Ethiopian Journal of Development Research Vol. 22, N°2, October 2000

ADOPTION OF RESEARCH AND FARMER DEVELOPED AGRICULTURAL INNOVATIONS IN MORETNAJIRU AND GIMBICHU DISTRICTS, ETHIOPIA

Workneh Negatu*

ABSTRACT: *The study was conducted to compare the adoption pattern of research and farmer developed agricultural technologies. The hypothesis was that farmer-developed technologies are not constrained by socio-economic, agro-ecological and institutional variables compared to that of research-developed technologies. The study was conducted in MoretnaJiru and Gimbichu woredas (districts) in the Central Highlands of Ethiopia. The innovations considered in the study were Bunigne tef variety (farmer-developed varietal innovation) and Et-13 wheat variety (research-based varietal innovation). The data collected from sample farmers were fitted to probit regression model. Most of the factors considered did not show a dichotomized pattern of effects on the adoption of the innovations.*

INTRODUCTION

Food insecurity and low-income characterize the majority of Ethiopia's population. An estimated 50 to 60 % of the population of the country is food insecure or lives below the poverty line (Befekadu and Berhanu, 1999/2000). Food supply is deteriorating because of, inter alia, decline in the growth of food production. Causes of the production decline include seasonal and annual fluctuation in the amount and distribution of rainfall, drought, land degradation

* Assistant Professor, Institute of Development Research, Addis Ababa University

and poor availability and use of productive inputs and improved technologies of production. The effects of these factors are aggravated by, and intertwined with, ill advised rural policies, socio-economic, institutional and political factors.

The technological structure of small holder farming systems is generally characterized by the traditional production methods which are not able to increase the productivity of the two main resources - land and labor. For instance, in the 1997/98 cropping season, only to 39.3% and 11.9% of the land cultivated with cereals by Ethiopian small holders were applied chemical fertilizers and pesticides, respectively (CSA, 1998). The shortage of capital and knowledge (including modern agricultural techniques) are key limiting factors of the performance of Ethiopia's agriculture (Befekadu and Berhanu, 1999/2000). The low level of use of modern agricultural technologies and poor knowledge of the nature and dissemination pattern of indigenous farmer agricultural innovations are among factors that impose Ethiopia's agriculture into low level equilibrium.

For farm households to meet their basic objectives of food and income earnings sustainably and ultimately to contribute to the national economy, facilitative interventions for the process of development of small-scale agriculture are required (Timmer, 1990; Todaro, 1992).

Facilitative interventions need to be based on appropriate strategies for farm household-led development. To design effective farm household development strategies, understanding the mechanism and nature of the development process in small holder farming systems is imperative (Ruttan and Hayami, 1990).

Agricultural growth in developing countries must be promoted as the key component of agricultural development strategy. Sustainable growth and development can be effected, however, only when economic growth, poverty alleviation and environmental protection are linked directly.

Agricultural technologies are a central and necessary component of any agricultural development strategy in developing countries (Staatz and Eicher, 1990). For a sustainable growth in agricultural productivity, the capacity to generate an ecologically adapted and economically viable agricultural technology is also an essential condition. In this regard, good understanding of the nature, adoption and impact of research and farmer developed technologies has important role in facilitating a sustainable agricultural development. Of course, technological innovation is not a sufficient condition for development of small holder farming systems. Other essential and complementary conditions include infrastructure, information, incentives, inputs and investment (Schultz, 1964; Mosher, 1966).

SOURCES OF AGRICULTURAL TECHNOLOGY

For the less developed agriculture of the developing world, the dominant assumption is that technologies are generated by formal central national or international R&D organizations. This focus on central sources of innovations would undermine the potential of the informal R&D systems (e.g. farmers, development agencies, NGOs, etc.). Conceptual discussion and empirical evidences that farmers do develop technological innovations are given by many authors (e.g. Chambers, et al, 1989; Scoones and Thomson, 1994).

Farmers conduct purposive experimentation on their farm fields, and search for information incurring costs in the form of land, labor, time and cash. They also innovate to adapt the existing technologies obtained from formal R&D or other sources to their needs and conditions within their technical capacity (Biggs and Clay, 1981; Okali et al., 1994).

ADOPTION OF FARMER-DEVELOPED TECHNOLOGICAL INNOVATIONS

Generally, adoption of agricultural technology is influenced by many factors and their interactions.[1] The nature and advantages of indigenous knowledge and innovations in connection with their impact on adoption decisions have been characterized by many authors (e.g. Farrington and Martin, 1988; Belshaw, 1980; Chambers et al, 1989; Biggs and Clay, 1981; Scoones and Thomson, 1994; Richards, 1985; Rhoades and Bebbington, 1995). One of the arguments for indigenous knowledge and innovations is that since farmers are both users and source of the innovation, they have the advantage of meeting their main needs by drawing on detailed knowledge of their environment and exploiting opportunities offered by natural selection, implying that the diffusion of such innovations is less hindered by agro-ecological barriers or the agro-ecology specificity of the innovations (Biggs and Clay, 1981). Farrington and Martin (1988) argue, however, that indigenous knowledge and innovations are not uniformly distributed within or across communities, as their diffusion is constrained due to problems of media (oral or direct experience). Rhoades and Bebbington (1995) also argue that the rate of diffusion of farmer-developed innovations might be slower than innovations from modern science and technology systems, arguing further that technical, ecological and economic contexts are ultimately the important factors for sustained use of innovation or production system. In general, in contexts of high variability of agro-ecological conditions, limited infrastructure and means of communication and subsistence-oriented production systems, the scope of wider communication and high rate of diffusion of technological innovation seems more likely to be constrained. On the other hand, it is suggested that locally developed innovations have a higher chance of adoption and diffusion (Chambers et al, 1989). The model seeks explanations for non-adoption of technologies in deficiencies in technology and in the process that generates it (Chambers, 1993). This implies that the diffusion of technologies developed by farmers to be less constrained.

