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Differential Adoption of Technologies and its Implications for Policy choice between Equity and Growth

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Abstract

Government policies often attempt to create simultaneous impact on economic efficiency and equity. The Ethiopian government optimistically has targeted to simultaneously achieve at improvement in agricultural efficiency (growth) and equitable distribution of the benefits by all farmers in the whole part of the country. However, many scholars most often argue that growth and equity are inversely related in most development processes. Thus, the main objective of the paper was to evaluate the interhousehold and interregional technology adoption pattern (implies both growth and equity). The conceptual relationship of growth and equity, and experiences in adoption studies were first assessed. Then three ecological potentials with 150 sample size each (a total of 450) were studied using Probit Model.

The study result has shown that only 35.5% of the sample adopted. The beneficiaries of the extension were relatively the resource rich farmers of which the largest proportion were concentrated in the high potentials areas. The high potential areas benefited remarkably higher net returns to land and management from the use of same technology than the other areas. Thus, alike the previous extension approaches used in the country and as supported by lists of literature, the new extension system could not be also free from such bias at least in the short-run. Conclusively, differential adoption of technology within a certain period of time can be regarded as a natural phenomenon. Hence, efforts to enable both the poor and the rich to equally adopt agricultural technology would rather imply substituting equity for growth at a very low level of the economy status that has immeasurable social cost. For countries like Ethiopia, which is at a very low level of economic status, focusing on growth through increasing the farm productivity of the potential adopters in the short-run, and designing special programs for the poor to follow their footsteps is suggestible. Otherwise, the country may remain behind while pulling both the poor and the rich together.

Key Words: Technology Adoption, growth and Equity

1. Introduction

The principal economic policy presently implemented by the Ethiopian governments is the Agricultural Development-Led Industrialization (ADLI). The implication is rapid agricultural growth to produce sufficient food for the citizens, exports and releases surplus of raw materials and labor to foster agro-industrialization. Hence the Five-year Development Plan of the Government (EPRDF, 1996) has put special emphasis on the

development of the agricultural sector. It primarily attempts to transform traditional low productivity agriculture into high productivity agriculture, and to provide enough income for the people; and secondly to raise the level of raw materials for industrial sector.

Naturally, there are two ways of increasing agricultural products: bringing more land and labor under cultivation and introduction of improved technologies. A large bodies of growth-accounting studies for developed economies shows almost unanimously that the part of agricultural output growth which can be explained by increase in the conventional factors, specially land and labor, is minor relative to technological changes broadly defined as a shift in production function relating output and inputs (Peterson and Hayami, 1977). Due to consistent rise in population pressure, unused land resources have been exhausted and cultivation frontier have been pushed to the point where further land opening endangers ecological balance seriously, and diminishes the marginal productivity of labor (Hayami, 1983). Therefore, it has generally been agreed that a sustainable increase in total factor productivity through technological change, resulting from an organized effort to apply scientific knowledge to production processes, underlay the rapid increase in the national product (Kuznets, 1966). The consensus is that in order to achieve agricultural output growth at a rate sufficient to meet the needs of developing country, it is imperative to develop and diffuse modern agricultural technologies suited for their resources endowments and ecological conditions. Therefore, delivery of physical inputs to farm households such as fertilizer, improved seeds or high yielding varieties (HYV), and improved cultural practices naturally becomes a paramount importance.

Through the diffusion of improved agricultural technologies, the Ethiopian government policy attempts to create simultaneous progress in both economic growth (efficiency) and equitable distribution of the benefit (equity) by households from the use of the transferred technologies. For this purpose, in 1995 a new extension approach referred “Participatory Development Training and Extension System (PADETES)” was formulated. It mainly comprises the delivery of improved seed, fertilizer, pesticide on a credit (at a Bank official interest rate) with a 25% down-payment. The number of extension participants increases every year at a multiple of 10. Therefore the Government then has ambitiously launched massive technology diffusion process in all parts of the country.

However, it is always argumentative that growth and equity are positively related in many circumstances. Although the direct effect of technological progress on growth is apparent, its effect on equity depends on the initial economic statuesque of the economy, individual’s factor endowment and the nature of the technology., and social and political situation in the system (Hayami, 1983; Kuznets, 1966; Peter and Hayami, 191977). The literature then concludes that it is often common to assume a trade-off between growth and equity in the development and use of modern technologies. Although such concern has been accentuated with the advent of the “green revolution” in the 1960s, the researcher still expects the problem to prevail in Ethiopia too. The question is that within the prevailing differences in social, economic and environmental circumstances farmers face, is the new extension approach likely to enable both the poor and the rich farmers equally access to improved technologies? Or does differential adoption persist as a

natural phenomena? If so, growth or equity should take the first priority to focus on in the development efforts of the economy given the prevailing conditions? Determination on such fundamental issues seriously affects the proper utilization of government budgets and other sources of productive resources in the courses of development endeavors. These are the researchable issues that deserve attentions of policy makers and economic planners.

