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Apple Based Agroforestry in Dendi Woreda, Oromiya Region: Income Contribution and Determinants for Adoption

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Abstract

A study was conducted to evaluate and compare households' income from apple based agroforestry system and identify factors that influence its adoption by smallholder farmers in Dendi Woreda, Oromia region. Two kebeles' were purposefully selected and from which 250 households were randomly taken, where 33 were adopters of the technology and the remaining 217 were non-adopters. To obtain the necessary information, both primary and secondary data were collected and focus group discussion was conducted. The result revealed that farmers predominantly carry out various livelihood activities such as production of grain crops, livestock, vegetables, and apple fruit. In agri-horticulture agroforestry approach apple trees were integrated with vegetables at homesteads by adopters. The mean gross income of adopters from apple fruit was 58,234.85ETB ha^{-1} yr^{-1}. Adopters' mean annual gross income from vegetable + apple fruit was 344,602.3ETB ha^{-1} yr^{-1} and mean annual gross income of non-adopters from vegetable was 219,932.9ETB ha^{-1} yr^{-1}. The income obtained from apple contributed 17 per cent to the income of the agri-horticulture system. Non-adopters annual net income from vegetables was 191,645.13ETB $ha^{-1}yr^{-1}$ and adopters' annual net income from vegetable + apple was 312,378.79ETB ha^{-1} yr^{-1}. The agri-horticulture system contributed 1.63 times higher net revenue for adopters in addition to its nutritional value. However, adoption of apple based agroforestry system was significantly influenced by different factor such as age (+), formal education levels (+), livestock holding (+), distance from market to home (+), sex (-) and total land holding (-). In order to maximize the benefits from the system land users are advised to follow integration of apple fruit trees in their food production activities incorporating their own farm resources to minimize input costs. Policy makers are also expected to advocate the systems performance in the study area and beyond.

Key word: Agri-horticulture system; Apple tree adoption; Household income

Introduction

Population needs are continuously growing for food, wood for fuel and construction and arable land (Abebaw Zeleke, 2006). In many parts of the world, food and wood supply are getting scarce and per capita production has decreased. Hence people relied mainly on the extension of the area of land under cultivation by clearing the remaining natural forest and wood-lands to satisfy their need. (Zebene Asfaw, 2003). This is major contributing factors to land degradation, reduction in crop and livestock productivity, in turn undermining the efforts of food self-sufficiency (Abebaw Zeleke, 2006).

The adoption of improved agroforestry technology has become valuable to meet growing demands of increasing population, to compensate forests in the wake of fast increasing rate of deforestation and soil degradation, and to conserve biodiversity (Batish *et al.*, 2008). Agroforestry can be considered as an alternative to some exhausted land-use practices that occur (Badege Bishaw and Abdu Abdelkadir, 2003). Negussie Achalu (2004) argues that carefully planned and executed agroforestry practices could enormously enhance household food-security through improved and sustainable land productivity and meet the increasing demands for tree products.

One of the promising agroforestry technologies is integration of fruit trees into farmlands, referred to as agri-horticultural land use system, and the main crop is the fruit tree (Dwivedi *et al*, 2007). The system consists of different species of plants with various morpho-phenological characters to get the most out of the natural resource use efficiency and improve total factor productivity (Das *et al*. 1993). Experts in the field claim that promoting fruit-based agroforestry systems will shift the conventional agroforestry system towards market-led 'trees for cash' and income-generating production systems. This signifies the incorporation of fruit bearing trees with agricultural crops to increase systems profitability.

Successful establishment of fruit tree based agroforestry system in the highland areas can increase farm household income, enrich their diets with essential minerals, vitamins and increase varieties of fruits available in the local markets. In Dendi *Woreda* of Oromia region apple trees were integrated with vegetable crops at homestead level to diversify the livelihood options of the resource poor rural community for more than ten years. The system was also designed to reduce the pressure of wood extraction from the surrounding Chilimo forest for trade in the near town of Ginchi by rural women and men in demand of money for supporting their family needs. Accordingly, this investigation was intended to find out the contribution of apple based agroforestry system in improving households' income along with the critical factors which limit the adoption process in the central highlands of Ethiopia.

