

**Review Article**

Agricultural Mechanization: Assessment of Mechanization Impact Experiences on the Rural Population and the Implications for Ethiopian Smallholders

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Abstract: Ethiopia is currently at its GTP II program implementation years. In these years, the country is expected to undergo transformation of its economy. The rural Ethiopia is expected to transform itself in many ways including but not limited to demography, farm power, intensification, employment reduction, diversification of livelihoods and most importantly increased productivity. In this aspect, the contribution of appropriate agricultural mechanization cannot be relegated given the research and actual evidences from within and other developing countries. Hence, utilization of appropriate agricultural mechanization is expected to enhance the transformation of rural Ethiopia and lead to a middle income country by 2025. Therefore, this review of literature was undertaken to bring to light the various opportunities of appropriate agricultural mechanization as an input for transformation. It tries to link the different effects of mechanization under a developing economy. Mechanization once implemented with great ambition and ultimate failure has resulted in unfitness to the Ethiopian condition. In addition to land holding and other institutional issues, demography resulted in the idea and conclusion by most Ethiopians that mechanization will not work in Ethiopia at all. The great deviation in assuming the contribution of mechanization to the development process as a whole is intensified by the poor perception of people about it. Most people declare mechanization only refers to tractor and combine harvester. However, mechanization includes the different small and medium agricultural implements used in the production, processing and transporting of agricultural produces. Generally Indian experience shows that mechanization has a positive overall effect on the development of rural areas. With certain opportunity costs especially little displacement of human labor, mechanization having a response coefficient of 0.45 bears an important part of the agricultural production system. However, owing to the land conditions of Ethiopian smallholder what is most important is selective use of mechanization technologies that could increase the technical efficiency of the smallholder through increasing the labor and land productivity. So from the review it is possible to conclude that mechanization of agriculture bears undisputed truth for improving food security, creating employment opportunities, increasing productivity, reducing loss and promoting economic gender empowerment while maintaining environmental degradation to lower levels.

Keywords: Developing Economy, Empowerment, Employment, Environment, Mechanization, Productivity, Rural Ethiopia, Transformation

1. Introductions

One of the major problems of Ethiopia for the last four decades is the inability of its agricultural population to produce enough to feed the population and/ or the inability of

its other sectors to grow and derive income for the majority to access food from any where else. This problem has proportionally aggravated till now with number of food insecure population increasing in size and the proportion maintained at around 20%. Population increase in the high

land areas forced the inclusion of more and more marginal lands for agriculture [1]. However, the increased production from these lands has not been significant that food shortage has become ordinary in the country. As a result one of the major challenges to rural development in the country is how to promote food production to meet the ever increasing demand of the growing population. It becomes very much relevant given the conditions prevailing of high population growth, low labor productivity, recurrent drought and similar dreadful situations the country has been experiencing.

Several methodologies have been devised and applied including the use of improved varieties of crops for improving food production in the country. However, the situation is still dire to a significant part of the population and the whole of the population in general dependent on subsistence oriented farming system. Generally, methods of increasing production are farm area expansion, use of external inputs, use of improved seeds, better seed bed preparation and use of other improved farm implements (for increasing farming area or improving technical efficiency). In the Ethiopian context, except in the low land areas expansion of farm lands is over due to obvious reasons of slope and marginality. Though use of improved varieties is going it is solely use and this requires harmony with improving the technical capacity of farmers. The government has devised a policy that centers the development of rural areas and transfers to industrialization and urbanization. This is due to reasons of resource availability in agriculture and insignificant industrial base of the country. The policy has formulated several strategies to achieve the development agenda. The strategy stresses on commercialization and intensification through use of other external inputs as a means to ensure food security locally as a means to combat the problem. Up until now, the problem has continued with scanty success stories. Several scholars pointed out that the problem of low production could largely be related to low technical efficiency. This is due to the time old implements and operation systems that are being used in using new crop technologies also.

The problem of Ethiopian agriculture cannot be primarily explained by natural endowments [2]. By any measure, Ethiopia is well endowed at least in part with a fertile soil, abundant water resources and good climatic conditions until recently. What needs careful analysis is why Ethiopian farmers continue to practice essentially the same farming methods with very little technical or management improvement for so long. The low productivity level of Ethiopian farmers even compared to African standards could largely be traced to low technical efficiency along with the decrease in fertility of soil. Recently for example, a preliminary research result by Melkasa research centered proved that traditional 'Mofer' attached Moald Board Plow has helped increase productivity of haricot bean on average by 23% compared to seed bed prepared using local 'Maresha' alone. In line BBM has been useful in increasing productivity at vertisols. The methods of improving technical efficiency are through improving the management activities. This could largely be achieved through utilization of appropriate

agricultural implements. However, the government and smallholders including other stakeholders has given little attention to use of agricultural implements (mechanization technologies). Lack of interest for mechanization is largely blamed for land conditions like fragmentation and small size. However, search for and utilization of appropriate mechanization technologies should be part of the strategy for increasing production and productivity. In this aspect recently the government has drafted a national mechanization strategy. The aim of the strategy is to 'increase national food production and security through enhanced and sustainable use of agricultural mechanization technologies in order to support Ethiopia's middle-income status by 2025'. Hence experiences should be re-reviewed and mechanization like the other technologies and inputs of agriculture should be promoted at a highest priority levels. The rationale is due to several reasons accompanying increased productivity and as a means to create alternative livelihoods for the majority of the population.