Therefore, it is worthwhile to look into the new extension approach whether it has really eliminated or at least minimized the difference between the rich and the poor in technology adoption and thereby the benefits. The main objectives of the study to assess the level and determinants of adoption of technologies transferred by the extension project, and then to identify and evaluate the beneficiaries of the project. The paper tries to relate the results of the case study with the principal relationship of growth and equity, and extrapolate its implication for the government to choice between growth and equity. In the next section, the paper presents a brief review of research evidences on the conceptual relationship between growth and equity, and experiences of adoption pattern in technology. The third section presents a summary of results of recent adoption case studies in Ethiopia. Then the papers results of a case study on the new extension project, PADETES, in different agro-ecological zones, and in the last section some conclusions and policy implications are incorporated.

2. Conceptual Analyses: research evidences

2.1 Equity and growth

Growth and equity are both components of welfare that we need to achieve in all possible means. As mentioned earlier, growth can occur either by moving from a less efficient to a more efficient use of the existing resources (that is by increasing the productivity of resources). That is, more output can be produced if more resources are available and/or level of technology of production is improved. The latter, strongly influences the former, since new technologies can both improve the productivity of existing resources and make use of resources that may previously have been idle. Equity, by contrast, refers to the distribution of this total output between individuals or social groups within the society. A simultaneous effect on equity change in technological progress undoubtedly results in economic growth, but its varies. However, the problem “who benefits from economic development” is one of the most challenging for economists since long ago and is both complex and profound.

However, growth (efficiency) objective and equity objective may and often do in practice conflict each other. Brewing and Johanson (1984) cited that it is often impossible to realize both objectives. Policy instruments designed to increase output growth always have effects of varying importance on income distribution. Likewise, policy instruments designed to improve income distribution (equity) always have direct or indirect effect on output growth (Ellis, 1996). Ellis thus, underlined that the pursuit of equity in the low level of economic status results in potentially high sacrifice of growth. A more detailed

analysis of the relationship between growth and equity is documented in the works of Kuznets.

Kuznets (1966) hypothesized that the distribution of income tends to worsen in the early phase of economic growth (represented by GDP per Capita) and to improve thereafter. On his subsequent research (Kuznets, 1972), he observed that the level of economic development is a major determinant of the extent of income inequality in a country. He noticed that relative income inequality rises during the early stages of development, reaches a peak and then declined in the latter stages. This relationship is illustrated graphically in the inverted *U-shaped* curve.

Kuznets's analyses imply that as the economy of the poor countries grow the income gap of the residents gets wider.

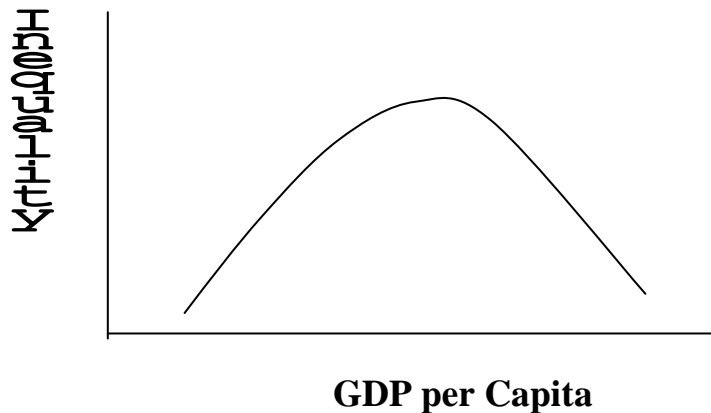


Fig 1: Relationship between Inequality and Growth

Further more, (Hayami, 1983) explains that the relationship between growth and equity differs from country to country (mainly because of their level of development) and in different periods of time based on the existing technology, factor endowment and social preferences.

Hayami and Kuznets (1983) has explained in detail the relationship between growth and equity in the application of modern agricultural technologies in developing countries. They have clarified the effects of important factors like population pressure on land resource and the interaction between technological and institutional changes base on positive economic analysis. If the cause of growing poverty and inequality is the population explosion on land, a technological change effective for the dual goals of growth and equity should be land-saving and labor-using ; it increases the marginal productivity of labor relative to that of land thereby increasing labor's income share at constant wage-rent ratio. Biological technologies such as improved seeds are fertilizer regarded as land saving and even neutral with respect to scale of land (i.e., they can be divisible into small units and can be used at all possible smaller quantities). Most commonly, these inputs are applied at much larger amount than a traditional practices

together with greater agronomic care. On the other hand, some biological technologies like herbicides are labor-saving and capital intensive technologies.

When technological changes that involve labor intensive (labor using) and land and capital saving diffused and adopted by the farmers, there is no trade-off between growth and equity. This is because both the resource poor and rich can access and acquire the technological components. Conversely, when technologies transferred and capital intensive but labor saving, then the new technologies generate more growth but less equity. Nevertheless, Gustav Ranis (1983) summaries that there are considerable evidences, drawn from extensive empirical research, that fast economic growth adversely affects the distribution of agricultural incomes. But at least in the long run there is no trade-off between growth and equity, rather they tend to relate positively.