Materials and Methods

The study area

The study was carried out in West Shoa zone, Dendi *Woreda*[1] and in two *kebeles*. Dendi is one of the 19 *Woreda* in West Shoa zone of Oromia region and consists of 48 k*ebeles*[2]. It is about 78 km west of Addis Ababa along the Addis Ababa-Nekemte highway. Of the 48 *kebeles* Gare Arera is located 2320–2620 m a.s.l. in the warm to cool mid-highlands (Ethiopian Mapping Agency, 1980). Ginchi town, the capital of Dendi *Woreda* is 12 Km Southwest of Gare Arera (Amare Haileslassie *et al*., 2006). Boda Bosoqa *kebele* is located 21 km away from Ginchi, the altitude of the area ranges from 2500 to 3200 m a.s.l (Kebede Ayele and Hailemariam Tefera, 1999).

The climatic of Boda Bosoqua *kebele* is mainly characterized by two agro-climatic conditions. It shares 79 per cent highland (*dega*[3]) and 21 per cent semi-highland (*weynadega*[4]) (Kebede Ayele and Hailemariam Tefera, 1999). Whereas, Gare Arera *kebele* has a tropical highland climate and has a bimodal rainfall distribution, the mean annual rainfall is 1117 mm (Amare Haileslassie *et al*., 2006).

The major crops grown in Gare Arera *kebele* were cereals, including barley, wheat, *teff*[5] and faba bean. In addition, *enset*, barley, wheat, *teff*, beans, peas, maize, potato and hopes are widely cultivated. The staple crops are *enset*[6], barley and wheat with the proportion of land share for these crops is 20 per cent, 30 per cent and 50 per cent, respectively (Kebede Ayele and Hailemariam Tefera, 1999).

In the central Plateau including Chilimo, the soils in the surrounding low plains are Luvisols, Cambisols and Vertisols (Amare Haileslassie *et al*., 2006). The type of soil observed in Boda Bosoqua *kebele* is mainly sandy loam and black and red in color (Kebede Ayele and Hailemariam Tefera, 1999).

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[1] *Woreda* is the second tier after 'zone' in administrative structure of Federal regions and it is composed of a number of *kebeles*(the smallest administration structure next to *woreda*)

[2] *kebele* is the smallest administrative unit of Ethiopia similar to ward, a neighborhood or a localized and delimited group of people.

[3] Dega is characterized by 12-16^{o}c temperature and annual rainfall 2300-3000 m a.s.l. of elevation, and with dominantly growing cereals of Wheat, Barley, Teff, Oats

[4] *Weyna Dega* is characterized by 16-21^{o}c temperature and annual rainfall greater than 1400 mm, 1500 –2300 m a.s.l. of elevation, and with dominantly growing cereals of Millet, Maize, Sorghum, Rice, Wheat, Barley, Teff, Oats

[5] *Teff* is a traditional Ethiopian cereal (Latin: *eragrostis tef)*, which is endemic to Ethiopia and Eritrea. The grain is ground into flour, fermented and made into enjera a sour-dough type flat bread

[6] Enset (Ensete ventricosum (Welw) Cheesm.), sometimes called the "false banana".

In the specific study areas, there were 2085 household heads. Of these about 1772 (85 per cent) are male and 313 (15 per cent) are female. Among the total population in the two *kebeles,* 274 household heads planted apple trees in their homestead farmland and the rest 1811 household heads did not plant apple trees.

