Chapter Two

Inefficiency and Incapability Gaps as Causes of Poverty:

A Poverty Line-Augmented Efficiency Analysis Using Stochastic Distance Function

By

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Abstract

This paper attempts to assess the link between poverty and efficiency in Ethiopia. Based on 214 households drawn from eight Peasant Associations (PAs) from two zones in Ethiopia's Amhara National Regional State, the study measures the levels of poverty and efficiency, and assessed the link between the two. Both objective and subjective measures were used to measure the level of poverty, which was found to be 28% and 27% by both measures, respectively. While 35.6% of households were found to be poor in relative terms (using the Cost-of-Basic-Needs approach), 76.4% were poor in terms of the one-dollar-a-day absolute measure of poverty. The study also shows that there was wide variation in the level of poverty between the sample districts. The stochastic frontier distance function with variable return to scale specification reveals that all input variables, with the exception of ox power, significantly determine the efficient level of output. Whereas the average efficiency score of sample households was 62.8%, indicating the existence of technical inefficiency among farmers in the study areas, the mean efficiency score of poor and non-poor households was found to be 58.3% and 74.4%, respectively. The logistic regression also reveals that efficiency plays an important role

in explaining the observed poverty incidences. Prediction of the marginal effects of a 10% improvement in efficiency reduced the probability of being poor by about 4%, while simulation of the effect of improved efficiency on poverty indicates that 14.1% of the poor households could get out of poverty by attaining a 25% improvement in the existing efficiency levels. The implication for policy is that improving access to resources without ensuring their efficient utilization could not have the desired impact in reducing poverty.
Key words: Inefficiency, Poverty, Stochastic distance function and Ethiopia

1. Introduction

In the past four decades, countries in sub-Saharan Africa have experimented with various nation-wide approaches such as growth and trickle down, structural adjustment, integrated rural development, poverty reduction strategic papers and more recently "growth corridor" in addressing poverty (Burke et al., 2007). These countries have also tested different approaches to poverty reduction that are theoretically applauded. However, many researchers have indicated that poverty remains deep and pervasive in many Sub-Saharan African countries. Thus, poverty reduction remains the overriding development policy objective of many developing countries.

In Ethiopia, poverty is deep, rampant and pervasive and it is one of the poorest countries in Sub-Saharan Africa. Since the mid 1980s, severe drought and large-scale starvation have become inexorably linked to the country. The country's per capita income is among the lowest in the world and the level of poverty is the highest in the world according to any standard measure, with the situation particularly bad among rural households. International emergency appeals for food aid have remained the regular business of the government.

Notwithstanding the various efforts made in the past to reduce poverty, several studies (e.g. Fekadu 2010; World Bank 2005; Brown and Teshome 2007; and Dercon and Krishnan, 1998) show that poverty in Ethiopia is still very high. Today, nearing 2015, the target date of the millennium development goals, and looking back at past achievements, the country's struggle towards achieving the first goal of halving the incidence of poverty by 2015 seems unattainable in such a short period. Like most other developing countries, agriculture in Ethiopia is the mainstay of the economy, providing the livelihood base for nearly 85% of the population, contributing over 50% to the gross domestic product, and accounting for about 90% of foreign exchange earnings. Moreover, many would also concur that the overall performance of Ethiopia's economy for the foreseeable future to a great extent depends on the developments in this sector. Poverty reduction in Ethiopia would thus require concrete growth in this main sector. But what constrains the growth in the agricultural sector? Perhaps, as Schulz (1964) noted, if we knew the economics of agriculture, we would know much of the economics of being poor.

Although poverty reduction seemingly requires concrete growth in the agricultural sector, the sector is characterized by subsistence farming where most of the households are cultivating small plots of degraded land that are also subjected to adverse weather conditions. These conditions are further exacerbated by high population growth, environmental degradation, and poor market and institutional arrangements. Even more frustrating is that agricultural productivity in many African countries could permanently and substantially decline if climate change is unmitigated in the future (Nordhaus and Boyer, 2000; Stern, 2007; and Parry et al., 2005) as these countries are more exposed and less resilient to climate hazards (World Bank, 2010).

Various efforts have been made in the past to improve the performance of agriculture and to enable farm households to derive the required income from their agricultural and related activities. More recently, all previous independent efforts of NGOs and the government itself to reducing poverty in the country have been consolidated into one programme called the Productive Safety Net Program (PSNP), which is financed separately by a consortium of donors.[1] The main focus of the programme is to protect asset depletion at household level and to build community assets. The main premise is that households lack the required resources and are susceptible to asset depletion in times of risk. Accordingly, the programme provides cash and productive assets to those deemed to be food insecure. Such interventions, in addition to the negative long-term impacts of creating dependency syndromes, may not have the intended outcome if the households are already inefficient in using the resources available. It can also discourage those households that strive and are able to get out of poverty and food insecurity on their own. The argument is that if households are internally inefficient, reducing this inefficiency could be more effective and economical than providing additional assets.

Individual differences in resource endowments, access to technology and other credit, markets, and similar services can be important in explaining poverty levels. Yet, households that have the same resource endowment could differ in their poverty status. The most important question should be "why are some rural households unable to meet their basic needs and hence are deemed to be poor while other households with the same resource endowments are not so poor?" In other words, the reason why some households are deemed to be non-poor is not because they have more resources and better accesses, but it could be that they use the available resources more efficiently than some poor households. More precisely, given more or less an equal resource base and accesses, some households could remain poor while others do not. Some may actually be resource-poor but efficient, i.e., they may lack the required resources (incapable) even if they use resources ef-

1 The PSNP provides resources to chronically food-insecure households via two means: payment to able-bodied members for participation in labour-intensive public work activities, and direct grants to labour-poor, elderly or otherwise incapacitated households. Food Security Programme (FSP) is a federal budget component that provides a federal grant to regions, often for promoting household income-generating packages through credit.

ficiently. But some others may not be resource-poor (hence potentially capable) but could still be poor merely because they are inefficient in using their resources.