Ethiopian farmers are generally endowed with indigenous agricultural technologies and knowledge. The adoption of these indigenous innovations is not, however, well studied. The objective of this paper is to examine adoption pattern of research and farmer developed agricultural innovations, and is guided by the following hypotheses: (i) The adoption of research-developed agricultural innovation is more affected by resource endowment and socio-economic status of small holders, compared with that of farmer-developed agricultural innovation; (ii) The adoption of research-developed agricultural innovation is more influenced by agro-ecological conditions and accessibility to institutional services, compared with that of farmer-developed agricultural innovation.

The second section of the paper discusses the research methodology, while the third section presents the results and discussion. The final section presents the summary and conclusion.

RESEARCH METHODOLOGY

DATA AND THE STUDY AREA

The data used for this study were collected in the 1995 cropping year as part of a bigger research project of the author. The data were collected from 192 randomly selected farm households in MoretnaJiru and Gimbichu *woredas* (districts) in central Ethiopia (96 farmers from each woreda), using a formal survey questionnaire method. The data and information on *Bunigne tef* cultivar, a farmer-developed innovation, was collected from Gimbichu *woreda*, while that of Et-13 wheat variety, a research based innovation, was collected from MoretnaJiru *woreda*.

MoretnaJiru is located in North Shewa Administrative Zone about 200 km north west of Addis Ababa. The *woreda* has two distinct agro-ecological circumstances: (1) highland plateau with annual average rainfall of about 900 mm and soil dominated by the vertisol type, and (2) gorge areas with rugged topography, non-vertisol dominated soil, a less reliable rainfall pattern and higher temperatures compared to the highland plateau of the same woreda. Gimbichu is located 85 km south east of Addis Ababa in East Shewa Administrative Zone (Oromiya Region). Gimbichu area is characterized by undulating to rolling lands, with some areas of nearly level plain (LUPRD, 1986). More than 85 % of the Gimbichu area is found on altitude of more than 1800 m.a.s.l. The rainfall pattern in Gimbichu is similar to that of MoretnaJiru - annual average rainfall (1970-1994) being about 900 mm.

ECONOMETRIC MODEL

The model employed was based on the model developed by Rahm and Huffman (1984) as presented by Adesina and Zinnah (1993) for the farmers' adoption decisions. Accordingly, farmers' decision is based on the assumption of utility maximization that remains unobserved. The decision whether to grow a new variety in relation to a traditional variety is based on a comparison of marginal net benefits of one against the other. Define the new and old (traditional) variety by symbol n and o. The preference of the ith farmer for the adoption Y_i^* is given by the difference between the marginal net benefits of the new against the old variety which is unobserved. $Y_i^* > 0$ corresponds to the net benefit of modern variety exceeding that of the traditional variety, while $Y_i^* \leq 0$ refers to the net benefits of the old variety being no smaller than that of modern variety. We may write the following equation in the unobserved variable Y_i^*

$$Y_i^* = \sum_{j=1}^{m} \beta_j X_{ij} + Ui \qquad (1)$$

$$i = 1,2,3...n$$

Where X_{ij}'s are explanatory variables and U_i is the error term. The observed variables are: $Y_i = 1$ when $Y_i^* > 0$; $Y_i = 0$ when $Y_i^* \leq 0$ for the ith farmer. In this formulation $\sum B_j X_{ij}$ is known as an index function.

It is not necessary that the function be linear. The ith farmer will select the modern variety if $U_i > - \sum B_j X_{ij}$. The model can be cast as a probit model where P_i is the probability of adopting the modern variety.

$$P_i = \text{Prob}\ (Y_i = 1) = \text{Prob}\ (\sum B_j X_{ij} + U_i > 0) \qquad (2)$$

$$= \text{Prob}\ (U_i > - \sum B_j X_{ij}) \qquad (3)$$

If the distribution is symmetric as are the normal and logistic,

$$\text{Prob}\ (Y_i^* > 0) = \text{Prob}\ (U_i < \sum B_j X_{ij}) = F\ (\sum B_j X_{ij}) \qquad (4)$$

$F(\sum B_j X_{ij})$ is the cumulative distribution function for U_i evaluated at $\sum B_j X_{ij}$. The above model is a probit model for the analysis of observed probabilities (1,0) where the information on the latent variable is only observed through the index function. The probability that a farmer will adopt the new variety is a function of the vector of explanatory variables and the unobserved error term. As the form of F is not known, we assume F to have a cumulative normal distribution on the assumption that U_i has a normal distribution. The explanatory variables used in the estimation of the empirical model are given in the Appendix table 1.