Statement of the problem

Despite the fact that smallholders exert optimum efforts to increase productivity of crops, the improvement seen is insignificant in relation to the plowed crop land, trend of population growth and input use. In all parts of the country, the problem of food deficit is not solved. Increasing the technical efficiency, way of increasing productivity by appropriate management, could help in the way forward. More over, introduction of medium or low level mechanization implements and technologies enables lighten burden of women who contribute most of the labor for agricultural production in Ethiopia. It is because it releases labor to be used for other on, off and non-farm activities, which are the strategies to increase resilience and productivity in the smallholder context in general. The current Ethiopian development policy stresses on development push from agriculture to industry based on use of all means's of increasing productivity and production. Hence it adheres to growth and development primarily from agriculture. One of the means's of development of agriculture is intensification of labor. Labor intensive refers both to employment of all available working labor and maximizing its output. In agriculture this can be done through use of management intensive operations and increasing the working labors productivity through mechanization. Mechanization is a multi-dimensional concept and includes social, economical bases, technical and agricultural engineering, agricultural machinery engineering, programming and more importantly management [3]. Farm mechanization has been helpful to bring about a significant improvement in agricultural productivity. Thus, there is strong need for mechanization of agricultural operations. Even thou mechanization is part of the Ethiopian research and extension system, it is sufficient to witness its recognition by the government and other stakeholders only by taking the representation of one research centre in Amhara region where more than 33% of the country's agricultural production takes place and the insignificant attention given at the low administration and agricultural bureaus except in campaign like activities. The

factors that justify the strengthening of farm mechanization in the country can be numerous. The timeliness of operations has assumed greater significance in obtaining optimal yields from different crops that has been possible by way of mechanization. Extremely scanty information about local experience affected for full exploitation of the learning experience. Thus the objectives of this assessment are to review the experiences of countries with smallholder farming system and scientific studies done to extrapolate to Ethiopia and to enable people look alternative ways of agricultural development strategies. This review is directed to provide information for decision makers, researchers and extension workers so that to encourage them invest optimum efforts for wider promotion of mechanization technologies and create overall awareness about favorable environments for rapid adoption of mechanization technologies.

Transformation of economy: refers to change of a nation's economy to a more resilient, advanced, managed system where environmental variables are becoming more controlled or

otherwise compensated for by engaging in production of economically comparative or absolute advantages. Academicians and politicians set various indicators of economic transformation of a country based on current status and desired ambitions. Hence, transformation in this context is defined as conceived in the GTP (2011- 2020) plan of Ethiopia.

Rural transformation: GTP II has placed several objectives to achieve transformation of rural areas focusing on major livelihoods. The transformations include improved infrastructure, increased productivity, diversified employment opportunities, managed ecosystem, conserved biodiversity and low pollution through green agriculture. Hence the above dimensions of rural transformation to achieve the objective of becoming a middle income country by 2025 can be achieved in several ways. Utilization of a basket of choices accessible and compatible to local communities is crucial. Amongst, use of appropriate mechanization is one standing tall to fulfill part of this ambition.

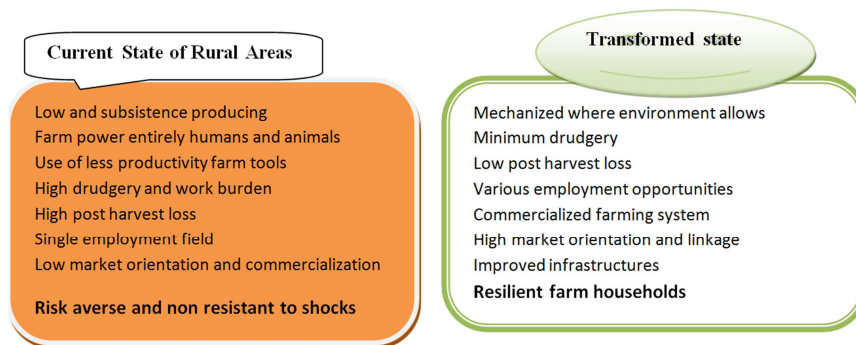


Fig. 1. Rural areas transformation indicators.

Farm Mechanization defined: Agricultural mechanization embraces the use of tools, implements and machines for agricultural land development, crop production, harvesting, preparation for storage, storage, and on-farm processing [4]. Others defined mechanization as application of suitable machines, recognition of technologies and applying suitable methods for production, processing of agricultural products, continuous increase of productivity as the result of the reducing the cost of production, reduction of the losses and increase of efficiency and increase of income [3]. Generally both refer to better farm power input to agriculture. Farm power consists of manual labor, agricultural tools, draught animals, tractors, implements, equipment, and machinery as an essential farm input. In almost any agricultural production system the annual expenditure on farm power, whether on labor, draft animals, or fuel and depreciation of machines, largely exceeds the costs of other inputs such as agro-chemicals and seeds. In many developing countries, agricultural production and food security are adversely affected because of insufficient use of farm power, low labor productivity and/or labor scarcity [4]. The need to improve agricultural labor productivity is increasingly recognized. In the case such as pump sets for irrigation, the need for machinery is undisputed. Rather than agricultural mechanization, it would be preferable to use the term farm

power or labor productivity enhancing technology, to recognize not only the importance of manual labor and hand tools, draft animals, and mechanical power, but also other issues related to labor scarcity, such as cropping and farming systems [4].

