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Income contribution and adoption potential of apple based agroforestry on homestead farms in West and North Shoa zones of Ethiopia

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To reduce the local people high reliance on the remnant forest, the then Forestry Research Center and GTZ introduced and provided Apple tree seedlings for selected residents in the West and North Shoa Zones of Ethiopia two decades ago. However, despite the provision of such variety of seedlings, a study that assessed the contribution of the fruit trees to the household economy improvement, and the various determinant factors that limit the adoption of the technology was lacking. Therefore, this study was initiated to estimate and compare households' income from apple based agroforestry system and identify factors that influence its adoption by smallholder farmers in both West and North Shoa Zones of Ethiopia. From three Woredas of the two zones, four potential Kebeles were purposefully chosen, and from which 600 households were randomly selected. The results showed that in both study areas, the aggregated adopter household mean annual gross income from vegetable + apple fruit was 24,337.22ETB $ha^{-1}yr^{-1}$ and mean annual gross income of non-adopters from vegetables was 7480.53ETB $ha^{-1}yr^{-1}$. The income obtained from apple contributes 16.84% to the income of agri-horticultural system. The agri-horticulture system contributed three-fold higher gross revenue for adopters in addition to its nutritional value. However, adoption of apple-based agroforestry systems was significantly influenced by formal educational levels (+), a Market problem (-), Disease and Pest to maximize the benefits from the system, interdisciplinary research needs to be conducted to reduce the problem of marketing and disease and pest.

Key words: Agri-horticulture system, apple tree adoption, household income.

INTRODUCTION

Fruit-tree-based agroforestry involves intentional, the simultaneous association of annual or perennial crops with perennial fruit-producing trees on the same farm unit. Trees grown on farms for their non-timber forest products such as fruits, nuts, and spices constitute the basis for many vibrant and sustainable farming systems. Because of a high market value of their products and the contribution of fruits to household dietary needs, fruit-tree-based agroforestry enjoys high popularity among resource-limited producers worldwide (Korwar et al., 2014). Farmers prefer fruit-producing species to other trees for on-farm planting and appreciate the dual

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contributions of food for consumption and the potential for income generation (Meseret, 2015). Fruit trees are considered advantageous because of the relatively high returns to labor resulting from low labor inputs (compared with annual crops); moreover, fruit tree-based systems also offer a more uniform distribution of income throughout the year than annual crop systems.

Most examples of fruit-tree-based agroforestry have developed over long periods of time in response to interactions between agro-ecological conditions, plant diversity, and farmer resources and needs. Because of this, the system performance at any given location will depend to a great extent on several site-specific features. Nevertheless, the system performance also follows some typical characteristics such as their potential benefits and limitations that are applicable to wider regions (Abhisherk, 2014). An understanding of such typical characteristics of these systems is helpful for adaptation and extension of the system to other highland areas with similar production environments. Successful establishment of fruit-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 (Gideon and Verinumbe, 2013). However, the relatively "free" availability of forest-based timber- and fuelwood products in some areas are seen as disincentives for growing tree species for those purposes (Meseret, 2015).

Promotions of on-farm tree/shrub plantings could also greatly relieve the pressure on the remnant natural forest by providing the variety of forest products (Sisay and Mekonnen, 2013). In order to minimize farmers pressure to the forest and improve the livelihood of the people the then Forestry Research Centre (FRC) in 2007, and GTZ in 2008, introduced and provided four apple varieties namely, Anna, Crispin, Dorset-golden, and Princesa, to the dwellers of North and West Shoa Zones of Ethiopia. This study is based on the premise that farmers in land-scarce situations can directly benefit by incorporating fruit trees into an agricultural landscape with few other trees and this also relieve the people pressure to the natural forest.

Since, fruit trees enjoy great popularity among subsistence farmers and provide tangible benefits in short time frames (Rankoana, 2017). Despite the provision of such variety of apple tree seedlings to the farmers in the area, knowledge of critical factors that can lead to the adoption of these systems as a land management alternative is yet to be identified. Thus, the objective of this investigation was to assess the income contribution and potential for adoption of apple-based agroforestry by smallholder farmers in an area similar in many respects to other highly-populated highland areas. We hypothesized that fruit-tree-based agroforestry would be of interest to smallholder farmers, but that potential differences in adoption rates could be explained by various socioeconomic factors.

