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Farmer's Site Selection Criteria and Adoption of Temperate Fruit Tree Management Practices in Kabale District, South-Western Uganda

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Abstract: Temperate fruit growing is a new but promising enterprise in the highlands of south-western Uganda. A study was conducted in three sub-counties of Bubare, Muko and Hamurwa of Rubanda county, Kabale district between May and December 2004, to: determine the factors that influence the adoption of Temperate Fruit Tree Management (TFTM) practices and identify the niche and site quality for fruit tree growth. Semi-structured questionnaires were used to collect data from 60 farmers selected using purposive sampling procedure. The assessment of the niche to grow fruit trees was done by measuring fruit performance as shown by the crown diameter, root collar diameter and tree vigour. Site quality was established by analysis of soil samples for nitrogen, phosphorus, potassium, calcium, magnesium, carbon and pH. The results of the logit analysis showed that variables related to resource endowment such as size of landholding, contact with extension service providers and access to credit impact significantly affect the adoption of TFTM practice. Farmers mainly consider soil fertility, tree-crop compatibility, tree maintenance and protection costs when selecting sites and niches to plant fruit trees. Most of the fruits were planted in the orchard and internal boundary and these were the niches where the fruits performed best. The farmers prefer planting fruit trees in the cropland than in the homestead. In the cropland, the temperate and tropical fruits survive best in the orchard, internal boundary and terrace boundaries.

Key words: Adoption, cropland, household, niche, site quality

INTRODUCTION

In the recent past, temperate fruits such as apples, pears, plums and peaches have been introduced by the FORRI-ICRAF Project mainly to provide income and nutritional options to the small resource poor farmers. Preliminary results show great potential of these fruit trees on-station (Agroforestry Trends, 1999). The majority of the indigenous trees have all disappeared from an area that was once lush tropical forest. The deforested and terraced hills present some major problems.

The temperate fruit growing was expected to help farmers who depend on traditional low-value crops like sorghum and using poor agricultural practices. This is because temperate fruits are of high value and have a potential to increase household incomes, food security and employment opportunities. The high value fruit tree management will offer employment opportunities for the redundant youth, who will be able to use degraded highlands and fields and be in position to contribute household nutritional needs (Peden, 1991). Temperate fruits such as apples, peaches, plums and nectarines are already found on the Uganda market mostly imported from South Africa which has a similar climate to that of the Kigezi highlands (Okorio and Hoekstra, 1988). The success of temperate fruit growing in Kabale will partly depend on availability of potential niches for harvesting. There is therefore an urgent need to identify farmer niches for fruit harvesting. Similarly, it is important to determine the criteria for farmer selection of sites for these temperature fruits. An orchard has a life span of over 30 years and harvested between 2-3 years and twice a year, the important factor to consider is the source and propagation of appropriate materials suitable for each altitude for the viable market.

Acceptance of such technological packages, however, depends on a number of social and economic factors, extending far beyond the simple cost-benefit calculations. Land allocation among the different components in the farming system food crops, cash crops, tree crops and livestock is primarily determined by a complex of social, economic and cultural factors. Most of the work hitherto done on the economics of social forestry is focused on simplistic financial profitability

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calculations while important issues like land tenure, size of land holding, dependence on land, farm labour availability and the whole dynamics of these are neglected or at best dealt with superficially.

Past studies (Masangano, 1996; Franzel *et al.*, 2001) have identified some of the farmers' characteristics that may influence adoption rate of agroforestry technologies including farmer's age, education level, gender, wealth, family size, group membership and farm resources are; farm size, land tenure, access to credit, or other inputs and labour. Farmers' adoption behaviour, especially in low income countries is influenced by a complex set of socio-economic, demographic, technical, institutional and bio-physical factors (Franzel *et al.*, 2001). The objective of this study, was to to determine the factors that influence the adoption of Temperate Fruit Tree Management (TFTM) practices and identify the niche and site quality for fruit tree growing practices in Kabale district, Uganda.

MATERIALS AND METHODS

Description of study area: The study was carried out in Kabale district is located in the Kigezi highlands of Southwest Uganda bordering with Rwanda. The district lies between latitudes 1°45^1-1°30^{1}S and longitudes 29° 18^1-30° 50^1 E. Kabale district has a rather temperate-like bio-modal climate characterised by mean annual rainfall ranges of 1000-1500 mm, with a good rainy season lasting from November to April followed by scattered showers from May to July. The topography is extremely rugged, consisting of narrow steep-sided valleys that run in various directions and are bounded by emergent hill crests lying at altitudes of 1,190 in the north and 2,607 in the south, deep arched river valleys, steep convex slopes (10°-35°) and gentle (5°-10°) slopes adjacent to reclaimed papyrus swamps. Temperatures range from a minimum of 10-12°C, to a maximum of 20-240 °C. The area has humic and ferralsols with declining fertility due to continuous cultivation. The population explosion has been followed with shortage of land which in turn has accelerated soil erosion in the area (Peden, 1991). The area is densely populated with an average of 840 persons km^{-2} and the growth rate is 2.3%. There is a very high farmer-extension interaction ratio (Peden, 1991). Subsistence agriculture is the major economic activity employing about 84% of population. The bulk of agricultural production is from manually cultivated rain fed crops. The intercropped range of rainfed crops vary with greater potentials for maize, banana, beans, cassava and sweet potatoes.

