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Adoption and Determinants Adoption of Improved Maize in Ethiopia

Musba Kedir
Ethiopian Institute of Agricultural Research, Assosa Agricultural Research Center,
Assosa, Ethiopia

Abstract: For most of the world's poorest countries and especially, those in Africa, agriculture continues to offer the leading source of employment and to contribute large fractions of national income. In many of these countries, however, agricultural productivity is extremely low. Maize plays a major role in the livelihood and food security of most smallholder farmers in Ethiopia. Maize is grown in most parts of the country with different productivity potentials. From 1970's-2014, 30 OPVs and 42 hybrid maize varieties have been released in Ethiopia. These varieties have different yield potentials and adaptability to different agro ecologies. The popularity of these varieties among farmers depends on how best these varieties fit to the farmers conditions and need. Between 2003/04 and 2007/08, the area for maize under the promoted technologies (fertilizer or seed or both) increased from 0.375-0.94 mln. ha, growing at 1.4% annually. The adoption rate of the new technology increased from 42% in 2009-48.5% in 2012 then fell below 47% in 2016. Relatively, improved maize varieties were more popular among households in the high maize potential areas than in the medium and low potential areas.

Key words: Adoption Ethiopia maize, low potential areas, households, countries, varieties, adoption

INTRODUCTION

For most of the world's poorest countries and especially, those in Africa, agriculture continues to offer the leading source of employment and to contribute large fractions of national income. In many of these countries, however, agricultural productivity is extremely low. Clearly, increasing agricultural productivity is critical to economic growth and development. One important way to increase agricultural productivity is through the introduction of improved agricultural technologies and management systems.

Rapid population growth in Ethiopia remains a major barrier to poverty reduction. The addition of more than 2 mln. persons per year puts tremendous strains on Ethiopia's environment, the economy and the ability to deliver proper services. According to the latest population and housing Census, Ethiopia's population was 73.8 mln. in May 2007. Ethiopian population is still overwhelmingly rural with 16.2% living in towns. Applying the official overall annual population growth rate of 2.585%, total population for mid-year 2012 has been projected by the CSA at 84.3 mln. (FAO/WFP., 2012).

In Ethiopia, agriculture still takes the lion's share (72.7%) in terms of employment (Anonymous, 2015). The sector is the livelihood of the overwhelming majority of Ethiopians. It is the source of food and cash for those who are engaged in the sector and others. Most agricultural holders acquire the food they consume and the cash they need to cover other expenses only from farming activities. Since, farming in Ethiopia is often precarious and usually at the mercy of nature it is invariably an arduous struggle for the holders to make ends meet. This, it often transpires is true to the frequent shortfalls in the volume of production that occur in the country (Anonymous, 2015).

The sound performance of agriculture warrants the availability of food crops. This accomplishment in agriculture does not only signify the adequate acquisition of food crops to attain food security but also heralds a positive aspect of the economy. In regard to this collective efforts are being geared to securing agricultural outputs of the desired level, so that, self-reliance in food supply can be achieved and disaster caused food shortages be contained in the shortest possible time in Ethiopia (Anonymous, 2013).

Agricultural production can be increased through intensification (i.e., through expansion of farm lands) or intensification (i.e. by using more inputs and technologies per unit of land). However, extensification is not a viable strategy to increase agricultural production in most of the food insecure countries where high population pressure is a critical bottleneck. Where land is scarce, intensification which entails investments in modern inputs and technologies is a better option to increase agricultural production and reduce food insecurity. This option was effectively implemented by several Asian countries in 1970's and was dubbed the "green revolution". New agricultural technologies and improved practices play a key role in increasing agricultural production (and hence, improving national food security) in developing countries. Where successful, adoption of improved agricultural technologies could stimulate overall economic growth through inter sectoral linkages while conserving natural resources cited by Tsegaye. Given the close link between food insecurity, farming and environmental degradation the impact of cultivation practices has received significant attention in the last two decades. New cultivation techniques have been introduced in many countries to enhance productivity in the agriculture sector.