Tackling poverty primarily requires a better understanding of the nature and causes of poverty. Currently, it could be relatively easy for sub-Saharan African countries to get external aid to finance their poverty reduction programmes. Although external financial support could help the countries in reducing poverty, the outcome of any poverty reduction programme should not only be judged in terms of its short-term outcome, but rather on its impact in reducing the dependency of the country by bringing sustainable development. That is, the programmes must encourage the poor to help themselves rather than incentivizing them to stay poor.

Many policies aimed at helping the poor sometimes have the unintended effect of discouraging the poor from escaping poverty on their own, as they create incentives for people to become "needy" (Mankiw, 2003). Many authors have found evidence that food aid programmes such as general food distribution or food-for-work in Ethiopia have at most a small impact on food consumption and often have only a short-run effect on aggregate consumption (Yamano et al., 2005; and Quisumbing 2003). Providing additional money to fill its consumption gaps will have no more than a transitory effect in lifting the household out of poverty. The choice of appropriate poverty reduction programme primarily requires a better understanding of the real causes of poverty. By far the most widespread technique used to identify the contributions of different variables to poverty is regression analysis (World Bank, 2005). The measured poverty or any other proxy is assessed against a number of socioeconomic variables. A wide variety of such regressions have been used by researchers. These studies differ mainly in their ways of measuring the dependent variable – poverty. While the choice of measurement method matters, finding appropriate independent variables (which are truly exogenous) is another difficult task in such a regression exercise.

The main motive of this research is to assess the relationship between poverty and efficiency. The paper attempts to propose a conceptual framework that can identify the sources of poverty by linking the consumption decision behaviour of households with their production decision behaviour. It suggests that this can be achieved by using a household model. The proposed frameworks aim to explain the sources of the observed overall poverty gap in relation to the productive capacity of households by employing a household survey data. The objectives of this study are to measure the poverty levels of sample households in the study areas using objective and subjective measures; determine the contributions of inefficiency and incapability gaps in explaining the poverty gap of sample farm households; evaluate the levels of technical inefficiency of households in production activities; and determine household-specific socioeconomic factors that explain the inefficiency and incapability differentials of households.

2. Literature Review

In countries where meeting "basic needs" is persistently difficult for the majority of the population, poverty reduction must be the overriding objective of development policies and programmes. Thus, stimulating agricultural growth is clearly important, but in order to make this growth more pro-poor, efforts should be made to affect the *pattern* of growth, i.e. to increase growth in the sector and in geographical areas with a high concentration of poor people. Such policy target requires identifying the poor: poor households and poor locations. The question then is how to identify the poor and how to measure poverty. Finding a consistent and specific measure that informs policy is crucial yet difficult. The current measure was defined by the contributions of a few economists such as Sen, Atkinson, Foster and Ravallion (Dercon, 2005).

Ravallion (1994) classified various methods of poverty measurements into two approaches: welfarist and non-welfarist. One of the crucial problems with the two approaches is that both fail to link production decisions with consumption decisions (see Duclos and Araar, 2006). Both have their own strengths and limitations, and thus the non-welfarist approach has been advocated as a multidimensional complement to the unidimensional standard of living measure adopted by the welfarist approach (Duclos and Araar, 2006).

The other issue in poverty measurement is the method of discriminating between the poor and non-poor. This is typically done by constructing a poverty line. The two commonly used and objective methods of constructing a poverty line are: the CBN[2] and the FEI methods (Ravallion and Bidani, 1993). While the CBN sets the poverty line by finding the actual expenditure on a consumption bundle deemed to be adequate for basic consumption needs, the FEI sets it by finding the consumption expenditure or income level at which a person's typical food energy intake is just sufficient to meet pre-determined food energy requirements. The CBN is utility consistent (welfarist approach) while FEI is utility inconsistent and has an arbitrary measure (non-welfarist approach), as shown by Ravallion (1998). The two approaches differ in the relative weight given to specificity (applying locally pertinent notions of poverty) and consistency (treating persons with the same living standards equally [Tarp et al., 2002]. Many researchers agree that the resulting poverty profiles are sensitive to the choice of poverty line methodology. Other methodological and conceptual issues arise in measuring poverty and the poverty line. These include choice of the reference (absolute or relative measure), the method of aggregation of poverty indices, heterogeneity of households and locations, the effects of changes in prices, mobility of households, and intra-household distributions.

Many studies (e.g., Sharp and Devereux, 2004; Dercon and Krishnan, 1998; and Ayalneh, 2011) have regressed poverty against household socioeconomic charac-

2.This method was initially used by Rowntree (1901) in his seminal study of poverty in York in 1899 (cited in Ravallion and Bidani, 1993).

teristics, but such studies only identified what socioeconomic variables are associated with poverty levels and failed to show how these socioeconomic variables possibly affect poverty. For instance, Ayalneh (2011) found household wellbeing to be negatively associated with household size. But the problem with such modelling is that it accepts the observed poverty gap without evaluating whether the household is using and allocating the existing resources efficiently or not. Such association never shows the mechanism by which the variable is related with poverty. The extent to which household size affects the poverty level of a household primarily depends on the extent to which members of the household contribute to household income. Suppose two households that are equal in size differ in their poverty status if the proportion of active labour force in the two households differs. The household with a higher active labour force has the potential to generate higher income than the one with the lower active labour force. Hence, the former could be better off than the latter. The household characteristics that affect consumptions in one direction may not affect productions in the same direction. Identifying the sources of poverty requires further assessment of the contributions of the observed socioeconomic behaviours to the production capacity of the household. Thus, before attributing a given socioeconomic characteristic to poverty, it is important to evaluate the contribution of that socioeconomic characteristic to household income.