MATERIALS AND METHODS

Study area

The study was conducted in West and North Shoa Zones of Oromia region. Dendi Woreda is one of the 19 Woredas in West Showa zone of Oromia region and consists of 48 Kebeles. It is about 78 km west of Addis Ababa along the Addis Ababa-Nekemte highway. The Woreda lies within the coordinates from 8° 43' North to 9° 17' North Latitude and 37° 47' East to 38° 20' East Longitude, by relative location, the Woreda shares boundaries with other seven Woredas: Jaldu and Ilfeta Woredas in the north, Dawo and Walliso Woredas in the south, Ejere and Ilu Woredas in the east and Ambo Woreda in the west (Dendi Woreda Agricultural and Rural Development Office (DWARDO), 2017). Among the 48 Kebeles, the study was conducted in two Kebeles of Dendi Woreda, namely Gare Area and Bejiro Kebeles'. The major fraction of Gare Arera Kebele is covered by Chilimo National Forest.

From the North Shoa Zone, Degem and Hindbu Abote Woredas were selected. Degem Woreda, lies between 9° 47 '29" - 9° 47' 13'' N latitude and 38° 31' 09" - 38° 32' 50" E longitudes about 125 km North of Addis Ababa. The Woreda covers a total land of 67,020 ha with a widely varying altitudinal range of 1500 - 3450 m.a.s.l., accordingly; 30% of the total land area lies in high land, 38% mid high land and 32% low land. The area receives a mean annual rainfall of 1157 mm, a mean maximum temperature of 20°C and a mean minimum temperature of 8.7°C (DWARDO, 2017). Degem woreda has eighteen peasant associations from this the dominant Apple based agroforestry producer is Ali doro kebele (DWARDO, 2017) (Figure 1).

Sampling

Dendi, Degem and Hindbu Abote Woredas were selected based on the productivity of apple-based agroforestry system. Before the selection of appropriate Kebeles, consultation with the expertise of the Woreda agricultural office was made to get information related to potential fruit producer Kebeles. Consequently, four Kebeles namely, Gare Area, Bejiro, Alidoro and Yaya Dakabora were purposefully selected based on high fruit production and accessibility.

Several rules-of-thumb have been suggested for determining the minimum number of subjects (households) required to conduct multiple regression analysis. For this study, a rule-of-thumb that $N \geq 50 + 8\,m$, where N is the minimum number of households and m is explanatory variables, was used (Bonett and Wright, 2014). The explanatory variables hypothesized to influence the adoption of apple-based agroforestry in this study were fourteen. Thus, a total of 600 farm households were randomly selected from the purposively selected four Kebeles. In each selected apple growing Kebeles, two groups of farmers were identified as adopters and non-adopters using adoption category as stratification criteria. From each strata using simple random sampling technique, proportional to the population of Kebeles identified, study sample respondents were selected randomly from the list of household heads. Accordingly, from all selected Kebeles a total of 85 adopters and 515 non-adopters were randomly identified.

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 the formal survey using a structured questionnaire. In addition, information collected using structured questionnaire was supplemented with group discussions