Believing the notion of improved technologies that it paves the way to growth, adoption of agricultural technologies obviously have a significant impact on growth and income distribution. It is also unambiguous that Ethiopia is amongst the poor countries and is at its very early stage of economic growth. Even if the diffused technologies are not so capital intensive, the severity of poverty in the nation would remain to explain differential adoption by households of different resource endowment and an increasing gap of income distribution. Therefore, one can conclude from the literature that in Ethiopian economy growth and equity seem to exhibit negative relationship.

2.2 Technology adoption pattern

So many studies on the adoption¹ of agricultural technologies have been made in both developed and developing countries. Roger (1983) and his colleagues have clearly and comprehensively summarized the nature of adoption process in relation to time. He has shown that adoption rate has a time dimension. He bolded that an individual user of a technology needs time to learn or understand about the technology, evaluate and finally decide to use it. This time dimension varies from individual to individual depend on the individual's socio-economic and ecological factors. On top of Roger's analyses, Girshon F., et al (1985) and Robert, S.(1985) have indicated that the frequency distribution of adopters over time follows a ***bell-shaped 'normal' curve*** and its cumulative frequency looks like the ***S-shape curve*** as depicted in figure 2a and 2b. Mansfield (1961), hypothesized that the S-shaped adoptions curve is a function of the extent of economic merit associated to the new technology, the amount of initial financial requirement to adopt, accessibility to information, and the degree of risks, complexity and availability of the technology. Thus, the S-shaped curve implies that few farmers initially adopt and benefit from the new technologies. However, over time, an increasing number of adopters appear. In the end, the trajectory of the diffusion curve slows and begins to reach level of attaining its apex (Mosher, 1979). The Author then emphasized that such type of adoption pattern results in a significant income difference between the early users and the late or non users of the technology.

¹ Roger (1983) defined technology adoption as farmers' decision that new practices or ideas are good enough for full-scale and continue to use.

Depending on time of adoption from the first to the last, adopters of new technology are, therefore, categorized as innovators, early adopters, early majority, late majority and laggards. The first two extremes are characterized as relatively resource rich, educated and young while the last category, the laggards, do have completely the opposite features. Accordingly, ability of these groups to afford initial investment, level of risk aversion and access to information, which ultimately influences time of adoption, widely differs.

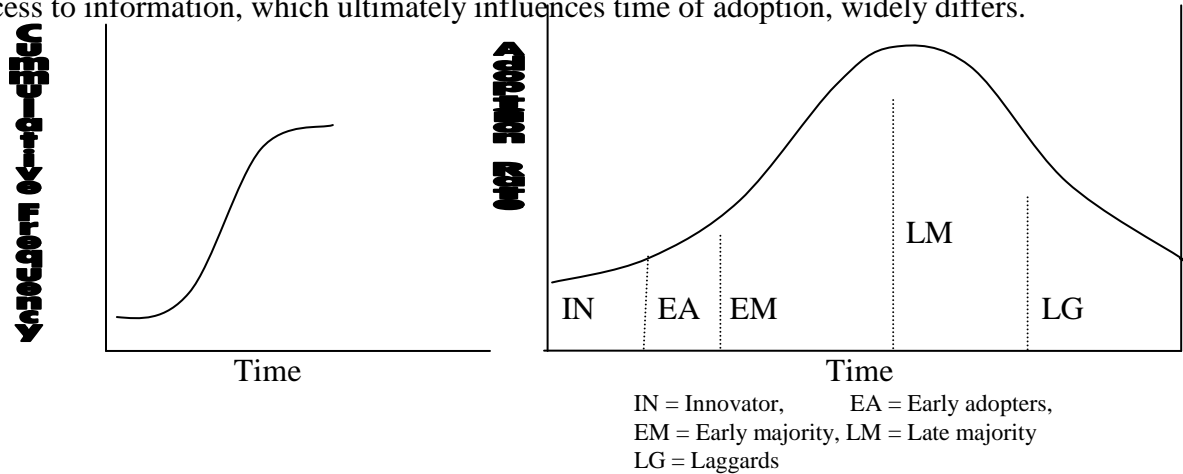


Fig 2a: Cumulative frequency distribution of adoption Fig 2b: Frequency distribution of adoption over time

Assefa, A and F, Heidhues (1996) has identified that farmers who had adopted improved technologies like fertilizer are superior in economic efficiency than the non-adopter. This has a direct implication for the growth of a national economy. In deed, it is unquestionable that technology adoption results in higher income for adopters and lower real price of agricultural products for consumers. This kind of technological effects have been experienced in almost every country including Ethiopia at a certain degree. In this regard studies by Beyene T, (1998) and Sara G, et.al, (1996) on impact of use of new technologies have showed that output of maize increased to unprecedented levels with significant income increases of the adopters compared to the non-adopters.

Thus, looking into the time relationship with adoption rate, and the impact of technology adoption on income, it is very transparent to perceive that income differentiation would likely to emerge. The income of the early innovators and the early adopters could shoot up quickly while that of the rest groups lag behind resulting in increasing income gap (worsening equity situation) at least in the short run. In deed, the poor might be benefited indirectly provided that the use of the technology create change in the real income of the society as a whole.

