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Full Length Research Paper

Adoption of improved agricultural technologies among smallholder farm households in Nakuru District, Kenya

Immaculate Njuthe Maina[1]*, Ingrid-Ute Leonhäuser[2] and Siegfried Bauer[3]

[1]Kenya Agricultural Research Institute (KARI), Socioeconomics and Applied Statistics Division, Kenya.
[2]Justus-Liebig-University Giessen, Nutrition Education and Consumer Behaviour, Germany.
[3]Justus-Liebig-University Giessen, Project and Regional Planning, Germany.

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Households are institutions that nurture, develop and sustain capabilities, material and social resources and activities necessary for their members to sustain livelihoods. This is possible through socialisation, communication, diffusion and adoption of improved technologies. In developing countries like Kenya, adoption of improved agricultural technologies is critical in facilitating households' productive and consumptive capabilities and functions for better livelihoods. Yet, the adoption of such technologies remains low. Households are made up of male and female members whose roles, responsibilities, rights and entitlements often differ. Therefore, there is need to understand how the conditions supporting the adoption process vary across male and female farmers and within households. This paper adopts the livelihood systems framework in analysing the influence of socio-economic characteristics that influence men and women to adopt improved agricultural technologies. The field survey involved individual interviews with 190 randomly selected rural households from Nakuru District, Kenya. Data analysis procedures included descriptive statistics, factor analysis and a binary logistic regression model. Results indicate that men are more likely than women to adopt improved technologies while the propensity to adopt increases with increasing distance to market. Adoption is supported by social inclusion and peace and is more likely to occur among poorer, younger farmers, without skills for off-farm employment. Given that a wide range of male and female farmers' socio-economic characteristics influence adoption, careful analysis should always precede all efforts aimed at encouraging adoption of new and improved agricultural technologies.

Key words: Nakuru, Kenya, sustainable livelihoods framework, agricultural technology, adoption, gender, sustainable livelihoods.

INTRODUCTION

Kenyan economy is largely agro-based, with the agricultural sector accounting for 26% of the gross domestic product (GDP), 60% of the export earnings, over 80% of employment and 57% of national income (GoK, 2004). Agriculture also links with manufacturing, distribution and service related sectors to make an indirect contribution of 27% to the gross domestic product (GDP) of the country. There is therefore a direct relationship between growth in the agricultural sector and that of the entire economy (Figure 1).

In developing countries like Kenya, where most of the rural people are involved in agricultural production, adoption of improved agricultural technologies is an important strategy for facilitating households' productive and consumptive capabilities for better livelihoods. Households are institutions that act individually and in social context to nurture, develop and sustain capabilities, material and social resources so as to develop human potential and shape everyday culture (Schweitzer, 2006). They are not homogenous units but instead are made up of male and female members whose spheres of influence, roles and responsibilities and

*Corresponding author. E-mail: inmaina@kari.org, Maina@gmail.com. Tel: +254-20-4183301-20. Fax: +254-20-4183344.

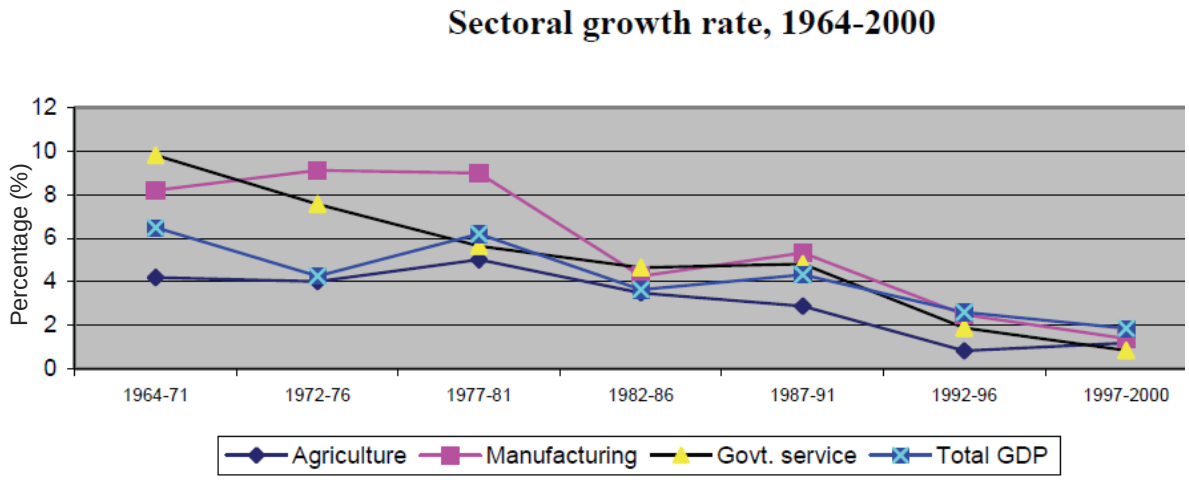

Figure 1. The relationship between growth in the agricultural sector and that of the entire economy.

entitlements differ. Thus, there is need to understand, the influence of individual characteristics of the female and male farmers and those of their households on adoption decisions.

Adoption of innovations has received great attention from scholars. The subject has been studied from the view of active knowledge accumulation (Feder and Slade, 1994); adoption of single farm inputs such as fertilizers or herbicides (Mbata, 1994; Omamo et al., 2002; Dadi et al., 2004; Freeman and Omiti, 2003); from the view of the household level characteristics including gender (Marenya and Barrett, 2007; Franzel et al., 2003), from the platform of broad policy issues (Lee, 2005; Smale, 2005; Anandajayasekeram et al., 1997); as a social learning process (Conley and Udry, 2001; Isham, 2000); as a method for improving research priority–setting (Batz et al., 2003; Elliott, 2004); it has been integrated into geographic information systems (GIS)-measures for understanding and differentiating locational effects such as market access, demographics and agro-climatic zones (Staal et al., 2002); it has been assessed as an interactive process between public investments and community health (Ersado et al., 2004) and also as a part of international development efforts for providing development support to developing countries (Baker and Edmonds, 2004). These studies emphasize the socio-economic environment within which the new technology is adopted and applied. They neglect to consider the factors that drive the innovation-decision process. This paper seeks to fill this gap by considering the factors that influence the way that men and women in small farm holdings make adoption decisions.

Adoption decisions have been shown to occur following the innovation-decision process (Rogers, 1995). The innovation-decision process consists of a series of actions and choices over time through which individuals or other decision-making unit evaluates a new idea and decides whether or not to include the innovation into existing practices. The process underscores demand for information about new ideas while creating opportunities for farmer empowerment through their active involvement in decision-making. Empowered clients are better able to articulate their needs, can negotiate effectively with public and private sector service providers, command recognition in collaborative efforts and can bear the consequences of their involvement in collaborative efforts (Lightfoot, 2004). The innovation-decision process (Figure 2) evolves through the following stages: the knowledge stage; the persuasion stage; the decision stage; implementation stage; and the confirmation stage (Rogers, 1995).