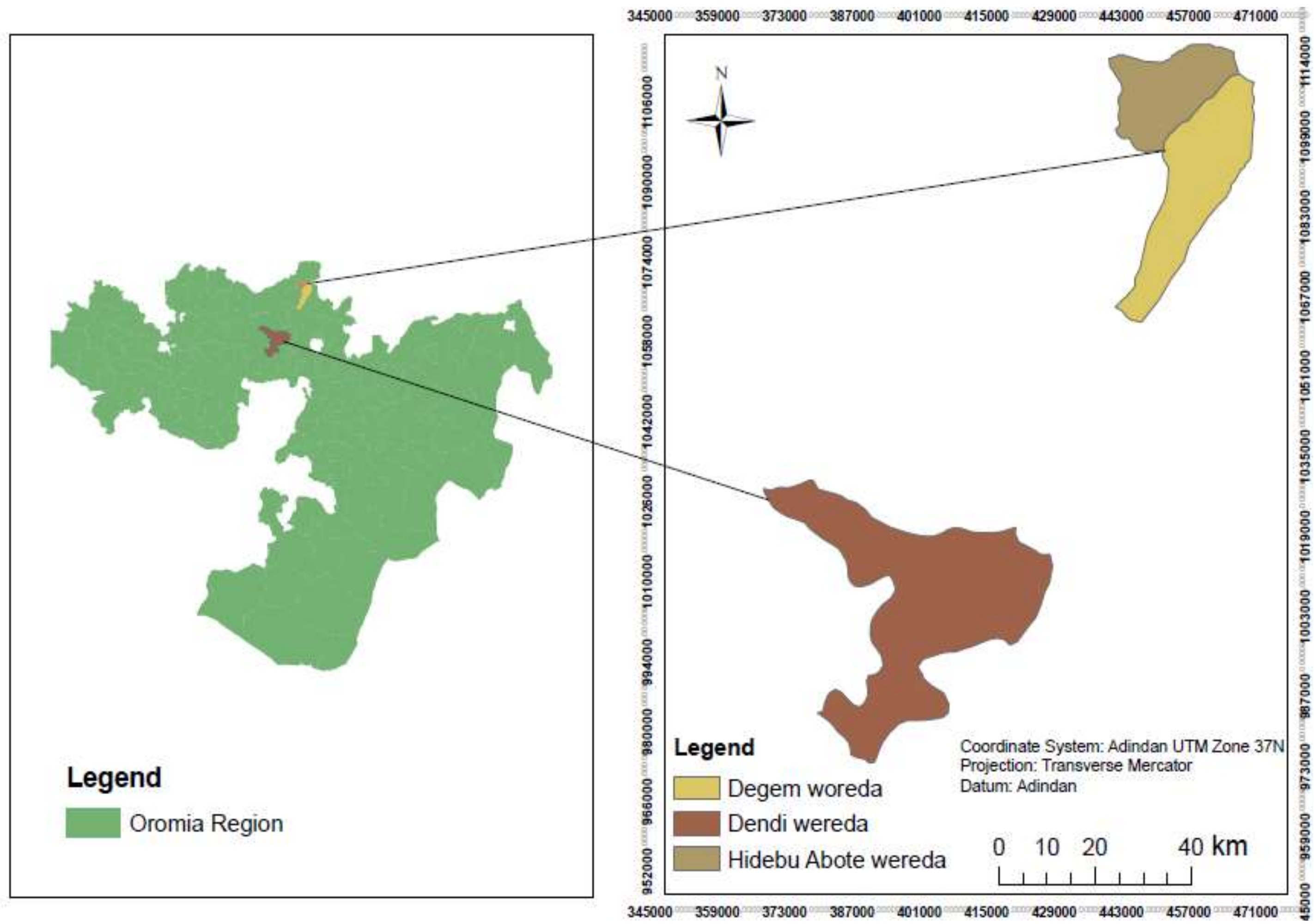

Figure 1. Map of the study area.

(GDs). The discussion was conducted to confer specific issues related to the purpose of the study by forming small groups with a homogeneous composition. Hence, eight GDs were held with selected farmers in the specific Kebeles and the researcher thoroughly investigated the advantage that adopters achieve and the various determinant factors that limit the adoption process. Secondary data that were important for supporting the primary data have been from the relevant Zonal and Woreda offices.

Method of data analysis

To meet the objectives of the study, both descriptive and econometric analysis was employed. To answer the question of factors influencing the adoption of apple-based agroforestry system, a binary logistic regression model was used. The model 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. 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 (Gujarati, 2004). Logistic regression model has been used by most of agroforestry adoption studies to analyze dichotomous adoption decisions in which the dependent variable is binary: 1 if household head is the adopter, 0 otherwise.

Variables used in the empirical model and hypothesized effects

Dependent variables: In this study, adoption of apple-based AF system used as a dependent 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, socio-economic characteristics and institutional characteristics in which farmers operate. In this study fourteen explanatory variables were considered as the determinant factors for the adoption of the system (Table 1).

The data obtained from all respondents 600 were considered in the model. The above explanatory variables (X_i) were included in the logit model as EDU, LABSHO, TLAHOLD, OFFFARMIN, CREDIT, EXTEN, MARPROB, DWATER, LONPROPER, AGE, LOWAWA, LACKACCESS, EXPENS, DISEPES.

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

Variable code	Description	Unit of measurements	Expected sign
ADOPTION	Apple fruit adoption	1=adopter, 0=non adopter	
EDU	Education level of the Household head	The level of formal education	+
LABSHO	Labor Shortage	Minimum number of available labor	-
TLAHOLD	Total Land Holding	Size of Land	+
OFFFARMIN	Off-Farm Income	Amount of money	-
CREDIT	Access to credit	1=Yes, 0=No	+
EXTEN	Access to Extension	1=Yes, 0=No	+
MARPROB	Market Problem	1=Yes, 0=No	-
DWATER	Distance from source of water	1=Yes, 0=No	-
LONPROPER	Longer production period	1=Yes, 0=No	-
AGE	Age of household head	Measured in years	-
LOWAWA	Low awareness about management	1=Yes, 0=No	-
LACKACCES	Lack access to Apple seedling	1=Yes, 0=No	-
EXPENS	Expensiveness of apple tree seedling	1=Yes, 0=No	-
DISEPES	Disease and pest	1=Yes, 0=No	-