3. A Brief Review of the Country Experiences and the Current Government endeavor

In Ethiopia, different extension systems were practiced one after the other before the PADETES (will be explained below) program in the mid 1990s has been coming into effect. In general , however, adoption studies made at different levels in different

locations indicate that technology transfer and adoption by farmers were highly hindered by external and internal problems. These are improper design of the extension approach, poor research-extension linkage, low extension worker-farmer ratio, poor motivation and multifarious activities of extension workers (Tennassie, 1985). As a result, no significant change in farmers' income could be perceived.

More over, the extension approaches of those days were condemned that they resulted in undesirable social changes like worsening income gap. In this respect, the Comprehensive Package Program (CPP), which was initiated in 1967 in Chilalo and Walyta Provinces, can be the best example. The CPP was tailored for the resource rich farmers who were able to provide collateral for credits offered for the extension program. Thus, all the benefits accrued to the wealthy farmers (the then landlords) while benefit to peasants was at best marginal. The program never met the needs of the small-scale farmers because they were unable to participate in the program. Consequently, CPP rather created rural elite (income disparity) in those areas (Lele, undated; Cohen, 1974; and Dejene A, 1995). All the efforts and the consequent beneficiaries in all the previous extension approaches were concentrated and limited to the main roadsides. All the successive extension programs such as the Minimum Package Program (MPP), the Peasant Association Development and Extension Project (PADEP) and even the Sasakawa-Global 2000 (SG-2000) Extension projects were blamed for being ran into such biases towards benefiting the resource rich farmers. In fact, the degree of the bias varies (Legesse D, 1998; Beyene T, 1998; and Lelissa, Ch. (1998). As a result, the resource poor farmers reap little benefit from the programs at least in the short-run .

Conclusively, many studies have shown that the benefit from technology adoption largely depends upon socioeconomic and agro-ecological factors facing the farmers (Itana, 1985; Chilot, Y. et. al, 1996 and Mulugeta, 1995) and the strategies and design of extension services (Gershon, et al, 1985). Beyene et.al, (1991) also identified that lack of cash and/or credit, poor and insufficient input delivery and low output price are the most limiting factors for technology adoption.

In spite of these facts, the Ethiopian government has been attempting to eliminate such differential benefits from the use of improved technology adoption through new extension approach. The new extension approach was formulated in 1995 as a hybrid form of T&V and the SG-2000 extension systems, and referred "*Participatory Development Training and Extension system*" (PADETES), Belay E, (1997). The PADETES is advocated for that it gives both the poor and the rich farmers an equal opportunity and access to improved technology. The government ambitiously expects the PADETES to promote uniform adoption of a technology by all farmers thereby enabling the nation to simultaneously achieve at both growth and equitable distribution of income and seemingly balanced development in all regions regardless of all social, economical and physical circumstances.

4. The Effects of PADETES on adoption pattern and its implication for Income distribution: A case study

In this section results of a case study taking samples from different regions and ecological zones are summarized. This is to understand whether the PADETES is really performing as expected to do so. The study focused on adoption differential with respect to selected socioeconomic and physical factors. Because of the difficulty to obtain data on financial and non-financial resources committed for the extension of technologies, cost-benefit evaluation of the extension practice was not done.

4.1 Data and the model

Maize was selected as a study unit since it has deserved the most breaks through in technology advancement and intensive extension involvements relative to other agricultural products. Primary information was collected from maize growing farm households using a standardized questionnaire. Sample selection was based on a stratified two-stage random sampling design. First, agro-ecological potentials for maize production as high, medium and low potential was considered. Localities like Bako (West Shewa and East Wallaga), Aris Negel (South-East Showa) and Awassa were selected as a representative of high potential areas, Bahirdar and Galmso (West Hararge) areas represented medium potential and Yeju (North Wollo) and Babile (East Hararge) areas represented the low potential areas.. Then peasant associations in the extension circle were selected, and from each ecological zones 150 farmers (which adds up the sample size to 450 farmers) were chosen using a simple random sampling method. Such information on variety of seeds, seed rate, fertilizer level and method of fertilizer application were collected. In addition, indicators of households' economic status such as area of land, human and oxen labor resources owned, and other household characteristics were gathered. The researchers do not assume that the three ecological zones have received exactly the same extension services but believes that in all areas much effort has been made for considerable number of years that could enable one to roughly compare some of the extension achievements

Assuming that farmers face the same input and output prices, the technology adoption decision function is defined as:

$$I^* = \beta_i Z_i + \delta$$

Where, the observed I^* is defined as:

$$I = 1 \text{ iff } I^* > 1 \text{ if a farmer is adopter, and } I = 0 \text{ iff } I^* < 0 \text{ otherwise.}$$

Z_i are exogenous variables, β is a vector of unknown coefficients and δ is a disturbance coefficient.