RESULTS AND DISCUSSION

GENERAL SOCIO-ECONOMIC SETTING OF THE STUDY WOREDAS

MoretnaJiru Woreda

Population features: According to estimation of CSA (1994) the population of the *woreda* was 89065, of which 45 % was female and about 9% was urban. The population was mainly of Amhara ethnic origin, and almost all subscribe to Ethiopian Orthodox Christianity. The area has been settled and farmed for centuries. The main staple food for the population of both *woreda*s consists of wheat and tef, eaten with *wot* (stew) made from relish crops (faba bean, fieldpea, lentil, etc.). In the gorge area of MoretnaJiru, sorghum is the primary staple crop, after which come *tef* and/or wheat.

The rural population was partly villagized during the villagization program carried out in 1986-89. Although some of the households dismantled their houses and returned to their old villages, the majority remained in their new villages. Those who remained in the new villages claim that these have offered them larger dwelling space than they had in their old villages.

The rural population was entirely dependent upon farming. The urban population was engaged in small trading and service activities and handicrafts (blacksmith, pottery, weaving, etc.).

Gimbichu woreda

Population features: According to estimates of the survey made by Gimbichu *woreda* MOA (1994), the total population of the *woreda* was 8, 4190, of which 45.5% and 6.3% were female and urban populations respectively. According to the same sample survey, about 99% of the population were of Ethiopian Orthodox persuasion, and 60 % of the population was of *Oromo* ethnic origin; the rest were from other ethnic groups, mainly *Amhara*.

SOCIO-ECONOMIC FEATURES OF THE SURVEY FARM HOUSEHOLDS

Household profile

The profiles of the sample households were examined in terms of the age and literacy status of household heads, family size and age structure of the farm households. With regard to average age of the household heads and average family size there was no significant difference between the two study *woredas*, the figures being 45-46 years and 7, respectively. On average, 57% and 42% of the sample farm households in MoretnaJiru and Gimbichu, were literate, respectively. On this basis, literacy was higher in MoretnaJiru than in Gimbichu. This could be partly due to the effect of the traditional literacy service of the Ethiopian Orthodox Christian church, which was established there long ago.

Family size and age structures of a household are important parameters as they impinge on labor supply and subsistence requirements. The distribution of adults and children in both areas followed the same pattern, the average number of children (fourteen years and below) in both areas was three. Variation in family size and numbers of adults and children within each area was high, however, particularly for children. The coefficient of variation for children was more than 50 %, and is expected to influence the subsistence pressure on the households.

Socio-economic features

The average size of landholding in MoretnaJiru was about 1.8 ha. (7.18 *kert)* while that of Gimbichu was 2.4 ha. (9.6 *kert*), showing a statistically significant difference. The landholding variation within each area was also considerable.

The farm income (the major income source) status of the farm households in both study *woredas,* measured in terms of farm gross margin (gross farm output minus variable costs), livestock wealth (excluding chicken[2]) and opportunity for non-farm employment of farm households are given in table 1.

The variation among farm households in farm income and livestock wealth within each *woreda* was high, with a coefficient of variation of about or more than 50 %. It was also found that there was a statistically significant difference in farm income and livestock wealth between the two study *woredas*. The average farm income of the sample farm households of MoretnaJiru was 3126 *Birr* for 1994/95, while that of Gimbichu was 4329 *Birr*.

The average livestock wealth, measured in Tropical Livestock Units (TLU[3]), was three for MoretnaJiru, while it was five for the sample farm households of Gimbichu. Significant differences were observed in mean livestock wealth between the *woredas* and among farm households within each *woreda*.

A very small proportion of farmers (12.5 % for MoretnaJiru and 11.5 % for Gimbichu) had access to non-farm activities such as petty trading, employment in local grain mills and government or non-government (e.g. Church organization) road maintenance and construction. Opportunities for off-farm employment were in general very rare in both *woredas*.

Table 1: Farm income, livestock wealth and off-farm employment in the study areas

Indicator	MoretnaJiru n = 96	Gimbichu n = 96	Significance
Farm income, *Birr*	3125.9 (177.29)	4329.0 (246.26)	t= 3.97***
Livestock, TLU	2.99 (0.16)	4.7 (0.29)	t=5.10***
Access to Non-farm income With access Without access	12 (11.5) 84 (84.5)	11 (11.5) 85 (84.5)	X^2=0.00 (Yates' corrected) ns

Source: Own survey data, 1995

Note: X^2 = Chi-square; *** = significant at one % level; ns = non-significant at ten %; t = computed t-value; figures in parentheses are standard errors (t-test) or expected value (Chi-square); n= sample size; one US$ = 8.12 Birr (November, 1999)

Thus, from the above statistical analysis of the major socio-economic features, it can be observed that the two study areas (*woredas*) differ significantly in farm income and livestock wealth status. Farm households in MoretnaJiru had lower income/wealth profiles compared to those in Gimbichu. Farm households within each *woreda,* however, differ significantly in levels of resource endowment and income/wealth status.

WHEAT AND *TEF* CULTIVATION AND ADOPTION OF THE CASE INNOVATIONS

Cultivation of wheat in MoretnaJiru Woreda

Wheat is the dominant crop in *the woreda,* grown by 97% of the sample farm households on a sample mean land area of 0.78 ha. (3.1 *kert*). In the 1994/95 cropping year it was grown on 40% of the cultivated land of the sample farm households.

