Attaining Household Food Security through Adoption of New Agricultural Technologies: The Case of Smallholders in Eastern Ethiopia

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Abstract

A survey was conducted in 1996/97 crop season in eastern Ethiopia to collect farm and household data necessary for estimation of the total household income per adult equivalent (AE). The effect of new varieties of maize and sorghum together with the introduction of chemical fertilizer has been determined taking the risky environment into account. A minimum subsistence level was defined. Using a stochastic simulation model, the probability of food insecurity with the use of the new technologies was assessed.

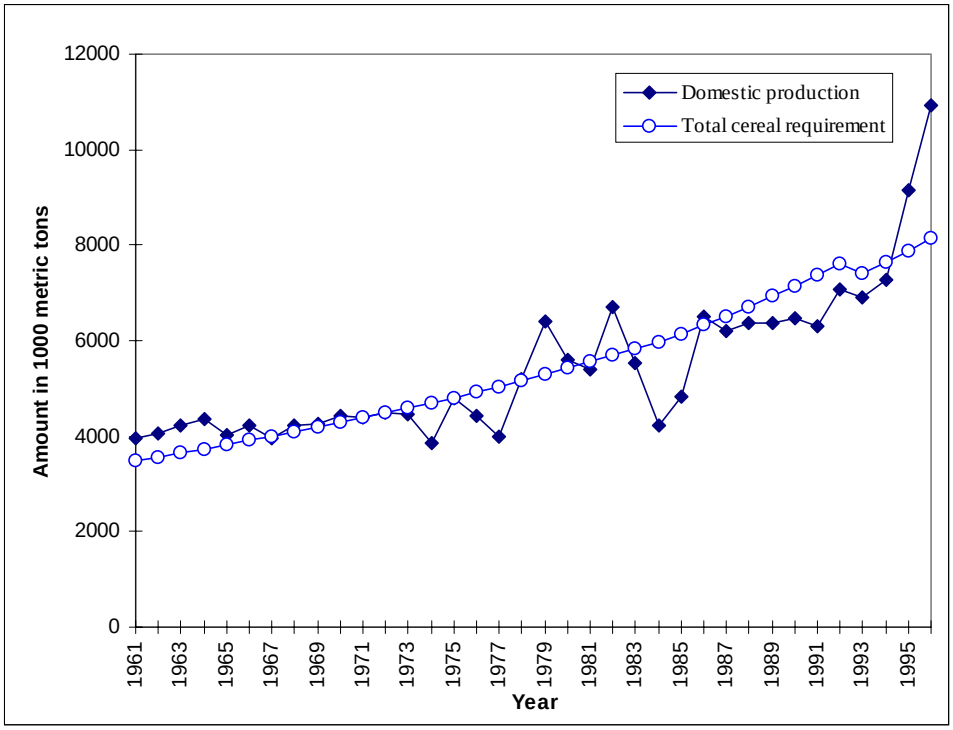
Results show that the use of new varieties and chemical fertilizer leads to 9-21% increment in net household income per AE. Under risk, the use of new seeds and chemical fertilizers increase a net income per AE by 5%. Given the defined level of subsistence requirement, the use of these technologies would increase the chance of being food secured.

Key Words: adoption, food security, new technologies, Ethiopia

1 Background

In Ethiopia, the state of food insecurity is one of the worst in the world with about 51% of its population being undernourished (FAO, 1999). The fact that the economy of the country depends largely on agricultural production which is very vulnerable to natural and man made disasters makes it subject to food insecurity. As a result of the recurrent food supply shortfalls, Ethiopia depended much on import of food. Assessment of the food production, consumption and deficit situation of the country over the past 35 years indicates that there were few years during which Ethiopia enjoyed surplus cereal production exceeding the consumption requirements (Fig. 1). The resulting gap between the domestic production and requirements were bridged by imports in the form of trade and/or donations. Recent studies made in food security at national level, however, concluded that inclusion of the commercial and food aid imports could not sometimes offset the domestic demand for food. According to Zegeye and Habtewold (1995), the overall food balance in the country during the 1984/5 to 1993/4 was negative. Recent work of Clay, et al. (1998) and the continued dependence of the country on food aid also confirm the persistence of food supply deficit in the country.