Sampling

Boda Bosoqua and Gare Arera *kebeles* were purposefully selected based on high fruit production and accessibility. In each of apple growing *kebeles,* two groups of farmers were identified as adopters and non-adopters. Adoption category was used as strata and used for stratified sampling. From each stratum using stratified random sampling technique, proportional to the population of *kebeles* identified, study sample respondents were selected. Accordingly, from both *kebeles* a total of 33 adopters and 217 non-adopters were randomly selected.

Source and Methods of Data Collection

Both primary and secondary data were collected to address the objectives of the study. Primary data were collected from sampled household heads by conducting formal survey using a structured questionnaire. In addition, information collected using structured questionnaire was supplemented with focus group discussions (FGDs). Whereas, secondary data were gathered from Dendi *Woreda* agricultural office, *kebele* agricultural office, Forestry Research Centre (FRC), Ethio-German Programme for the Sustainable Utilization of Natural Resource for Food Security (SUN) and Netherland Development Organization (SNV).

Method of Data Analysis

To meet the objectives of the study, both descriptive and econometric analysis were employed. The collected data was analyzed using Statistical Package for Social Sciences (SPSS) version 16, STATA version 10 and Microsoft Office Excel 2007.

Model Specification

To answer the question of factors influencing the adoption of apple based agroforestry system, a binary logistic regression model was used. The model was used to describe the relationship between dependent variable and a set of independent variables. The dependent variable was binary or dichotomous and had only two groups: adopters and non-adopters, whereas, the explanatory variables could be continuous, categorical or dummy Thus, the logistic function was used since it represents a close approximation to the cumulative normal distribution and is easier to use than other types of model Logistic regression model has been used by majority of agroforestry adoption studies to analyze dichotomous adoption decisions in which the dependent variable is binary: 1 if adopters, 0 otherwise (Mercer, 2004). As a result, the probability to be adopter is:

$$P_i = \frac{1}{1+e^{-Z_i}} = \frac{e^{Z_i}}{1+e^{Zi}} \quad \text{......................} \quad \textbf{(1)}$$

Where, in the notation P_i represents the probability that an individual will make a certain choice, in this study whether the i^{th} farmer adopts apple based agroforestry system or not. Moreover, ***e*** denotes the base of natural logarithms which is approximated at 2.718. Z_i is a function of *m* explanatory variables (X_i) (shown in Table 1), and expressed as:

$$Z_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + ... + \beta_m X_{mi} \quad \text{.............} \quad \textbf{(2)}$$

If P_i is the probability of the i^{th} farmer to adopt apple based agroforestry system, is given by (equa.1), then ($1-P_i$), is the probability of the i^{th} farmer to not adopt apple based agroforestry system.

$$1 - P_i = \frac{1}{1+e^{Z_i}} \quad \text{................} \quad \textbf{(3)}$$

Dividing [1] by [3], we get

$$\frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-Z_i}} = e^{Z_i} \quad \text{.........} \quad \textbf{(4)}$$

$\frac{P_i}{1-P_i}$ is simply the odds ratio in favor of the i^{th} farmer to adopt the system to the probability to not adopt it.

Taking the natural logarithm of the odds ratio in both sides of [4] will result in what is known as the logit model as indicated below:

$$\ln\left(\frac{P_i}{1-P_i}\right) = \ln\left(\frac{1+e^{Z_i}}{1+e^{-Z_i}}\right) = \ln\left(e^{Z_i}\right) \quad \text{...} \quad \textbf{(5)}$$

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + ... + \beta_m X_{mi} \quad \text{....} \quad \textbf{(6)}$$

Variables Used in the Empirical Model and Hypothesized Effects

Dependent variables: In this study, adoption of apple based AF system used as a dependant variable.

Independent variables: It is hypothesized that farmers' decision to adopt or reject new technologies at any time is influenced by the combination of various factors. This includes both dummy and continuous variables such as: household characteristics, socioeconomic characteristics and institutional characteristics in which farmers operate. In this study eleven explanatory variables were considered as the determinant factors for the adoption of the system.