Improved wheat varieties were introduced in the *woreda* for the first time in the mid-1980s. The improved wheat varieties under cultivation in the *woreda* were *Et-13, K-6295E and Enkoy*. All the varieties were released by the national research systems of the country. These improved wheat varieties were grown by 74% of the sample farm households on 53% of the wheat area. The most widely grown improved variety was *Et-13*. This variety was grown by 74% of the sample farmers on average on 51% of the sample wheat area, with a considerable variation (Coefficient of variation, CV = 78 %).

Cultivation of tef in Gimbichu Woreda

Before the early 1970s, *tef* was grown mainly in the lower lands of Gimbichu (e.g. areas bordering Ada *woreda*). In 1994/95 cropping year, *tef* was grown by 89% of the sample farmers in Gimbichu woreda on 21% of cultivated land area. The factors behind *tef* expansion are better prices, attractiveness for home consumption because of a higher output of *injera* (thin spongy pan-like bread) from a given quantity of *tef* seeds when compared to wheat, preferred straw quality, availability, and use of fertilizer (Workneh, 1996).

The *tef* varieties grown in Gimbichu area in 1994/95 cropping year were white seeded *tef* (*DZ-01-196*), *Sergegna* (*DZ-01.354* - medium white), red seeded variety (*DZ-01-99*) and B*unigne.* The first three varieties were identified to be improved seeds (selected and recommended by researchers), obtained either from other farmers in exchange, by buying in the market or from farmers' group farms

(*Yehiberet Ersha*) which existed during 1976-1979. The last is a farmer-selected variety (i.e. farmers' variety). In the same cropping season, *Bunigne* occupied 28% of *tef* area (table 2).

The diffusion periods and adoption levels of the technological innovations are given in table 2. As shown in the table, the diffusion of *Bunigne tef* variety in Gimbichu and improved wheat variety (Et-13) in MoretnaJiru is a relatively recent phenomenon.

Table 2: Year of Initial Introduction of the Innovations and Adoption Levels

Innovation	Initial year	n*	Adoption incidence, %*	Adoption intensity, %*
Et-13 Wheat variety (in MoretnaJiru)	1986/87	96	74.0	51.0 %
Bunigne tef variety (in Gimbichu)	1989	95	42.00	28 %

Source: Own survey data, 1995

- Adoption incidence refers to the percentage of users of the innovation, while adoption intensity refers to proportion of land allocated to the varietal innovations. n = number of responses.

FARMERS' REASONS FOR ADOPTION OR NON-ADOPTION OF THE CASE INNOVATIONS

Responses of farmers (table 3) who did not grow Et-13 wheat variety indicated that unavailability of seeds and lack of awareness about the new variety were the two major reasons for not growing the variety. The 'other' item in the table shows a high % age due to the fact that it includes miscellaneous reasons like land shortage, poor straw quality, doubt about its performance, not motivated. The main reason for its adoption, as indicated by the adopters, is its better yield performance compared to that of the local varieties.

Table 3: Farmers' reasons for not growing Et-13 improved wheat in MoretnaJiru *Woreda*

Reason	% of mentions
Lack of awareness	23.0
Finance problem	8.0
Seed Unavailability	42.0
Other	27.0

Source: Own survey data, 1995

The main reasons for not growing *Bunigne tef* variety by the non-growers were lack of seeds and unawareness of the new expanding variety. Those who grew *Bunigne* indicated that the main reason for growing the cultivar was primarily its early maturing trait (table 4).

Table 4: Farmers' Reasons for Adoption or Non-adoption of *Bunigne Tef* Variety in Gimbichu *Woreda*

Growers' Reasons for Adoption		Non-growers' Reasons for Non-adoption	
Reason	% of mentions	Reason	% of mentions
Early maturity	73.5	Lack of seeds	45.6
Grain yield	20.4	Lack of awareness	24.6
Adaptation to poor soil	2.0	Land shortage	8.8
Other	4.1	Other	21.1

Source: Own survey data, 1995

RESULTS OF ECONOMETRIC ANALYSIS

The probit regression estimations of the adoption of Et-13 wheat variety and *Bunigne tef* cultivar are given in table 5. Since the probit model is non-linear, the reported coefficients are not equal to the marginal effects (derivatives) of expected values with respect to a variable (Greene, 1995:124). The marginal effects computed at the overall means of the sample observations are given in table 6.

Farm size

The positive and significant (at 10 % level) coefficient of farm size in the adoption of Et-13 variety indicates that the greater the farm size, the higher is the probability of adoption of the improved wheat variety, other factors remaining constant. The marginal effect coefficients (table 6) suggest that if there is an increase in farm size by one *kert,* the probability of adoption of the variety will increase by 0.025 probability units in MoretnaJiru, *ceteris paribus.* A positive and significant impact of farm size on adoption of modern wheat has been reported for case studies in West Shewa (Itana Ayana, 1985) and in Arsi (Tesfai Tecle, 1975), but a non-significant relation was found in a case study in South Shewa (Legesse Dadi, 1992). The result agrees also with the observation that large farmholders are early adopters of varietal innovations (Ruttan, 1977; Nkonya et al, 1997). In the probit analysis of the adoption of *Bunigne tef* variety, however, farm size is not found to be significant.