RESULTS AND DISCUSSION

Production and income from apple based agroforestry system

In selected districts, sampled household heads mainly depends on crop and livestock production. Among the total sampled households in Degem districts, about 87.5% of Adopters and 97.1% of non-adopters rely on crop production. Besides, in Dendi District 76.8% of adopters and 77.6% non-adopters relays on crop production. Farmers in the study area plant various vegetables solely or in integration with apple tree and use the product for household consumption and/or as an income source. The mean annual production (in Quintal) and income from vegetables and apple fruit (in ETB) are summarized in Tables 2 to 10.

Cabbage (*Brassica oleracea*): Annual cabbage production of adopters and non-adopters was 1.33 and 14.41 quintal ha^{-1} yr^{-1}, respectively. The gross financial return for adopters was 500 ETB ha^{-1} yr^{-1} and for non-adopters 4412 ETB ha^{-1} yr^{-1}. The income difference was statistically significant (P<0.01). Hence, non-adopters' income from the cabbage production exceeds adopters 9 times.

Potatoes (*Solanum tuberasum*): Annual cabbage production of adopters and non-adopters was 59.55 and 13.53 quintal ha^{-1} yr^{-1}, respectively. The gross financial return for adopters was 23,818 ETB ha^{-1} yr^{-1} and for non-adopters 5445 ETB ha^{-1} yr^{-1}. The income difference was statistically significant (P<0.01). Hence, adopters' income from the potato production exceeds non-adopters 4 times.

Tomato (*Lycopersicon esculuntum*): Annual Tomato production of adopters and non-adopters was 0.56 and 3.56 quintal ha^{-1} yr^{-1}, respectively. The gross financial return for adopters was 279 ETB ha^{-1} yr^{-1} and for non-adopters 1633 ETB ha^{-1} yr^{-1}. The income difference was statistically significant (P<0.01). Hence, non-adopters' income from the Tomato production exceeds adopters 6 times.

Enset (*Ensete ventricosum*): Annual Enset production of adopters and non-adopters was 122.20 and 24.73 number ha^{-1} yr^{-1}. The gross financial return for adopters was 11245 ETB ha^{-1} yr^{-1} and for non-adopters 2317 ETB ha^{-1} yr^{-1}. The income difference was statistically significant (P<0.01). Hence, adopters' income from Enset production exceeds non-adopters 5 times.

Non-adopters' annual income from the whole produced vegetables were 6768.69 ETB ha^{-1} yr^{-1} and adopters obtained 29,277.75ETB ha^{-1} yr^{-1} (Table 3). An independent sample t-test was carried out to compare the mean gross annual income of adopters and non-adopters. There was a positively significant gross annual income difference between adopters and non-adopters, p = 0.001 (two-tailed).

Adopters' annual income from the whole produced vegetables and apple fruit were 39525.250ETB ha^{-1} yr^{-1}, and non-adopters obtained 6768.69ETB ha^{-1} yr^{-1} (Table 4). An independent sample t-test was carried out to compare the mean gross annual income of adopters and non-adopters. There was a positively significant income difference between adopters and non-adopters, p = 0.001 (two-tailed). Apple fruit contributes 35% of the income for the agri-horticultural system.

Potatoes (*Solanum tuberasum*): Annual cabbage

Table 2. Households total annual income from vegetable productions in the homestead farmland in Degem district.

Vegetables	Adopters (n = 16)		Non-adopters (n = 284)		t-value
	Mean	Std. Dev	Mean	Std. Dev	
Cabbage	500.00	489.89	4411.85	4800.68	-1.98*
Potato	23818.46	54766.04	5445.46	5981.76	4.61***
Carrot	1156.50	1650.93	3026.40	2920.81	-1.19
Tomato	279.17	110.02	1632.95	1511.81	-2.16**
Chili	242.67	140.93	2284.93	4061.14	-0.86
Onion	1041.67	1264.49	1375.00	1124.21	-0.46
Garlic	492.00	209.57	4685.71	5254.66	-1.76
Leeks	50.00		275.00	318.19	-0.56
Beetroot	367.50	467.17	1388.00	1297.73	-2.16**
Gesho	4125.00	3944.93	1452.38	1588.26	2.38**
Enset	11245.45	15387.093	2317.81	2860.40	4.35***

***, ** Significant at 1 and 5% probability level; Mean values with different superscript letters along the same rows are statistically different.
Source: Own survey.