The term mechanization is unfortunately often very narrowly perceived while its real purpose, namely, enhancing productivity of land and labor is often not well understood. In fact an agricultural mechanization strategy ought to be part of an agricultural technology or development strategy. In this context, three principal purposes of mechanization may be summarized [4]. The first is increase in labor productivity. The introduction of machinery to substitute for labor ("labor saving") is a common phenomenon associated with the release of labor for employment in other sectors of the economy or to facilitate cultivation of a larger area with the same labor force. The other principal purpose is increase in land productivity enabling production of more output from the existing land. Machinery is a complementary input, required to achieve higher land productivity, for example, through the introduction of pump sets, or faster turn-around-times to achieve higher cropping intensity. However, in labor surplus economies, net labor displacement or replacement should be avoided. The third purpose is decreasing the cost of production. Introduction of a machine may lower production costs or offset increased

costs of draft animals or labor. This goes with the objectives of GTP II strategy that promotes the use of labor-intensive methods to increase output and productivity. Generally, improved farm implements and machinery are used for different farm operations to increase productivity of land and labor through timeliness of operations, efficient use of inputs, improvement in quality of produce, safety and comfort of farmers and reduction in loss of produce and drudgery of farmers. As a result, mechanization fostering intensive cultivations on farms gives more food to the excluded group (i.e. landless farmers and agricultural labors with reduced drudgery). Thus, farm mechanization is a boon for the farmers and agricultural labors [5].

Africa needs to achieve a sustainable and structural transformation of its agriculture and rural economy (i.e. a process that involves a move from highly diversified subsistence modes of production towards more market orientated production systems). This integration will be facilitated by greater specialization, exchange and by the harnessing of economies of scale. Over the long term, resources and employment are to be transferred from agriculture and other sectors producing primary goods to higher productivity [6]. As opposed to this, developing countries like Ethiopia have been relegating the benefits of mechanization thinking that the costs are high. The major reason in promoting agricultural mechanization is fear of labor displacement. An experience of other countries provides a great help in devising development alternatives through mechanization. The best example could be Indian experience. India, without counting the current technological advancement in the urban areas, provides similar agricultural system with Ethiopia. According to Verma, Indian agriculture is characterized by overwhelmingly small holdings due to higher population density and nearly two-third of its population residing in the rural areas coupled with unabated land fragmentation due to the inheritance laws of the country. Nearly 62 per cent of the estimated 142 m ha area is rain fed. The principal outcomes and effects of mechanization are discussed below.

2. Benefits of Agricultural Mechanization

2.1. Agricultural Production and Productivity

The factors that justify the strengthening of farm mechanization can be numerous. The timeliness of operations has assumed greater significance in obtaining optimal yields from different crops, which has been possible by way of mechanization. For instance, the sowing of wheat in Punjab is done up to the first fortnight of November. A delay beyond this period by every one week leads to about 1.50 quintals per acre decrease in the yield [7]. However mechanization facilitates timely sowing and thus avoids loss that could be incurred. Farm mechanization is regarded as *sine-quanon* to reduce the human drudgery and enhance the agricultural productivity [8]. During the post-green revolution period of India, the impact of farm

mechanization on agricultural production and productivity has been well recognized. Post harvest grain loss of 6% in harvesting and threshing with traditional methods, and 2-4% with combines. The linear regression function to examine the effect of important inputs on crop productivity for the State of Punjab showed high for mechanization. Standardized regression coefficients were calculated for relative efficiency of different inputs. The elasticity of productivity for fertilizer, irrigation and farm power was reported to be significant in the production function. Relative efficiency of farm power was higher followed by fertilizer and irrigation. The coefficient for relative efficiency and standardized regression coefficient for fertilizer, irrigation and farm power was reported to be 0.23, 0.35 and 0.45, respectively. The effect of farm power, however, showed decreasing effect beyond 3.24 kW/ha.

Tractorization resulted in a positive correlation for area sown with variables such as percent of double cropped area, percentage area irrigated, percentage area under high-yielding varieties, percentage area of holding with more than twenty hectares, wages of agricultural labor and annual growth rate of agricultural output. However, there was negative correlation of tractors with agricultural labor and working animals per 100 acres of net area sown. It was observed that tractorization was significantly associated with higher level of high-yielding varieties and HYV's were positively correlated with irrigation. Thus the interaction between tractors, high-yielding varieties and irrigation had led to the observed association between tractors and rate of growth of agricultural output [8]. The quality and precision of the operations are equally significant for realizing higher yields. The various operations such as land leveling, irrigation, sowing and planting, use of fertilizers, plant protection, harvesting and threshing need a high degree of precision to increase the efficiency of the inputs and reduce the losses [7]. In sum higher productivity of land and labor is the factor that clearly justifies use of farm mechanization. A study in Ethiopia, According to field experiments conducted by agronomists over two seasons, a row planter (a simple animal drawn semi automatic row planter was developed at AIRIC) gave 30% more grain yield compared to manual placement of two seeds. The study also revealed as farmers reporting a 20 to 100% increase in yield by using moldboard plow, low level mechanization as it uses the traditional implement system [9].

2.2. Cropping Intensity

Agricultural mechanization has made significant contribution in enhancing cropping intensity. A study in India (on 162 farming households) concluded that the cropping intensity showed consistently positive relationship with tractorization. Within the given size groups, tractor-owning farms had higher cropping intensity as compared to tractor-using or animal operated farms. The time taken to perform sequence of operations is a factor determining the cropping intensity to ensure timeliness of various operations [7].