The ability and willingness of a farmer to adopt recommended technologies depend on his/her household characteristics, resource endowment and on the socio-economic environment he/she is faced with. The explanatory variables hypothesized to influence farmers' decision to adopt maize technologies are explained below. Then, the probit model was employed for the analyses.

Dependent variable:

Y = 1 if farm household head adopted, 0 otherwise

Explanatory variables:

HHAGE: The age of the farm household head. Age is a proxy for experience with farming. It affects decision to accept or reject new interventions, but the direction is not clear.

HHSZ: The household size. It represents the number of potential active family members. Use of improved technologies demand proper management of farm operations. Thus, higher endowment with family labor is expected to adopt extension recommendations more quickly.

HHEDUC: Education level of the household head. 0 if illiterate, 1 if 1 to 6 years of education, 2 if 7 to 8 years of education and 3 if greater than 8 years of education. Education improves access to information on new ideas and inputs provided by extension workers. Therefore, the more the household head educated the more likely he/she is to get improved inputs and use them in farm operations.

TFRMSZ: Total farm size owned by the household, in hectare. Farmers with larger landholding are likely to participate in the extension, and thus there is a high probability to adopt.

NOXEN: Number of oxen owned by the household. The number of oxen owned is hypothesized to be positively related to technology adoption as it represents the wealth status of the households.

DSROAD: Distance of the household's residence from the main road, in walking minutes. The closer the household to the main road the more access to extension information would be, and thus positively related to technology use.

PMRKT: Proximity to the market center, in walking minutes. Households nearer to market center are likely to be access to information on new inputs, and thus positively related to use of improved technologies.

GETCRDT: Credit availability for down payment. 1 if farmer has access to credit, 0 otherwise. It is expected to have a positive impact on technology adoption.

WORKOFF: Participation in off-farm work. 1 if household-head work off-farm, 0 otherwise. The higher the source of income from off-farm works the less likely a household to participate in extension activities.

ACCEXT: Access to extension service. Farmers who have frequent contact with extension agents are hypothesized to be access to information on new inputs, and hence, are more likely to adopt than those who are not do.

AVPAKG: Availability of the package. 1 if yes, 0 otherwise. Timely availability of the package at a desired quality and quantity and time would enhance adoption.

Dummy: It represents the suitability of agroecology of the areas for maize production such as soil condition, climate, pests and diseases in general. The more favorable is the environment for growing a particular crop, the more is the benefit and the less are risks of loss and hence the more is adoption rate by the growers. 1 if low potential, 2 if medium and 3 if high.

4.2 Results and Discussion

4.2.1 Characteristics of the sample farm households, resource endowment and technology adoption

Of the total sample size only 35.5% of farm households adopted the improved technology of maize and the great majority (64.5%) was not. Considering the ecological differences, relatively the largest portion of the high potential areas (50%) adopted followed by the medium potential (34%) and at the last is the low potential areas where only 16% of them adopted (Table 2). It is clear, therefore, that the rate of adoption differs from areas to areas with a diminishing proportion as one goes from the high potential to the low potential areas. The household characteristics and their resource endowment and physical factors do have implications for such phenomena.

Table 1 presents the descriptive statistics of the household characteristics of the adopters and the non-adopters of pulled data. Average age of household head of the sample farmers is about 42 with standard of deviation (SD) of 13.50, which is almost the same for both adopters and non-adopters. The level of formal education in the study area appears to be low. Out of the total sample, 38.3% reported that they had received formal education, of which more than 90% had attended only a primary level. But there appeared a significant difference between the adopters and the non-adopters. The average household size of the total sample farmers was 8.7 persons with SD of 4.14, and ranged from 3 to 28 persons which is significantly different (at 1% level) for the two groups. The average family size of the adopters was about 8 persons with SD of 4.7, while that of the non-participants averaged 5.5 with SD of 3.4. Moreover, the adopters are identified to be much closer to the main road relative to the non-adopters, which is highly significant at 1 % level.

Table 1: Comparison of Adopters and Non-adopters with Respect to Selected Characteristics

Error! Bookmark not defined. Variable	Mean		t-test for paired samples
	Adopters	Non-adopters	
HHAGE	42.56 (10.66)	42.0 (14.8)	1.54
HHEDUC	1.04 (4.01)	0.73 (3.24)	1.86*
HHSZ	8.0 (4.70)	5.50 (3.41)	2.05**
TFRMSZ	2.26 (2.10)	1.22 (1.41)	3.55***
DSROAD	24.0 (15)	36.38 (26.03)	-2.51**
PMRKT	31.50 (28.40)	48.34 (33.00)	-4.12***
NOXEN	2.50 (2.30)	1.05 (1.60)	5.56***

*, **, and *** indicate significance level at 10%, 5% and 1% respectively, and figures in the parentheses are the Standard of Deviations. Figures in parentheses are Standard of deviation

Table 2 summarizes household resource endowment in relation to adoption rate for the different potential areas. The main farm resources considered for this study were farm size and number of oxen and farm labor owned by farm households.