Figure 1. Domestic cereals production and consumption in Ethiopia (1000 metric tons)



Source: Computed based on statistical data base of FAO (1996)

In order to overcome the national food insecurity, the economic policy of the country has given due emphasis to tackling household food insecurity through increased agricultural productivity. Household food security, according to World Bank (1986) definition and adapted here, means access by all people at all times to enough food for an active and healthy life. The emphasis on agricultural production is, however, only one aspect of approaching food insecurity since policies which stabilize consumption and/or increase household income may also increase access to food. The agricultural development policy of the country encourages farmers to adopt packages of new agricultural technologies.

Adoption of technological innovations attracted attention of development economists since the majority of the population of the developing countries derives its livelihood from agricultural production and because the new technology seems to offer the opportunity to increase agricultural production and income (Feder, et al., 1985). Scientific studies have shown the existence of substantial opportunities of increasing food production per capita through the use of improved technologies (Sen, 1996). Appropriate agricultural technologies help to increase agricultural output thereby increasing access to food for the consumers through supply-demand mechanism (Sen, 1996; Foster and Leather, 1999). Experiences have also shown that considerable increment in world cereal production between 1970 and 1990 was attributed to increased yield per unit of land than to increased area (94% increment in yield versus 6% increment in area) (Dyson, 1996, as cited by Sen, 1996). Moreover, most

recent studies have also emphasized the need for innovations to raise productivity and stimulate production growth necessary to reduce hunger and poverty (e.g. Heidhues, 1996; von Braun, 1997).

Development efforts in Ethiopia are, thus, geared towards promoting agricultural production and ensuring food self sufficiency. Several rural development efforts have been underway. Currently, the Participatory Demonstration and Training Extension System, based on the experience of the Sasakawa Global 2000 (SG2000) which was initiated in 1993, has been adapted as a new extension program of the Ministry of Agriculture. The core of this strategy is the so called Extension Management Training Plots (EMTP) which is a half hectare on-farm technology demonstration plot established and managed by the participating farmer. The development agent uses the EMTP to train the participating farmer and his neighbors so that they can put the technology package into practice (SG2000, 1995).

SG2000 reported successful demonstrations in the productions of maize, wheat, tef and sorghum in the Oromia, Amhara, Tigray and Southern Regional States. A remarkable achievement was made on the half hectare EMTP due to (i) very high intensity of the package use i.e. timely and adequate provision of inputs, proper extension services and follow up, (ii) relatively normal or good weather conditions and (iii) good prices attracted at the inception of the project. The model is then taken up by the Ethiopian government as a national strategy to extend the technologies to farmers with the objective to achieve food security (SG2000, 1996).

Agricultural production in the country is, nonetheless, vulnerable to natural and man made disasters. For small scale farmers, food security is a primary objective. Such farmers are exposed to production risk, market risk and institutional risk (Ellis, 1988; Hardaker, et al., 1997). Assuming that small scale farmers are generally risk averse, it would be important to evaluate the extent of downside risk of adopting the new technologies. The study was, therefore, initiated to evaluate the contribution of the new varieties and chemical fertilizer to the households' food security.

2 Conceptual Framework

Food insecurity arises from a decline in access to food due to either a decline in domestic production or inefficient distribution mechanism and, hence, a rise in food prices or a general decline in the income that enables entitlement to food or due to health condition. A household is food in-secured if the dietary intake is inadequate even under a normal situation. In terms of food security equation, a household becomes food in-secured when the income and liquid assets (including savings) available in the household's food budget is at least not enough to purchase enough food to cover the food production deficit (Foster and Leathers, 1999).

The concept of food security is limited, in this study, by defining food security indicators as the extent to which net household income per adult equivalent (AE) covers the basic needs. The household resources are allocated to farm and non-farm activities. The income generating activities include crop and livestock production and off-farm activities such as working for wage or involving in income generating activities such as petty trade. Due to the risk associated with farm and non-farm activities, the income of the household is not known with

certainty. Hence, stochastic household income distribution was defined. Income could also be earned from other sources such as gift or transfer from the society. All costs incurred in order to generate the household income are deducted from the income to arrive at the net household income. The net household income per AE is then compared with the minimum required for subsistence in order to determine the state of food security.