A household might not be able to generate "sufficient" income but it could have the potential to do so. As a result, such regression models identify the symptoms of the problem of poverty rather than the real causes. They focus on outcomes without questioning the reason behind the outcomes and simply show how poverty is associated with community and household socioeconomic characteristics. Nevertheless, informing and guiding poverty reduction programmes require better answers to the question of why, not how. As a result, such regression models identify the symptoms of poverty not its real causes because they focus on observed outcomes rather than identifying the driving forces behind the outcomes. Thus, such relationship does not clearly show the mechanism by which the observed poverty levels are related to the socioeconomic behaviours and hence will have little relevance for policy guidance. Perhaps a more direct and better option is to identify factors that impede poor households from generating an income level that is sufficient to meet their basic needs. The implication of institutional and other socioeconomic factors on poverty can be more directly explained if we can assess their influence on production and marketing. Most literature on poverty also increasingly recognize productivity as an important instrument for poverty reduction (Pineau, 2004).

Identifying the real causes of poverty should go beyond assessing the observed outcomes. It should assess the constraining factors underlying the outcomes. Perhaps evaluating the person both in the space of production goods and consumption goods could provide better information about the reasons.

The conventional welfarist approach considers a person as poor if they are unable to meet their minimum basic needs. That is, if they are unable to consume the minimum bundle of basic food and non-food commodities. There is no problem with judging a person as poor if they are unable to meet minimum basic needs. What is more important is “what is the reason behind this outcome?”. The person may choose to consume below the minimum level even if they have the potential to consume above that level. The capability approach will not judge them as poor. This is logical from a preference diversity viewpoint, but the problem is then how to measure their potential. Income could be an important indicator of this potential but income itself is an outcome and hence cannot indicate the true capability of a person. For instance, a person may prefer to substitute leisure for income but could have the capacity to generate sufficient income if they chose to do so. It could also be possible that, for various reasons, they are unable to generate the necessary income even if they have the necessary resource endowments. Or it may be that they lack the necessary resources to achieve the minimum income. Still another reason could be that they might be able to generate the necessary income but are unable to consume the minimum bundle of basic goods due to external factors such as absent markets, inaccessibility and discrimination.

Thus, an assessment of the sources of poverty has to begin by evaluating the production behaviour of households. Some farm households could escape poverty merely by improving their efficiencies: technical or allocative, or both. Others are poor even if they are efficient (efficient but poor). Such households are poor due to factors that are beyond their control such as resources, technology and the market. Others may be poor because they are resource poor and at the same time inefficient (poor and inefficient).Still others may not be resource poor (hence capable), but are poor merely because they are inefficient in using the resources (poor but capable). For instance, a household may use its resources efficiently but may still be poor due to a lack of appropriate/necessary resources, while other households may have the necessary resources but may still be poor due to their inability to use them efficiently. Conversely, whereas some households may lack both resources and efficiency, some others may produce sufficient income to meet their basic needs but may be unable to access them for various institutional and other reasons. The prescription for these different categories of households must vary accordingly.

Linking poverty with efficiency analysis

It is important to focus on those aspects that can give direction for the improvement of productive capacity of households. Poverty reduction that considers only the consumption side of welfare without considering its implication to sustainable income growth, and hence wealth improvement, cannot have a sustainable impact on poverty itself. It could even have an unintended negative impact on social welfare by discouraging efforts of individuals to improve their own living standards.

In a farm household model, the capability of a person needs to be evaluated both in the space of consumption goods and in the space of production goods.

This is because in farm household models a household makes production, labour allocation and consumption decisions that may be interdependent on one another (Taylor and Adelman, 2003). Observing a person in the space of consumption goods helps to understand the person's choice of bundle of consumption goods given their budget and other constraints. Evaluating the same person in the space of production goods shows the income that results from the allocation of resources and choice of combination of goods, given their resource endowment and other market and institutional constraints. While the former help to judge the welfare status, the latter provides reasons for the observed welfare status. Together, they provide useful information about the possible sources of poverty. Farm household models can combine these two decisions; the constraints typically include cash income, family time and endowments of fixed productive assets, and production technologies.

The standard microeconomic models analyze consumption decisions independent of production decisions. Such approach is roughly a good representation of the socioeconomic structure of developed countries. In traditional agrarian economies, however, household consumption decisions and production decisions are closely linked. In such cases, household models that combine consumption and production decisions can better represent the objective realities of these economies.

In agrarian and subsistent economies, where the consumption and production units are the same and decisions are simultaneous, such approach provides more direct and integrated answers to the question of the sources of poverty. If household production and consumption decisions are interdependent, analyzing the consumption side alone to identify the sources of poverty will not be consistent with reality as the consumption decision is not only based on fixed budget constraints but also on the amount of profit earned from production activities and, hence, endogenous income. The fundamental difference between an agricultural household model and a pure consumer model is that, in the latter, the household budget is generally assumed to be fixed, whereas in household farm models it is endogenous and depends on production decisions that contribute to income through farm profits. It therefore enables one to see the potential welfare effects of production-related interventions.