a) Farm land: Except in Bako area land is generally considered to be short. The difference in farmland owned between adopters and non-adopters was so large; mean farmland owned by sample adopters 2.26 hectares and that of the non-adopters was 1.2 hectares, significantly different at 1% level (Table 1). Table 2 portrays that about 45% of the sample household owned 2 or less hectares, the remaining 39.6% of the sample farmers owned 3 to 4 hectares, and 15.4% of them owned over 4 hectares. The sample farmers were grouped into three classes based on the size of land they owned, that is, small (less than 2.0 hectares), medium (between 2.10 and 4.0 hectares) and large (over 4.0 hectares). In Table 2, it is shown that the proportion of sample farmers adopted the extension recommendations increased with the land size they owned. Accordingly, about 22% of small farmers, 37% of medium sized farmers and 70% of the large farmers adopted.

b) Draft power: Ox is the only source of draft power in the study areas. The average number of oxen owned by adopters were 2.5 and that of the non-adopters was 1.05 oxen (Table 1). Like the case of farmland oxen power was also short. In Table 2 it is indicated that over 40% of the sample farmers owned one or no ox though 60% of them owned two and above oxen. Similar to farmland, the distribution of oxen between the two groups was also large. The proportion of households participating in adopting the extension recommendation was consistent with that farm size. While only 13% of sample farmers with zero or one ox adopted, increasingly larger proportion of sample farmers with two to three oxen (41%) and over three oxen (73%) adopted the technologies (Table 2).

Table 2: Farmers' resource endowment and level of adoption as percent of all Farmers belonging to the indicated categories

Farmer group	Farm size owned			Number of oxen owned			Farm labour owned		
	≤ 2 n=202	2_1_4 n=178	≥ 4 n=69	≤ 1 n=180	2_3 n=195	≥ 4 n=75	1_3 n=158	4_8 n=188	>8 n=104
Total Adopters: (35.5%)	22	37	70	13	41	73	33	47	17
High potential (50%)	64	48	45	65	44	48	50	39	40
Medium potential (34%)	25	36	38	27	34	38	32	35	45
Low potential (16%)	11	16	17	8	22	10	18	24	5
Non-adopters (64.5%)	78	63	30	87	59	27	66	53	83
Total household	45	39.6	15.4	40	43.3	16.7	35.2	41.8	23

c) Farm labor: Members of a household in the study areas, similar to any other part of the country, are the largest source of farm labor. Mean of family size of adopters was statistically significantly greater than that of the non-adopters at 1-% level. Basically, all healthy family members between 12 and 75 years participate in agricultural, though their skill and efficiency could actually be different. Thus, household members in this age range were categorized as farm labor. Considering this category, the average farm labor of the adopters was 5.7 person with SD of 3.05 and the farm labor of non-adopters was 4.3 with SD of 2.15 persons. Similar to family size, farm labor of the adopters was significantly larger than that of the non-adopters. As indicated in Table 2, about 35% of the total sample had two to three farm laborers, about 42% four to eight farm laborers and 23% over eight farm laborers. In the same table it is shown that a lower proportion of sample household (33%) with small farm labors (one to three) were adopters, and much more proportion of households (47%) with farm labor between four and eight persons adopted the extension recommendations. Household group with over eight laborers comprised the lowest proportion of adopters (only 17% of the group adopted). This could be because of the limited capacity of their land, oxen and other farm resources to hold large family size under the existing level of technology. So this kind of families could be financially so poor to afford cost of the improved technologies.

From the analyses of household characteristics and their resource endowments, one can generalize that substantially more households with larger endowments of farm land and oxen power and reasonably large farm labor adopted. These groups of farm households imply clearly economically the better ones. Appreciating the variations among the ecological potentials, Table 2 also depicts a clear differences in adoption rate of among them. The proportion of adopters in all ecological potentials exhibit a similar trend in all categories of household resource endowment. The rate of adoption positively related with the amount of resources farmers endowed. The high potential areas take the lions share followed by the medium potential areas and the low potential at the last. The difference could be mainly because of ecological factors such as soil and rainfall condition, diseases and pests etc. It can be, therefore, extrapolated the consequence of such variation on distribution of the benefits from adoption of the technology. The largest economic benefit is geared to the high potential areas and/or adopters and the lowest benefit to the low potential areas and /non-adopters resulting in a wider interregional and intrahousehold income disparity.

4.2.2 Econometric Analysis of the Determinants of adoption differential

The idea of factors affecting farmers' adoption is useful since they are either the vehicles or obstacles to extension systems to influence farmers' decision making on the use of agricultural innovations. A farmer's adoption decision is affected by the supply of extension services in general. Farmers, however, have a demand for adoption that is governed by factors related to his/her household characteristics, socio-economic and agroecological factors. Then, some selected variables hypothesized to affect farmers' decision to adopt maize technologies were fit to the Probit Model.