3 Data Needed and Analysis

3.1 Data for the supply side

Data necessary to estimate production or income of the household were collected from 148 farm households in Babile district of eastern Oromia of Ethiopia during 1996/97 cropping season. Structured questionnaire were used to gather information about farm activities (crops and livestock) and off-farm activities (involvement and remuneration), resource endowment and its allocation, actual level of production and prices of inputs and outputs. Moreover, variables which are expected to influence new agricultural technology adoption and the food security of the farm households were collected. Such variables include family structure, age and education; farming experience; access to credit as well as coping mechanisms. Besides, farmers' expectations of the minimum, the most likely and the maximum levels of yield were collected.

3.2 Data for the demand side

Food, clothes and shelter are basic necessities needed for survival. The quality and quantity of these basics vary depending on natural, social and economic factors in which the households are situated. Moreover, food intake depends on factors such as age, sex, body size and weight, climatic factors, etc. (Cremer, 1983). This implies that there will be variation among the individuals in terms of the minimum nutrition they require to maintain normal body functions as well as to acquire the energy required to undertake other duties. Thus, adult equivalent has been computed accounting for the age and sex of the household members.

In this study, the minimum level of income required per adult equivalent was computed based on the amount of food required by adult person, minimum expenses needed for clothes, minimum health care, and the amount of money required to pay a short term credit (see Table 1). According to the Ethiopian Nutrition Institute, an adult person requires a minimum of 2200 kcal per day. With the presumption that a kilo gram of cereals provide 3400 kcal, as established by the Nutrition Institute, 236 kg of cereals is needed per AE per year. The value of this amount of cereals at an average price of grain in the local markets (i.e. 1.22 Birr/kg) would be 288 Birr. Besides, information from different available sources were used to estimate the minimum amount of money needed to purchase clothes, to meet the health care and other basic expenses.

Table 1. Estimation of minimum expense per AE per year and sources of information

Expense category	Amount (Birr)[a]	Source of Information
1. Staple food	288	Computed based on minimum calorie requirement.
2. Other food: relish, pulses, vegetables, stimulants, animal products, etc.	60	Based on monitored information in Storck, et al. (1997).
3. Clothes	40[b]	Storck, et al. (1997)
4. Health care	56	World Bank (1993)[c]
5. Land use tax	5	Minimum land use tax policy, 25 Birr/farm.
6. Sort term loan	13	The amount the farmers currently owe others is considered.
Total	**462**	

[a] 1 US$ = 7.00 Birr in 1996/97.

[b] Observation about the situation of the farmers clearly indicates that the farmers are poorly dressed and the hygiene is poor. Although the minimum expense for a standard clothing should be searched, it is believed, here, that nakedness is a situation below the farmers current clothing standard and this is assumed to be the minimum. Thus, the amount of money spent for cloth purchase per AE (as in Storck et al. p 178) is taken.

[c] In a low income economy, World Bank (1993, pp9-11) estimates the minimum expense per person for a **minimum package of essential clinical services** which include some treatment for minor infection and trauma, pregnancy related health care, family planning services, tuberculoses control, and care of common serious illnesses per person to be **US$8 per year.**

In general 462 Birr was estimated as a minimum income per AE required for subsistence. The estimated minimum level of income depends very much on the level of the prices of the commodities and services. For instance, a 10% increase in the price of cereals would increase the minimum amount required to 491 Birr. Hence, the minimum level may oscillate between the 462 Birr and any upper level defined by change in the prices of goods and services. This implies that the higher the price variation, the more food in-secured the consumers who depend much on purchased food would be.

3.3 Data Analysis

Despite the current extension approach which urges farmers to use the technology package following the demonstration by the SG2000, the farmers modified the recommended technology package. Only 31% of the surveyed households used both chemical fertilizer and new varieties but at lower than the recommended rates of application. Another 33% applied chemical fertilizers to the local maize and sorghum without introducing new varieties while 18% of the households introduced the new varieties without chemical fertilizer. The remaining proportion have used neither chemical fertilizer nor new varieties. As a result, the households were grouped into four categories depending on the type of technology used i.e.

adopters of both (if they used both chemical fertilizer and new variety), adopters of fertilizer (if they used chemical fertilizer but not new variety), new variety adopters (if they used new variety but not chemical fertilizer), and non-adopters (if they used neither of the new technologies). Table 2 provides some of the characteristics of these groups of farmers. The result shows that adopters of both technologies have better resource endowment (land and labour) and wealth (livestock) than a typical farmer. This finding is consistent with that of Howard et al. (1998).