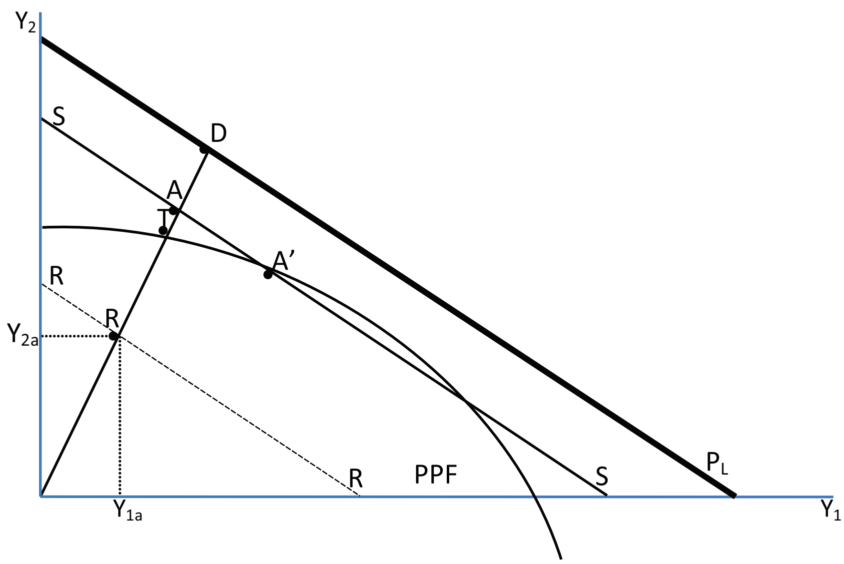
To explore the relationships between production behaviours of households in poverty, we need a poverty line that discriminates between the poor and non-poor households. The poverty line can be estimated by using the CBN or FEI methods. Once the poverty line is derived from the consumption commodities, it could be transformed into an equivalent poverty line for production commodities. In a purely subsistent household, the poverty lines are equal in both consumption commodities and production commodities. The transformation is achieved through several steps. First, it derives a poverty line with the usual approaches. Then, it transforms the poverty line into an equivalent revenue line i. This level sets the minimum threshold profit level that needs to be generated from production activities. Then, the poverty-equated revenue line is plugged into the profit functions to evaluate the gap between the required, potential and actual profits levels.

The first step in the transformation is for the “real” CBN-based income to be normalized by a price index to transform it into a nominal profit line as a function of prices and quantities of outputs *Y*, q and purchased inputs, X_i. This would give the amount of nominal profit that is sufficient to finance a bundle of food and non-food “basic need” items. The full transformation equation is derived in the theoretical model (see Equations 1 to 15), based on the ground-breaking work of Farell (1957). The purpose is to theoretically show how the overall poverty gap can be decomposed into an inefficiency gap and an incapability gap.

Figure 1 shows the relationship between two outputs with a given set of inputs such as labour, land and other resources, as well as a given production technology. The analysis also hinges on traditional assumptions such as increasing opportunity cost, profit maximization behaviour and competitive markets. Constant returns to scale is also assumed for the sake of convenience. In addition, the analysis demands an important assumption that assumes all incomes are derived from productive activities.

Suppose a household produces only two products, Y_1 and Y_2, and its income is entirely generated from the production of two products. The concave curves represent a typical production possibility frontier (PPF). Given resources and technology, the household produces on or below the PPF. Given the prices, the line SS represents the isorevenue or the total income of the producer-household. The slope of the income line is given by the negative output price ratio, P_1/P_2. The ray through the origin

Figure:1 Inefficiency and poverty interactions



to point A represents a fixed proportion of output and can be considered an expansion path (Coelli et al., 1998). The bold line (P_L) represents a transformed poverty equated revenue line as described in the previous single input–output relationships.

Starting with the resource-poor group of producers, the letter "R" represents a poor and inefficient producer. The distance OD represents the combination Y_1 and Y_2 which R requires to cover its "costs-of-basic-needs" or to meet its "food-energy intakes", i.e., so as not to be deemed poor. Of this total combination of outputs, R produces a combination of outputs given by OR. Thus, OR/OD is the ratio of actual revenue earned to the required revenue given by the poverty line. It is a measure of degree of competence of the household, or can be thought of as the poverty gap. The household needs to increase both Y_1 and Y_2 to fill its poverty gap and to escape from poverty. The total incompetence of R can be disaggregated into an inefficiency gap and an incapability gap. The total inefficiency gap is represented by the distance RA while the incapability gap is represented by the distance AD. This means that the ratio RA/OA represents the degree of overall inefficiency and the remaining AD/OD represents the degree of incapability.

The overall inefficiency can be further disaggregated into three traditional measures of inefficiency: TE, AE and EE. Accordingly, the ratio OR/OT explains the technical efficiency of R, in other words the ratio RT/OT explains the technical inefficiency. Similarly, the ratio TA/OA explains the allocative inefficiency. The ratio RA/OA provides a measure of overall economic (revenue) inefficiency. A household represented by T is poor but efficient. Given its resources, it uses the best production technique and produces the maximum possible output (given its factor endowments and technology) and hence it is technically efficient. As it is unable to produce revenue equal to Y_p, it is poor. The policy implication of this is that anti-poverty programmes should either provide household T with adequate additional resources or help it to use improved technology.