Data sources: The study was carried out in three sub-counties of Bubare, Muko and Hamurwa of Rubanda county, north western part of Kabale district between May and December 2004. A semi-structured questionnaire was used to solicit information on how local communities adopt and choose the niches for planting temperate fruit trees on their farms. Personal observations of the type of fruits and the niches in which they were planted were made. Using a hand-held GPS set (GARMIN GPS 12XL), the geographical co-ordinates of the households were recorded on the questionnaire. A combination of qualitative and quantitative data collection methods was employed. Semi-structured questionnaires were used to collect data from 60 farmers selected using purposive and random sampling procedures. An interview was carried out in each household to find out what farmers considered when choosing to plant the temperate fruit trees. Lists of all the farmers who grew temperate fruits provided by both AFRENA and AFRICARE were obtained. The fruit tree grown included apples, pears, plums, which are temperate fruits and, avocados and tree tomatoes as tropical fruits. The apples, pears and avocados were selected because they are the most commonly grown fruit trees in the study area. The socio-economic data was also obtained and all the data from each household was recorded on a separate questionnaire. Descriptive statistics were used to describe the farmers' socio-economic characteristics, while simultaneous equation Logistic models were estimated in analysing the intensity of adoption. The conceptual and econometric underpinnings of the discreet choice models used to analyse the various socio-economic factors that influence adoption of the TFTM practices are outlined in the following sub-sections.

After the household survey, a sample was taken from which agronomic data of the fruit trees and soil samples were obtained. This was done by stratifying all the farmers into those that grew some fruits in their homestead and those that grew them on the cropland. In a garden of more than five trees per species, five trees were selected randomly and data was recorded based on the following characteristics: The fruit trees were observed and rated with a score of 0-5. Dead or absent = 0, very poor = 1, Poor = 2, average = 3, Good = 4, excellent vigor = 5; the root collar diameter (cm) was measured using a calliper at the region of the stem just below the first branching; to determine the crown diameter (cm), different measurements were taken in three different lateral directions above the crown of the tree; the height of trees was measured using a metre rule. Other parameters such as age of the tree, position of garden on the hill slope, steepness of the slope and the site of garden (whether cropland or homestead) and type of niche were recorded.

Soil samples were taken from the gardens of the 16 farmers. This was done by using a soil auger to collect

Table 1: Explanatory variables and their expected signs

Variable	Variable definition
AGE	Age of the respondent (Years)
GEND	Sex of head of household (Female=0, Male =1)
LDSZ	Farm Land Size (ha)
FMLY	Number of Family members
EDUC	Education level (No formal education = 0, Formal educ = 1)
TECH	Use of spraying machine (Use = 1,No = 0)
CRDT	Credit obtained (Yes = 1, No = 0)
EXT	Contact with Extension staff (Yes = 1, No = 0)
LBP	Labour demand for tending operations (Man-days)
FA	Attitude to agroforestry fruit trees growing (Correct = 1, Incorrect = 0)
FWK	Number family members working full time (persons)
CLP	Cost of Land Preparation (Shs.)

Table 2: Multinomial Logit Estimates (MLEs) of the factors influencing adoption of temperate fruit tree management technology in Kabale district

Variable	Estimate	SE	t-ratio	p-value	Marginal effect on harvesting early
Constant	0.37	0.88	0.42	0.82	0.16
AGE	-0.02	0.02	-0.91	0.42	-0.06
EDUC	0.14	0.08	0.08*	0.08*	0.02
GEND	-0.48	0.34	0.15	0.16	0.21
FMLY	-0.002	0.04	0.08	0.86	0.001
OFFY	0.46	0.34	1.48	0.18	0.21
LDSZ	-0.44	0.21	-0.86	0.02**	0.18
TECH	-0.26	0.42	-0.72	0.49	-0.12
CRDT	0.58	0.32	1.82	0.06*	0.27
EXT	-0.48	0.28	-1.78	0.08*	-0.21
FWK	0.02	0.14	0.28	0.02**	0.003
FA	1.72	0.78	2.48	0.01**	0.12
LBP	0.3	0.04	1.66	0.28	0.006
CLP	-0.004	0.0001	-0.22	0.72	0.000
µ1	0.72	0.12	5.68	0.02	

soil samples at the depth of 0-15cm and 15-30 cm at a distance of 2 paces from boundaries in the garden or by making diagonals in orchards and then soil collected from 5 points along the diagonals. For each tree species, the soils from the same depth were mixed in the same basin. The quarter method was used to get the final sample of soil which was about 0.5kg. This soil was put in a polythene bag, a knot was made in which a label with details like farmer's name, sub-county, niche of the fruit tree, soil depth and type of the garden was tied so as to rid of confusion between the different soil samples.