2.3. Employment of Human Labor

The problem of unemployment stems in part from the dominance of South Asia in the mechanization literature, but also from the low total number of hours in agricultural activities reported in many studies for Africa [6]. Almost certainly there is available labor that can and will respond to adequate incentives, as reflected yearly when family members and communities mobilize in order to meet peak season requirements. It is well known that the livelihood strategies of most African rural households are well diversified. In many areas, arable farming provides half or less of household incomes and in some, substantially less. Even in areas that are heavily reliant on crop farming, significant amounts of income are derived from beer-making, transport, small trading, brick-making and other activities, as well as wage employment and remittances. There are, in brief, many competing demands from other activities. Most of these other activities have low real wage rates, but unfortunately, returns to labor in agriculture are often even lower, except in peak periods when labor flows from other activities to agricultural ones. Displaced labor may be absorbed in the other alternatives created by the increased mechanization such as manufacturing, repair and service shops and the sale services. Thus, it only results in the shifting of the labor from one vocation to the other [7]. The impact of farm mechanization on labor employment, particularly in a labor surplus country like India, has been a matter of concern and debate. The available evidences suggest that mechanization had helped in overall increase in employment of human labor. A study [10] had showed that both tractor as well as non-tractor farms had on an average 8.2 persons per farm and the labor force at their disposal was neither surplus nor inadequate. GIPE [11] concluded that tractorization generated greater demand for labor by facilitating more intensive cultivation. Thus, there was no significant displacement of human labor after tractorization. Mechanization accompanied by use of new seed technology and adoption of modern cultivation methods had a beneficial effect on employment [12]. Kahlon [13] reported that reduction in aggregate labor use on tractor-operated farms owning tube wells was only 1.3% as compared to bullock. The Indian Committee called Bhagwati on Unemployment concluded that mechanization of agricultural operations, by and large, displaced bullock labor and not human labor [8]. In another study [14] increased use of tractors was associated with marked rise in employment due to their effect on cropping intensity. AERC [15] concluded that the use of tractors had, in most cases, displaced only one pair of bullocks. The overall human labor input for crop production per cultivated hectare was practically the same for both types of farms. The study reported that the technological displacement of labor associated with tractor use was compensated by the employment of labor owing to increased yield as a result of tractor use among farms characterized by partial tractorization. The net employment effect of tractor use turned out to be positive when its complementarity with

other techniques was taken into account. Tractors replaced mainly family labor time on small farms and permanent labor time on large ones. Use of threshers displaced mainly family and casual labor time on small farms and family and permanent labor time on large ones. The combined effect of family labor time was increased in the use of permanent and casual labor time on farms of most size groups [16]. With the addition of power threshers, these effects were lessened.

Patil and Sirohi [17] studied the employment per hectare of cropped area. The total labor employment was the highest on small farms and decreased as the farm size increased in respect of all categories of farms. The overall human labor employment was the highest for tractor operated farms followed by tractor plus bullock operated farms. The ratio of family labor to total labor employed per hectare decreased with an increase in farm size. On an average, the per hectare employment of hired labor and total labor was higher by 39 per cent and 24 per cent on tractor operated farms and by 43 per cent and 22 per cent on tractor plus bullock operated farms respectively than that of bullock operated farms. The higher percentage of hired labor employment with the increase in farm size, in general, and of tractor-owning farms in particular disproved the general opinion held regarding displacement of human labor by mechanized farming. Aggarwal and Mehra [18] reported an estimated displacement of casual labor by cost of combine harvester to the extent of 9 man days per acre. Another study found that harvester combine displaces labor on a large scale and was costliest from social point of view. The use of harvester combine resulted in saving of about 15 man-days of unskilled labor per acre [19]. Singh [7] states that it is worth mentioning that it is wrong to say that all sorts of mechanization are unjustifiable. Thus, the question of farm mechanization and unemployment is basically concerned with the use of tractors, threshers, combine harvesters etc. However, these machines bring timeliness and remove drudgery for farm operations and reduce unit cost of production in improving competitiveness. Hence, medium size and improved low level mechanization that are currently in use by countries like china and South East and Far Asia should be recognized.

Introduction of mechanization to address peak season labor constraints could consequently be expected to have two benefits leading to an increase in employment and wages. One is the substitution of capital for labor when meeting peak season labor constraints, thereby allowing household members to continue to engage in their other nonfarm activities that are put on hold during peak seasons though otherwise remunerative. The second and more important is the increase of labor demand in agriculture in the non-peak seasons through increases in scale and/or increases in land productivity because of more timely and high quality land preparation [6]. Reduction of the extreme seasonality of labor in agriculture could lead to an increase in time devoted to agricultural production from 15 % up to 50 % [20]. There was labor displacement in the area of plowing and transport [21]. However, this was more than compensated by higher

employment in other agricultural operations notably, fertilizing, weeding, inter culture, pest control, irrigation, harvesting, threshing etc. According to field tests by farmers, in Melkassa area by AIRIC, animal-drawn inter row weeder reduced the time and labor required for manual weeding, up to 18 fold [9]. Thus, freeing labor for another employment opportunity and increasing productivity through timely operations. Generally, different studies conducted on mechanization indicated that net human labor displacement in agricultural operations was not significant and it was more than compensated by increased demand for human labor due to multiple cropping, greater intensity of cultivation and higher yields.

2.4. Subsidiary and Non-farm Employment

The demand for non-farm labor for manufacture, services, distribution, repair and maintenance as well as other complementary functions increased substantially and helped in relieving rural unemployment to some extent. Mechanization in agriculture provided indirect employment to skilled and unskilled persons engaged in operation, repair and maintenance of prime movers and farm equipment. Besides many subsidiary activities like dairying and poultry keeping got generated [22]. Mechanization through provision of more free time helped in increasing the subsidiary activities that ultimately increase income of the farm household. Mechanization has generated many non-farming and subsidiary activities among the farming households. On one hand additional employment was created in the manufacture of farm machinery, distribution of the equipment and spare parts, repair and servicing etc. Tractorised farms reduced their draught animal stock and increased their milk stock [22]. Tractor-owners and tractor-users had 82% and 25% more milk cattle's, respectively as compared to bullock farms [23, 24]. A tractor owner was able to increase his household income by undertaking supplementary activities such as dairying and provisions of custom-hiring. A tractor owner with a land holdings of 6.28 ha, had an average gross income of Rs. 47,534 which exceeded that of a bullock farm and tractor-user household by 285% and 132%, respectively [22].