Table 5: Probit Estimates of Adoption of Et-13 Wheat Variety in MoretnaJiru *Woreda* and *Bunigne Tef* Cultivar in Gimbichu *woreda*

Variable	Et-13 wheat variety	*Bunigne*
Constant	-6.613*** (2.474)	-4.836*** (1.581)
Farm size, *kert*	0.181* (0.107)	0.081 (0.057)
Extension frequency	0.399 (0.317)	0.046 (0.398)
Labor-land ratio	2.871 (2.002)	2.834* (1.575)
Proximity to supply	0.567** (0.289)	-0.520** (0.204)
Literacy	0.777 (0.607)	0.585 (0.387)
Marketing frequency	-0.899 (0.577)	0.506 (0.367)
Vertisol proportion	1.895** (0.861)	2.558*** (0.707)
Income/kert (*Birr*)	0.007*** (0.002)	0.002*** (0.000)
Log likelihood function	-21.831	-34.905
Chi-squared	48.549***	37.559***
Degrees of freedom	8	8
Correct prediction. %		
adopters	98.4	97.0
non-adopters	95.2	97.9

Source: Own survey data, 1995

Note: *** = significant at one % probability; ** = significant at five % probability; * = significant at 10 % probability; figures in parentheses are standard errors.

Table 6: Marginal effects of adoption of Et-13 in MoretnaJiru and *Bunigne Tef* Cultivar in Gimbichu *Woreda* with Respect to the Explanatory Variables at their Mean Values.

Variable	Et-13 wheat variety	*Bunigne*
Constant	-0.945** (0.427)	-1.798*** (0.556)
Farm size, *kert*	0.025(0.018)	0.030(0.021)
Extension frequency	0.057(0.044)	0.017(0.148)
Labor-land ratio	0.410(0.230)	1.054* (0.582)
Proximity to supply	0.081(0.051)	-0.193*** (0.074)
Literacy	0.111(0.080)	0.218(0.141)
Marketing frequency	-0.129(0.084)	0.188(0.136)
Vertisol proportion	0.271* (0.144)	0.951*** (0.254)
Income/kert (*Birr*)	0.001*** (0.000)	0.001*** (0.0003)

Source: Formal survey data, 1995

Note: *** = significant at one % probability; ** = significant at five % probability; * = significant at 10 % probability; figures in parentheses are standard errors.

Soil type

In the adoption analysis of Et-13 the impact of vertisol proportion is found to be positive and significant. The marginal effect coefficient suggests that an increase in vertisol proportion by one % will result in an increase of the probability of growing the improved wheat variety by 0.271 probability units in MoretnaJiru, other factors remaining the same. The relationship might imply the greater appropriateness of the variety for vertisol. This situation also implies the limited available choice of improved wheat varieties for those farmers where land is dominated by a non-vertisol soil type. Literature indicates that in the adoption of Green Revolution technologies at the final phase of diffusion (post early 1980s), agro-ecological factors have played a greater role. It was also observed in Northern Nigeria that the diffusion of maize varieties in remote areas was constrained by soil type (Goldman and Smith, 1995).

For *Bunigne tef* adoption, the vertisol proportion is significant with positive influence, suggesting that if vertisol proportion increases by one %, the probability of adoption of *Bunigne* will rise by 0.951 probability units, *ceteris paribus*. This implies that the growers are in a more flexible position regarding allocation of the vertisol to wheat and/or tef. The non-vertisol is usually preferred for pulses - faba bean, lentil and fieldpea. Also from a land quality point of view, we can see that the adopters of the varietal innovation are better endowed with relatively fertile (vertisol) soil types. It also seems that farm households with limited vertisol proportion are less likely to risk growing a new variety of tef.

Family labor

The effect of the labor-land ratio on the adoption of the improved wheat variety (Et-13) is non-significant but positive, reflecting the weak potential effect of labor in the adoption decision. Chilot (1993) in a case study in West Shewa also reported the insignificant role of family size in improved wheat variety adoption.

In *Bunigne tef* adoption the labor-land ratio is positive and significant (at 10 % probability), suggesting that an increase in labor-land ratio by one unit would result in a rise in the probability of adoption of *Bunigne* by 1.054 probability units (marginal effect), *ceteris paribus*. Labor is an important factor for cultivation of tef, which is characterized by labor-intensive management practices from land preparation through weeding and up to harvesting, threshing and winnowing. The result also implies that a larger family size has lower risks if the *Bunigne* variety is included alongside other varieties.

Income status

In the probit analysis of the adoption of improved wheat variety, farm income is significant and positive. The marginal effect coefficient suggests that if income per *kert* of land rises by one *Birr*, the probability of the adoption of *Et-13* by 0.001 probability units, *ceteris paribus*. The result implies the need for income, and hence the importance of improving income levels of farm households and/or strengthening credit services to enable them to buy seeds and fertilizer. The positive influence of livestock wealth (as source of income) on the adoption of modern wheat varieties has been reported in the case studies by Chilot (1993) and Itana Ayana (1985). Farmers in Northern Tanzania (Nkonya et al, 1997) are hindered from using improved maize seeds and fertilizer because of cash shortage relative to the prices of inputs.

Farm income is found to have a significant and positive influence on *Bunigne* adoption. The marginal effect coefficient suggests that an increase in income by one *Birr* per kert of cultivated land would result in an increase in the probability of adoption of *Bunigne* by 0.001 probability units, *ceteris paribus*. Implied here is that better income earning farm households are more likely to adopt the *Bunigne* variety than less income earning farm households. A higher income also gives better risk-lowering ability.