Table: 1. Definition of independent variables, which were included in the econometric model and expected sign

Variable code	Description	Types of variable	Unit of measurements	Expected sign
ADOPTION	Apple fruit adoption	Dummy	1=adopter, 0=non adopter	
SEX	Sex of household head	Dummy	1=Male,0=Female	+/-
AGE	Age of household head	Continuous	Measured in years	-
NATIVE	Household head being native to the area	Dummy	1=Native, 0=Not native	+
EDU	Education level of the Household head	Continuous	The level of formal education	+
FAMSIZE	Family size	Continuous	Number of family member	-
TLANHOLD	Total land holding of household head	Continuous	Measured in hectare	+
DWATER	Distance from source of water	Dummy	1=Yes, 0=No	-
DISEASE	Disease incidence of apple	Dummy	1=Yes, 0=No	-
LIVTLU	Livestock holding of a household head	Continuous	Measured in tropical livestock unit (TLU)	+
DISMARKT	Mean distance of market from residence	Continuous	Measured in km	-
CREDIT	Access to credit	Dummy	1=Yes, 0=No	+

The data obtained from all respondents (250) were considered in the model. The above explanatory variables (X_i) were included in the logit model as SEX, AGE, NATIVE, EDU, FAMSIZE, TLANHOLD, DWATER, DISEASE, LIVTLU, DISMARKET and CREDIT.

Given the above explanatory variables, the general form of Eq. (6) was rewritten as follow to represent the likelihood adoption of apple tree based agroforestry system.

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 SEX + \beta_2 AGE + \beta_3 NATIVE + \beta_4 EDU + \beta_5 FAMSIZE + \beta_6 TLANHOLD$$
$$+ \beta_7 DWATER + \beta_8 DISEASE + \beta_9 LIVTLU + \beta_{10} DISMARKET + \beta_{11} CREDIT$$

.... (7)

In this study, the above econometric model was used to identify factors that influence adoption of the apple based agroforestry technology.

Results and Discussion

Production and income from apple based agroforestry system

The study indicated that the rural community in the study area carries out agricultural activities such as production of livestock, grain crops, vegetables and integration of vegetable with apple tree as source of income and for household consumption. Most farmers hold two types of cultivated agricultural lands. The first one is field farm land, found far from their home, where farmers mostly cultivate *teff* (*Eragrostis tef*), wheat (*Triticum aestivum*), maize (*Zea mays*), barely (*Hordeum vulgare*), bean (*Phaseolus spp*) and peas (*Pisum sativum*). The other land is homestead farmland, where farmers produce vegetables like cabbage (*Brassica oleracea*), Ethiopian cabbage *(Brassica oleracea)*, potato *(Solanum tuberasum)*, carrot *(Daucus carota)*, tomato (*Lycopersicon esculentum*), chili *(Capiscum annuum)*, onion *(Allium cepa, Allium ascalonicum)*, garlic *(Allium sativum)*, leeks *(Allium ampeloprasum v. porrum)* and beetroot *(Beta vulgaris)*. The type of vegetables cultivated by adopters and non-adopters were similar however, apple and beetroot merely found on adopters land.

Income obtained from homestead agricultural land was distinct for both adopters and non-adopters (Table 2). Hence, vegetables that provided the highest annual income for adopters were onion, carrot, potato, chili, garlic, Ethiopian cabbage, leeks, tomato, cabbage and beetroot. Besides, for non-adopters more income was obtained from garlic, chili, Ethiopian cabbage, onion, potato, tomato, leeks, carrot and cabbage in their order of economic importance.

Table 2: Adopters and non-adopters mean annual income from vegetable production per hectare (in ETB) in Dendi *Woreda*.