2.5. Post-Harvest Technology

Post-harvest management is the handling, processing and preservation of crop produce at the time and after harvesting. The average post-harvest losses of food crops such as Teff, Sorghum, Wheat and Maize are 12-9%, 14.8%, 13.6% and 10.9% respectively [25]. Thus, whether the gain in crop yield is marginal or significant, it could be nullified because of inappropriate or unreliable post-harvest management employed. In a country where production is much lower than the national demand and supplemented with the above stated level of post-harvest loss, shows how much effort is needed in the area of generating technology that minimizes this loss. One way to overcome this problem is to increase local value-added food products. The thrust of the post-harvest technology is to improve existing small and medium scale processing

enterprises (both formal and informal) that produce a wide range of traditional basic food items that are so important for nutrition and food security in many areas of Africa. This includes the vibrant root crop processing sector in West Africa, as well as milling of basic grain staples in Southern Africa. The emphasis is on traditional products that are important in the basic diet of rural and urban people, and on the employment generated through the value added by such processing. Often, potential exists to make significant advances in value added (and thus the profitability of these enterprise) through relatively low cost interventions such as improved grading and packaging as well as storage and processing [26].

2.6. Contribution for Women's Economic Empowerment

Gender equality promotes poverty reduction and economic growth. In Kenya, one study estimated that giving women farmers the same level of agricultural inputs and extension services as men farmers could increase yields obtained by women farmers by more than 20%. Macro- and micro-level analyses of the links between gender inequality and growth show that gender-based asset inequality acts as a constraint to growth and poverty reduction in SSA. For example, gender inequality in education and in employment is estimated to have reduced SSA's per capita growth in the 1960-92 periods by 0.8% per year [27]. Women prevent the poverty of the ultra-poor households from worsening. In post-transition Mongolia, if women's contributions were ignored, the rural Gini coefficient and household's poverty gap ratios would be 0.63 and 32%, respectively. But when women's income is taken into account, the ratios drop to 0.49 and 29% respectively. This means that for the ultra poor households, women are crucial in preventing their poverty from worsening. Strategies that consider how best to enhance women's economic contribution can in turn enhance their potential for reducing household poverty [28] and promote gender equality and women empowerment as effective means to combat poverty. Mechanization may be a means of freeing women and children from agricultural work to more rewarding occupations and education [4]. Women in rural areas spend 1-2 hours daily on domestic transport, carrying water, firewood and crops on their heads and traveling on foot. Studies in Ghana show that women contribute to 60-70% of the transportation time for crop productivity, harvesting and marketing. An African woman uses 13 hours to pound maize that is enough to feed a family for four to five days. She spends 4-5 hours every day to prepare the food her family eats. This is twice the time it takes the villagers to grow and gather food and cash crops [29]. Throughout Africa, many small-scale food processing operations are undertaken mainly by women. Hence there is a need to lighten the burden on women as women are also key to the success of post-harvest operations as enterprises or businesses [26].

Women's time burdens are an important time constraint on growth and development. For example, a study in Tanzania shows that reducing such constraints in a community of smallholder coffee and banana growers increased household cash incomes by 10%, labor productivity by 15% and capital

productivity by 44% [28]. Therefore mechanization technologies by easing the drudgery of farm work and providing more time for women enable to achieve the economic empowerment through other employment opportunities. Such action also helps achieve two of the four dimensions of gender sensitive poverty reduction strategies. These are; (i) the opportunity dimension where by among others reduction in women's travel and time burdens is a critical intervention [30], and (ii) provision of water and energy that could be facilitated by use of several pumping methods like rope-washer pump that is highly in use in East Gojam Zone of the Amhara Regional State, Ethiopia.

2.7. Contributions to Environment or Promoting Green Economy

Finding solutions to environmental problems in agriculture requires (improved) agricultural tools and machinery, for example for soil tillage and pesticide application, the latter also addressing health concerns. By largely avoiding use of pesticides, insecticides, and other chemicals it is possible to attain productivity levels through mechanization. This results in saving the natural biodiversity useful to the continuation of man-land nexus. Thus, it is now recognized that agricultural mechanization is crucial in the fight against hunger and poverty, and at the same time to address environmental and health concerns [4]. Additionally the freed labor especially man could be directed for natural resource conservation and management works as being used currently in Ethiopia.

2.8. Gross Farm Income and Net Return

Farm mechanization has greatly helped the farming community in the overall economic upliftment. The studies conducted on impact of mechanization on farm income clearly support this view point. Studies revealed that the gross income was higher on mechanized farms than non-mechanized farms [15]. The gross crop output per cultivated hectare was reported to be Rs.3144 for tractor operated farms as compared to value Rs.2677 for bullock operated farms. Tractor farms secured 21% more income per hectare of gross cultivated area compared to bullock farms [23]. The net return per hectare of gross cropped area or net cultivated area was higher for tractorized farms than the non- tractorized farms as a result of better utilization of resources. Another study [22] revealed that the tractor owners and users derived higher per hectare gross income compared to bullock farms. The gross income per hectare of an average tractor-owned house hold was 63% higher than that of a household using only bullock labor. The gross income per hectare of tractor-using households as a group exceeded that of the bullock farms by 31%. The average net return from a tractor-owning farm on a cropped hectare exceeded that of a bullock farm by 152%. A tractor using farm also derived a net additional income of 84% over a bullock farm. A tractor-owning farm spent 57% more than bullock users on material inputs and 62% more on human labor. An average tractor owner and user, in spite of spending more on cultivation expenses, derived higher net income on a cropped

hectare compared to bullock farm. However, this should not be attributed entirely to tractor usage as other factors such as hybrid seeds, fertilizer and irrigation also contributed to it. A study confirmed that the gross return were higher by about 33 to 34% on tractor-owning farms than those on bullock operated farm [17]. Net return per hectare from mechanized farms having tube wells and tractors and partially mechanized farms having only tube well were 49% and 29% higher respectively than that from non-mechanized farms [24].