In the knowledge stage, farmers are exposed to innovations in existence within the agricultural knowledge system and they gain some understanding of their functioning. This occurs in an active process of communication between farmers and various external actors including agricultural researchers and extension agents. This stage is a social process in which men and women may have different entitlements, priorities, leadership styles or socio-economic characteristics all affecting how knowledge is sought and utilized (Rogers, 1995). For farmers to make the decision to invest their limited resources in new technologies, these technologies must possess certain attributes and components that appeal to the farmer. The technologies should also fulfil the farmers' varied needs. Perceptions of farmers towards technologies have been found to affect adoption of technologies (Rogers, 1995; Heffernan et al., 2008). At the persuasion stage, farmers' groups actively seek information about technologies that are deemed to have the greatest potential in satisfying their needs and discriminate against those that do not. Information plays an important role in mediating the understanding and effective use of the technology. This information base is

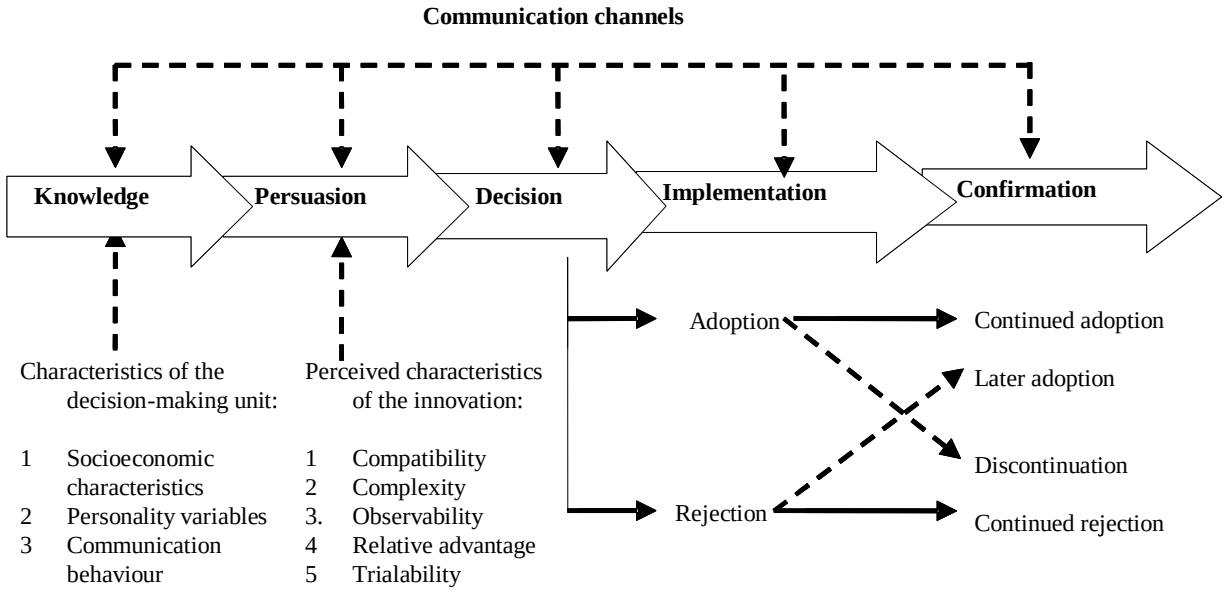

Figure 2. The decision-innovation process. Source: Rogers (1995).

intrinsic and not supplementary to any technology because a focus on the product without knowledge of its use and application renders the physical entity useless (Bozeman, 2000). Rogers (1995) argues that it is at the decision stage that a technology is fully accepted (continued adoption) or is rejected. However, sometimes a technology may be used for a time and then abandoned (discontinuance) and at other times the rejected technology may be adopted later (later adoption) or it may be subjected to continued rejection. Implementation of the demanded technology occurs when the decision-making unit puts the innovation to use (Rogers, 1995). For effective application of new knowledge farmers require guidance and support. Confirmation occurs when the innovation-decision is reinforced (Rogers, 1995).

Furthermore, most of these adoption studies use the female-headed households and male-headed households' dichotomy to establish the determinants of technology adoption in each gender. The female-headed, male-headed households dichotomy may mislead because such a dichotomy assumes that adoption decisions, made by the household head apply broadly within the household and overrides those of individual (male and female) farmers within the same household (Morrison et al., 2007). Yet, empirical evidence shows that adoption decisions within households are undertaken in decentralized processes (Ashaw and Admassie, 2004). Many economic decisions made within households are dependent upon the characteristics of both men and women members (Doss and Morris, 2001; Doss et al., 2003). This study analyzes the gender differences in factors that constitute the innovation-decision process using the dichotomy of male and female farmers, instead of female-headed households and male-headed households. This is intended to establish whether, or not, gender is a statistically and practically significant determinant of technology adoption, and whether, or not, women are systematically disadvantaged relative to men with respect to the factors under study. The acknowledgement of gender as a policy issue that has far reaching implications in society can be found in the third Millennium Development goal (MDG): promote gender equality and empower women (UN Millennium Project, 2005).

Theoretical framework

In discussions regarding rural development, poverty reduction and environmental management, the term sustainability is linked to sustainable rural livelihoods (Scoones, 1998; Chambers and Conway, 1991; Ellis and Alison, 2004). The concept of sustainable rural livelihoods seeks to understand the context (including the politics settings, politics, history, agro-ecology and socioeconomic conditions) and the livelihood resources available to rural populations and which determine their livelihood strategies. Rural persons pursue different livelihood strategies in support of their families. Some of the strategies include agricultural intensification, livelihoods diversification and also migration. Analysis of sustainable rural livelihood is ultimately interested in the outcomes realised by rural households and the roles played by the formal and informal institutions upon which rural households depend on for their everyday living conditions.

For ease of analysis the aforementioned concepts are

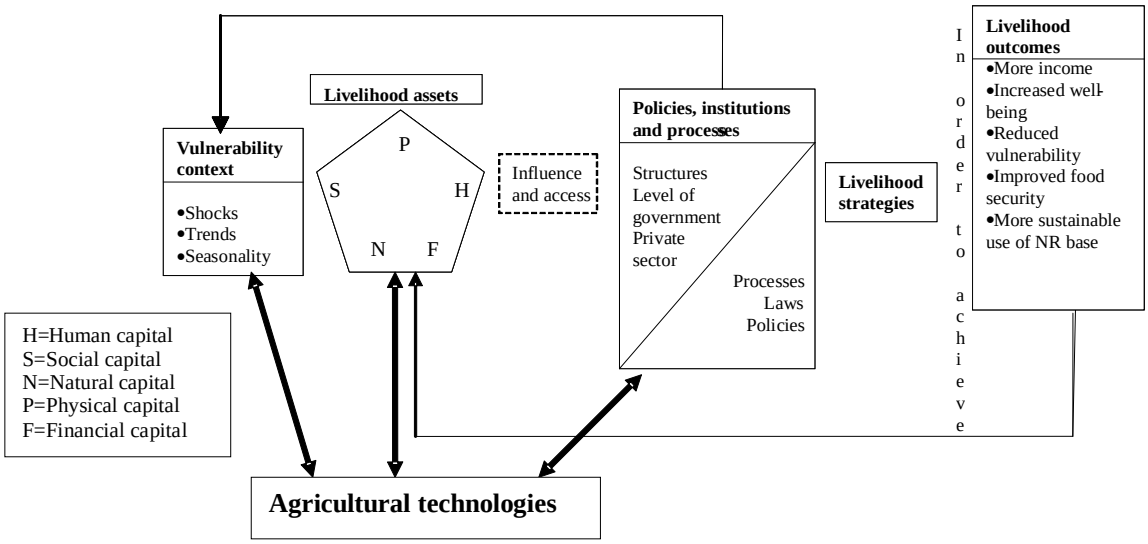

Figure 3. Sustainable livelihoods framework. Source: Adato and Meinzen-Dick (2002).