	Non-adopters (n =217)		Adopters (n = 33)		
Vegetables	Mean	Sta. Dev	Mean	Sta. Dev	t-value
Cabbage	19,324.23^{b}	11554.99	38,769.23^{a}	16569.6	-5.54***
Ethiopian cabbage	128,549.68	101103	85,000	28504.39	0.96
Potato	83,380.28^{b}	42251.43	170,545.45^{a}	40571.78	-9.05***
Carrot	59,353.85^{b}	64713.38	231,250^{a}	189242	-2.99***
Tomato	77,000	46192.15	68,250	7685.21	0.41
Chili	147,259.26	37440.25	132,857.14	82125.77	0.61
Onion	100,000	51639.78	382,812.5	519282	-1.59
Garlic	206,258.5^{b}	81427.18	107,142.86^{a}	31339.16	3.17***
Leeks	55,000	21602.47	77,678.57	47579.04	-1.22
Beetroot			12,750	6860.21	

Source: Own survey;

*** Significant at 1% probability level; Mean values with different superscript letters along the same rows are statistically different (P<0.01).

Adopters mean annual gross income from vegetable + apple fruit was 344,602.3ETB $ha^{-1}yr^{-1}$ and mean annual gross income of non-adopters from vegetables was 219,932.9ETB $ha^{-1}yr^{-1}$. Adopters' annual gross income from vegetable + apple exceeded non-adopters income from vegetable nearly 1.6 times. Non-adopters annual net income from vegetables was 191,645.13ETB $ha^{-1}yr^{-1}$ whereas adopters' annual net income from vegetable + apple was 312,378.79ETB $ha^{-1}yr^{-1}$. Adopters' net annual income exceeded non-adopters income by 1.63 times (Table 3). Results observed by Agena Anjulo (2009) also coincide with the present study. The author evaluated the profitability of apple based agroforestry system in wet temperate zone of Himachal Himalayas where the highest monetary net returns were achieved from the intercropping of apple with tomato (Rs.1577489.08 ha^{-1}) and pea (Rs.1330199 ha^{-1}), which is equivalent to US$ 33,707 and 28,423 ha^{-1}, respectively. Furthermore, Dwivedi *et al*. (2007) on the study of agri-horticultural system for household livelihood revealed that farmers prior to the adoption of agroforestry technologies used to get net income of Rs. 3,400 ha^{-1} or USD 80 ha^{-1} whilst after adoption of Aonla based agri-horticultural system their annual net income turn out to be Rs.11, 715 ha^{-1} that is equivalent to USD 275.52 ha^{-1}.

Table 3. T-test to compare mean gross and net annual income (ETB ha^{-1}) of adopters from vegetable + apple fruit and non-adopters income from vegetable in Dendi *Woreda*

Adoption	Mean Gross income	Sta. Dev	T-value	Mean net income	Sta. Dev	T-value
Non-adopters	219,932.9^{b}	157966	-3.7***	191,645.13^{b}	153262	-3.66***
Adopters	344,602.3^{a}	276013		312,378.79^{a}	273057	

Source: Own survey; ***Significant at 1% probability level; Mean values with different superscript letters along the same columns are statistically different ($p<0.01$).

The mean annual apple fruit production was 3639.68kg $ha^{-1}yr^{-1}$ and the annual gross income from apple fruits was 58,234.85ETB $ha^{-1}yr^{-1}$. Results of the present study agree with the findings of the study that was conducted at Harar to compare income obtained from fruit growing, vegetables, and cereals (sorghum and maize). The result showed annual income from fruit growing was 60,000ETB $ha^{-1}yr^{-1}$, compared to 2,000 for maize and only 1,000 for sorghum (PFMP, 2004). Furthermore, income obtained from apple contributed 17 percent of the total income from the agri-horticultural system. A study conducted in Northern Pakistan showed that income from fruit was 21 per cent of the farm income; the report exceeds the current study finding (Essa *et al*. 2011). Thus, agri-horticultural system is more profitable than the cropping system without horticultural trees (Dwivedi *et al*., 2007).