The recently adopted 5 years Growth and TransformationPlan(GTP)(2010/11-2014/15) gives special emphasis to the role of agriculture as a major source of economic development. Following the Agricultural Development-Led Industrialization (ADLI) strategy and building on PASDEP achievements, the GTP has the priority to intensify productivity of smallholders and strongly supports the intensification of market-oriented agriculture, either at national or international level and promotes private investments. The plan includes scaling up of best practices to bring average farmer's productivity closer to those of best farmers, expanding irrigation coverage and shifting to production of high value crops to improve income of farmers and pastoralists with complementary investments in market and infrastructure development. Although, the commercialization of smallholder farming is expected to continue to be the major source of agricultural growth, support will also be given to increase private investments in large commercial farms, especially in lowlands. Regarding pastoralists, the GTP gives priority to water and infrastructure development. In particular in areas suitable for irrigation, resettlement of pastoralists on voluntary basis will be considered. Rapid agricultural growth will be ensured also by strengthening extension services and adopting new technologies and best practices that conserve soil and natural resources (FAO/WFP., 2012). Maize is the most widely-grown staple food crop in Sub-Saharan Africa (SSA) occupying more than 33 mln. ha each year. The crop covers nearly 17% of the estimated 200 mln. ha cultivated land in SSA and is produced in diverse production environments and consumed by people with varying food preferences and socio-economic backgrounds. More than 300 mln. People in SSA depend on maize as source of food and livelihood (Parvan, 2011). Like in many other Sub-Sahara African countries, maize plays a major role in the livelihood and food security of most smallholder farmers in Ethiopia. Maize is grown in most parts of the country with different productivity potentials. For many years, maize in Ethiopia has been the first in production and second (next to teff) in area of cropped land (Legese *et al*., 2011). Data from Anonymous (2010) shows that during the 2009/10 production year, Ethiopia produced 3.89 mln. tons of maize on 1.77 mln. ha of land. This gives an average productivity of 2.2 tons/ha which is the highest of all cereal crops produced in the same year.

Objectives of the review: The general objective of the review is to review adoption and factors affecting adoption of improved maize in Ethiopia. Specific objectives include:

- To review the adoption of improved maize in Ethiopia
- To review the most important factors determining adoption of improved maize in Ethiopia

MATERIALS AND METHODS

Concepts in adoption of improved varieties

Why study adoption?: There is no more distinctive feature of agriculture than its dynamism. Farming practices change continually. Farmers build on their own experience and that of their neighbors to refine the way they manage their crops. Changes in natural conditions, resource availability and market development also present challenges and opportunities to which farmers respond. In addition, farmers learn about new technologies from various organizations, programs and projects dedicated to research, extension or rural development. These organizations develop and promote new varieties, inputs and management practices. It is essential that such organizations be able to follow the results of their efforts and understand how the technologies they promote fit into the complex pattern of agricultural change in which all farmers participate.

There are several reasons to invest in studying the adoption of agricultural technology. These include improving the efficiency of technology generation, assessing the effectiveness of technology transfer, understanding the role of policy in the adoption of new technology and demonstrating the impact of investing in technology generation.

Measuring the impact of technology generation and transfer: Another important use of the information from adoption studies is to assess the impact of agricultural research and extension and to measure the returns to investments in these activities. Research and extension institutions are often engaged in a battle to maintain their budgets and this implies the necessity for demonstrating results. Adoption studies are an important tool for measuring and assessing impact. They also provide data that can be used to estimate the returns to investment in research or extension. Such an analysis may be used to justify further investment in these sectors or to help identify the most productive opportunities for investment within research or extension. An important question on the minds of policymakers is who benefits from new technology. Adoption studies may be designed to document what kinds of farmers and what areas of the country have profited most from the development of a particular technology.

Defining adoption: One of the most important issues in designing an adoption study is the definition of criteria for adoption. If we are interested in the diffusion of a new variety, for instance what constitutes adoption? Are farmers who plant even a few rows of the new variety considered adopters or do they have to plant a certain minimum proportion of their fields with the new variety? If we are interested in the adoption of crop management practices how closely does the farmer have to follow a recommendation before being considered an adopter? Is any fertilizer use to be counted as adoption for instance or does the rate and timing of application have to fall within certain limits?

In defining the criteria for adoption it is also important to remember that although recommendations may be presented to farmers as a package of several practices, some components of the package may be adopted first, others may be adopted later and some may never find widespread acceptance. The adoption study should therefore ask specifically about each component of the package, bearing in mind that individual components may be adopted at different times or under different conditions.

Generally, the adoption of a new technology can be defined in several ways. In all cases, the definition of "adoption" needs to be agreed upon. Sometimes it may be sufficient simply to report on the proportion of farmers using the technology (at some defined level). In other cases, the actual proportion of fields or crop area under the new technology will need to be estimated.