Table 2. Characteristics of the Four Groups of Farmers

Features	Adopters of both technologies	Fertilizer adopters	New variety adopters	Non-adopters	All cases
Cultivable area (ha)	2.26	1.8	1.72	1.47	1.87
Adult equivalent	6	5.4	4.8	4.5	5.3
Man equivalent	3.3	3	2.8	2.7	3
Livestock unit	6.13	5.18	3.16	3.49	4.8
% Illiterate	28	48	54	75	48
% Participated in formal school	39	25	19	14	26

Source: Own Survey

4 Results and Discussion

4.1 Household Income and its Components - Actual

The extent to which farm households are food secured/in-secured can only be assessed if all components of income and expenses are matched as suggested in the so called food security equation. Farm families derive their incomes from crops, livestock, off-farm activities and other sources (e.g. gift and transfer). Crops produced for consumption provide food needed by the household. Furthermore, cash earned from sales crops as well as from the other activities in which some members of the household are engaged increases the household's access to food. The income from crop production constitutes the largest share of the household income in the study area (Table 3).

Table 3. Share of major activities in the Household Income (%), 1996/97

Activities	Adopters	Fertilizer adopters	New variety adopters	Non-adopters	All cases
Annual crops	81.1	77.3	78.6	81.4	**81.2**
Perennial crops	2.2	2.9	1.5	2.7	2.7
Crops, total	**83.3**	**80.2**	**80.1**	**84.1**	**83.8**
Livestock	4.9	10.9	5.5	0.3	6.8
Off-farm activities	10.5	5.9	10.5	**13.1**	6.8
Others*	1.3	3.0	3.9	2.5	2.6
Total	100.0	100.0	100.0	100.0	100.0

***** Include gift and transfer incomes
Source: Own field survey

Income from the livestock sub-sector includes values of animals born, animal products and average change in the livestock inventory. The average change in the livestock inventory was computed by summing up the net changes in the beginning and ending values of the livestock, and net values of the purchases and sales of the animals. Usually, variable costs of livestock production such as costs of feed, veterinary services, and livestock maintenance costs are deducted from the gross income to arrive at the gross margin of the livestock. Except the replacement costs which has been captured through the inventory changes, no other costs of livestock production have been incurred by the farmers since livestock production in Ethiopia is generally based on traditional methods and purchased inputs are quite limited. The result is consistent with that of the previous studies conducted in the region (Storck, et al. 1997).

In general, income from the livestock sub sector constitutes about 7% of the household's income while off-farm and other incomes such as gift and transfer constitute roughly 10% and 15% of the net household income of the adopters of both technologies and the non-adopters respectively. Net household income is the total sum of the net farm income, income generated from the off-farm activities and income from other sources. This amount implies the family budget to cover all expenses of the household including repayment of debts, consumption, social obligations, health care, school fees, clothing, saving for future investment, etc. The highest net farm income is earned by the adopters of the new varieties and chemical fertilizer while the smallest amount was earned by the non-adopters.

The analysis of the households' income with and without using the new varieties and chemical fertilizer revealed that the average income per AE increased due to the use of the new technologies. Table 4 shows that annual crops yield more income when the new varieties and chemical fertilizer are used than without these technologies. As a result of using the new technologies, the household income per AE generally increased by 21%, 6% and 9% for the adopters of both technologies, fertilizer adopters and the new variety adopters respectively.