Table 3. Mean household heads total annual income from vegetable in Degem District (North Shoa Zone).

Adoption	Mean	Std. Dev	t-value
Adopters	29277.7500	49461.83272	6.465***
Non-adopters	6768.6937	7902.64453	

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

Table 4. Mean household heads total annual income from Apple fruit + vegetable in Degem District (North Shoa Zone).

Adoption	Mean	Std. Dev	t-value
Adopters	39525.250	72483	7.08***
Non-adopters	6768.69	7902.64	

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

production of adopters and non-adopters was 26.86 and 12.86 quintals ha^{-1} yr^{-1}, respectively. The gross financial return for adopters was 10639 ETB ha^{-1} yr^{-1} and for non-adopters 5136 ETB ha^{-1} yr^{-1}. The income difference was statistically significant (P<0.01). Hence, adopters' income from the potato production exceeds non-adopters 2 times.

Enset (*Ensete ventricosum*): Annual Enset production of adopters and non-adopters was 100 and 39 number ha^{-1} yr^{-1}. The gross financial return for adopters was 8973 ETB ha^{-1} yr^{-1} and for non-adopters 3791 ETB ha^{-1} yr^{-1}. The income difference was statistically significant (P<0.01). Hence, adopters' income from Enset production exceeds non-adopters 2 times.

Adopters' annual incomes from the whole produced vegetables were 18869.86 ETB ha^{-1} yr^{-1} and non-adopters obtained 8356.13ETB ha^{-1} yr^{-1} (Table 6). An independent sample t-test was carried out to compare the mean gross annual income of adopters and non-

Table 5. Households total annual vegetable productions in the homestead farmland in Dendi district.

Vegetable	Adopters (n = 69)		Non-adopters (n = 231)		t-value
	Mean	Std. Dev	Mean	Std. Dev	
Cabbage	1730.00	1619.95	1371.02	1116.17	1.35
Ethiopian Cabbage	2860.00	5123.28	925.45	2369.75	1.06
Potato	10639.22	16652.98	5136.60	5601.43	3.543***
Carrot	2655.00	6206.73	1795.00	1540.40	0.64
Tomato	5466.67	4387.86	4127.27	4784.16	0.44
Chili	1422.22	1277.48	1983.33	4522.40	-0.36
Onion	4810.00	5953.40	1378.57	632.98	2.240**
Garlic	4453.33	5439.66	5660.78	9688.39	-0.72
Leeks	193.18	221.39	233.50	222.13	-0.48
Beetroot	1206.94	1371.02	1584.68	1167.49	-1.02
Gesho	2050.00	1533.10	1755.43	1806.23	0.70
Enset	8973.17	9859.16	3791.52	3267.04	4.256***

***, ** Significant at 1 and 5% probability level; Mean values with different superscript letters along the same rows are statistically different.
Source: Own survey.

Table 6. Mean household heads total annual income from vegetable in Dendi District (West Shoa Zone).

Adoption	Mean	Std. Dev	t-value
Adopters	18869.86	20823.84	5.402***
Non-adopters	8356.13	11515.64	

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

Table 7. Mean household heads total annual income from Apple fruit + vegetable in Dendi District (West Shoa Zone).

Adoption	Mean	Std. Dev	t-value
Adopters	20697.1	20737.87	6.38***
Non-adopters	8356.13	11515.68	

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

adopters. There was a positively significant gross annual income difference between adopters and non-adopters, p = 0.001 (two-tailed).

Adopters' annual income from the whole produced vegetables and apple fruit were 20697.1 ETB ha^{-1} $yr^{-1}$and non-adopters obtained 8356.13 ETB ha^{-1} yr^{-1} (Table 7). An independent sample t-test was carried out to compare the mean gross annual income of adopters and non-adopters. There was a positively significant gross annual income difference between adopters and non-adopters, p = 0.001 (two-tailed). Apple fruit contributes 8.83% of the income for the agri-horticultural system.

The aggregated analysis was conducted to determine households' annual income from the homestead farmland. Adopters' annual income from the whole produced vegetables and apple fruit were 24337.22 ETB ha^{-1} yr^{-1} and non-adopters obtained 7480.53 ETB ha^{-1} yr^{-1} (Table 10). An independent sample t-test was carried out to compare the mean gross annual income of adopters and non-adopters. There was a positively significant gross annual income difference between adopters and non-adopters, p = 0.001 (two-tailed). Apple fruit

Table 8. Households total annual vegetable productions in the homestead farmland in both district (North and West Shoa Zones).