often organized into a framework; the sustainable livelihoods framework (Figure 3). The sustainable livelihoods framework is used to analyse these cross-sectional and multi-occupational characters of contemporary rural livelihoods (especially in low-income countries), as well to understand the complexity of livelihood strategies needed to reduce rural poverty. The framework provides a checklist of issues and their linkages; shows schematically the main influences and processes and depicts the multiple interactions that exist between the different factors that affect rural livelihoods. The five main features of the framework include the vulnerability context, the livelihood assets, the transforming structures and processes, livelihood strategies and the livelihood outcomes.

In the framework, sustainable livelihoods, are defined in relation to livelihood resources (natural, economic, financial, human and social capitals) which are combined in the pursuit of different livelihood strategies and also to the range of formal and informal organisational and institutional factors that influence sustainable livelihood outcomes (Scoones, 1998). Another important feature of the sustainable livelihoods framework is that it recognizes people, whether poor or not, as actors with assets and capabilities with which they actively pursue their own livelihood goals (Adato and Meinzen-Dick, 2002). This paper specifically assesses the five livelihood capital assets (human; social natural, physical, financial) and their influence on adoption of improved agricultural technologies.

Assets matter because assets beget assets; they influence earnings; they are required for production; they smooth consumption; buffer risk; they are required to enable households make additional purchases and their accumulation is instrumental to households' escape from poverty (Schreiner, 2005). Assets also influence behaviour, so that, the better off have positive attitudes towards their future (Sherraden, 1991). Wealth indicator variables have been linked to adoption of technologies (Asfaw et al., 2011) and to reduction in risks associated with adoption of technologies (Mariam et al., 1993).

MATERIALS AND METHODS

Study area

This study was carried out in Nakuru district (Figure 4), which holds 4% of Kenya's total population at a population density of 164 persons per square kilometre and at a growth rate of 3.4%. According to the 1999 National Population and Housing Census, the gender division of this population was 588,336 (or 49.6%) females and 598,708 (or 50.4%) males (GOK, 2001).

Sampling and data collection

The sampling frame was constituted from lists of men and women, members of farmers' groups that were implementing technologies listed in Table 1. Farmer groups are organizations for collective action often formed among neighbours and peers based on the principle of free membership, to pursue specific common interests of their members (Hussein, 2001). Farmers' groups, especially those formed by smallholders, are important institutions for agricultural technology uptake in Kenya (Place et al., 2002; Davies et al., 2004).

The simple random sampling procedure was used to select men and women from 20 farmers' groups. The total membership of these groups was 494, made up of 200 men and 294 women. To ensure representation, the size of the sample selected for the study followed the procedure for "estimation of a population proportion" outlined by Scheaffer et al. (2006). Following the procedure: $y_i = 0$ if the ith element sampled does not possess the character of interest, (non-adopter) and $y_i = 1$ if it does (adopter). Then the total number of elements in the sample of size n possessing the specified

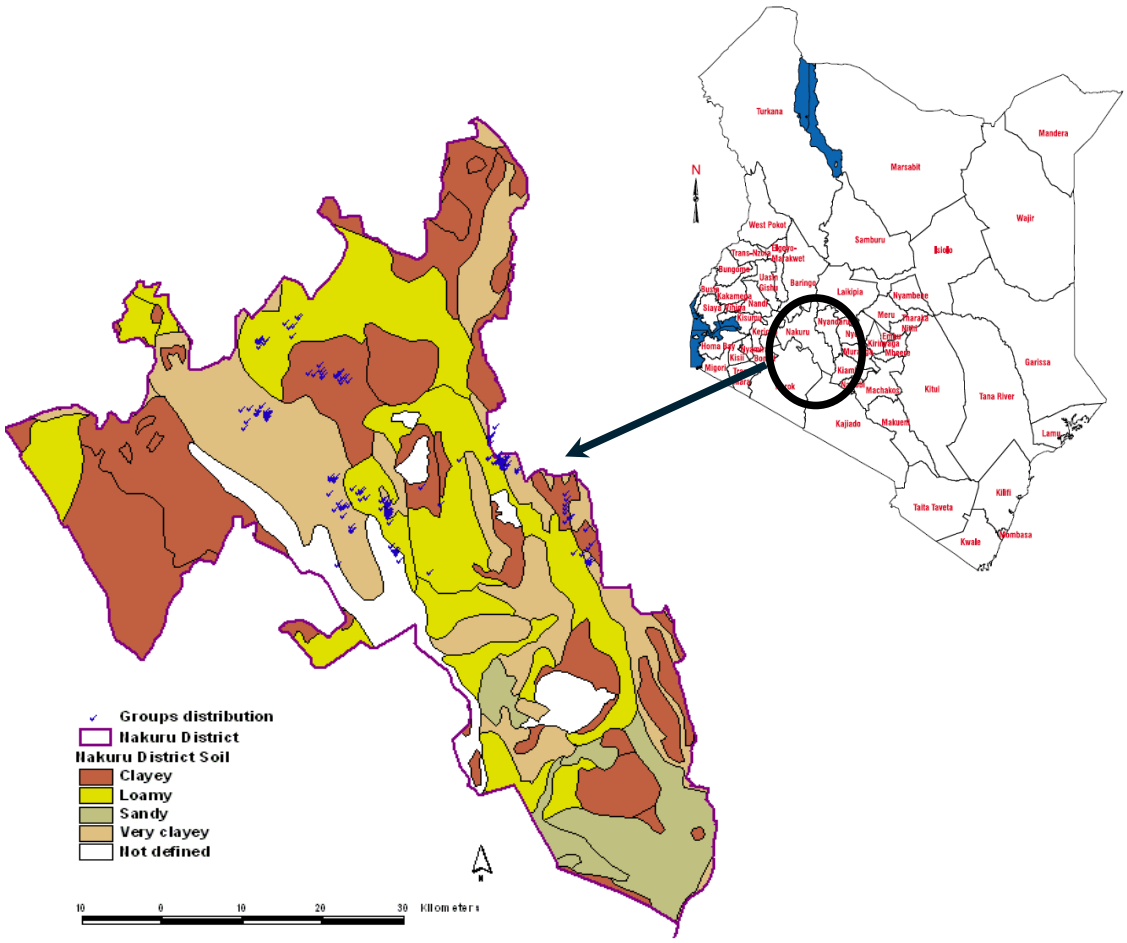

Figure 4. Map of Nakuru District showing the soil types in the district and the location of sampled households Source: International Livestock Research Institute (ILRI); geographic information systems (GIS) laboratory with distribution of group members' households from the field data.