Soil analysis was carried out in the soil science laboratory at the Faculty of Agriculture, Makerere University. The soils were air dried for three days before they were crushed and sieved. Nitrogen, Phosphorous, Potassium, Magnesium, Calcium, Carbon and pH were tested using analysis methods (Wortmann and Kaizzi, 1998).

The factors influencing the adoption of TFTM were analysed using maximum likelihood estimation of a logistic regression model. The derivation of the binary and multinomial logit model is based on the random utility model. The farmer household characteristics were used in this study:

$$Z_{ij} = b_{i0} + b_{i1}AGE + b_{i2}GEND + b_{i3}LDSZ + b_{i4}FMLY + b_{i5}EDUC + b_{i6}TECH + b_{i7}CRDT + b_{i8}EXT + b_{i9}LBP + b_{i10}FA + b_{i11}FWK + b_{i12}CLP + \ldots\ldots\ i.$$

In the model above i = household (1-60) and the details of cut off values used in transforming variables into binary form are given in Table 1.

RESULTS AND DISCUSSION

The logistic regression coefficients showed that correct Farmer Attitude fruit trees (FA) was positively related to the adoption of TFTM technology. Those farmers whose attitudes to fruit trees are positive will most likely adopt it faster than those whose attitude is negative (Okorio and Hoekstra, 1988). The probability of adopting TFTM technology is increased by 12% when the farmers' attitude of TFTM matches the technical recommendation from technical service providers. A farmers' attitude in this regard, therefore, may be indicative of overall correct understanding of TFTM issues in Kabale district Table 2. The adoption of any innovation, technology or agricultural practice will be accelerated if farmers have an accurate understanding of the principles underpinning extension recommendations (Semana *et al*., 2002).

Farmers' contact with Extension (EXT) was found to be negatively associated adoption. Lack of contact with agroforestry technical service providers would reduce the probability of adoption by 21%. Extension credibility may suffer in situations where their recommendations to farmers are unsuitable for their (farmers') conditions (Franzel *et al*., 2001). The farmer's contact with the extension staff is still more important in this study area. According to UBOS (2002) this is because of the high illiteracy levels (60%). Education in general increases the facility and speed with which new skills and techniques can be learned and adopted.

The uptake of new technologies is greatly influenced the farmer's contact with extension services. Our study supports the findings of Adesina *et al*. (2001), Alavalapati *et al*. (1995) and Masangano (1996) who reported that farmers with high extension contact are more likely to adopt agroforestry technologies. The adoption of any innovation, technology or agricultural practice will be accelerated if farmers have an accurate understanding of the principles underpinning extension recommendations (Semana *et al*., 2002). Hence extension has the potential to increase the rate of adoption by directly increasing awareness, imparting skills and knowledge of the new technology. This suggests that government should focus on strengthening its extension arm to develop more interpersonal contacts with extension staff and potential adopters.

Chi Squared 31.60 Degrees of Freedom 15, Significance level 0.05, McFadden's R2=0.12

Unrestricted Log likelihood –113.0 Restricted Log likelihood –129.0

Symbols * = p = 0.01, ** = p= 0.05, *** = p = 0.001 significance, p= 0.01, 0.05 and 0.001 significance, respectively.

Formal schooling (EDUC) was positively associated with probability to adopt TFTM. An increase in education levels of 1 year leads to 2% increase in adoption. This illustrates the importance of formal schooling in enabling decision-makers to appreciate the principles of temperate fruit tree management practices. Household heads that studied in higher institutions of learning only planted their fruits in the internal boundaries of their crops. The farmers with low (primary) education levels planted their fruits in the orchard and least in the homestead scattered and upper terrace boundary. Those with no formal education preferred to plant their fruits in the upper terrace boundary, orchard, internal boundary, cropland, or lower terrace boundary.