Describing adoption the logistic curve: It is useful to distinguish between adoption which is measured at one point in time and diffusion which is the spread of a new technology across a population over time. Much of the literature on diffusion assumes that the cumulative proportion of adoption follows an S-shaped curve in which there is slow initial growth in the use of the new technology followed by a more rapid increase and then a

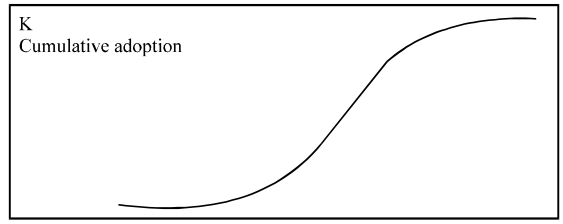

Fig. 1: Logistic regression

slowing down as the cumulative proportion of adoption approaches its maximum (which may be well below 100% of the farmers).

The most common function used to portray the curve is the logistic function. For technology adoption, the y-axis represents the proportion of farmers or area adopting a technology and the x-axis represents time (Fig. 1). This curve can be described mathematically:

$$Y_t = K / e(-a-b_t)$$

Where:

- Y_t = The cumulative percentage of adopters or area at a time t
- K = The upper bound of adoption
- B = A constant, related to the rate of adoption
- A = A constant, related to the time when adoption begins

Evidence on technology adoption and input use in maize production: The adoption of the promoted technology package in maize is measured as the area under maize production using chemical fertilizer or improved seed or both. Between 2003/04 and 2007/08, the area for maize under the promoted technologies (fertilizer or seed or both) increased from 0.375-0.94 mln. ha, growing at 1.4% annually. The adoption rate of the new technology increased from 42% in 2006-48.5% in 2011 then fell below 47% in 2012 (Table 1).

Knowledge of improved maize variety: From 1970's-2014, 30 OPVs and 42 hybrid maize varieties have been released in Ethiopia. These varieties have different yield potentials and adaptability to different agro ecologies. The popularity of these varieties among farmers depends on how best these varieties fit to the farmers conditions and need. Households also vary in their level of gathering information on new maize varieties. The survey data shows that 10% of the sample households could not name a single improved maize variety. On the other side, there are farmers who mentioned names of ten improved maize varieties they knew. Farmers know on average, two

Table 1: Area, production and yields of maize using modern inputs or traditional technology

Crop and technology	Total area (000 ha) 2009	2012	2014	2016	Share in crop area (%) 2009	2012	2014	2016	Growth Rate (%)
Fertilizer and improved seed	197.2	158.1	188.9	192.2	23.4	17.7	17.7	21.6	-0.6
Fertilizer and local seed	99.5	124.6	211.2	146.3	11.8	13.9	19.7	16.4	10.1
No fertilizer and improved seed	10.7	9.5	9.9	5	1.3	1.1	0.9	0.6	-17.3
No fertilizer and local seed	536.1	601.6	660.1	547.9	63.6	67.3	61.7	61.5	0.5
Total	843.5	893.8	1070.1	891.4	100.1	100	100	100.1	1.4

Ethiopia Strategy Support Program II (ESSP II)

improved maize varieties. Overall, farmers knew the names of more hybrids than of OPVs. Since, the number of improved maize varieties known to farmers is a count data, they used Poisson model in examining its determinants Tura *et al*. (2010).

According to Tura *et al*. (2010). There is a clear difference in knowledge and adoption between hybrids and OPVs by Ethiopian smallholder farmers. Only 17% of the respondents knew improved OPV maize while 85% know at least one improved hybrid maize variety. The maximum number of improved verities a farmer could mention was 4 for OPVs and 8 for hybrids. Relatively, improved maize varieties were more popular among households in the high maize potential areas than in the medium and low potential areas. 9.7% of the sample households could not able to list a single improved maize variety they are aware of (be it hybrid or OPV). Overall, hybrid maize varieties are more popular than OPVs.