Extension service

In the adoption of Et-13, extension contact is found non-significant. The importance and positive influence of extension contacts are reported for some case studies of adoption of wheat varieties in the Central Highlands (Itana, 1985; Legesse, 1992; Chilot, 1993) and in the Arsi area (Aregay, 1980). These case studies seem to have captured the positive effects immediately after an extension program to promote newly introduced varieties.

Empirical studies indicate that although there are cases where extension service is shown to be significant in the diffusion of the Green Revolution technologies, there are also recent case studies which show the opposite (Feder and Umali, 1993). Clearly, many factors can have an effect on extension effectiveness; the identification of operative factors needs to be done on case-by-case basis.

In the adoption of the farmers' varietal innovation *(Bunigne tef)*, extension service is positive but non-significant. The development agents may not be aware of the on-going dynamics of the new *tef* cultivar (*Bunigne*) in the area, or if they are aware, they may not give it adequate attention. This is because the emphasis of the formal extension system is usually on research-recommended technologies. For example, the training given to the development agents (DAs) by the Training and Visit (T&V) -oriented extension system was centered on research-recommended innovations.

Proximity to input supply centers

For the adoption of the wheat variety proximity to a supply center is positive and significant. The marginal effect coefficient implies that the nearer farm households are to a supply point, the higher (by 0.081 probability units) is the probability of the adoption of the improved varieties, other variables remaining the same. Farmers who are near to towns or centers of extension, seeds and fertilizer supply have better opportunities to gain access to the distributed inputs. This reflects the importance of proximity to supply centers, specially where motor transport is scarce.

The negative effects of distance from town centers on adoption of new improved wheat varieties have been reported in other case studies in the Central Highlands (Itana, 1985; Beyene et al., 1991; Chilot, 1993). Remoteness of areas from centers has been reported to be one of the bottlenecks to diffusion of maize varieties in Northern Nigeria (Goldman and Smith, 1995).

In the analysis of *Bunigne* adoption the coefficient for proximity to supply center is negative and significant. This suggests that farmers who are far away from supply points are more likely to adopt *Bunigne.* A possible explanation for this result is that the low marketability (red seed color) of *Bunigne* in the popular markets found in the far-off locations (where for most farm households supply points are far) may influence farmers to grow this variety for home consumption in order to produce other *tef* varieties (white or medium white seeds) which have higher demand in the national market.

Education level

With improved wheat variety adoption, literacy is positive but non-significant. A positive impact of literacy on wheat variety adoption has been reported in case studies in the Arsi (Tesfai, 1975) and West Shewa areas (Itana, 1985); but a non-significant effect was found in another case study in West Shewa by Chilot (1993). Empirical studies in Zambia and China have suggested a positive role of education (literacy) on the adoption of Green Revolution technologies (Lin, 1991; Jha et. al, 1990). There are also cases, as reported in Feder and Umali's review (1993), in which education plays a non-significant role. In *Bunigne* adoption, literacy has also a positive but a non-significant coefficient.

SUMMARY AND CONCLUSION

The results of probit multivariate analysis show that the adoption of improved wheat variety (*Et-13*) is significantly and positively influenced by farm size, income, vertisol proportion, and proximity to supply centers. Probit regression estimation of the adoption of the *Bunigne tef* variety for the Gimbichu area reveals that income status (positive), vertisol proportion (positive), labor-land ratio (positive) and proximity to supply centers (negative, most likely because of availability of local grain markets in remoter sub-areas) are the most important factors influencing the adoption of the new farmer-derived variety in the Gimbichu area.

The findings, thus, indicate that while the adoption of the research-developed wheat variety is significantly influenced by farm size, farm size has not influenced significantly the adoption of the farmer-developed *tef* variety (*Bunigne*). While proximity to supply centers affected the adoption of the research-developed wheat variety positively, it has influenced the adoption of *Bunigne* negatively. Labor was found to influence the adoption of Bunigne, but not that of the research-developed wheat variety. The rest of the variables or factors did not show a dichotomous pattern of effects on the adoption of these research and farmer developed innovations. Although dichotomy has been observed with effects of some factors mentioned above, it would be difficult to conclude strongly that the adoption of farmer-developed innovations is less affected by resource endowments, socio-economic status, agro-ecological factors and access to institutional services compared to the adoption of research-developed innovations.

The findings imply that research, extension and development policies that aim to facilitate adoption of research and farmer developed agricultural innovations need to focus primarily on measures that enhance farm household income. The results of the descriptive analysis of reasons for not growing *Bunigne tef* imply the importance of farmers' awareness in the adoption and diffusion of farmer-developed agricultural innovations.

As adoption studies on farmer-developed innovations and knowledge are few in this country more studies are commendable in this area to get adequate empirical evidence on comparative adoption pattern of farmer and research developed innovations and knowledge.

Limitations of the study: The findings reported are dependent only on one year (1995) cross sectional data on one innovation from each of the two categories of innovations, limiting its scope. The indictor (marketing frequency) used to measure farmers' access to markets is not strong and specific enough to capture the role of access to markets in technology adoption. In future, one needs to look for sharper indicators.

NOTES

1. Workneh Negatu and Parikh (1999:208) categorized the models of adoption of agricultural innovations into three broad groups: the innovation-diffusion model, the economic constraints model, and the technology characteristics and user's context.