Credit access (CRDT) was positively related to adoption of TFTM, whereby a per capita increase in credit access will increase the probability of adoption by 27%. The policy implication of which is that availability of credit should ease any case or labour constraints a farmer faces and foster timely operations (Jacovelli and Caevalho, 1999). According to Franzel *et al.* (2001), capital in the form of either accumulated savings or access to capital markets is necessary to finance the uptake of new agricultural technologies. Credit support to smallholders is very important in view of the importance of credit in TFTM practices which include purchase of seedlings from reliable sources, tending costs and transport to marketing centres since TFTM products are highly perishable hence need immediate delivery to markets (Agroforestry trends, 1999).

There is a negative relationship between the size of landholding (LDSZ) and adoption of TFTM as the major land-use activity. The negative association is understandable because adoption costs, when considered as fixed expenses, often tend to discourage adoption of TFTM technology by smallholders. This is because the small-scale farmers are likely to face more severe resource constraints to compared to the resource-rich progressive farmers. The smallholder farmers with limited landholdings would often prefer to commit their pieces of land to growing annual food crops rather than perennial agroforestry fruit trees.

The number of Family members Working Fulltime (FWK) positively influenced the adoption of TFTM technologies since the more people available to work fulltime on the farm, the more likely that the farm household will have some of its labour constraints relaxed. Temperate fruit tree management is more labour demanding compared to the traditional shifting cultivation approach. This observation supports the argument that an innovation will be modified as it diffuses (Franzel *et al.*, 2001). Combining temperate fruit tree growing with annual food crop production on the small farmland is labour demanding and families constrained with labourforce may not be able to practice TFTM.

The size of landholding affects the tree species diversity index (rX_4Y_2 = 0.0504), whereby households with big plots of land plant a variety of tree species to serve their ecological, economic and social requirements. There is a negative relationship between the level of formal education and intensity of extension services with tree species diversity (rV_1Y_2 =-0.2287), this means that the farmers have not responded positively to advise given by extension field workers, this is true because the farmers are poor and fear to undertake risks of investing in expensive, exotic tree species instead continue with the traditional farming methods long used by their grandparents.

Agronomic practices: Farmers planted their fruits on two sites, either on the homestead compound or in the cropland. In these sites, there were patterns or niches in which the fruits were grown and these were: The external boundary, internal boundary, homestead scattered, cropland scattered, upper terrace boundary, lower terrace boundary and the orchard. The results also show the relationships between the niches of the fruit trees with various variables like age and socio-economic status of the farmers.

Most farmers planted their fruit trees on land that was near to the home so that these fruits could easily be protected from theft and destruction from thieves and destruction from people and grazing animals. For this reason,, one would expect the farmers to plant their fruits on the homestead compounds rather than the cropland but results showed the reverse. Despite of the fact that many studies have shown that farmers plant high value trees on the homestead compounds, the survey showed that the majority of the farmers planted their fruits on their cropland than on the homesteads. However, all these croplands apart from one were so close to the homestead, at distance not more than 100 m hence supervision of the crops would be easy.

The main reason why farmers could have planted in the cropland rather than the homestead was because there was limited space in the homestead garden so the farmers chose to plant the fruits on nearby fields. Farmers also would like to have their crops benefit from the positive effects of the trees so they prefer to plant them with the crops than to plant them on the homestead. These positive effects are such as addition of organic mater to the soil through decay of leaf fall and soil erosion control. The farmers preferred planting in the orchard the to other niches because it is easier to maintain fruits when they are planted in one particular place. Some farmers planted their fruits in the orchard or internal boundary because they had observed this practice from AFRENA project or other farmers.

Planting sites and niches: Eighty one percent of the farmers planted their fruits in the cropland whereas 19% planted in the homestead. The farmers who planted fruits in the cropland because it was easy to provide protection to the fruits. Croplands were very close to the homesteads and within a distance of 100 m away from the home. The response as to the cropland being the only space where the fruits could be grown was given by one farmer. Generally, the main reason given in planting in a given site is because of easy protection from animals and people. Though the same reason coupled with proximity to home was also a major reason in planting in the desired site (Fig. 1).

With regard to the niche, the majority of farmers preferred to plant in the orchard, followed by the internal boundary and the least popular niche was homestead (Fig. 2).

The reasons for selection of particular niche ranged from the need for proper maintenance, ecological compatibility, soil fertility conservation, experiences leant from other farmers, advise from AFRENA Project staff and prevention of shade crops.

The farmers that considered the distribution effects of the fruit trees on the crops planted their fruits in the internal boundary, cropland scattered and lower terrace boundary.