Determinants of Apple Tree Adoption

The maximum likelihood estimates of the logit model shows that among six potential continuous and five dummy explanatory variables, six variables were found to be significant determinants of apple based agroforestry adoption [Table 4]. These variables take account of sex of the household head (SEX), age of the household head in year (AGE), educational level of the household head in years of education (EDU), total land holding in hectare (TLANHOLD), total livestock holding in TLU (LIVTLU) and market distance in km (DISMARKET).

Table 4.Maximum likelihood estimates of the binary logit model

Explanatory Variables	Coefficient	Robust Std. Err	Marginal Effect
SEX	-1.683*	0.957	-0.0342
AGE	0.049*	0.027	0.0005
NATIVE	1.415	1.034	0.0090
EDU	0.139*	0.076	0.0013
FAMSIZE	0.220	0.161	0.0021
TLANHOLD	-1.151***	0.338	-0.0108
DWATER	-0.504	0.541	-0.0053
DISEASE	1.209	0.760	0.0116
LIVTLU	0.252**	0.097	0.0024
DISMARKET	1.089***	0.414	0.0103
CREDIT	0.417	0.557	0.0038
CONS	-12.502	3.289	

Maximum likelihood estimates	
Dependent variable	Adoption of apple based agroforestry system
Number of observation	250
Log likelihood function	-43.87
Correctly predicted percent	55.04
Chi-squared	42.83***
Degree of freedom	11

Source: Own Survey 2011/12

***, **,* Significant at 1%, 5% and 10% probability level

Sex of the household head: the direction of influence of sex variable for apple based agroforestry adoption was predicted to indeterminate. It may affect adoption positively or negatively. However, as shown in the model summary, sex is found to influence adoption of apple based agroforestry negatively and significantly at 10% probability level and the probability of adoption of male headed households was reduced by 3.42 per cent than female headed households [Table 4]. Rocheleau *et al*. (1988) reported that women have been the main contributor in homestead agroforestry projects all over Africa than males. Females high likelihood in favor of adoption of apple based agroforestry may be homestead land provide a right place for women to cultivate agricultural crops since they are usually located close to the home compound. However, the finding was contrary to Adesina *et al.* (2000) who reported women adoption potential of new technology is less likely than males because of either lack of rights to grow trees or secured land rights.

Age of the household head: the probability of the household being adopter of apple based agroforestry increased as age of the household head increased. As it is observed from the result, an increase in the age of the household head by one year increased the probability of adoption by 0.05 per cent. The positive effect of age on adoption of apple based agroforestry system may be due to the accumulated experience of older farmers that helps them to make early adoption decision, since agroforestry has long time dimension to realize its benefit. As a result, farmers with old age have better chance to recognize this benefit earlier than young aged farmers. The current finding is in line with Zenebe Gebreegziabher *et al*. (2010) who reported the positive relation of age of the household head with tree adoption in Tigray region. Nonetheless, the study was contrary with the findings of Motamed and Singh (2003), who reported young people are more flexible in deciding for the adoption of new technology than aged people.

Education: As hypothesized, formal education level of the household head was statistically significant ($p < 0.1$) and had positive relation with the adoption of apple based agroforestry system. The positive sign of coefficient indicated that increase in educational level by one year increased the probability of adoption by 0.13 per cent. The current result agrees with the finding of Teklewold *et al*. (2006) who discovered that farmers with a high level of education were better adopters of new farm technologies than those with lower levels of education. This positive correlation shows the influence of education on adoption of the new technology. Educated producers have exposure to new technologies and innovations; they are more receptive to new ideas and willing to adopt. However, the finding was contradictory to the report of Asnake *et al.* (2005). They conducted a study on adoption of improved chickpea varieties in Ethiopia and the result revealed that education had no significant effect on the adoption of improved chickpea varieties.