3. Conceptual Framework

Generally, the household asset base of rural people lies at the heart of the farm power system. Household composition and group membership determine the labor available for farm work. The education, skills and off-farm employment experiences of the household head are often associated with specific power sources. The strength of the association between farm power and wealth suggests that the source of farm power may be taken as a proxy for a household's asset-based wealth within a given community. As a result farm power is central to productivity as indicated by [31] the inefficiency of maize growers (that could have been increased by 22%) was attributed to, among others, labor. Similar studies [32] [33] showed the role of labor. The basic assumption is that Ethiopian agricultural development could better be promoted by the use of appropriate mechanization technologies. Appropriate refers to research supported and lead trial and diffusion of technologies in which technology failure is minimized and appropriate places for each levels of mechanization are scientifically identified.

Several inputs could be used for increasing productivity to feed the booming population, provide raw material for industries, facilitate empowerment of rural women that constitute the larger proportion of the rural poor through increasing the technical efficiency of farmers. Hence the contribution of mechanization that is highly disvalued in the country should be counted for. The idea is though mechanization, through cooperative farming, has been implemented during the Derg period with great ambition and with no such care of failurity and support from other stakeholders, the ultimate failure partly due to political reasons has resulted in mis-conception by many Ethiopians that mechanization will not work in our country. Of course it is locally conceived mechanization referring to directly tractor and combine harvester, engine powered, that are being used by large farm owners. Rather mechanization includes the low levels, mechanically driven farm implements and small scale motorized machines suitable for smaller farms. As Singh put, there are good chances to reduce the cost of production if farm operations are mechanized as it saves labor, both human and bullock. In the absence of mechanization, the ever-increasing wage rate of human labor and cost of upkeep of draught animals could have increased the cost of production much higher. It also encompasses use of improved storage and processing methods that could minimize post harvest loss. An efficient post-harvest system

aims to minimize losses and maintain the quality of the crop until it reaches the final consumer. When food losses are minimized, both food security and income increase, and this is vital for smallholders. From a socio-economic point of view, the implementation of an efficient post-harvest system in any community must provide equitable benefit to all those involved in the system [34]. Similarly, machines are required to assist with post-harvest loss reduction and on-farm processing. As Singh stated as production increases with mechanization of the farm operations, it creates a good scope for commercialization of agriculture that is also Ethiopia's national orientation. The following two reasons underlie the rational behind promotion of mechanization.

3.1. Farm Power as a Determinant of Livelihood Strategies and Food Security

There is no doubt that farm-power technologies other than a hoe offer considerable advantages in terms of area cultivated, total yields achieved, levels of drudgery, opportunities to redeploy family labor, and household food security. Households relying on family labor for all their farming needs survive at the margin of subsistence. Many do not even have sufficient essential hand tools for all household members, and they are extremely vulnerable to the loss of key household members. Their lives are a continual struggle and they race against time from the initial preparation of their land for planting through to harvest, and the untimely sale of produce to raise essential cash. The timeliness of their operations is often compromised by the need to hire out their labor to others at the busiest times of the year. Households headed by women tend to be overrepresented among this group, partly as a result of the loss of assets typically associated with widowhood, and they are often among the poorest in a community [4]. The motivation to mechanize is primarily driven by a wish to increase a family's food security, increase household income, or improve the quality of life. There are significant economic and social benefits to be reaped from farm-power mechanization. These are economic and social. Economic benefit refers to increasing the efficiency of labor, reducing

costs, increasing the area cultivated, undertaking more timely production, improving the quality of cultivation, increasing yields, adopting new crops, reducing harvest and post-harvest losses, and earning a rental income through hiring farm-power services to others. Social benefit refers to reducing drudgery and workloads (particularly for women), improving safety, gaining prestige. The other benefit is encouraging younger and more innovative people to remain in rural areas and work on the land.

3.2. Potential Role of Farm Power as a Lifeline in Communities Under Labor Stress

In the absence of the widespread adoption of alternative cropping systems and practices, tillage and weeding are the major labor bottlenecks. Improved access to farm power for primary tillage and subsequent cropping activities will be vital to overcome the constraints that are arising as a result of the impact of diseases and employment opportunities on the agricultural workforce. However, addressing the primary-tillage component alone will not bring substantial advantages in terms of household food security and other livelihood outcomes could be driven.

Current migration of the youth from rural areas to urban centers in Ethiopia also ticks an alarm signal to future labor availability and farming population who is willing to continue as a farmer. With household level agricultural productivity enhanced, the outcome will be a better rural population capable of resisting shocks, dependent on market oriented production, with diverse employment opportunities due to the increased productivity, better managed landscapes, healthy and capable of investing for better infrastructure, connected to industries for producing raw materials, research is within the reach of their hands, drudgery and burden are highly minimized, only selected activities are done manually or with small machines, external input use is minimized, the poor and landless are employed in other related areas, women are economically empowered and in general transformed rural areas from rudimentary farm tools and operations to more advanced and technological farm operations and living conditions.