From the survey, 17 hybrid and 16 OPVs were identified as most popular maize varieties. From the hybrid maize, BH-660 is the most known IMV in all the three maize potential categories. Overall, 47% of the sample households reported their familiarity with BH-660. In addition, BH-540, BH-140, Tabor (30H83) and Shone (30G19) were also known hybrid maize varieties. In high potential areas were hybrid varieties perform well, farmers knew more hybrid maize varieties. OPV maize varieties are better known in low potential areas. Awassa-511 is the most well-known OPV and reported by 19% of the sample households from low maize potential areas. Next to Awassa-511, Katumani, Fetene, Gibe-1, Melkassa-1 and Melkassa-2 are also popular varieties from the OPV maize (Kessa *et al*., 2013).

Factors affecting adoption of improved maize: The importance of maize in the country's agricultural economy and household level food security calls for increasing its production and productivity through use of modern technologies. However, smallholder farmer's knowledge and use of agricultural technologies in general and improved maize varieties in particular are limited due to various factors that are either internal or external to the farmer's circumstances. Most commonly studied internal factors that affect adoption and use of agricultural technologies are farmer's attitude towards risk (Feder *et al*., 1985), household characteristics that affects the level of production and consumption, resource endowments, etc. External factors could be access to technologies in particular through a well-developed seed system (Shiferaw *et al*., 2008; Asfaw *et al*., 2011) infrastructure, institutions (Beke, 2010).

RESULTS AND DISCUSSION

Empirical studies on factors determining adoption of improved maize in Ethiopia: Motuma *et al*., used bivariate probit model on the study "Adoption and continued use of improved maize seeds: Case study of Central Ethiopia." analyzes the factors that explain adoption as well as continued use of improved maize seeds in one of the high potential maize growing areas in central Ethiopia. Using a bivariate probit with sample selection model approach, the study provides insights into the key factors associated with adoption of improved maize seed and its continued use. The result revealed that human capital (adult workers, off-farm work and experience in hiring labor), asset endowment (size of land owned), institutional and policy variables (access to credit, membership in cooperatives) all strongly influence farmer's decisions to adopt improved maize varieties.

Descriptive study of Motuma ***et al.*** showed that only 7.5% of the sample households have never grown improved maize varieties. About 63% of the sample households have been using the improved seeds since, they first adopted them whereas the remaining 37% have disadopted the improved seeds. Accordingly, adoption rate of maize seed in the study area is more than 92% while discontinuance is about 37%.

Those households which discontinued using the improved seeds were asked to state the reasons why they could not continue using the improved maize seed. Most farmers (61.5%) identified high price of seed and fertilizer as reasons for discontinuance, mainly due to lack of financial resources. Since, prices of seed and fertilizer are the major components of cost of production, a rise in input cost may render farm activities unprofitable.

According to Tura ***et al.*** (2010) smallholder farmers have heterogeneous characteristics and differ from one another in their operation and level of improved maize variety knowledge. Poisson estimation results on the number of improved maize varieties known by households show that, on average, male, younger and educated household heads know a larger number of improved maize varieties than their counterparts. The same works for the number of hybrid maize known by farmers. The number of known varieties increases with the number of social networks household members is involved in. Variety information and opportunities to get acquainted to different improved maize could be enhanced through interactions and discussions in both formal and informal social networks. Households with more number of oxen for plowing know more number of hybrid maize. The number of improved maize variety farmers know increases with increasing maize potential, i.e., compared to farmers in low maize potential districts, farmers in high and medium potential maize districts know more number of hybrid maize varieties. However, compared to the low potential areas, the number of OPV maize varieties that farmers know decreases in high and medium potential areas. This is due to the fact that most OPVs are drought tolerant or early maturing varieties that could escape late drought spells and best fit in low potential districts.

Yenealem *et al*. used logistic regression in the study determinants of adoption of improved maize varieties for male headed and female headed households in West Harerghe zone, Ethiopia. The logistic regression model analysis result indicates that cultivated farm size exerted positive influence ($p<0.05$) on the adoption of improved maize varieties for MHH. If farm size can be increased by unitary value, the odds in favor of adopting improved maize varieties would increase by a factor of 5.078 for MHH. This result implies that MHH with large farm size are more likely to adopt improved maize varieties than those FHH who have small land size. But, the separate logit model built for FHH has shown that there is no significant influence on adoption decision of FHH. In fact in the study area, FHH have significantly less area of cultivated land compared to male-headed households ($t = -5.671$, $p = 0.001$).