Table 1. Types of technologies implemented by the farmers groups.

Technology class	Type of technology	Number of farmers' groups
Livestock production	Rearing dairy goats	6
	Rearing sheep	1
	Rearing indigenous chickens	1
	Beekeeping	2
Farm mechanization	Use of motor chaff cutters	1
Soil and water management	Drip irrigation	2
	Water harvesting technology	2
	Tree nursery	1
Crop management	Sunflower	1
	Tissue culture banana	1
	Seed potato production	1
	Fruit production	1
Total		20

characteristic is:

$$\sum_{i=1}^{n} yi \quad (1)$$

When a simple random sample of size *n* is drawn, the sample proportion, $\hat{p}$, is the fraction of the elements in the sample that possess the characteristic of interest. In this case, $\hat{p}$ of adopting farmers in Nakuru District is:

$\hat{p}$ = Number of adopting farmers sampled or:

$$\hat{p} = \frac{\sum_{i=1}^{n} yi}{n} = \bar{y} \quad (2)$$

Number of farmers sampled:

$\hat{p}$ is the average of the 0 and 1 values from the sample.

Similarly, the population proportion is the average of the 0 and 1 values for the entire population, hence, $p = \mu$. The estimator of the population proportion *p* is:

The estimated variance of $\hat{p}$ is:

$$\hat{p} \cdot \bar{y} = \frac{\sum_{i=1}^{n} vi}{n} \quad (3)$$

Where $\hat{q}$ = 1 - $\hat{p}$

$$\hat{V}\left(\hat{p}\right) = \frac{\hat{p}\hat{q}}{n-1}\left(\frac{N-n}{N}\right) \quad (4)$$

The bound on the error of estimation is:

$$\sqrt[2]{\hat{V}\left(\hat{p}\right)} = \sqrt[2]{\frac{\hat{p}\hat{q}}{n-1}\left(\frac{N-n}{N}\right)} \quad (5)$$

Sample size required to estimate *p* with a bound on the error of Estimation *B* is:

$$n = \frac{Npq}{(N-1)D + pq} \quad (6)$$

When the value of *p* is unknown, as was the case in this study, (since there exists no other past surveys for the population of interest; that is, the farmers adopting KARI/ATIRI technologies in Nakuru District), in such circumstances, substitution into the equation with p = 0.5 is done (Scheaffer et al., 2006: 95). Hence:

$$n = \frac{Npq}{(N-1)D + pq}$$

$$= \frac{(494)(0.5)(0.5)}{(493)(0.000625)+(0.5)(0.5)} = \frac{123.5}{0.558125} = 221 \quad (7)$$

Therefore, the required sample size was thus determined to be 221 respondents.

Procedure for determining proportionate samples of men and women

The population, from which the sample of men and women was drawn, was considered as two strata made up of the gender. Sampling at the level of the population and also at the level of the group was stratified between the two genders. In order to establish proportional numbers of men and women in the total population for all the groups the following formula was applied:

$$s = \left(\frac{N}{M}\right)n \quad (8)$$

Where:

s = Strata, N = sample size, M = total population, n = total number in the strata.

Therefore, the required sample for men was:

$$\left(\frac{221}{494}\right)200 = 89$$

and for women:

$$\left(\frac{221}{494}\right)294 = 131 \quad (9)$$

Procedures for data collection

Data was collected in a field survey through structured individual interviews. A formal survey using a structured questionnaire was administered to individual men and women, members of farmers' groups, by the researcher with the help of enumerators. The questionnaire included on-site recordings of the exact location of the household of the individual group member by global positioning system (GPS) and physical verification of the adopted technology. At the end of data collection and after data cleaning and entry, 190 questionnaires (69 questionnaires from male respondents and 121 questionnaires from female respondents), were admissible for further data analysis.

Operationalisation of variables

Human capital refers to the knowledge, skills and capabilities that people need for life and work, including the education and health levels of people as they affect economic productivity (World Bank, 2007). The factor of human capital is represented by education

Table 2. Rotated varimax factor loadings for social capital.

Statements describing social capital	Principal components		
	Factor 1	Factor 2	Factor 3
	Social inclusion	Trust	Social cohesion
Most people in this neighbourhood can be trusted	0.006	0.811	0.101
In this neighbourhood one has to be alert or someone is likely to take advantage of you	0.010	-0.760	0.029
Most people in this neighbourhood are willing to help if you need it	0.334	0.404	0.263
In this neighbourhood, people generally do not trust each other in matters of lending and borrowing money	-0.571	-0.336	0.283
If I need immediate help, members of my group would come to my help	0.789	-0.160	0.194
People in my group are always interested in each others welfare	0.740	0.067	0.351
I feel accepted as a member of my group	0.108	0.164	0.771
Our group contributes to the welfare of the community	0.153	-0.036	0.798
Eigenvalues	1.643	1.569	1.553
% of variance explained (59.567)	20.538	19.616	19.412

Extraction method: Principal component analysis with Kaiser Normalization.

levels of the respondents and their children, their personal skills and the occupations that employ them to earn additional off-farm income, as well as the amount household labour available to them. Thus, human capital is hypothetically mediated by gender, age and household size.

Social capital refers to social resources upon which people draw in pursuit of their livelihood objectives. This includes networks and connectedness, membership to formalised groups and relationships of trust, reciprocity and exchanges including common rules, norms and sanctions in society (Woolcock and Narayan, 2000; Sobel, 2002). To assess levels of social capital, this study focused on the perceptions that farmers hold towards eight statements describing social capital (Table 2). Since social capital is unlikely to pervade situations of conflict and despondency, it was also assessed through five ranks of peace in the neighbourhoods and perceptions towards levels of social deprivation. Deprivation of five public services including education, water resources, health services, transportation and justice were used as a proxy for social exclusion.

Natural capital refers to the natural resources and ecosystem services for livelihoods including soils, vegetation, forests, water and natural habitats that people depend on in support of their livelihoods. In this study, natural capital was taken to refer to all activities that support the sustainable use of soil and water resources, as the principle natural elements supporting livelihoods in any farming community. Ten technologies for soil and water conservation were considered together to provide an appropriate proxy for the natural capital availbe to the respondent by virtue of belonging to the household.

Physical capital refers to the basic infrastructure and producer goods needed to support livelihoods. In this study, the two aspects of physical capital were considered: affordability of transport from the village to the market and the physical structure of the family house. The costs one pays to and from the market, travelling by public means (matatu), were considered as transaction costs that affects accessibility of the market by respondents and hence, as a proxy for economic isolation. The variable was divided into two levels: low level of economic isolation refers to paying Kenya shilling (KShs) 40 to 80, while and high level of economic isolation means paying more than KShs. 80. These costs were approximated as almost equivalent to paying less than or more than 1 US dollar, the monetary poverty line, that is often used. The mean annual exchange rates of the Kenyan shillings to the US dollar according to the Central Bureau of Statistics were 72.101 (2006) and 75.554 (2005).