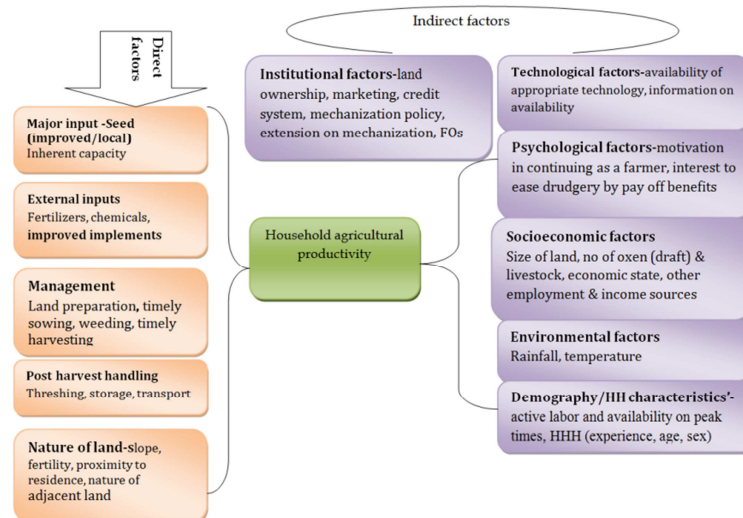


Fig. 2. Factors affecting productivity of smallholders (source: own developed from literature).

For households experiencing extreme labor stress, the opportunity to release labor from time-consuming and repetitive household tasks (such as fetching water or fuel wood) may be vital not only for generating sufficient capacity to work on their own farms but also to enable some household members to work for cash or food elsewhere (a crucial coping strategy for livelihoods security).

4. Conclusion

Broad-based poverty reduction in Africa, including Ethiopia, simply will not occur without a vibrant agricultural sector providing income, employment and affordably priced staple foods. What is more important is the contribution of mechanization should not be overlooked [35]. A common finding that emerged from various studies was that tractorisation displaced mainly bullock labor, but its impact on man-power was much less. Various studies concluded that owing to this relatively low displacement of man power that was unavoidable, mechanization should not be viewed in isolation. Indeed, mechanization opened up new avenues for human employment such as managerial and supervisory jobs on the one hand and driving, servicing, maintenance and repair of the machines on the other [36]. Therefore, they recommended selective mechanization in an increasing manner for farms as animal, mechanical and engine power work complemented each other. Majority of the studies done on impact of mechanization led to the following broad conclusions; (i) Farm mechanization led to increase in inputs on account of higher average cropping intensity and larger area and increased productivity of farm labor, (ii) It increased agricultural production and profitability on account of timeliness of operation, better quality of work done and more efficient utilization of inputs and (iii) It increases on-farm human labor marginally, whereas the increase in off-farm labor was much more and displaced animal power but resulted in lesser time for farm work. Generally, APO [37] recognized time saved, freedom from overburdened work, improvement in social status, increase in overall production, timeliness of operations, reduction in cost, increase in the number of cropping and adoptions of inter-cropping as gains. Increased debt, cost of fuel and repair, unemployment, disparity in income were considered as losses due to farm mechanization (that is highest level). Ultimately, for farm power is to have a greater role in rural livelihoods, farmers will have to be informed, educated, skilled and financially empowered to purchase, repair and maintain farm-power resources.

Recommendations

The adoption process for mechanization (labor productivity enhancing technology) follows stages that our farmers should experience from low to high for better productivity and food security that ultimately enhances the development desired [4]. Therefore, after reviewing these studies the researchers recommend selective use of

mechanization technologies for better productivity. Promotion of mechanization should recognize undertaking a national survey using multi disciplinary team for delineation of land suitability for medium and higher level mechanization, devising a clear national agricultural mechanization strategy [36], delivering mechanization based extension services to farmers and undertake intensive land use and sustainable activities, strengthening the capacity of local actors in developing agricultural implements that could be modified locally and formulation and implementing supporting policy systems including production of highly calibrated professionals and researchers in both the physical and social sciences of this sector.

References

- [1] Rebeka Amha, 2006. Impact Assessment of Rainwater Harvesting ponds: the case of Alaba woreda, Ethiopia. MSC thesis submitted to Addis Ababa University.
- [2] Samuel Gebreselassie, 2006. Intensification of Smallholder Agriculture in Ethiopia: Options and Scenarios.pdf accessed at www.futureagricultures.org/publications/agricultureethiopia/file
- [3] Bagheri, N. and Moazzen, S. A. (2009). Optimum strategy for agricultural mechanization development in Iran. *Journal of Agricultural Technology*, 5(2): 235-237.
- [4] Rijk, A. G. 1989. *Agricultural Mechanization Policy and Strategy*. Asian Productivity Organization, Tokyo.
- [5] Ganesh Sah. Role of Farm Mechanization in Poverty Alleviation. Agricultural Implement Research Center. Ranighat, Birgunj, Parsa, India.
- [6] Geoffrey C. Mrema *et al.* 2008. Agricultural mechanization in sub-Saharan Africa: time for a new look. FAO, Rome, Italy.
- [7] Singh J., Scope, Progress and Constraints of Farm Mechanization in India. Department of Economics, Punjab Agricultural University, Ludhiana, India.
- [8] Verma, S., 2016. Impact of Agricultural Mechanization on Production, Productivity, Cropping Intensity, Income Generation and Employment of Labor. Punjab Agricultural University. Ludhiana, India. Accessed at citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.511.5214
- [9] Melesse Temesgen. 2000. Animal-drawn implements for improved cultivation in Ethiopia: participatory development and testing. In Kaumbutho P G, Pearson R A and Simalenga T E (eds), 2000. Empowering Farmers with Animal Traction. Proceedings of the workshop of the Rao and Singh, 1964. Tractorization in Kanjhawala Block in Delhi Territory.
- [10] GIPE. 1967 Study on Tractor Cultivation in Shahd Taluka, Dhulia District, Maharashtra. Report by Gokhale Institute of Politics and Economics, Poona, India.
- [11] UPAU. 1969. Impact of Farm Mechanization on Labor Use of Developing Agriculture under New Technology in Rudrapur District. Report by G. B. Pant Univ. of Agril. & Tech. Pantnagar, Nainital.