Table 4. Average income and expense of the household with and without new technologies (Birr) (1996/97)

	Adopters of both technologies		Fertilizer adopters		New variety adopters		Non-adopters	All cases	
Components:	With	Without	With	Without	With	Without		With	Without
Gross income, crops	3101	2391	2292	1983	1906	1687	1601	2194	1911
Total direct cost, crops	526	335	492	306	294	278	239	422	296
Gross margin, crops	**2575**	**2056**	**1800**	**1677**	**1612**	**1409**	**1362**	**1772**	**1615**
Livestock income	144	144	232	232	105	105	5	136	136
Gross margin, total	**2719**	**2200**	**2032**	**1909**	**1717**	**1514**	**1367**	**1908**	**1751**
Total Indirect cost	108	108	96	96	82	82	93	97	97
Net farm income	**2611**	**2092**	**1936**	**1813**	**1635**	**1432**	**1274**	**1811**	**1654**
Off-farm income	311	311	125	125	201	201	198	136	136
Other incomes	38	38	64	64	74	74	37	51	51
Household Income									
Total	2960	2441	2125	2002	1910	1707	1509	1998	1841
Per adult equivalent	**493**	**407**	**394**	**371**	**388**	**356**	**335**	**377**	**347**

Source: Own computation

4.2 Stochastic Household Income

The information used to compute the income earned by the household to meet the subsistence requirements of its members were deterministic. In reality, however, yield and price levels are variable making the income from crop activities uncertain. The income from the livestock activity could also be variable depending on the vegetation cover, amount of crop residue available for feed and the prices of animals and animal products. The average income from off-farm activities could also depend on the wage rate and job availability. It is, therefore, useful to analyze the stochastic income of the farm household.

To this end, the triangular yield (using expected yield) and price distributions were defined to estimate the stochastic income from the cropping activities. All relevant variable costs were deducted from the stochastic income to derive the gross margin from crop production. The simulated outcomes were weighted by the area allocated to the different crops or crop mixes in order to derive the income the household would earn from that particular cropping system. Moreover, the observed minimum, mean, maximum and the standard deviations of incomes per household from perennial crops, livestock and off-farm activities were used to define Truncated Normal Distributions of the income from these activities. A similar distribution was assumed for the fixed expenses.

In order to evaluate the impact of using the new varieties and chemical fertilizer, the with and without situations were considered. The difference between the income levels under the with

and without situation is totally attributed to the difference in the use of the new technologies. The use of new varieties and chemical fertilizer, accounting for risk, would increase the net income per AE by about 5%. In order to judge the status of food security under risk, the cumulative probability that income per AE falls below a given subsistence level, both with and without the new technologies, were prepared and summarized in Table 5. The summary shows that, given the currently defined minimum subsistence requirement of 462 Birr per AE per year, there is a small probability (0.4%) that the average income per AE of the adopters fall below the minimum level though the chance of being food in-secured would have increased to 3% without these technologies. Similarly there is a better chance of being food secured with the use of chemical fertilizer than with only new varieties. The use of new varieties without the application of chemical fertilizer would not improve the chance of meeting the stated minimum requirement.

Table 5. Cumulative probability that net income per AE falls below ... Birr (%)

Level of net Income	Adopters of both technologies		Fertilizer adopters		New variety adopters		Non-adopters	
	With	Without	With	Without	With	Without	Without	With
<462	0.4	3	1.5	4.3	1	1	5	5
<600	6.6	9.6	10	17	8	9	29	23
<700	20	27	32.8	39	32	34	57	50

Source: Own computation

However, if the minimum requirement level oscillates due to changes in prices of commodities and services, for instance, the probability that the net income per AE falls short of the minimum required for subsistence increases (Table 5). As food and basic services get expensive and the minimum subsistence level increases say to 700 Birr per AE (equivalent to US$100 at the time of the survey), the probability that the household is food in-secured would be at least 20% whereby the worst happens without the new technologies. In all cases, as the minimum income level rises, the probability of food insecurity increases and in most cases, the probability of food security is higher with the new technologies than without them.

5 Conclusion

The use of new varieties and chemical fertilizer have increased the access of the households to food. Taking also risk into account, the contribution of the technologies, under the condition of the study area, is not so high as expected from the package program launched in the country. It appears that households with better resource endowment may benefit from the technology if the rainfall and market situations are normal. The result suggests that the demand for appropriate technology by the resource poor farmers has not been yet met. These technologies may be found involving the farmers in the research process. These may also help to avoid the danger of future food insecurity due to less bio-diversity emerging from emphasis on non-local improved breeds of crops (Shiva, 1996).

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