The physical quality of the house was measured as a factor of the quality of walls, floor and roof of the main family house. An additive index for ‘quality of housing’ was constructed in which scores were assigned to each type of roof, floor and wall according to durability and quality of material used.

Financial capital as used in the sustainable livelihoods framework denotes availability of cash and equivalents that support livelihood decisions and actions. The types of financial resources considered in this study were household income, land resources and livestock holding. Household income refers to all sources of income whether from paid or self-employment, involvement in primary products, rents, interest and dividends received, patents, current transfers (such as social security benefits, pensions and life insurance annuity benefits, alimonies), etc; and any other benefits flowing to

the household (GoK, 2005). When land has secure tenure, through a title deed, it can readily be exchanged in the market for money or used as collateral to obtain money from a financial institution. For this reason, land is considered a financial good. Livestock is important as a means of asset accumulation and as a saving and as insurance when there is need for immediate cash (Christoplos et al., 2001). Such cash may influence the investment in new improved agricultural technologies. The individual man or woman was assumed to be a beneficially of financial resources administered at the level of the household rather than at the individual level. This is because the assumption was made that resources for investment in new technologies are most likely negotiated at household level.

In examining adoption of technologies, a distinction is often made between the proportion of farmers that adopt a given technology, regardless of the level of use (rate of adoption) and the intensity of adoption in which consideration of levels of use of the technology is made (Doss and Morris, 2001). In this study, the proportion of farmers that used a given technology was considered adopters of the technologies. This was regardless of the level of use. The level of use refers to the self-assessment designation of use of a technology that progresses from non-use; orientation; preparation; mechanical use; routine; refinement; integration to renewal (Griffin and Christensen, 1999). A similar understanding of adoption has been asserted by Karugu (2006), where a farmer is presumed to have adopted a technology if he/she uses it to any extent. During data collection, each farmer who claimed to have adopted a technology was also expected to show evidence of that technology within their farm. This helped to verify their adopter status.

Data analysis

Descriptive statistics that included percentages, frequencies, means, and standard deviations provided the basic scenarios of the various aspects of the study. Factor analysis based on the principal component analysis (PCA) was used in data reduction to identify a small number of factors that explained most of the variance that was observed in the statements describing social capital.

To determine the influence of capital assets on adoption, a binary logistic regression was applied. Binary logistic regression was adopted because of the qualitative nature of the binary dependent variable, y =1 for adoption and y = 0 otherwise. The objective was to find out the probability of occurrence of the event:

$$P(Y) = \frac{1}{1 + e^{-(b_0 + b_1 X_1 + b_2 X_2 + \ldots + b_n X_n) + \varepsilon_i}}$$

Following Field (2005: 220), the binary logistic regression model was specified as:

Where:

1) *P(Y)* is the probability of Y occurring, 2) *e* is the base of natural logarithms, 3) b_0 is a constant, 4) $b_1..b_n$ are the coefficients associated with each of the explanatory variables, 5) X_1 - X_n are predictor variables and 6) ε_i is the error term.

RESULTS AND DISCUSSION

The respondents were 63% female and 37% male. Of these, 80.5% were married, 3.7% were single and 15.8% were widowed. Male-headed households were 81.1 and 18.9% were female-headed households. They ranged in age from 24 to 90 years old, with a mean of 51 and a standard deviation of 12. Most of the households were medium in size with the number of children in each family varying between 0 and 12 with a mode of 5. The minimum number of persons providing labour to the households was 1 and the maximum was 14. External labour through employment was available to 37% of the households. There existed a significant association in the number of persons available to provide labour to male-headed and female-headed households (Pearson chi-square 32.155; df = 13; p<0.005).

Labour is a major variable input into farming, whose scarcity limits production. Farmers seek higher returns to labour by adopting new crops, production methods and production combinations deemed to improve returns to work (Ruthenberg, 1976). In Kenya the bulk of farm labour is provided by the household members. In cases where the household is short of its own labour and does not have the means to hire external labour, its farm productivity is highly compromised. New and improved technologies and innovations often indicate new labour expenditures; hence, the amount of household labour available influences adoption decisions. Marenya and Barrett (2007) found that the number of adults per household was statistically significant and positively associated with the adoption of natural resources management practices in Western Kenya. It is thus expected that, the more the number of persons in a household, the higher is its labour force. This factor should therefore elicit positive affects on adoption decisions since available labour can be used in implementation of the new technology.

It was found that a high number of women respondents were uneducated or had primary school level education. Few respondents had attended technical schools or undertaken apprenticeship courses. Levels of education between female and male-headed households differed significantly (p<0.05). Female-headed households recorded lower levels of education. Among the 975 children (48.1% female and 51.9% male), and a significant difference (p<0.05) between the education levels for male and female children was noted. More female children had lower levels of education than the male children. The results are consistent with the overall estimates of literacy in Nakuru district where literacy levels for males and females, are 52.9 and 47.1%, respectively (GoK, 2002).

New or improved technologies are often knowledge intensive, and hence the target population is best able to benefit from them when there exists within such communities or organizations, a basic level of formal education. Where this is not the case, extension and agricultural development projects present an opportunity through which low levels of educational attainment can be improved through management training and skills building (Marenya and Barrett, 2007). Higher levels of

education also increase ones potential to earn a higher income which could be invested in acquisition of improved technologies, especially those technologies that require an initial investment. However, in Kenya, schooling attainment has been found to have no impact on technology adoption (Place et al., 2007). Thus, education could either encourage greater adoption of technologies, or it may have no implication on adoption decisions.

Most respondents (68.4%) did not have skills with which to earn off-farm income, hence majority (80.2%) was engaged full-time as small scale farmers. The respondents (19.8%) who had ventured out to engage in non-farm activities, were employed both in formal and informal settings. A chi-square test showed that there was no significant gender association of men and women engaging in non-farm livelihood diversification strategies (Chi square = 1.146, p = 0.284).

It is well established that due to high levels of material uncertainty and risk, rural populations often diversify their livelihoods through occupational flexibility, mobility, including rural-urban migration and dependence on rural non-agricultural income generating activities, even if farming continues to play a major role in their lives (Baumann, 2004). Livelihood diversification can assist households to shield themselves from environmental and economic shocks, trends and seasonality hence reducing their vulnerability. For a person to engage in off-farm activities, they require skills that can support an occupation other than agriculture. The earnings from off-farm activities may be invested in new agricultural technologies to increase household productivity. Or, the non-farm income diversification activities may be in competition for time and energy with implementation of new technologies. This could discourage the skilled persons engaged in a non-agricultural occupation from adopting new technologies.

Results of factor analysis (Table 2), provide three main factors of social capital. Factor 1 also called ‘social cohesion’, which explained 20.5% of the total variance, shows that social capital is associated with ‘help’ and ‘concern’ from the members of the group. Factor 2, which explained 19.616% of variance is related to ‘trust’. Factor 3 also referred to as ‘social inclusion’, explained 19.4% of variance, and was associated with ones ‘acceptance within the group’ and also with the ‘contribution that the farmers’ groups made to community welfare’. Up to 75% of the respondents perceived their neighbourhoods as peaceful. There was no significant difference between the views of men and women towards the level of peace in their neighbourhoods (Pearson chi-square = 7.239; df = 4; p-value = 0.124). This could be an indicator that gender-based violence is not widespread in the study area.