The model result also indicated that number of Tropical Livestock Units (TLUs) affects positively and significantly the probability of adopting improved maize varieties at ($p<0.01$) and ($p<0.05$) for MHH and FHH, respectively. This result shows that those farmers with large number of tropical livestock units are more likely to adopt improved maize varieties than those who own small number of TLU. Cattle can be a source of income that can be used to buy improved maize variety. It enhances the shock absorbing capacity of the households in case of crop failure. The result hints that on increase in TLU by one unit would mean that, the odds in favour of adopting improved maize varieties could increase by a factor of 2.415 and 5.448 for MHH and FHH, respectively. In addition, female-headed households are less likely to own livestock but those female-headed households with relatively more land size have more number of livestock.

Extension contact had also a positive and significant influence on the probability of adoption of improved maize varieties at <1 and 10% significant level for MHH and FHH, respectively. The result indicates that, women and men are faced by differential access to new technologies. However, farmers who had extension visit have higher probabilities towards adoption than those with less exposure. The odds in favour of adopting improved maize varieties increased by a factor of 22 and 55.076 for MHH and FHH, respectively that had access to extension services. However, in the study area, MHH received more visits by extension agents compared to FHH.

Age has negative and significant influence ($p<0.01$) on the probability of adoption for MHH. The negative association suggests that the likelihood of adopting improved maize varieties declines as the age of the improved maize variety decreases by a factor of 0.903 as the age of the household head increases by 1year for MHH. The possible explanation for this result is that FHH do not benefit much from extension services.

Distance to the nearest input market is also another factor which has a negative and significant influence on the probability of adoption of improved maize varieties at <5% significant level for MHH. The negative association suggests that the likelihood of adopting improved maize varieties declines as the distance from market center increases. In other words, if the distance between MHH's homestead and the market area is longer, the farmers will be discouraged from adopting improved maize varieties. The result mirrored that odds in favor of adopting improved maize variety decreases by a factor of 0.564 as the market distance increases by 1 km. This finding agrees with a priori expectation in that farmers who live far away from market place have limited access to input market and tend to be reluctant to take up new technologies as compared to those farmers who live near to input market places. However, it is found that there is negative but insignificant influence on adoption decision of FHH because as stated earlier FHH benefit less from these extension services, regardless of distance to input markets.

The main explanation of access to improved seed is the possibility of reducing the fixed knowledge cost related to adoption of the new technology. Among the variables related to this fixed cost, the large and positive coefficient of access to extension services highlights the important role that extension services play in the adoption of improved seed. A second major variable explaining access to improved seed is the share of crop land under improved seed in the district where the household is located which as with fertilizer, suggests a peer effect and better access to knowledge about the new technology. Among holder's characteristics, education and gender rather than age as with fertilizer are the variables with the greatest effect on access to the new technology.

Gecho and Punjabi (2011) on his study, determinants of adoption of improved maize technology in Damot Gale, Wolaita, Ethiopia, A logit model was fit to estimate the effects of the hypothesized explanatory variables on the probabilities of adoption. Among the 19 variables used in the model, 11 variables were significant with respect to adoption of improved maize varieties with less than 10% of the probability level. These variables include farm size, oxen ownership, tropical livestock, cash availability, access to credit, distance to market, radio ownership, input price, farm experience and availability of fertilizer on time and attending on demonstration.

The study has revealed the key roles of livestock in crop production. Farmers with large number of livestock are more likely to adopt and use improved technologies such as maize. Therefore, efforts to promote crop production in a mixed farming system requires a concerted efforts to the livestock sector, through for instance improved veterinary service, credit for livestock purchase, feed and water development as deemed necessary.

The study also revealed that technological change among smallholders requires an external financial source through credit. Farmers who have access to credit tend to adopt improved maize technology more than those who do not have access to credit. In spite of four decades of exposure to improved technologies in the study area, response to extension communication through various methods is still effective in the area.

It was found that farm size significantly affects improved maize adoption. The result shows that the new maize technology is more likely to be adopted by farmers with large farms. This implies need of research, extension and planning agencies to be sensitive to the needs of smaller farmers through developing and disseminating technologies and strategies that are relevant to their needs.

According to Awake (2013) used tobit model on his study "Determinants of Adoption of Improved Maize Technology in Damot Gale, Wolaita, Ethiopia." Found that improved maize seed practice in this study area shows variation among the grower households in the level of adoption or use of these practices. On the other hand for various reasons farmer's practices were found to deviate from the rate recommended by the research. As mentioned by sample respondents the reasons for deviation ranges from the financial capacity of farmers to other household, technological and institutional related factors.