Effect of eco-physiological factors on fruit tree growth: The food crops grown in the homestead or cropland do not significantly ($p>0.005$) affect the height, root collar diameter of the apples, pears and avocados. However, it was observed that site characteristics also do not affect the vigour and crown diameter of apples and pears

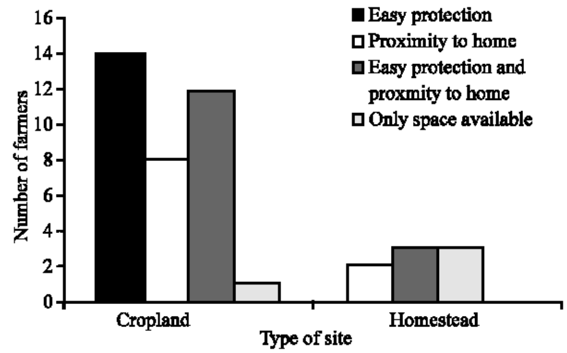

Fig. 1: Relationship between site and reasons for planting in the site

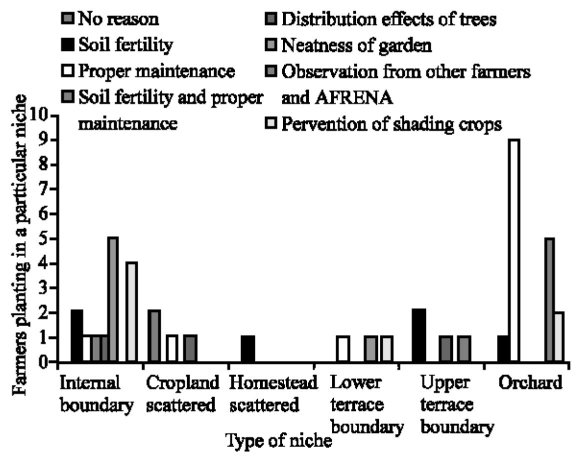

Fig. 2: Relationship between type of niche and reason for planting

although it affected the growth performance and vigour of avocados ($p<0.005$) Table 3. The type of niche significantly affected the crown diameter of apple ($p<0.005$) whereas the crown diameter of apples and pears was mainly affected by the position of the garden and slope condition ($p<0.005$).

The varied topography found in the study area leads to wide variations in the soil types and fertility, microclimate and vegetation over short distances. These diversified agro-ecological, landscape, morphology, lithology and topographical conditions have given rise to a diversity of tree species. The tree species diversity index (Y) is strongly influenced by local physical and edaphic factors such as slope length, slope steepness and soil erodibility as shown by the coefficient determination 41% of the variations in the tree diversity index. There is a strong positive relationship between slope length ($rX_1Y_2 = 0.508$), soil erodibility ($rX_2Y_2 = 0.487$) with the tree species diversity index (Y_1) as illustrated in the mathematical regression model:

Table 3: Effect of site on growth parameters of different fruit trees (age taken as a covariant)

	Growth parameters											
	Height (cm)			Root collar diameter (cm)			Vigour score			Crown diameter(cm)		
Site	AP	PE	AV	AP	PE	AV	AP	PE	AV	AP	PE	AV
Cropland	82.6	99.0	197.0	2.55	1.32	5.17	3.39	2.41	2.11	44.7	43.8	89.0
Homestead	99.9	114.1	239.0	1.97	1.35	5.84	2.68	2.76	3.66	69.5	55.9	153
F-prob.	0.243	0.482	0.116	0.710	0.953	0.27	0.77	0.457	0.03	0.099	0.464	0.032

Key: AP = Apple, PE = Pear, AV = Avocado

Table 4: Effect of niche on growth parameters (age is a covariant)

	Growth parameters											
	Height (cm)			Root collar diameter (cm)			Vigour score			Crown diameter (cm)		
Niche	AP	PE	AV	AP	PE	AV	AP	PE	AV	AP	PE	AV
External boundary	*	*	118.0	*	*	4.55	*	2.67	*	*	*	101.0
Internal boundary	81.1	71.8	239.0	4.33	0.782	6.21	2.31	1.39	3.95	17.8	24.9	164.0
Cropland scattered	52.7	29.2	304.0	0.0	0.719	6.40	3.51	0.87	4.32	27.5	44.2	162.0
Homestead scattered	*	*	169.0	*	*	4.21	*	*	3.10	*	*	138.0
Upper terrace boundary	104.5	113.6	*	3.60	1.790	*	2.65		3.26	53.9	45.3	
*Lower terrace boundary	108.2	97.6	227.0	2.82	0.965	5.06	4.01	3.76	1.59	99.7	52.4	69.0
Orchard	87.5	117.8	*	1.89	1.502	*	3.12	2.74	*	58.5	56.5	*
F-prob.	0.64	0.521	0.261	0.469	0.248	0.200	0.101	0.253	0.063	0.012	0.737	0.063

NB: * Fruit tree specie was not found in the niche. AP = Apple, PE = Pear, AV = Avocado

Table 5: Effect of position of garden on growth parameters (age taken as a covariant)