Social capital describes circumstances in which individuals use membership in groups and networks to secure benefits (Grootaert, 2001). It has been found that communities with high levels and diverse supply of social capital are better able to deal with poverty, vulnerability, disputes and also to take advantage of new opportunities (Woolcock and Narayan, 2000). Social cohesion ensures that the community will pull together to initiate mechanisms for self support and in provision of necessary resources and services (Kummssa and Mbeche, 2004; Amudavi, 2005). Such cohesion is favourable to peaceful co-existence. However, social capital is double edged; it has positive and negative aspects to it. On the positive side it helps the poor manage risk and vulnerability. Its manifestations are negative in isolated and parochial situations such as within organized crime syndicates or when it supports caste inequality, ethnic exclusion or gender discrimination (Woolcock and Narayan, 2000). The former is called productive social capital while the latter has been referred to as perverse social capital. Therefore, social capital can positively or negatively influence adoption depending on the existing social networks and social relationships.

The percentage of respondents identifying deprivation in public services in their neighbourhoods are shown in Figure 5. Overall, the community under this study faces institutional barriers, that could inhibit access to developmental and welfare opportunities including attainment of the Millenium Development Goals (MDGs). A high number of respondents perceived deprivation in education (facilities and opportunities) (64.7%), water resources (59.5%), health services (47.4%) and means of transportation including poor roads (43.9%). Deprivation in education (facilities and opportunities) has implications for human resources and institutions, which are important predictors of growth in an economy, so much so that, poor technological flow to poor countries has been linked to poor human capital endowment (Lucas, 1990).

Water is a critical commodity without which agriculture and daily living are highly compromised. Deprivation of water sources means that a lot of time is wasted in collecting the commodity from far off sources which increases the burden of domestic tasks, especially for women (Morrison et al., 2007). Where such sources are of low quality, water-borne diseases compromise the health status of household members, increase household expenditures due to increased payments for medical care and also affect labour allocation decisions seriously compromising the likelihood of adoption of improved agricultural technologies (Ersado et al., 2004). The situation could be highly compounded by the lack of means of transport and health facilities which are important institutions in support of the general well-being of rural communities.

Figure 6 shows the frequency of use of each of the soil and water conservation technologies. The frequencies of use of technologies, give credence to the fact that rural people depend on natural resources and ecosystem services for their livelihoods and often contribute to their improvement by adoption of improved technologies and management practices (Bewket, 2007).

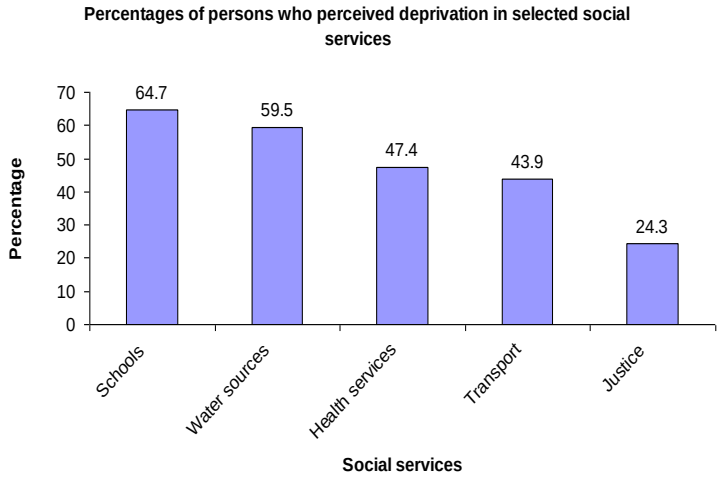

Figure 5. Deprivation within the neighbourhoods.

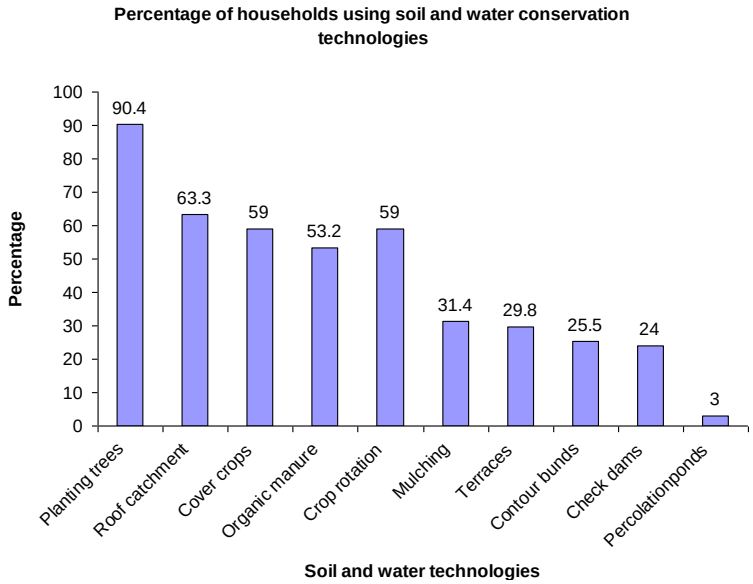

Figure 6. Technologies for soil and water conservation.

Table 3. Affordable transport as a measure of level of economic isolation.

Level of economic isolation	Frequency	Percent
Low level of economic isolation – paying up to KShs. 80 to travel to and from market (=$1)	84	44.2
High level of economic isolation – paying up more than KShs. 80 to travel to and from market (>$1)	106	55.8
Total	190	100

More than half of the study population (56%) faced a high level of economic isolation as shown in Table 3. This could increase their costs of operations and constrain their active participation in the market. In Kenya, smallholder farmers living far from the market face constraints in accessing service providers and consumers of their produce, as well as high exchange costs related to poor transportation systems occasioned by lack of information, and poor access to assets (Alene et al., 2007).

Shelter in the study site can generally be considered as good, because durable roofs made of iron sheets or clay tiles were noted in 97% of the households, 31% of the households had houses with durable walls made of stone or bricks, while 48% of the households had good quality cemented or wooden floors. According to Kenyan participatory poverty assessment studies, poor shelter is among the leading manifestations of poverty (Kimalu et al., 2002; Nafula et al., 2005). Quality of housing was used as a proxy for wealth status. It is expected that wealthier households own better quality housing made up of durable roofs and walls as well as clean floors. Such households are more likely to have surplus income to invest in acquisition of new technologies. These households are also likely to be involved in non-farm activities for income generation, a fact that may remove their participation in agriculture.

Of the total number of respondents, 75% recorded total monthly incomes of up to Kshs. 5000.00. Considering a mean dollar rate of KShs. 80, this translates to an income of about $62.5 a month, which means a daily income of approximately $2 per day for a 30-day month. This means that most households in the study area are relatively poor. Most of the respondents had up to 5 acres of land as shown in Table 4. An acre of land is equal to 4,046.85 m^2. The respondents with more than 10 acres of land were 6.1%. Of all the land owners, 86% had title deeds to their land while 14% did not have title deeds. Livestock ownership including livestock breeds and their average farm-gate prices, as well as total value, were as shown in the Table 5. The farm gate price was the price that the farmer was willing to offer for each animal at the time of data collection.