By our assumption, all households represented by R, T and A have equal resource endowments and they use the same technology. However, their poverty gaps are different because they differ in their efficiency. For instance, a household represented by R suffers from technical and revenue inefficiency and hence its poverty gap is the largest. On the other hand, a household represented by T has less of a poverty gap than R because it is technically efficient, but it could still reduce its poverty gap by improving its allocative efficiency. A household represented by A (i.e., supposed to represent point E that is lying just on the PPF*)* is better than the other two households as it is technically and allocatively efficient and hence its poverty gap is smaller than the others. The important implication is that helping producers to improve their efficiencies contribute to poverty reduction. The extent to which improving efficiencies contributes to poverty reduction depends on the relative magnitude of the two gaps: the inefficiency and incapability gaps.

The decision as to whether the observed resource and technological constraints are practically beyond the control of the household (and should therefore be considered a part of incapability) or not, is a matter of judgement. In practice, some groups may have more access to new technology than others. Even when producers have equal access to technology, they could still differ in their speed of adopting the technology – some are innovative or early adopters while others are slower on the uptake. The former (access) could be thought as incapability while the latter (adoption/adaptation) can be considered as adaptive inefficiency (which can be considered as part of inefficiencies). The PPF of those producers that have better access and adoption skills could lie above those of their counterparts. Barnum and Squire (1978) recommended that tests of economic efficiency should be preceded by tests of the nature of technology.

4. Methodological Framework

Efficiency measurement methods

Traditional microeconomic theory presupposes the full and efficient utilization of resources, perfect knowledge and free mobility of resources. The area of efficiency analysis has become the central issue in performance analysis since the groundbreaking work of Farell in 1957. In these analyses, technical efficiency measurements are carried out using frontier methodologies, which shift the average response functions to the maximum output or to the efficient firm. These frontier methodologies are broadly categorized into two groups: parametric and non-parametric frontier models.

Since the groundbreaking work of Farell (1957), various researchers have contributed to the development and refinements of the Stochastic Production Frontier (SPF) method (Meeusen and Van den Broeck, 1977; Schmidt and Lovell, 1979; Greene, 1980; Kopp and Smith, 1982; Kumbhakar, 1987; and Schmidt and Sickles, 1984). Similarly, Charnes et al., 1978; Banker, et al., 1984; Aigner and Chu, 1968 and others have also contributed to the development of data envelopment analysis (DEA).

Despite these developments and refinements, there are still controversies over the different methodologies developed so far in the field of efficiency analysis. Several studies have compared parametric to non-parametric methods (see Alene and Zeller, 2005; Thiam et al., 2001; Sharma et al., 1999; Battese and Broca, 1996; Lovell and Schmidt, 1982; Button and Weyman-Jones, 1994; Neff et al., 1993; Kopp and Smith, 1980; and Banker et al., 1987). Most of these and other studies emphasize the sensitivity of empirical measures efficiency to the choice of methodology.

A number of methodological issues need to be considered in the specification process. The importance of issues such as noise, the type of distribution, the functional form and the behavioural assumption matter in the selection and specification of models. Many researchers argue that SPF is likely to be more appropriate than DEA in agricultural applications of efficiency analysis due mainly to noise, which is inherent in agricultural production (see Coelli et al., 1998; Mohammad and Premachandra, 2003; Thiam et al., 2001; Ajibefun, 2002; and Parikh and Shan, 1996).

One of the critical limitations of SPF is that it is less useful in a multi-output multi-input production setting. An alternative method in a multi-output multi-input setting is to use the distance function rather than to estimate a single production function or its dual cost or profit functions (Coelli and Perelman, 2000). In addition, when flexible functional forms are employed, input and output distance functions can provide good representations of the underlying technology (Hailu and Veeman, 2001). The notion of distance function was introduced independently by Malmquist (1953) and Shephard (1970), but their applications have gained popularity in the field of efficiency analysis in the 1990s (Coelli and Perelman, 2000). Empirical economists have used distance functions to estimate parametric non-parametric and frontiers; Fare, Grosskopf and Lovell (1985, 1994); Fare and Primont (1995); Coelli and Perelman, (1999); and Chavas and Cox (1999), among others, have made important contributions to the development of the models.

Derivation of the poverty-equated income line

This conceptual model is appealing as it relates productive capability with poverty in some way. By analyzing the consumption decision behaviour of households as an integral part of their production decision, it attempts to relate poverty to production capability. The classic models that incorporate the consumption goals of households into microeconomic models of peasant households' decision making are the so-called agricultural household models, which have become popular for explaining the behaviour of farm households (as consumption and production units) in both perfect and incomplete market contexts (Taylor and Adelman, 2003). This model typically incorporates the notion of full household income (Becker, 1965) and conceives of the household as a production unit that converts purchased goods and services as well as own resources into use values or utilities when consumed.

The technique comprises several steps. The first task is identifying the poor and estimating the poverty gap. This can be done by measuring income/consumption of households generated by productive activities. Researchers argue that expenditure/consumption data are more reliable and simple to compute than income (Deaton, 1997; Dercon, 2005; and Duclos and Araar, 2006). Once the poverty line is derived, the next task is to express the poverty line in terms of production goods. The poverty line is usually calculated based on real prices of goods that constitute the basic consumption bundle. However, this minimum standard income/expenditure can be transformed into an equivalent poverty line of commodities in the space of production. In this case, the poverty line shows the minimum income that needs to be generated from production activities. It also shows the possible combination of production goods that should be produced to generate income sufficient to finance basic consumption goods. Suppose k food and non-food items constitute the bundle of basic consumption goods, then the total cost is

$$c = f(X_i, P_i)$$

where $I = 1, 2, \ldots k$ (1)

where X_i is the quantity of the i^{th} good, and P_i is the real price of the i^{th} good.