2. Chicken owned was not included, for it was found difficult to obtain reliable data.

3. The livestock numbers are converted into TLU adopting the conversion factors given by Jahnke (1982). The conversion factors used are: dairy cow = 0.9; ox = 0.8; heifer/bull = 0.6; calf = 0.1; donkey = 0.5; horse = 0.8; mule = 0.7; sheep/goat = 0.1

REFERENCES

Adesina, A. and M. Zinnah 1993, Technology Characteristics, Farmers' Perceptions and Adoption Decisions: A Tobit Model Application in Siera Leone, *Agricultural Economics*, 1 (13), 1-9.

Aregay Waktola 1980, Assessment of Diffusion and Adoption of Agricultural Technologies in Chilalo, *Ethiopian Journal of Agricultural Sciences*, 2(12), 51-68.

Befekadu Degefe and Berhanu Nega (eds.) 1999/2000, *Annual Report on Ethiopian Economy*. Addis Ababa: The Ethiopian Economic Association.

Belshaw, D. 1980, Taking Indigenous Knowledge Seriously: The Case of Inter-Cropping Techniques in East Africa. In D. Brokensha, M. Warren and O. Werner (eds.), *Indigenous Knowledge Systems and Development*, London: University Press of America, pp.197-203.

Beyene Seboka, Asfaw Negassa, W. Mwangi and Abubaker Musa 1991, Adoption of Maize Production Technologies in the Bako Area, Western Shewa and Wollega Region of Ethiopia. Research Report, no. 16, Addis Ababa: IAR.

Biggs, S. D. 1990, A Multiple Source of Innovation Model of Agricultural Research and Technology Promotion, *World Development*, 11(18), 1481-1499.

Biggs, S. D. and E. J. Clay 1981, Sources of Innovation in Agricultural Technology, *World Development*, 4(9), 321-36.

Chambers, R., A. Pacey and L. Thrupp 1989, *Farmer Innovations and Agricultural Research*. London: International Technology Publications.

Chambers, R. 1993, *Challenging the Professions: Frontier for Rural Development*. London: International Technology Publications.

Chilot Yirga 1993, Factors Influencing Adoption Decision and Rate of Adoption of New Wheat Technologies in Wolmera and Addis Alem Areas of

Ethiopia, Unpublished MSc Thesis, Alemaya University of Agriculture, Ethiopia.

CSA (Central Statistical Authority) 1998, Statistical Bulletin 193. Addis Ababa

CSA, 1994, Statistical Bulletin, Addis Ababa

Farrington, J. and A. Martin 1988, *Farmer Participation in Agricultural Research: A Review of Concepts and Practices*. London: Overseas Development Institute.

Feder, G. and D. L. Umali 1993, The Adoption of Agricultural Innovations, A Review, *Technological Forecasting and Social Change*, 43, 215-239.

Goldman, A. and J. Smith 1995, Agricultural Transformation in India and Northern Nigeria: Exploring the Nature of Green Revolution, *World Development*, 2 (23), 243-263.

Gould, B.W., W. E. Saupe and R.M. Klemme 1989, Conservation Tillage: The Role of Farm and Operator characteristics and the perception of Erosion. *Land Economics*, 65, 167-182.

Greene, W. H. 1995, *LIMDEP, User's Manual, Version 7.0*. New York and Castle Hill, Australia: Econometric Software, Inc.

Hayami, Y. and V.W. Ruttan 1985, *Agricultural Development: An International Perspective*. Revised Edition, Baltimore and London: Johns Hopkins University Press.

Itana Ayana 1985, An Analysis of Factors Affecting the Adoption and Diffusion Patterns of Packages of Agricultural Technologies in Subsistence Agriculture: A Case Study in Two Extension Districts of Ethiopia. Unpublished MSc Thesis, Addis Ababa University.

Jahnke, H. E. 1982, *Livestock Production System and Livestock Development in Africa*. Kiel, Germany: Wissenschaftsverlag.

Jha, D. B. Hojjati and S. Vosti 1990, The Use of Improved Agricultural Technology in Eastern Province. In Celis, R., J. T. Milimo and S.

Wanmali (eds.), *Adopting Improved Farm Technology: A Study of Smallholder Farmers in Eastern Province, Zambia*. Washington, D.C.: University of Zambia, Government of the Republic of Zambia and IFPRI.

Legesse Dadi 1992, Analysis of Factors Influencing Adoption and the Impact of Wheat and Maize Technologies in Arsi-Negele, Ethiopia. Unpublished MSc Thesis, Alemaya University of Agriculture, Ethiopia.

Lin, J. Y. 1991, Education and Innovation Adoption in Agriculture: Evidence from Hybrid Rice in China, *American Journal of Agricultural Economics*, 73, 713-723.

LUPRD (Land Use Planning and Regulatory Department) 1986, Resource Map: *Haykoch ina Butajira* and *Yerer-Kereyu Awrajas* (Shewa). Addis Ababa.

Mosher, A. T. 1966, *Getting Agriculture Moving*. New York: Praeger Inc

Nkonya, E, T. Schroeder and D. Norman 1997, Factors Affecting Adoption of Improved Maize Seed and Fertilizer in Northern Tanzania, *Journal of Agricultural Economics*, 1(48), 1-12.