- [12] Kahlon, A. S. 1978. Use of Tractors & Agricultural Employment. Proceedings of Symposium on Farm Mechanization Problems and Prospects. ISAE North Chapter and ISAT PAU, Ludhiana pp 18-33.
- [13] Johl, S. S. 1970. Mechanization, Labor Use and Productivity in Indian Agriculture. Economics and Sociology, Occasional Paper No.23. Ohio State University, USA.
- [14] AERC, 1970. Economics of Tractor Cultivation-A Case Study in Karnal District, Haryana. Agro - Economic Research Centre, New Delhi.
- [15] Aggarwal, Bina.1983. Mechanization in Indian Agriculture. An Analytical Study based on Punjab. Monograph in Economics No. 6 Delhi School of Economics
- [16] Patil, A. S. & Sirohi, A. S. 1987. Implications of Tractorization on Employment, Productivity and Income in an Irrigated Area of Ahmednagar District, India, AMA 18 (3): 36-40.
- [17] Aggarwal, P. C. and Misra, M. S., 1973. The combine harvester and its impact on labor: A Study in Ludhiana. Indian J. Industrial Relations 9(2).
- [18] Mishra, P. and Sundram. (1975). Some aspects of the economics of harvest combines in Punjab. Economic & Political Weekly. 10(39).
- [19] Cleave, J. H. 1974. African farmers: labor use in the development of smallholder agriculture. Praeger, New York.
- [20] Baig, M. A. 1978. The Tractor in India: A significant instrument for future development. Proceedings of the Symposium on Farm Mechanization; Problems and Prospects ISAE. North Chapter and ISAE, PAU, Ludhiana pp. 57-66.
- [21] NCAER (National Council of Applied Economic Research), 1980. Implication of Tractorization for Farm Employment, Productivity and Income. National Council of Applied Economic Research, New Delhi.
- [22] NCAER (National Council of Applied Economic Research), 1974. Agricultural Sector assessment a strategy for development of agriculture in Botswana. Ministry of Agriculture, Government Printer Gaborone Botswana.
- [23] Balishter, Gupta, V. K. and Singh, R. 1991. Impact of mechanization on employment and farm productivity. *Productivity*. 32(3): 484-489.
- [24] Shimelis Admassu. Post- harvest Sector Challenges and Opportunities in Ethiopia. Food Technologist, Ethiopian Agricultural Research Organization. Addis Ababa, Ethiopia.
- [25] Ferris S. and Wheatley C., 2001. FAO/GFAR Global Initiative on Post-harvest Technology, Phase 1; Report on the Regional Workshop for Africa Held at Entebbe, Uganda 17-19 September 2001.
- [26] Blackden, M. and Bhanu C., 1999. Gender, Growth, and Poverty Reduction: Special Programme of Assistance to Africa. 1989 Status Report on Poverty in Sub-Saharan Africa. Technical Paper, No. 428. World Bank, Poverty Reduction and Social Development, African Region, Washington, D. C. March 1999.
- [27] Subbarao, K. and Ezemenari, K., 1995. Transition, Poverty and Social Assistance in Mongolia. ESP Discussion Paper 55. World Bank, Washington, D. C. 1995.
- [28] Zuckerman, E., 2001. Engendering PRSPs: Why it reduces poverty and the Rwanda case: WIDER Debt Relief Conference, Helsinki, August 18.
- [29] Miriam Jato, 2004. Gender-Responsive Programming for Poverty Reduction: Technical Paper. UNFPA CST, Addis Ababa, Ethiopia. Accessed at www.unfpa.org/sites/default/files/pub-pdf/gender-responsive.pdf.
- [30] Gezahegn Aynalem, 2006. Technical Efficiency in Maize Production: A Case of Smallholder Farmers in Mecha District, Ethiopia. A Thesis Submitted To The School Of Graduate Studies of Haramaya University.
- [31] Gelaw Fekadu, 2004. Analysis of Technical Efficiency of Wheat Production: A Study in Machakel Woreda, Ethiopia. A Thesis Submitted to the School Of Graduate Studies of Alemaya University.
- [32] Gebregziabher Gebrehaweria, Namara Regassa E. and Holden Stein, 2012. Technical Efficiency of Irrigated and Rain-Fed Smallholder Agriculture in Tigray, Ethiopia: A Comparative Stochastic Frontier Production Function Analysis. *Quarterly Journal of International Agriculture*, 51(3): 203-226.
- [33] Grolleaud, M., 2001. Post-harvest losses: Discovering the full story overview of the phenomenon of losses during the post-harvest system. Rome, FAO.
- [34] Gabre-Madhin, E. and Haggblade, S. 2004. Successes in African agriculture: results of an Expert survey. *World Development*, 32(5): 745-766.
- [35] Geoffrey Mrema, Doyle Baker and David Kahan, 2008. Agricultural mechanization in sub-Saharan Africa: time for a new look. Agricultural Management, Marketing and Finance Occasional Paper 22, FAO.
- [36] Asian Productivity Organization (APO), 1983. Farm Mechanization in Asia, APO, Tokyo.