The poverty line is calculated from consumption goods. Our aim is to derive an equivalent poverty line that can be used in the space of production goods. Since

$$P_L = P_L^R * \varphi \tag{2}$$

P_L sets the minimum income/expenditure a household requires in order not to be deemed poor. Now, suppose R^* represents a value in the space of production which is equivalent to the nominal poverty line (P_L). Thus:

$$P_L = R^* \tag{3}$$

Following Singh et al.'s (1998) household model, a utility maximizing household faces time constraints; it cannot allocate more time to leisure, on-farm production, or off-farm employment than the total time available to the household, which is given by:

$$X_l + F = T \tag{4}$$

where T is the total stock of household time. It also faces a production constraint or production technology constraints that show the relationship between inputs and farm output, expressed by:

$$Q_\alpha = Q(L, \mathrm{K}, \mathrm{V}, \mathrm{A}) \tag{5}$$

where A is the household's fixed quantity of land and K is its fixed stock of capital, L is total labour required, and V is the quantity of variable inputs. The two constraints can be expressed as:

$$P_m X_m + P_a X_a + P_l X_l = P_l T + \pi_y + E \tag{6}$$

P_m and X_m are vectors of market prices and quantities of purchased commodities, respectively; P_a and X_a are vectors of market (imputed) prices and quantities of production commodities, respectively; π_y are profits; P_l is the wage rate; and i is non-labour income. The profit function is:

$$\pi_y = P_a Qa(L, K, V, A) - P_e V_e - P_l L \tag{7}$$

where $Q_a(.)$ is the production function; V_e is the vector of variable inputs; P_e, is the vector of the market price of inputs; P_l is market wage; and L is labour input (Singh et al., 1986). Ignoring leisure hours ($F = T$), Equation 7 will then be:

$$P_m X_m + P_a X_a = P_l F + \pi_y + E \tag{8}$$

If (L-F) is positive, the household incurred hired labour cost; if it is negative, the household earned labour income hence increasing its profits. Equation 8 is reduced to:

$$P_m X_m + P_a X_a = \pi_y + E \tag{9}$$

The left-hand side provides the total expenditure of the household that can be financed by total income in the right-hand side the above equation. Our intention is to find total revenue that a household should generate from its production that is sufficient to meet the household's basic needs and that can cover its purchased inputs. This required amount of revenue, R^*, should cover the costs of purchased input and the remaining amount should be equal, when consumed and sold, to the estimated nominal poverty line (P_L). If the required vectors of purchased and produced basic items are X^*_m and, X^*_a then

$$P_L = P_m X_m^* + P_a X_a^* \tag{10}$$

The required total income consistent with poverty-equated net income line (I^*) is then

$$P_L = \pi_y^* + E = I^* \tag{11}$$

Assuming the producer/household is a price taker, the required profit is

$$\pi_L^* = P_a Q_a^*(L^*, V^* A^*, K^*) - P_a V_e^* - P_l L^* \tag{12}$$

Replacing the profit function in Equation 7 and deducting external incomes, E, such as rent income, remittance, transfers or pension from I^*(as they need not be covered from production income), we obtain:

$$P_L = I^* - E = P_a Q_a^*(L^*, \mathrm{V}^*, \mathrm{A}^*, K^*) - P_e V_e^* - P_l L^* \tag{13}$$

Rearranging Equation 13 we get:

$$I^* - E + P_e V_e^* + P_l L^* = P_a Q_a^*(L^*, \mathrm{V}^*, \mathrm{A}^*, K^*) \tag{14}$$

The right-hand side of Equation 14 is the total revenue that is sufficient enough to cover purchased inputs, cost of hired labour, and household food and non-food expenditures. Let us call this value poverty-equated revenue line, R_L^*, given as:

$$I^* - E + P_e V_e^* + P_l L^* = R_L^* = P_a Q_a^* \tag{15}$$

where $\boldsymbol{P}_{\alpha}$is a vector of market price, and $\boldsymbol{Q}_{\alpha}^{*}$ are output vectors that the household ought to produce to meet its basic needs, i.e. $\boldsymbol{Q}_{\alpha}^{*}$is output vectors, either consumed or sold, and are sufficient to cover the household's food and non-food expenditure. The results of such estimation enables us to estimate the output gap (production gap), which can be considered as the poverty gap in the space of production. This transformed poverty line will then be incorporated into the distance function.

5. Methodology

Data and collection method

The study was conducted in Ethiopia, where farm households consist of highly subsistent peasants and their production decisions are closely linked to their consumption decisions. The primary objective of the production decisions of such households is to meet the household's food demand. Thus, to minimize price and other risks, they tend to give priority to the production of food crops, particularly cereals. They also produce cash crops or more of the same food crops to meet their cash demands. Generally, Ethiopian rural households are semi-subsistent and they produce partly for home consumption and partly for cash (in order to cover other non-food consumption items).

Primary data were collected for analysis from sampled households in four districts (wDistricts) that were selected from two administrative zones of the Amhara National Regional State (ANRS), namely, Eastern Gojjam and Western Gojjam. Data collectors were recruited and trained for about four days, both in class and on the field. The draft questionnaires were pre-tested after which the necessary corrections were made before administering interview. A total of 208 sample households were drawn using a two-stage sampling technique. That is, in the first stage PAs were stratified into two groups based on their production potentials. Then four sample PAs were randomely selected from each group. In the second stage, 97 and 111 sample households were randomely drawn proportional to population size of higly productive and less productive areas, respectively. .