	Growth parameters											
	Height (cm)			Root collar diameter (cm)			Vigour score			Crown diameter (cm)		
Position	AP	PE	AV	AP	PE	AV	AP	PE	AV	AP	PE	AV
Foothill	91.4	115.5	224.0	4.15	1.359	5.96	3.39	3.08	3.78	65.1	57.4	149.0
Hill middle	83.1	98.4	239.0	1.49	1.316	5.45	2.68	2.35	2.02	36.4	41.8	87.0
Valley bottom	96.3	164.0	149.0	2.73	2.446	4.12	3.77	4.14	2.95	100.4	151.4	153.0
F-prob.	0.836	0.556	0.315	0.36	0.248	0.231	0.27	0.32	0.068	0.017	0.044	0.104

Key: AP = Apple, PE = Pear, AV = Avocado

$$Y = 2.569016 + 416744X_1 + 410436X_2$$

The slope length (X_1) had the greatest influence over tree species index whereas slope steepness (X_3) had the least effect. Therefore, using the backward regression method, only slope length and soil erodibility are important towards tree species index. The slope length shows the biggest relationship (r = 0.5077), hence can reliably be used for the prediction of the future condition of temperate fruit tree species index. The soil erodibility gives doubtable results with very small relationship (r = 0.0520) which practically should not be used for predictions of the potential of the fruit tree growing (Table 4).

Position of the garden on the slope only affected the crown diameter of apples and pears ($p<0.005$). There is a strong positive relationship between TFT species diversity index (Y_1) and slope length ($rX_1Y_2 = 0.5077$), soil erodibility ($rX_2Y_2 = 0.4865$) at ($p>0.001$), this implies that highly eroded soils are planted with different temperate fruit trees and long slopes have got more diversity of fruit tree species. The successful establishment and growth fruit trees depend largely on correct choice of species, soil working methods, silvicultural practices and management techniques suited to the different tree species and site conditions (Table 5).

There was a weak relationship between slope steepness and tree species diversity index ($rX_3Y_2 = 0.052$) in Bubare sub-county, this was because the sub-county is generally of uniform steepness with minor differences which did not significantly affect the species diversity. However, under normal conditions the steeper the slope the more the diversity of tree species planted.

The crown diameter of apples and avocado was affected by the slope of the garden but pears were not affected. There is strong positive correlation relationship between slope length and tree stand density / ha ($rX_1Y_4 = 0.506$), this implies that that the longer the slope length, the more close (densely populated) are the tree stands planted with the aim of protecting the soil against

Table 6: Effect of slope on growth parameters (age taken as a covariant)

	Growth parameters											
	Height (cm)			Root collar diameter (cm)			Vigour score			Crown diameter (cm)		
Slope	AP	PE	AV	AP	PE	AV	AP	PE	AV	AP	PE	AV
Flat	79.4	73.3	195.0	2.19	1.66	4.5	3.33	1.96	1.58	73.1	77.5	74.0
Gentle	99.7	126.2	252.0	1.85	1.45	5.74	3.5	3.10	3.68	64.8	63.0	145.0
Steep	78.4	92.9	215.0	3.34	1.20	6.37	2.11	2.11	4.19	27.3	37.0	169.0
Very steep	86.4	105.2	*	2.27	1.64	*	3.16	3.06	*	45.2	38.3	*
F-prob.	0.45	0.455	0.316	0.899	0.409	0.076	0.083	0.164	0.068	0.051	0.244	0.046

NB: * Fruit tree specie not found. AP = Apple, PE = Pear, AV = Avocado

Table 7: Availability of soil nutrients in niches for apples

	N (%)		P (ppm)		K Meq/100g		Ph		Ca (Meq/100g)		Mg (Meq/100g)		C (%)	
Niche	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)
Internal boundary	0.2800	0.250	104	96.3	1.16	1.19	5.75	5.65	7.26	6.78	3.57	3.46	2.707	2.543
Cropland scattered	0.200	0.185	33.5	38.9	1.74	1.74	6.08	6.16	5.64	5.19	2.47	2.20	2.120	1.915
Upper terrace boundary	0.300	0.260	24.5	12.3	3.10	1.97	6.82	6.72	9.99	9.46	5.50	5.70	2.81	2.230
Lower terrace boundary	0.210	0.180	22.6	22.2	2.26	1.79	6.18	6.08	3.53	3.21	2.51	2.36	2.000	1.650
Orchard	0.255	0.227	78.6	74.2	2.27	2.08	5.93	6.29	9.27	7.61	3.75	3.72	2.546	2.429
F-prob.	<0.001	<0.001	0.08	0.099	0.003	0.142	0.66	0.301	0.04	0.006	0.008	0.003	0.001	<0.001

erosional agents that cause surface run-off. The positive relationship between soil erodibility and tree stand density ($rX_2y_I = 0.484$) means that the soils that are highly susceptible to erosion are planted with very close tree stands to add on the resistance capacity of the soil against erosion (Table 6).