In a cross-sectional data, socio-economic variables usually have the problem of multicollinearity that would result in unexpected relationship between the explanatory variables and the dependent variable. Hence, to make the estimates more reliable, all the variables hypothesized to influence farmer's decision to adopt were first taken together and were checked for multicollinearity. A bivariate correlation matrix was computed to test for high collinearity. Then variables that showed highly significant collinearity were excluded from the model. Accordingly, PMRKT and WORKOFF were highly associated with each other and to DSROAD. WORKOFF was also strongly and negatively correlated with NOXEN and TFRMSZ. Hence, PMKT and WORKOFF were dropped from the analysis. In the end, some selected important variables were used in the analysis.

The Maximum Likelihood Estimates of the probit model is presented in Table 3. The partial derivatives (marginal effects) of the variables on the probability of farmers' adoption decision are also shown in the third column of the Table. The marginal effects of the vector characteristics are computed at the means of the variables for all observations. As indicated in the Table, all variables have the expected signs. Out of the 10 variables entered into the analysis, only one variable, HHAGE, was found to be not significantly influencing farmers' decision to adopt. DSROAD has a negative sign significant at 1% level with a marginal effect of about 27% all other variables kept at

their mean. It implies the farther the household residence is from the main road, the more he/she tends not to adopt the maize technologies. Farmers who live far from the main road could be less accessible to extension services and cannot get sufficient information on improved farm technologies, and hence are more unlikely to adopt.

The NOXEN and TFRMSZ have positive signs and significantly affect the farmers' decision to participate at 1% and 5% level, respectively. This supports the notion that oxen and farmland are among the most important and basic farm inputs (assets) without which farmers may not be able to smoothly operate their farm activities. The two variables may also proxy the wealth status of a household. They can be sources of cash and security against risks of crop failure. This result is consistent with the result of Donal, et al (1977) that indicated wealthy farmers are relatively less risk averse and hence are faster to use new technologies. All variables held at their mean level, the marginal effect of the NOXEN is about 10%, and that of TFRMSZ is 13%. The change of TFRSZ of an individual farmer from 0.5 to 2.0 hectares would increase the probability of adoption by about 23%.

Table 4: Probit Maximum Likelihood Estimation of the Extension

Explanatory Variables	Coefficients	Partial Derivatives	Means of Variables
Constant	-2.036 (2.48)**	-0.811	—
DSROAD	-0.416 (4.29)***	-0.266	2.94
HHSZ	0.498 (1.91)*	0.220	8.79
NOXEN	0.234 (3.17)***	0.093	2.55
HHAGE	-0.010 (0.91)	-0.104	41.50
TFRMSZ	0.033 (1.95)**	0.130	2.89
HHHEDU	0.377 (1.85)*	0.150	0.88
GETCRDT	1.878 (2.91)***	0.328	0.39
AVPAKG	1.6 (2.1)**	0.401	0.45
ACCEXT	0.33 (2.5)**	0.130	0.34
Dummy	0.25 (3.0)	0.210	2.0
Chi-square (10) = 91			
Log likelihood = -95			
Restricted Log likelihood = -141			
Sample Size = 450			

Figures in the parentheses are t-ratios; and ***, **, and * indicate significance levels at 1%, 5% and 10% respectively.

HHEDUC and HHSZ have also positive signs as expected. HHEDUC is statistically significant at 5% level, and a change of farmer's schooling from the lower to the next higher level has a marginal effect of about 10% on his/her probability to adopt. The other important variable was the effect of the HHSZ (taken as proxy for labor availability)

which has a marginal effect of 22%. Increase in household size from two to ten would increase the probability of individual farmer to participate in extension program by 15%. GETCRDT was positively related to the farmers' decision to participate in the extension, and is highly significant at 5% level. The marginal analysis also showed that other factors held at their mean level, credit availability for down payment alone affected farmer's probability to adopt by about 33%. Credit enables farmers to buy costly inputs such as fertilizer and thereby promote the adoption of the improved practices. Likewise, AVPKAG and ACCEXT were also significantly affected adoption decision at 1% and 5% level and their marginal effects were 40% and 13% respectively. The ecological potential difference represented by the Dummy variable was strongly significant at 1% level with a marginal effect of about 21%.

In general, the analyses suggest that availability of technological packages and access to credit were the most important factors determining farmers' probability to adopt. The result also showed larger farmers (in terms of both farm area and number of oxen owned), households with moderately large size were more likely to adopt with further increase in probability under favorable ecological zones, without underestimating the impact of the other aforementioned factors.

Table 3: Frequencies of Actual and Predicted Outcomes of adoption rate

	Predicted			
		0	1	Total
	0	225 (77%)	67 (23%)	292
	1	41 (26%)	117 (74%)	158
	Total	253	197	450

Table 3 reports the maximum probability of predicted outcomes. The probit model correctly predicted 77% farmers as non-adopters and 74% as adopters with the overall efficient measure of classification indicated by Count $R^2=76\%$ (significant at 10% level).

4.2.3 Returns to Maize Production

The impacts of natural endowment and socioeconomic characteristics of farm households are also reflected on the returns farmer obtain from their farm activities. The average Net return to land and management (net income plus cost of land and management) for the three ecological potential areas was estimated at respective local average price (Table 3). It was observed that farmer using the same level of technology of maize obtained quite significantly different returns, those which are in the high potential areas obtained almost as large as twice of the low potential areas.