Financial capital denotes financial resources that people use to achieve their livelihood objectives. The three forms of financial resources considered in this model are: household livestock holding, household monthly income and household land resources. Household livestock holdings and household land resources are expected to have a positive influence on adoption of technologies. Livestock can be sold easily to raise cash. Land can be used as collateral to acquire money from financial institutions to invest in new technologies. Availability of land also directly supports the adoption of new technologies by availing the necessary physical space to do so. Monthly income can positively influence adoption where such non-farm income is invested in new technologies.

The study found that a large percentage of respondents were adopters of the technologies that had been demanded by their groups (Figure 7). This high number of adopters may be related to the integration of the individuals within farmers' groups. A similarly high number of adopters were noted in Brazil by Filho et al. (1999) who used a dynamic econometric framework (duration analysis) to analyze the determinants of farmers' decisions on whether or not to adopt low-external-input and sustainable agriculture (LEISA) technology. After considering a wide range of potential determinants (both economic and non-economic) they suggest that the probability of a farmer adopting increased if the farmer was more integrated within farmers' organizations.

Factors influencing adoption of technologies: Model explanatory variables and expected signs

The wide range of factors, each related to the five livelihood assets, is assessed in relation to their influence on adoption decisions. These variables and their expected signs are summarised in Table 6.

Results of the binary logistic model

Results of the model (Table 7) show significance coefficients for 'age', 'gender of respondent', 'availability of a skill', 'cost of travelling to and from the market', 'social inclusion', 'social cohesion', 'level of peace in the community and monthly income'.

Age was significant ($p<0.05$) but negatively related to the dependent variable. This suggests that younger farmers are more likely to adopt new technologies compared to the older ones. Tauer (1995) found that generally, farmer's efficiency increases and then decreases with age. This has implications for the efficiency of farming and decisions to adopt new or improved technologies. In Kenya older farmers are often the owners of the land, the patriarchs of their families when they are male and repositories of farming knowledge, especially indigenous knowledge. They may be more unwilling to try out new ideas than the younger more innovative farmers.

Gender was positively related to the adoption of technologies ($p<0.05$). The positive sign suggests that men are more likely to adopt new technologies compared to women. Gender is an important consideration of human capital since in many studies, equality and equity in the determinants of technology adoption including, access to production resources such as land, labour, credit and information, between men and women, is shown to be elusive (Doss and Morris, 2001; GoK, 2004; Akinboade, 2005; Morrison et al., 2007). In Kenya, women and girls bear most of the direct toll of this disparity: they work longer hours contributing between 60 and 80% of labour in household, reproductive activities and in agricultural production, are poorer in health, are less educated, have lower nutritional status and higher mortality rates (GoK, 2004). In spite of this overwhelming evidence to the contrary, in Kenya, the policy environment considers gender a social issue. In the stratgey for revitalizing agriculture (SRA) (GoK, 2004), gender is considered a part of the social development

Table 4. Classes of land ownership.

	Frequency	Percent
Landless	2	1.1
Landsize between 0.1 - 2.5 acres	56	30.9
Landsize between 2.6 - 5.0 acres	66	36.5
Landsize between 5.1 - 7.5 acres	26	14.4
Landsize between 7.6 - 10 acres	20	11.0
Landsize greater than 10 acres	11	6.1
Total	181	100.0

Table 5. Livestock breeds and their value.

	Number of owning households	Number of animals	Average Unit cost (KShs.)	Value (KShs.)
Zebu cattle	9	34	16,000	544,000
Cross breed/exotic cattle	146	433	20,000	8,660,000
Indigenous goats	46	222	2,000	444,000
Dairy goats	47	85	8,000	680,000
Indigenous sheep	127	759	2,000	1,518,000
Cross breed/exotic sheep	6	43	3,500	150,500
Poultry layers	3	387	250	96,750
Poultry broilers	1	200	300	60,000
Indigenous chicken	163	2675	200	535,000
Beehives	36	172	2,100	361,200

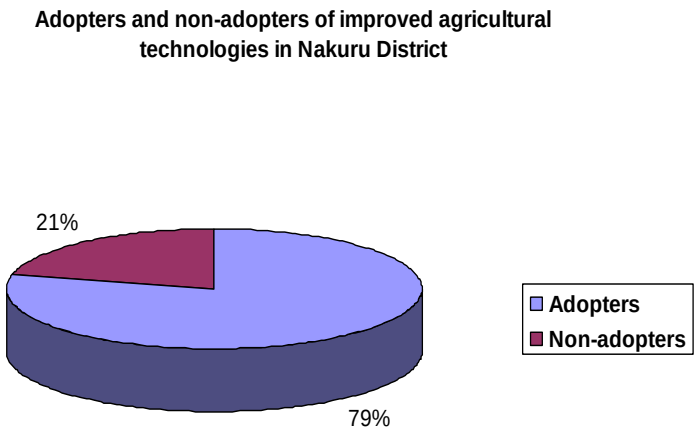

Figure 7. The number of respondents reporting adoption of improved agricultural technologies.

issues that are necessary to coordinate agricultural development with other sectors. Furthermore, although existing laws in Kenya provide for equal rights and privileges for both men and women, cultural and social interpretation of these laws, especially through common laws and social conventions often compromise them (GoK, 2004). Thus, in Kenyan society, the existing legal systems may lead men and women to experience either equalities or inequalities in opportunities depending on the interpretation adopted.

The 'skill' variable was significant and negative in the model results ($p<0.05$). The negative sign indicates that those without skills were more likely to adopt the new technologies as compared to the skilled. This is acceptable because non-farm income diversification activities may be in competition for time and energy with

Table 6. Socio-economic characteristics as explanatory variables and their expected signs.

Description of the explanatory variables	Expected signs of the model coefficients
Human capital	
Age of respondent in years	+/-
Gender of the respondent (1 = male; 0 = female)	+/-
Number of persons in the household	+
Number of persons aged 15-64 in the household	+
Dummy for respondent with a skill (1 = yes; 0 = no)	+/-
Dummy for income diversification (1 = yes; 0 = no)	+/-
Respondents' level of education (1>Secondary school;0 = otherwise)	+
Natural capital	
Score for soil and water conservation measures	+
Physical capital	
Cost of travelling to and from the market ($)	+/-
Score for quality of main family house	+/-
Social capital	
Social inclusion as a component score from PCA	+
Trust as a component score from PCA	+
Social cohesion as component score from PCA	+/-
Score for perceived social exclusion	+
Score for perceived level of peace in the community	+
Financial capital	
Total value of household livestock holding in KShs. (10,000s)	+
Estimated monthly income in KShs. (1000s)	+/-
Total household land holding in acres	+

implementation of new technologies and could discourage the skilled persons, who are engaged in a non-agricultural occupation, from adopting new technologies. In addition, for a person to engage in off-farm activities, they require skills that can support an occupation, away from farming. However, as noted earlier, a large percentage of the respondents did not possess employable skills.