Total land holding: The regression analysis showed that there was strongly negative and significant ($p < 0.01$) relationship between total land holding and apple based agroforestry adoption. The negative sign of the coefficient imply that the increase of the land size by one hectare decreases the probability of adoption by 1.08 per cent. The negative effect agrees with the finding of Johannes *et al*. (2010). They concluded in the study of adoption of maize and cassava production technologies in the forest savannah zone of Cameroon: implication for poverty reduction, the decision to adopt the technology is not contingent upon having large acres of land. The negative result of total land holding with apple based agroforestry adoption may be due to the fact that smallholder farmers always look for the best alternatives that secure food supply from their small land with the objective of getting high cash income. Moreover, farmers who possess large lands gain sufficient yield to supply their family need. Therefore, they may not want to be much concerned about integrating apple trees in the homestead farm land. This also may be attributed to the intensive labor requirement of apple tree to be productive. However, this finding was different from the findings of Asnake *et al.* (2005) who conducted a study on adoption of improved chickpea varieties in Ethiopia and found that farm size was positively related to the adoption of improved varieties.

Livestock holding: As hypothesized, there was significant and positive ($p < 0.05$) relationship between livestock holding and apple based agroforestry adoption. The positive sign of the coefficient imply that as the livestock ownership increased by one TLU, it increases the likelihood of adoption by 0.24 per cent. The current result agrees with the finding of Kidane Gebremariam (2001) who reported the positive influence of livestock holding on adoption of improved agricultural technologies. The positive association of apple based agroforestry adoption with livestock holding may be accounted for satisfying the demand for organic manure for apple tree since apple tree requires a large amount of fertilizer to be productive and fruitful. Thus, possession of livestock by households had a significant influence on the extent of apple based agroforestry adoption.

Market Distance: Differed from the expected effect. The regression analysis showed that there was strongly positive and significant ($p < 0.01$) relationship between market distance and apple based agroforestry adoption. The positive sign of the coefficient imply that as the distance to market from home increased by 1 km the probability of adoption increases by 1.03%. Tesfaye Zegeye *et al*. (2001) reported that distance to the nearest market centre significantly and positively influenced the adoption decision of improved maize varieties. The positive relation of market distance with adoption of apple based agroforestry in the present study area may be associated with the formerly provision of apple tree to farmers who lived far from marketplaces. For the reason that, the objective of the organizations, that distributed the trees, was to minimize deforestation, soil degradation and to enhance the economic status of the people. As discussed above, the residents of Gare Arera *kebele* are found in Chilmo forest and caused a high rate of deforestation due to their dependence on this forest. Moreover, in Boda Bosoqua *Kebele* the inhabitants were suffering from the problem of land degradation. Basing the above facts the organizations that provided apple tree disseminated it to these distant areas. Besides, the places have water access and suitable climatic condition for the growth of the temperate fruit. However, the current finding is opposite to the work of Shivani *et al*. (2000). They reported that distance to market is negatively related to chick pea adoption.

From the result discussed above it can be inferred that adopters of apple based agroforestry system obtained higher net and gross annual income than non-adopters. Among vegetables that provided the highest income for adopters were onion, carrot, potato, chili, garlic, Ethiopian cabbage, leeks, tomato, cabbage and beetroot. While, for non-adopters, more income was obtained from garlic, chili, Ethiopian cabbage, onion, potato, tomato, leeks, carrot and cabbage in their order of economic importance.

The mean gross income of adopters from vegetables + apple was 1.6 times higher than the income of non-adopters from vegetables. The mean annual gross revenue of adopters from solely apple fruit production constituted about 17 per cent of the total income obtained from vegetable + apple. The mean net annual income of adopters from vegetables + apple fruit was 1.63 fold higher than the income of non-adopters from vegetables.

In the study area, apple based agroforestry system had both nutritious supplement and monetary value. However, adoption of the system was significantly influenced by different factors. Age (+), formal educational levels (+), livestock holding (+), distance from market to home (+), sex (-) and total land holding (-). Thus, the current study proved that in the presence of determinant factors that limit the adoption process, apple based agroforestry system provides significant economic advantage for adopter as compared to non-adopters.

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