**Table 3: Average Net Returns to land and management of maize production
(Birr/ha), 1999/2000**

Ecological potential for maize production	Improved practice	Traditional Practice
High potential	1260	386
Medium Potential	875	285
Low potential	643	140

Although the extension attempt is to create an atmosphere whereby all farm households obtain similar benefit from the use of improve technologies, it has been noticed that considerable number of them could not adopt and even those who adopt were incomparably grasping different amount of benefits. Such differential opportunities could be regarded as a natural phenomena to exist and persist for which development programs like agricultural extension may not provide a remedy at least in the short run.

5. Conclusions and Policy Implications

In an economy where agricultural sector is the mainstay, the development prospect of that economy is largely governed by growth the agriculture that policy makers need to always pay attention for. With all due respect the, present economic policy of Ethiopia is Agricultural Development-Led Industrialization (ADLI), that is, fast growth in agricultural sector that would enable subsequent industrialization. In attempt to improve the growth of agricultural sector, the policy has also been endeavoring to simultaneously achieve at interhousehold and interregional balanced distribution of benefits (equity issue). For this purpose, a new technology extension system termed PADETES has been launched in the whole parts of the country and attempts have been made to reach each and every farm households since the mid 1990s irrespective of the differences in socio-economic and natural circumstances. The extension system said to be designed in such a way that both the rich and the poor farmers get equal opportunity to participate in the technology diffusion and adoption process.

In fact, agricultural extension should be directed to all social and economic segments of the population. However, how the benefits from such programs are distributed among the various social groups in the process of growth remain always a challenge to economists and policy makers. Therefore, the main argument lies whether growth and equity can be simultaneously achieve or not. Although the direction of technological change on growth is apparent, the direction of its effect on equity depends on the statuesque of the economy, factor endowments and social developments. The purpose of this paper is, therefore, mainly to assess the extent of technology adoption and the type of beneficiaries that imply both growth and equity at household level and agro-ecolical potentials. Data were collected from three ecological potentials, high, medium and low with 150 farmers each totaling 450 sample size. A two stage simple random design and descriptive and econometric tools were employed.

The result revealed that only 35.5% of the total sample farm household adopted the improved technologies of maize transferred by the extension. The extent of adoption and the magnitude of benefits were appreciably different among the different ecological potentials. Of the total sample adopters, the largest proportion was concentrated in the high potential areas(50%) followed by the medium potential (34%) and lastly the low potential (16%). The net return to land and management from the use of the same technology was remarkably different across the ecological potentials. In the high potential areas the average net return to land and management was about 1260 Birr per hectare, in the medium potential was 875 Birr per hectare and in the low potential was only 643 Birr per hectare (by half less than the first). The traditional experience of farm income also had similar pattern. This clearly indicates inequitable benefits even by the adopters of the same technology mainly because of ecological potential difference.

Both the descriptive and the econometric analyses of the characteristics and the determinant of adoption decision support the findings in the literatures. Household characteristics, resource endowment and other socio-economic variables were identified affecting farmers' adoption decision of the recommended maize technologies. Education level of the household head, proximity to the main road, size of land and number of oxen owned, availability of the technological package and credit for down payment significantly affected farmer's adoption decision. Farmers status of resource endowment was the main factor. The adopters (beneficiaries of the extension) were found to be relatively the resource rich farmers. The new technologies introduced to raise agricultural productivity has remained limited in horizon, just as if the extension program was addressed to the rich. It failed to spin off the benefits for the poor. Therefore, it is clearly shown that the rich farmers were the first group to reap the benefit from adopting improved technologies which in turn creates a wider gap of income between the rich and the poor (the likely non-adopters).

Therefore, it could be concluded that the design of extension strategy would not change the adoption pattern of farmers that rest largely on their ecological endowment economic background under the current level of technology. The rich are always the first beneficiaries and the poor may be at the end, if at all they adopt. This is a universal truth as supported by list of literatures unless technologies and an extension approach are exclusively directed towards the poor, which in fact, could be costly to do so. Therefore, an attempt of extension to induce balanced technology adoption between the poor and the rich would imply the substitution of equity for economic growth or efficiency.

In deed, as rightly put by Kuznets (1966) that income inequality worsens at the lower level of growth (adoption can proxy growth), but later once the economy reaches a certain level of economic growth the inequality diminishes with increase in growth. While the devotion of upgrading the living of resource poor in general and ecologically disadvantaged areas in particular is appreciable from the social point of view, it is worthy as well to take in to consideration its opportunity cost in terms of growth. Thus, in formulating development strategies, like this type of extension of technologies, for poor

countries like Ethiopia, planners and policy makers need not give equal focus for growth and equity. It would be more beneficial at least at a macro level to give priority for fostering growth of the economy. Otherwise, the ambition of achieving higher economic growth with balanced income among the households, at the present level of the country's economic status may result in tremendous irreversible social costs.

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