Direct field observation revealed that diversity of fruit tree species largely depended on the size of the landholding. Households owning large pieces of land, had big diversity index compared to those with smaller plots of land. Owing to marked differences in rooting habits, physiological requirements, growth pattern and life cycle, the physical (slope length and steepness) and edaphic (soil erodibility) factors do influence the performance and survival of the fruit trees (Table 7).

Available soil nutrients in the niches: The results of the chemical analysis showed variations of Nitrogen (N), phosphorus (P), exchangeable Magnesium (Mg^{2+}), Potassium (K^+), Calcium (Ca^{2+}) and Carbon (C) in the soils for the different fruits. The available nitrogen content varies significantly from niche to niche and also decreases with depth ($p<0.005$). Phosphorus and potassium generally decreased in depth for all the niches. The pH was moderate though it also reduced with depth. For the top soil, the pH ranged from 5.75-6.72 and 5.6-6.72. Calcium, magnesium and carbon also reduced significantly with depth for all the niches ($p<0.005$). Availability of all the ions was significant ($p<0.005$). Potassium and magnesium ions were significantly high in the sub soil (15-30 cm). The pH was slightly acidic (Table 8).

For all the niches where avocados grew, all the nutrients were significantly present and generally decreased with depth ($p<0.005$). Nitrogen, potassium phosphorous, magnesium and carbon where highly significant ($p<0.005$) in the niches. Only calcium was not significant at depth 15-30 cm ($p>0.005$). Nitrogen generally decreased in the soils were the fruits were grown. This could be due to leaching and wash away during soil erosion. For the pears, potassium and magnesium ions where significantly high ($p<0.005$) at depth 15-30 cm probably due to leaching of these nutrients to the deeper layers of the soil. Nitrogen is the main limiting nutrient in the Kigezi highlands (Briggs and Twomlow, 2002) (Table 9).

The upper part of nearly every terrace is infertile due to erosion and downward tillage. Hard compacted soils are exposed on the upper terrace and limited crop growth to less than a quarter of what is produced on the lower part of the same terrace (Agroforestry Trends, 1999). The lower terrace boundary was generally more fertile than the upper terrace boundary.

The soil nutrients were generally highly significant ($p<0.005$) in almost all the niches and depths of avocados than the temperate fruits probably because avocados have got deeper roots than the temperate fruits, hence the former being deep feeders.

Table 8: Availability of soil nutrients in niches for pears

	N (%)		P (ppm)		K Meq/100g		Ph		Ca (Meq/100g)		Mg (Meq/100g)		C (%)	
Niche	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0 -15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0 -15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)
Internal boundary	0.224	0.2180	103.9	42	1.16	0.77	5.75	5.17	7.26	4.66	3.57	2.01	2.707	2.336
Cropland scattered	0.200	0.1850	33.5	39	1.74	1.74	6.08	6.16	5.64	5.19	2.47	2.20	2.120	1.915
Upper terrace boundary	0.3000	0.2600	24.5	12	3.10	1.97	6.82	6.72	9.99	9.46	5.50	5.70	2.810	2.230
Lower terrace boundary	0.2100	0.1800	22.6	22	2.26	1.79	6.18	6.08	3.53	3.21	2.51	2.36	2.000	1.650
Orchard	0.2757	0.2838	28.6	111	2.27	2.69	5.93	6.71	7.947	8.53	3.75	4.10	2.546	2.564
F-prob.	0.003	0.001	0.0015	0.0016	0.003	<0.001	0.656	0.008	0.004	0.001	0.008	<0.01	0.001	0.002

Table 9: Availability of soil nutrients in niches for avocadoes

	N (%)		P(ppm)		K Meq/100g		Ph		Ca (Meq/100g)		Mg (Meq/100g)		C (%)	
Niche	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)	0-15 (cm)	15-30 (cm)
External boundary	0.2800	0.2500	21.00	20.0	0.38	0.28	4.640	4.50	3.71	2.96	1.30	2.01	2.900	2.990
Internal boundary	0.2211	0.1778	26.0	13.4	1.02	0.96	5.327	5.152	4.67	3.13	1.85	2.20	2.236	1.893
Cropland scattered	0.1700	0.1500	7.4	9.8	0.85	0.75	4.300	4.290	1.89	1.61	0.71	5.70	1.660	1.610
Homestead scattered	0.2900	0.2700	84.7	81.4	3.75	3.32	5.747	5.427	9.26	6.35	4.85	2.36	3.347	2.100
Lower terrace boundary	0.2000	0.2200	8.2	9.3	0.56	0.38	5.140	5.290	3.82	4.28	1.91	4.10	2.280	2.140
F-prob.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.018	0.038	0.007	0.001	0.001	<0.001	<0.001	<0.001

This leaves most of the nutrients available in the top layers and hence explaining why more nutrients were found in avocado niches than temperate fruit niches.