Farm households were observed to use local measurement units in measuring the amounts of outputs, the size of land and the amounts of inputs., As other studies have confirmed the conversion factors for such local measurement units is Districthomogenous among farmers within the Districts (see Capéau and Dercon, 2004). Thus, the study used conversion factors used in the Ethiopian Rural Household Survey (ERHS) data to convert the local measurement units into standardized units such as hectare and kilogram. In addition to the primary data, secondary data were collected from research institutions, food security offices, the ministry of agriculture, and other related offices.

Data collection was carried out using structured questionnaires in two phases: one at the beginning of the cropping season and one after harvesting. This helped to minimize loss of memory of household members interviewed and considered seasonal variations in consumption. Relevant data on production, consumption decisions and household characteristics were collected during the survey. Other data include socioeconomic, institutional, infrastructural and agro-ecological variables which were collected at each administrative level.

Econometric model

Efficiency measurement methodologies usually construct a frontier of best practice and evaluate other observations relative to the frontier. Unlike other previous empirical studies in the area of efficiency, this study was careful to select an appropriate model that enabled the decomposition of the overall poverty gap into the various inefficiencies. It therefore becomes important to specify a model that can measure the total distance between the observed outputs and the transformed poverty-equated income line. The total distance is then decomposed into inefficiencies and incapabilities. The general stochastic distance function used can be expressed as:

$$-1nq_{Mi} = TL(X_i, \mathrm{q}_{mi} / \mathrm{q}_{Mi}, \alpha, \beta, \delta) + \nu_i - u_i \quad i = 1, 2, ..., N. \qquad (16)$$

where q_{mi} is a vector of m crop-livestock outputs produced by the i^{th} sample households; x_i is the vector of inputs of labour, land, capital, seed, fertilizer, etc; $\ln q_{Mi}$ is the distance of the M^{th} output; ν_i is the random error term of the model; and u_i is a non-negative random variable associated with the technical inefficiency of sample households. Using a flexible translog form, the deterministic output distance function can be written as:

$$1n(D_{oi} / qM) = \alpha_o + \sum_{m=1}^{M-1} \alpha_{mi} 1nq^*_{mi} \quad + \frac{1}{2} \sum_{m=1}^{M-1} \sum_{n=1}^{M-1} \alpha_{mn} \ln q^*_{mi} \ln q^*_{ni} + \sum_{k=1}^{k} \beta_\kappa \ln x_{ki}$$

$$+ \frac{1}{2} \Sigma_K^K = {}_1\Sigma_l^K = \beta_{kl} 1nx_{ki} 1nx_{li} \quad + \Sigma_k^k = {}_1\Sigma_{m=1}^{M-1} \delta_{km} 1nx_{ki} 1n\,\mathrm{q}^*_{mi}, \quad \mathrm{i} = 1, 2, ..., N, \quad (17)$$

where $q^*_{mi} = q_{mi}/q_{Mi}$.

Let , $1n(D_{oi} / qMi) = TL(\mathrm{x}_i, q_{mi} / \mathrm{q}_{Mi}\, \alpha, \beta, \delta), \quad i = 1, 2, ..., N,$ (18)

Rearranging the terms provides the stochastic distance of the M^{th} output as:

$$.-1n\ qMi = TL(x_{i,} q_{mi} / q_{Mi}, \alpha, \beta, \delta) - 1\,\mathrm{n}(\mathrm{D}_{oi}), \quad i = 1, 2, ..., N. \qquad (19)$$

Adding the error term into the deterministic distance function, the stochastic distance of the M^{th} output can be written as:

$$.-1n(q_{Mi}) = TL(x_{i,}q_{mi} / \mathrm{q}_{Mi}, \alpha, \beta, \delta), + v_i - u_i \quad i = 1, 2, ..., N. \quad (20)$$

where $\ln(D_{Oi}) = u_i$ is the error component associated with the technical inefficiency of the sample household in the production of the M^{th} output.

The corresponding distance function for the estimation of revenue-based allocative efficiency, the given vector of output prices, can be written as:

$$-1n(p' q_{mi}) = TL(x_i, p' q_{mi} / p'_{qMi}, \alpha, \beta, \delta) + v_i^* - u_i^* \quad i = 1, 2, ..., N. \quad (21)$$

where u_i^* is the error component associated with the revenue-based allocative inefficiency of the sample household in the production of the m outputs. The gap associated with the incapability-given revenue maximizing production can be expressed as:

$$-1n(\mathrm{P}_{Li}) = TL(x_i, 1\mathrm{n}\ \mathrm{P}_{Li} / p' q_{mi}, \alpha, \beta, \delta) + v_i^* - D_i^* \quad i = 1, 2, ..., N. \quad (22)$$

where D_i^* is a parameter associated with the incapability of the sample household in generating a revenue equal to the poverty line.