Okali, C., J. Sumberg, and J. Farrington 1994, *Farmer Participatory Research: Rhetoric and Reality*. London: Intermediate Technology Publications, on Behalf of ODI.

Rahm, M.R and W. E. Huffman 1984, The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables, *American Journal of Agricultural Economics*, November, 405-413.

Rhoades, R. and A. Bebbington 1995, Farmers Who Experiment: An Untapped Resource for Agricultural Research and Development. In D. Warren, M., Slikkerveer and D. Brokensha (eds.), *The Cultural Dimension of Development: Indigenous Knowledge Systems*, London: Intermediate Technology Publications, pp.323-332.

Richards, P. 1985, *Indigenous Agricultural Innovation: Ecology and Food Production in West Africa*. London: Hutchinson Education.

Rogers, E. M. 1962, *Diffusion of Innovations*. New York: Sage.

Ruttan, V. W. 1977, The Green Revolution: Seven Generalisations, *International Development Review*, 19, 16-23.

Ruttan, V. W. and Y. Hayami 1990, Induced Innovation Model of Agricultural Development. In: C. K. Eicher and J. M. Staatz (eds.), *Agricultural Development in the Third World*, Second Edition. Baltimore: Johns Hopkins University Press, pp.97-112.

Schultz, T. W. 1964, *Transforming Traditional Agriculture*, Chicago and London: University of Chicago Press Edition, 1983.

Scoones, I and J. Thomson 1994, Knowledge, Power and Agriculture - Towards a Theoretical Understanding: In: I. Scoones and J. Thomson (eds.), *Beyond Farmer First: Rural Peoples' Knowledge and Extension Practice*, London: Intermediate Technology Publications, pp. 16-32.

Staatz, J. M. and C. K. Eicher 1990, Agricultural Development Ideas in Historical Perspective. In: C. K. Eicher and J.M. Staatz (eds.), *Agricultural Development in the Third World*, Second Edition. Baltimore: Johns Hopkins University Press, pp.3-38.

Tesfai Tecle 1975, Application of Multivariate Probit Analysis to Adoption of New Agricultural Practices, *Ethiopian Journal of Development Research*, 1(2), 47-54.

Timmer, P. 1990, The Agricultural Transformation. In: Eicher, C. and J. M. Staatz (eds.), *Agricultural Development in the Third World*, Second Edition. Baltimore: John Hopkins University Press, pp. 47-69.

Todaro, M. P. 1992, *Economics for a Developing World. An Introduction to Principles, Problems and Policies for Development in the Third World*. Second Edition. Baltimore and London: Johns Hopkins University Press.

Workneh Negatu and Ashok Parikh 1999, The Impact of Perception and Other Factors on the Adoption of Agricultural Technology in Moret and Jiru Woreda (district) of Ethiopia. *Agricultural Economics*, 21, 205-216.

Workneh Negatu 1996, Cereal-based Farming Systems in the Central Highlands of Ethiopia: Technological Innovation for Surplus Production and Alleviation of Poverty. Ph.D. Thesis. University of East Anglia, Norwich, UK

Appendix 1: Explanatory variables and their measurements

Variable name	Measure of Variable
Farm size (CULTVATA)	Total cultivated land in *kert* (one *kert* =0.25 ha.) in 1994/95 cropping year
Soil type (PRPVERT)	ratio of vertisol land to the total landholding
Family labor (LABLANDR)	total full time equivalent farm workers (= full time workers + 0.5x part time workers) per *kert* of cultivated land. The part time workers are students and other members of a household who are not fully engaged in farm activities; on the basis of the consensus from farmer group discussions, they are assumed to contribute about half the labor time spend by the full time farm workers)
Oxen (OXLANDR)	number of working oxen per *kert* of cultivated land
Farm income. (INCLAND)	income in terms of farm gross margin (= total gross income minus variable farm cash costs) for 1994/95 cropping year, per *kert* in *Birr*
Access to extension. (EXTFREQ)	number of contacts with local development agent per year (1994/95)
Proximity to supply. center (FERTDIST)	proximity of a farm household to input (fertilizer) supply store (near or far)
Access to markets. (MODMKT)	frequency of marketing to a nearby local market (frequently or less frequently)
Education status. (LITERACY)	level of education of the household head (literate or non-literate)

INSTITUTE OF DEVELOPMENT RESEARCH
ADDIS ABABA UNIVERSITY
ETHIOPIAN JOURNAL OF
DEVELOPMENT RESEARCH
(EJDR)

The Ethiopian Journal of Development Research (EJDR) is a bi-annual journal devoted to development oriented research and published by the Institute of Development Research.

The publication covers wide areas of the development process. It is devoted to the multi-disciplinary study of development problems of Ethiopia in particular and the less developed world in general. Book reviews, synopsis of major research, theoretical and methodological approaches in the general area of development are also acceptable to the publishers of this journal. Contributions are welcome from any part of the world.

Subscription rate: *In Ethiopian Birr 12.00 per issue for individuals and Birr 15 per issue for institutions.*
Elsewhere US $20.00 per issue for individuals and US $25.00 per issue for institutions.

Address: *For editorial (and all others) communications:*
Managing Editor, EJDR, IDR
Addis Ababa University
P.O .Box 1176, FAX 55-13-33, Telephone: 12-32-30
Addis Ababa, Ethiopia.