( )
Agree ( )
Uncertain ( )
Disagree ( )
Strongly disagree ( )

2. Fertilizer rate when used in wheat production is profitable.

Strongly agree ( )
Agree ( )
Uncertain ( )
Disagree ( )
Strongly disagree ( )

3. Pest and disease control when used in wheat production if profitable.

Strongly agree ( )
Agree ( )
Uncertain ( )
Disagree ( )
Strongly disagree ( )

4. Improve wheat varieties is consistent with farming systems, objectives and values.

Strongly agree ( )
Agree ( )
Uncertain ( )
Disagree ( )
Strongly agree ( )

5. Fertilizer use is consistent with the farming systems, objectives and values.

Strongly agree ( )
Agree ( )
Uncertain ( )
Disagree ( )
Strongly agree ( )

6. Pest and disease control is consistent with past experience, farming systems, objectives and values.

Strongly agree ( )
Agree ( )
Uncertain ( )
Disagree ( )
Strongly agree ( )

7. Improved wheat varieties can be tried on small area without interfering with other activities.

Strongly agree ( )

Agree ( )

Uncertain ( )

Disagree ( )

Strongly disagree ( )

8. Fertilizer use in wheat production can be tried on small area without interfering with other activities.

Strongly agree ( )

Agree ( )

Uncertain ( )

Disagree ( )

Strongly disagree ( )

9. Pest and disease control can be tried on small area without interfering with other activities.

Strongly agree ( )

Agree ( )

Uncertain ( )

Disagree ( )

Strongly agree ( )

10. Improved wheat varieties present a complex task to implement in wheat production.

Strongly agree ( )

Agree ( )

Uncertain ( )

Disagree ( )

Strongly disagree ( )

11. Fertilizer use presents a complex task to implement in wheat production.

Strongly agree ( )

Agree ( )

Uncertain ( )

Disagree ( )

Strongly disagree ( )

12. Pest and disease control presents a complex task to implement in wheat production.

Strongly agree ( )
Agree ( )
Uncertain ( )
Disagree ( )
Strongly disagree ( )

13. Use of improved wheat varieties in wheat production can show its superiority in terms of yields.

Strongly agree ( )
Agree ( )
Uncertain ( )
Disagree ( )
Strongly disagree ( )

14. Fertilizer use in wheat production shows its superiority in terms of yields.

Strongly agree ( )
Agree ( )
Uncertain ( )
Disagree ( )
Strongly disagree ( )

15. Pest and disease control in wheat production shows its superiority in terms of yields.

Strongly agree ( )
Agree ( )
Uncertain ( )
Disagree ( )
Strongly disagree ( )

APPENDIX 2

Livestock units for various livestock categories

Livestock		Livestock units
Cows	Dairy grade, breeding bulls	1.00
	Dairy crosses	0.80
	Indigenous	0.65
Heifers and steers drought	Dairy	0.90
	Cross	0.70
Oxen (2-3 years)	Indigenous	0.60
Heifers and steers		
(1-2 years)	Dairy	0.65
	Cross	0.50
	Indigenous	0.45
Heifers and steers		
(up to 1 year)	Dairy	0.30
	Cross	0.25
	Indigenous	0.20
Sheep/Goats	Mature	0.15

Source: Farm Management handbook of Kenya Vol. 111B
Agricultural costs and Prices 1983

APPENDIX 3

Table of Pearson Product Moment Correlation Coefficient for Testing Multicollinearity among the Independent Variables

Variable	$FP_{Tchseed}$	$FP_{Tchfert}$	HH_{Nakuru}	HH_{Male}	HH_{Age}	HH_{Size}	HH_{Educ}	FA_{Size}	HH_{Exper}	Mkt_{Seed}	Mk_{tFert}	EX_{cont}	$HH_{CreditT}$	TL_{Units}	HH_{organ}	$HH_{Off-farm}$
$FP_{Tchseed}$	1															
$FP_{Tchfert}$	.315**	1														
HH_{Nakuru}	.098	-.092	1													
HH_{Male}	.059	.227**	.071	1												
HH_{Age}	-.124	.044	-.014	.124	1											
HH_{Size}	-.182*	.076	-.091	.034	.616**	1										
HH_{Educ}	.256**	.134	.169	.219**	-.371**	-.477**	1									
FA_{Size}	.022	.147*	.105	.123	.289**	.216**	.183*	1								
HH_{Exper}	.043	.202*	.125	.089	.271**	.169*	.120	.503**	1							
Mkt_{Seed}	.136	.145	-.034	.077	.122	.115	.120	.065	.261**	1						
Mk_{tFert}	.131	.065	.031	.109	.022	.043	.242**	.032	.074	.598	1					
EX_{cont}	.177*	.096	.080	.119	.027	.089	.214**	.109	.123	-.055	.065	1				
$HH_{CreditT}$	.036	..061	.000	.101	.002	.006	.029	.006	.027	.002	-.046	.004	1			
TL_{Units}	.137	.235**	.196*	.065	.192*	.151*	.113	.458**	.326**	.115	.147*	.139*	-.055	1		
HH_{organ}	-.007	-.095	.279**	-.049	.107	.086	-.027	.093	.110	.089	.020	.212**	.068	.164	1	
$HH_{Off-farm}$	.021	.072	.027	.108	-.015	.004	.129	.099	-.049	.114	.036	-.011	.048	.102	.132	1

Note: ** Significant at P<0.01 probability levels

* Significant at P<0.05 probability levels

Source: Field Survey Data