Variation in adoption among the sample households was assessed in view of various factors theoretically known to influence farmers "adoption behavior of new technologies. These variables were categorized as household personal and demographic, socio-economic, institutional and psychological factors. Result of descriptive statistics using t-test, Chi-square and bivariate correlation tests indicated that from 15 explanatory variables that hypothesized to influence farmers" adoption of improved maize 12 of them were significantly related with adoption of improved maize varieties. From personal and demographic factors education, labour availability and maize farming experience were the significant factors that influence the adoption of improved maize varieties significantly. From household's economic and wealth related variables which were hypothesized to influence improved maize production were size of own cultivate land, livestock owner ship, off-farm employment, farm income and income from chat were found to be positively and significantly related with adoption of improved maize. Concerning institutional variables, participation in cooperatives, contact with extension agent, access to and use of credit were found to have positive and significant relationship with adoption and intensity of adoption of improved maize varieties.

Moreover, among socio-psychological factors cosmopolitan (frequency of visiting nearby town) household head were found to be positively and significantly related with adoption of improved maize. Since, adoption practices as it involves use of different package practices such as seeding rate, fertilizer rate, chemical application rate and spacing. Farmers need to get information and close advices on technical use of the recommended practices. Other institutional supports such as farmers participation in cooperatives and provision of credit services were also found to be very crucial to enhance adoption of improved maize production. On the other hand, results of the econometric model indicated the relative influence of different variables on adoption of improved maize production. A total of 14 significant explanatory variables were included in the model of which seven of them had shown significant relationship with adoption of improved maize production. Accordingly, size of own cultivated land, education status of the house hold, off-farm employment, participation in cooperatives, access to credit, contact with extension agent and income from chat were found to have positive and significant influence on adoption of improved maize production.

CONCLUSION

For most of the world's poorest countries and especially, those in Africa, agriculture continues to offer the leading source of employment and to contribute large fractions of national income. In many of these countries, however, agricultural productivity is extremely low. In Ethiopia, agriculture still takes the lion's share (72.7%) in terms of employment. The sector is the livelihood of the overwhelming majority of Ethiopians. It is the source of food and cash for those who are engaged in the sector and others.

There are several reasons to invest in studying the adoption of agricultural technology. These include improving the efficiency of technology generation, assessing the effectiveness of technology transfer, understanding the role of policy in the adoption of new technology and demonstrating the impact of investing in technology generation. The adoption of a new technology can be defined in several ways. In all cases, the definition of "adoption" needs to be agreed upon. Sometimes it may be sufficient simply to report on the proportion of farmers using the technology. In other cases, the actual proportion of fields or crop area under the new technology will need to be estimated.

Maize plays a major role in the livelihood and food security of most smallholder farmers in Ethiopia. Maize is grown in most parts of the country with different productivity potentials. For many years, maize in Ethiopia has been the first in production and second (next to teff) in area of cropped land.

The adoption of the promoted technology package in maize is measured as the area under maize production using chemical fertilizer or improved seed or both. Between 2003/04 and 2007/08, the area for maize under the promoted technologies (fertilizer or seed or both) increased from 0.375-0.94 mln. ha, growing at 1.4% annually. The adoption rate of the new technology increased from 42% in 2006-48.5% in 2011 then fell below 47% in 2012.

Relatively, improved maize varieties were more popular among households in the high maize potential areas than in the medium and low potential areas. Hybrid maize varieties like BH-660 are more popular than OPVs. OPV maize varieties are better known in low potential areas. Awassa-511 is the most well-known OPV variety in low maize potential areas.

Most commonly studied internal factors that affect adoption and use of agricultural technologies are farmer's attitude towards risk household characteristics that affects the level of production and consumption, resource endowments, etc. External factors could be access to technologies in particular through a well-developed seed system infrastructure, institutions.

Different researchers conducted research on factors determining adoption of improved maize in different parts of Ethiopia. Among them, Motuma *et al*., Tura *et al*. (2010), Gecho and Punjabi (2011) and Aweke (2013) are few of them.

They used logistic or probit regression analysis in their study and most of them found that human capital, farming experience, farm size, credit service oxen ownership, TLU, Extension contact, age of household head, distance to nearest market and access to improved seed have significant effect on adoption of improved maize in their respective study areas.

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