Vegetables	Adopters (n = 85)		Non-adopters (n = 515)		t-value
	Mean	Std. Dev	Mean	Std. Dev	
Cabbage	1525.00	1557.17	2819.04	3724.45	-2.044**
Ethiopian Cabbage	2860.00	5123.28	1444.62	2927.01	0.746
Potato	13316.25	28634.88	5316.35	5819.97	4.828***
Carrot	2155.50	5079.63	2157.18	2074.81	-0.002
Tomato	2008.33	3398.29	2464.39	3174.62	-0.377
Chili	1127.33	1214.53	2171.83	4194.73	-0.849
Onion	3396.88	4951.13	1376.79	895.23	2.114**
Garlic	4003.18	5269.78	5579.52	9381.79	-1.031
Leeks	181.25	215.09	237.27	222.74	-0.709
Beetroot	948.65	1222.87	1496.88	1219.87	-1.892*
Gesho	2326.67	2037.36	1660.46	1734.62	1.655
Enset	9453.85	11114.85	3131.96	3167.60	6.170***

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

Table 9. Mean household heads total annual income from vegetable in North and West Shoa Zones.

Adoption	Mean	Std. Dev	t-value
Adopters	20828.99	28366.44	8.18***
Non-adopters	7480.53	9713.30	

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

Table 10. Mean household heads total annual income from Apple fruit + vegetable in North and West Shoa Zones.

Adoption	Mean	Std. Dev	t-value
Adopters	24337.22	36611.07	8.77***
Non-adopters	7480.73	9713.38	

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

contributes 16.84% of the income for the agri-horticultural system. Results of the present study agree with the findings of the study that was conducted in Pakistan to assess the economic comparison of Agriculture (sugarcane cultivation) with Agroforestry (sugarcane cultivation in combination with trees). The result showed that the benefit cost ratio of sugarcane system was computed as 2.16 whereas net present worth was found as Rs. 149810.2. Beside Benefit cost ratio of sugarcane in combination with trees was computed to be 2.28 whereas net present worth found to be Rs. 151098.5 (Anjum et al., 2011). Furthermore, income obtained from apple contributes 17% of the total income from an agri-horticultural system. Ndalama (2015) reported that in the rural household communities of Balaka, Malawi, adoption of agroforestry contributed 51.7% of the farm households' income.

Determinants of apple tree adoption

Fourteen explanatory variables were identified to explain

Table 11. Maximum likelihood estimate of the binary logit model for Adoption determinant factors in Degem District.

Explanatory variable	B	S.E.	Wald	P>|z|	e^{β}
Education	1.62*	0.979	2.749	0.097	5.068
Labor shortage	-0.23	1.004	0.050	0.823	0.799
Total Land Holding	0.46	0.894	0.267	0.605	1.588
Off-farm income	2.08	1.112	3.510	0.061	8.030
Access to Credit	-19.61	25164.028	0.000	0.999	0.000
Extension Service	-1.94	1.294	2.250	0.134	0.144
Market Problem	-2.78***	0.916	9.196	0.002	16.086
Water Distance	-0.29	0.224	1.677	0.195	0.748
Longer production period	1.67	1.054	2.525	0.112	5.336
Age of Household head	1.09	1.160	0.886	0.347	2.980
Low awareness	-0.84	0.877	0.917	0.338	0.432
Lack Access	0.64	1.142	0.315	0.574	1.899
Expensiveness	-1.12	0.896	1.548	0.213	0.328
Disease and pest	-5.94***	1.571	14.295	0.000	380.010
Constant	1.21	50328.057	0.000	1.000	

Log-likelihood (χ^2) = 68. 29, Wald Chi-square=55.29***, Correctly predicted percent = 94.8, N= 300; *, ** and *** represents statistically significant at 10, 5 and 1% level of significance, respectively.

factors influencing the adoption of apple tree-based agroforestry system in North and West Shoa Zones. The effects of the independent variables on the log odds of adopting apple based agroforestry system are reported as odds ratio alongside the parameter estimates. For independent variables, the odds ratio (e^{β}) represent the amount by which the odds favoring the decision to adopt apple based agroforestry system (adopter =1) changes for a change in that independent variable (Tables 11 to 13).

Out of fourteen explanatory variables included explaining the dependent variable, three were found to be significant. Formal educational level of the household head, market problem and the problem of pest and disease were significant independent variables.