Survival of the fruits in different niches: Apples survived best when scattered in the cropland, upper terrace boundary, lower terrace boundary and orchard where they had a 100% survival. In the internal boundary, 20% of them died. Pears had 100% survival in all the niches apart from the internal boundary where they had an 80% survival. Avocados grew best in the external boundary, internal boundary and scattered in the cropland. The least survival percentage (40%) was observed in the lower terrace. The temperate fruits survived in all the niches (100%) apart from the internal boundary. This could be that the temperate fruits are competing for soil nutrients with the other crops in the cropland. The avocados survived least in the lower terrace boundary with a 40% survival. This could be due to collection of water after heavy rain, because avocados do not grow well in water logged soils.

CONCLUSION

The study revealed that variables related to resource endowment such as size of family labour force, contact with extension service providers and access to credit impact significantly on the adoption of TFTM technology in Kabale district. The other household characteristics such as number of years of formal schooling, farmer's attitude to agroforestry temperate fruit growing also represent important factors that influence the adoption of the TFTM practices. The important recommendations drawn from these findings are that policy interest should be rekindled in the search for ways of providing sustainable credit support to smallholders in view of the importance of credit in TFTM practices which include purchase of seedlings from reliable sources, tending costs and transport to marketing centres since TFTM products are highly perishable hence need immediate delivery to markets. Furthermore, due to low levels of formal schooling among smallholder farmers, extension policy should now move away from its prescriptive focus of recommending pre-packaged techniques towards emphasis on effects meant to make up for low educational attainments in rural farming communities.

Farmers prefer planting the temperate fruit trees in orchards. They plant fruits in the internal boundary, lower terrace boundary, upper terrace boundary, scattered cropland and homestead in that order, should be planted in the lower terrace boundary, upper terrace boundary or scattered in the cropland and tropical fruit trees (Avocados) are planted in the internal boundary of a garden or scattered in the cropland or homestead compound. The soil erodibility and slope length are some of the biophysical factors that significantly affect performance of fruit tree growing.

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REFERENCES

Adesina, A.A., D. Mbila, G.B. Nkamleu and D. Endamana, 2001. Econometric analysis of the determinants of adoption of alley farmingby farmers in the forest zone of southwest Cameroon. Agric. Econ. Sys. Environ., 80: 255-265.

Agroforestry trends, 1999. Agroforestry Trends. Highlights of Agroforestry Research and Development (AFRENA)-Uganda.

Alavapati, J.R.R., M.K. Luckert and D.S. Gills, 1995. Adoption of agroforestry practices: A case study of Andhra Pradesh, India. Agroforest. Sys., 32: 1-14.

Briggs, L. and and S. J. Twomlow, 2002. Organic material flows within a smallholder highland farming system in southwestern Uganda. Agric. Ecosys. Environ., 8: 11-212.

Franzel, S., R. Coe, P. Cooper, F. Place and S.J. Scherr, 2001. Assessing the adoption potential of Agroforestry practices in Sub-saharan Africa. Agric. Sys., pp: 6 37-62.

ICRAF, 1996. Annual Report. International Center for Research in Agroforestry, Nairobi, Kenya.

Jacovelli, P. and J. Caevalho, 1999. The private forest sector in Uganda-Opportunities for greater involvement. Forest Sector Review. Ministry of Water, Lands and Environment. Kampala, Uganda.

Masangano, C. 1996. Diffusion of Agroforestry Technologies. URL. http://www.msu.edu/user/masangn/agrof.html.

Okorio, J. and D. Hoekstra, 1988. Agroforestry Research Proposal for Kigezi Annual Montane Food Crop System in the Highlands of Uganda, AFRENA Report No. 11. ICRAF, Nairobi.

Peden P. G., 1991. AFRENA Project Uganda. Progress report for period ending March 11. AFRENA Report No. 43. ICRAF Publication. Nairobi.

Semana, A.R., R. Percy and P. Kibwika, 2002. Sharing Experiences on Participatory Technology Development. Department of agricultural Extension/ Makerere University and International and Rural Development Department, the University of Reading.

UBOS (Uganda Bureau of Statistics), 2002. Provisional Population Census Results. Entebbe, Uganda.

Wortmann, C.S. and C.K. Kaizzi, 1998. Nutrient balances and expressed effects of alternative practices in farming systems of Uganda. Agriculture Ecosystems of Uganda. Agric. Ecosys. Environ., 71: 115-130.