'Economic isolation' as a factor of cost of travelling, to and from the market, was positively and significantly related to the dependent variable ($p<0.1$). This suggests that the propensity to adopt technologies increased with longer distance to the market. In Kenya, smallholder farmers living far from the market face constraints in accessing service providers and consumers of their produce (Alene et al., 2007). Therefore, this result goes against the norm that increased costs of operations constrain active participation in the market and negatively affect adoption of improved technologies. This would suggest that availing improved technologies to people living far from the market provides them an impetus to seek means for active participation in the market in spite of the constraints.

Social inclusion was positively and significantly related to adoption ($p<0.05$). The positive relationship exhibited in the variable 'social inclusion' suggests that where farmers trust and share their knowledge with others, adoption levels are better.

Social cohesion shows a significant ($p<0.05$) but negative relationship to adoption of technologies. Social cohesion deals with connections and relations between individuals and groups (Berger-Schmitt, 2000). Loyalty and solidarity in a group serves to cement relations and connections between individuals. However, the negative relation between adoption and social cohesion might be evidence of negative social capital. This is exhibited when members of farmers groups exclude other members of their communities. This may occur in the form of restrictive networks in which information flow is restricted so as to reduce competition by excluding the participation of others in the innovation-decision process. When social capital is used to exclude others it may lead to social exclusion, and increase inequalities and disparities in access to information and services, hence limiting adoption to a select few. It would seem that some of the farmers' groups in the study area exhibit this form

Table 7. Socio-economic characteristics that influence adoption of technologies.

Explanatory variable	Dependent variable: Adoption of technologies with y = 1 for adoption and y = 0, otherwise				
	Variable description	B	S.E.	Sig.	Exp(B)
Age	Age of respondent in years	-0.072	0.026	0.005**	0.930
Genders	Gender of the respondent (1 = male; 0 = female)	1.323	0.589	0.025**	3.754
HH Size	Number of persons in the household	-0.014	0.104	0.892	0.986
TTHHL abourforce	Number of persons aged 15 to 64 in the household	0.154	0.095	0.104	1.167
Skillres	Dummy for respondent with a skill (1 = yes; 0 = no)	-1.259	0.613	0.040**	0.284
Occupationres	Dummy for income diversification (1 = yes; 0 = no)	-0.979	0.628	0.119	0.376
Educ Level Dummy	Respondents' level of education (1 > secondary school;0 = otherwise)	-0.888	1.136	0.434	0.411
Soil water con	Score for soil and water conservation measures	-0.831	1.365	0.543	0.435
Cost travel mrkt$	Cost of travelling to and from the market ($)	1.216	0.691	0.078*	3.375
Hse quality	Score for quality of main family house	0.053	0.122	0.664	1.054
S inclusion	Social inclusion as a component score from PCA	1.187	0.439	0.007**	3.276
Trust	Trust as a component score from PCA	-0.111	0.260	0.669	0.895
S cohesion	Social cohesion as component score from PCA	-0.775	0.235	0.001**	0.461
S exclusion	Score for perceived social exclusion	0.322	0.206	0.118	1.379
Peace comm	Score for perceived level of peace in the community	3.932	1.654	0.017**	50.984
Value total livestock	Total value of household livestock holding in KShs. (10,000s)	0.025	0.043	0.568	1.025
M monthly income thou	Estimated monthly income in KShs. (1000s)	-0.168	0.077	0.028**	0.845
HH landholding	Total household land holding in acres	-0.007	0.061	0.905	0.993
Constant		2.607	2.060	0.206	13.560

Number of observations: 162; percentage of correct predictions: 84%; omnibus test of model coefficients: Chi-Square = 56.254; df = 18; significance = 0.000***; model summary: -2 log-likelihood = 110.215; Cox and Snell R Square = 0.293; NagelKerke R Square = 0.457; Hosmer and Leme show test: Chi-Square = 5.660; df = 8; Significance = 0.685 (>0.05)
*, **, *** denote significance at 10, 5 and 1% respectively.

of negative social capital.

Peace in the community was significant ($p<0.05$) with a positive coefficient suggesting that adoption is most likely to take place more effectively within peaceful communities. Obviously, peaceful conditions support exchange of information and allow free movement of individuals including external agents involved in agricultural research and extension. This is unlike in situations of conflict where such movement is curtailed and fear of attacks, limits the necessary contacts between the farming communities and external agents.

Estimated mean monthly income in thousands of Kenya shillings has a negative coefficient but significant relationship ($p<0.05$) with adoption of technologies. This means that adoption increased with reducing income levels. This inverse relation implies that poorer households were more likely to adopt improved technologies than well-off households. This may be so because the pooling of meagre resources amongmembers of farmers' groups enables poorer group members, to take the collective risk associated with new technologies. This ensures the participation of poorer households in the innovation-decision process and gives credence to the importance of farmers' groups as institutions that support the poor. This underscores the importance of supporting agricultural production for improved

household food security and increased household incomes.

Conclusions

In Nakuru district, adoption of technologies occurs in an environment that is conditioned by the socioeconomic characteristics of the adopting household and the demographic characteristics of the individuals therein. Important factors include age and gender. Younger farmers and men were more likely to adopt new technologies. Thus, dissemination of technologies cannot be conceived as affecting all persons in a similar manner and adoption behaviour cannot also be assumed to have similar effects on men and women. Extension workers working in similar rural systems must endeavour to understand the gender relations inherent within specific study areas. Additionally, they must be deliberately sensitive to existing social inequities in order for men and women to benefit from research and extension services.

The lack of employable skills could affect adoption of new technologies because the unskilled may sell their labour to earn an income at the expense of spending time on their farms to improve their production systems using the new technologies. Thus technologies targeted at unskilled need to incorporate a 'money-earning' component or should realize monetary benefits in the short term to enable unskilled persons deal with immediate daily consumption needs unlike a focus on technologies whose benefits are in the long term.

Targeting households who are off the main infrastructural developments such as roads is beneficial first because their physical isolation often translates to less contact with extension agents and hence with new technologies. Thus, they would be most needy of such services. Secondly, lack of many alternative technologies may make them enthusiastic learners of the new technology which they may consider a means of greater interaction with markets.

Social inclusion and peace are positive factors of social capital that are beneficial of any innovation-decision process. These two factors underlie collective action an approach that allows poorer farmers to pool resources to undertake activities they may consider risky like adopting new technologies. These factors require promotion by all actors working within rural systems.

Social cohesion, another factor of social capital showed a negative relationship to adoption. This could be indicative of exclusiveness, gate-keeping tendencies and lack of community representation among farmers' groups. It could imply that groups that work directly with extension agents 'hoard' information from the rest of the community. This indicates that tapping into existing social networks requires careful consideration to ensure that existing social capital remains intact and that such engagement should seek to remove barriers to self-organization.

RECOMMENDATIONS

Any external agent, either in agricultural research or extension, should make the effort to understand the dynamics within which men and women function and their livelihood asset endowments while promoting any agricultural technology. Policies for rural development stand to have greater impacts if they focus on building rural assets such as schools, roads, security infrastructure and the natural resource base while encouraging self-organization and social networking by tapping into, building and supporting existing networks to deliver relevant services.

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