The formal education level of the household head as expected had a positive influence in the adoption of apple-based agroforestry system. Keeping other factors constant, the odd ratio indicated that increase in educational level by one year increase the favor of adoption by a factor of 5.008. The endpoints of a 95% confidence interval (CI) of the odds ratio is (2.495, 10.050). However, the finding is against the study carried out by Mwema et al. (2012) who found out that a higher level of formal schooling is associated with less collection and dependency on fruit producing trees. A higher level of education provides a wider range of employment opportunities and as a result alternative sources of income.

The market problem was statistically significant ($p < 0.01$) and had the negative relationship with the adoption of apple-based agroforestry system. Keeping other factors constant, the odd ratio indicated that as apple fruit market problem increase the favor of adoption decrease by a factor of 4.746. The endpoints of a 95% confidence interval (CI) of the odds ratio is (2.406, 9.361). Because the marketing aspects are also important to the farmer, they need to have access to information about the market (e.g. prices, demand and supply, expectations). A farmer will not decide to change their production system unless they see the security of marketing possibilities. Farmers are not likely to be interested in producing commodities if transport costs are high. They will also be reluctant to make or continue investments in AF if prices fluctuate widely. Knowledge of market is critical, as it can help identify whether agroforestry interventions have the possibility of saturating them and therefore bringing prices down. During the Group Discussion that conducted in Bejiro Kebele farmers stated that the demand for apple fruit is very low and a majority of the people did not even know what Apple is. Besides in Degem Woreda, farmers stated that to sell apple fruit they travel to Addis Ababa, which is about 125 km far from their residence because the people there well know the fruit's nutritional values. Considering the serious market problem, non-adopters becomes reluctant to plant the apple tree, and one farmer among the group discussant stated "why do you bother us to plan apple fruit; what tangible benefits did adopters obtain? It helps us if we plant vegetables in the homestead farmland rather than taking space through planting apple fruit tree."

Disease and pest were statistically significant ($p < 0.01$) and has negative relationship with the adoption of apple-based agroforestry system. Keeping other factors constant, the odd ratio indicated that as apple fruit

Table 12. Maximum likelihood estimate of the binary logit model for Adoption determinant factors in Dendi District (West Shoa Zone).

Factor	B	S.E.	Wald	df	Sig.	Exp(B)
Education	1.728***	0.497	12.081	1	0.001	5.628
Labor shortage	-0.173	0.508	0.115	1	0.734	0.842
Total Land Holding	-1.109***	0.404	7.548	1	0.006	0.330
Off-farm income	-1.178	1.401	0.707	1	0.400	0.308
Access to Credit	-0.864	1.381	0.391	1	0.532	0.422
Extension Service	0.961*	0.422	5.184	1	0.023	2.614
Market Problem	-1.005**	0.460	4.778	1	0.029	2.731
Water Distance	-0.048	0.417	0.013	1	0.909	0.954
Longer production period	-0.872	0.655	1.771	1	0.183	0.418
Age	-0.217	0.794	0.075	1	0.785	0.805
Low awareness	-0.011	0.115	0.009	1	0.926	0.989
Lack Access	-0.764*	0.445	2.945	1	0.086	0.466
Expensiveness	0.961	1.029	0.872	1	0.351	2.615
Disease and pest	-3.859***	0.633	37.174	1	0.000	47.407
Constant	-4.063	2.217	3.359	1	0.067	0.017

Log-likelihood (χ^2) = 182.922, Wald Chi-square=80.31***, Correctly predicted percent = 85.9, N= 300; *, ** and *** represents statistically significant at 10, 5 and 1% level of significance, respectively.

Table 13. Maximum likelihood estimate of the binary logit model for Adoption determinant factors in Dendi and Degem District (North and West Shoa Zone).

Factor	B	S.E	Wald	df	Sig.	Exp(B)
Education	1.611***	0.355	20.544	1	0.000	5.008
Labor shortage	-0.039	0.408	0.009	1	0.924	0.962
Total Land Holding	-0.370	0.332	1.241	1	0.265	0.691
Off-farm income	-0.235	0.701	0.112	1	0.738	0.791
Access to Credit	-1.443	1.093	1.742	1	0.187	0.236
Extension Service	0.102	0.152	0.446	1	0.504	1.107
Market Problem	-1.557***	0.347	20.188	1	0.000	4.746
Water Distance	-0.017	0.172	0.010	1	0.919	0.983
Longer production period	0.272	0.431	0.398	1	0.528	1.313
Age	0.072	0.605	0.014	1	0.905	1.075
Low awareness	-0.082	0.081	1.043	1	0.307	0.921
Lack Access	-0.393	0.341	1.333	1	0.248	0.675
Expensiveness	-0.079	0.494	0.026	1	0.873	0.924
Disease and pest	-3.020***	0.409	54.462	1	0.000	20.500
Constant	-4.860	2.002	5.892	1	0.015	0.008

Log-likelihood (χ^2) = 311.675, Wald Chi-square= 229.736***, Correctly predicted percent = 89, N= 600; *, ** and *** represents statistically significant at 10, 5 and 1% level of significance, respectively.

infestation increase the favor of adoption decrease by a factor of 20.5. The endpoints of a 95% confidence interval (CI) of the odds ratio is (9.191, 45.723). During the field observation, the problem was high in West Shoa Zones as compared to West Shoa. One model farmer that lives in Gare Kebele stated that "I used to get much money from apple fruit during the first production period, but recently apple pest and disease discourages me most and makes effort irrelevant. Mostly I decided to throw away the fruit tree but I lose my confidence to do so because it supports my family while it was productive."

From the result discussed above, it can be inferred that adopters of apple-based agroforestry system obtained higher gross annual income than non-adopters. Among vegetables that provided the highest income for adopters in all study sites were potato, onion, and Enset. While, for non-adopters, more income was obtained from cabbage and beetroots. The mean gross income of adopters from vegetables + apple was 3.8 times higher than the income of non-adopters from vegetables. The mean annual gross revenue of adopters from solely apple fruit production constituted about 16.84% of the total income obtained from vegetable + apple.

Conclusion

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, that is, formal education levels (+), the market problem (-), and apple fruit and tree disease and pest (-). The current study proved that in the presence of determinant factors that limit the adoption process, apple-based agroforestry system provides the significant economic advantage for adopter as compared to non-adopters. Thus, the promotion of agroforestry technologies is important because it offers the prospect of increasing production and hence raising farmers' income. Sustainable development through AF can be achieved through concerted effort to actively and continuously encourage farmers' involvement in AF activities. Recognizing and tackling main factors that determine the participation of farmers in AF practices affects an AF project to successful local involvement. These findings are relevant to the adoption of agroforestry technologies involving economic, social and economic considerations.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Anjum K, Khan S, Afzal M, Khan H (2011). Economic Comparion of Agriculture with Agroforestry in Tesil Kamalia, District Toba Tek Singh, Pakistan. J. Agric. Res. 49(4):551-561.

Bonett D, Wright T (2014). Sample size planning for multiple correlation: reply to Shieh. Psicothema 26(3):391-394.

Dendi Woreda Agricultural and Rural Development Office (DWARDO) (2017). Dendi Woreda Agricultural and Rural Development office Annual Report.

Gideon P, Verinumbe I (2013). The contribution of Agroforestry tree products to rural farmers in Karim-Lamido Local Government Area of Taraba state. J. Res. For. Wildelife Environ. 5(1):50-62.

Gujarati D (2004). Basic Econometrics. Fourth edition. New York. The McGraw−Hill Companies. https://www.pdfdrive.net/gujarati-basic-econometrics-fourth-edition-d1209950.html

Korwar R, Prasad S, Rajeshwara R, Venkatesh G, Pratibha G, Venkateswarlu B (2014). Agroforestry as a strategy for livelihood security in the rainfed Areas: Experience and Expectations. In Livelihood security and Ecosystem Services. pp. 117-154.

Meseret KD (2015). Land Use/Cover Changes and the Role of Agroforestry Practices in Reducing Deforestation and Improving Livelihoods of Smallholders in Maytemeko Watershed, Northwest Ethiopia. Dissertation for obtaining a doctorate degree at the University of Natural Resources and Life Sciences, Vienna, Austria. https://forschung.boku.ac.at/fis/suchen.hochschulschriften_info?sprache_in=en&menue_id_in=206&id_in=&hochschulschrift_id_in=10256

Mwema C, Mutai B, Lagat K, Kibet L, Maina M (2012). The contribution of Selected Indigenous Fruits on Household Income and Food Security in Mwingi, Kenya. Curr. Res. J. Soc. Sci. 4(6):425-430.

Ndalama E (2015). Agroforestry Contribution to the Improvement of Rural Community livelihoods in Balaka, Malawi. Int. J. For. Hortic. 1(1):5-11.

Rankoana A (2017). Subsistence Food Production Practice: An approach to Food Security and Good Health. Int. J. Environ. Res Public Health 14(10):1184.

Sisay M, Mekonnen K (2013). Tree and shrub species integration in the crop-livestock farming system. Afr. Crop Sci. J. 21(3):647-656.