For the purpose of describing the poverty profile, Forster-Greer-Thornbecke or the FGT measures were used. Assuming the Cobb-Douglas functional form, the distance function can be expressed as:

$$1n\ D_{0i} = \alpha_0 + \Sigma_{m=1}^{M-1} \alpha_{mi} 1n\ q_{mi} + \Sigma_k^K =_1 \beta_k 1n\ x_{ki} \quad (23)$$

Imposing the restriction required for the homogeneity of degree +1 in output, $\alpha_1 + \alpha_2 = 1$ results in:

$$1n(D_{0i} / q_M) = \alpha_0 + \Sigma_{m=1}^{M-1} \alpha_{mi} In\ (q_{mi};/q_M) + \Sigma_k^K =_1 \beta_k In\ x_{ki}$$

$$-1n\ q_M = \alpha_0 + \sum_{m=1}^{M-1} \alpha_{mi} In(q_{mi};/q_M) + \sum_{k=1}^{K} \beta_k In\ x_{ki} - In\ D_{Oi} \quad (24)$$

The actual model will then be:

$$-InCrop = \alpha_o + \alpha_1 1n(\tfrac{Livestock}{Crops}) + \alpha_2 InArea + \alpha_3 InLabor$$

$$+\alpha_4 \text{ In } Fertilizer + \alpha_5 1nOxenPwr_i + \alpha_\delta InSeed_i - D_{oi} \qquad (25)$$

The stochastic frontier form of the output distance function is:

$$-InCrop = \alpha_o + \alpha_1 1n(\tfrac{Livestock}{Crops})_i + \alpha_2 InArea + \alpha_3 InLabor$$

$$+\alpha_4 \text{ In } Fertilizer_i + \alpha_5 1nOxenPwr_i + \alpha_\delta InSeed_i + \varepsilon_i - u_i \qquad (26)$$

The following are measurements of input and output variables used:

Area is the area of all plots operated by the i^th household, in hectare

$Livestocck_i$; is the value of livestock value and other incomes, in birr

Crops is value of all crops grown by the i^th household, in birr

Labor is measured in person days

Fertilizer is the cost of total Di-Ammonium Phosphate (DAP) and Urea fertilizers used by the i^th household, in birr

O*xenPwr* is the ox power used in the production of crops, measured in oxen days

Seed is the value of all seeds used in the production of all crops by the i^th household, in birr

The input distance function with the restriction of homogeneity of degree +1 in input can be expressed as:

$$-InArea = \alpha_0 + \alpha_1 1nLivestock_i + \alpha_2 InCrops_i + \alpha_3 In(\tfrac{\text{Labor}}{\text{Area}})_i + \alpha_4 In(\tfrac{\text{Fertilizer}}{\text{Area}})_i +$$

$$a_5 1n(\tfrac{\text{oxenPwr}}{\text{Area}})_i + \alpha_\delta In(\tfrac{\text{Seed}}{\text{Area}})_i + \varepsilon_i - u_i \qquad (27)$$

6. Result and Discussion

Demographic structure of households

Generally, education level is thought to be important in determining the living standard of people. Of the total sampled households, about 36% never attended a school and hence cannot read and write. The remaining 64% of the households could at least read, largely due to the Adult Literacy Campaign that had been launched by the previous regime in the 1970s and 1980s. Some of the households have also had a few years of formal education.

Table 1: Formal school attendance level in the sample households

Number of persons in a household	Formal education		Elementary school		Secondary school		Higher education	
	N	%	N	%	N	%	N	%
0	10	4.8	25	12.0	76	36.5	298	96.8
1-2	66	31.73	126	60.6	107	51.4	10	3.2
3-4	89	42.79	47	22.6	23	11.1	0	0.0
>5	43	20.67	10	4.8	2	1.0	0	0.0
	208	100.0	208	99.99	208	100	208	100

Although most households are illiterate, they may have at least 1–2 people who had attended or are attending formal education (Table 1). Nevertheless, there are very few households with a household member who has had formal school attendance in higher education.

Table 2: Family size of sample households

Variable	n	Mean	Std. Dev.	Min	Max
Male	208	3.27	1.38	1	8.00
Female	208	2.87	1.26	1	8.00
Total	208	6.11	1.84	1	13.00

As shown in Table 2, the average household size in the study area is 6 persons per households. This can have positive and negative effects on the welfare of the households. On the one hand, large household size can be considered an asset in the rural setting of the study areas as they supply labour for production, on the other hand it could be a liability if the ratio of active labour in the household is low and/or the marginal productivity of land is nearly zero or negative for various reasons.

Table 3: Land ownership types of the land operated by households in 2010

Variable	Obs	Mean area in ha	Std. Dev.	Min	Max
Owned	193	1.16	0.84	0.10	3.83
Rented-in	52	0.35	0.33	0.03	1.42
Rented-out	1	0.75	.	0.75	0.75
Shared-in	72	0.46	0.34	0.03	2.13
Shared-out	14	0.31	0.31	0.03	0.92
Borrowed	40	0.41	0.45	0.02	2.23

Table 3 describes the land tenure of the study area. Land is the key resource to farm households whose main livelihood is based on crop production. Land is a state-owned resource and farmers have only use-rights. As shown in the table, most farmers operate on owned land, but they also obtain land through renting and a share-cropping system. The average land holding is 1.2ha and there are about 15 landless sample farmers.

The land in the study area is not only very small, but that small piece of land is also highly fragmented and scattered across different locations of the PA (Table 4).

Table 4: Number of plots operated by households in 2010 cropping season

No. of plots operated	No. households	Per cent
1–3	25	12.0
4–6	112	53.8
7–9	56	26.9
More than 10	15	7.2
Mean number of plots	1.87	
Stand. Dev.	1.45	

The majority of sample households operate a large number of fragmented plots of land scattered across different locations of the PA. The survey result shows that, on average, a farmer travels about 7.5km to reach all the plots with a standard deviation of 6.9 km. Farmers also indicated that they acquire land through share-cropping and renting from neighbouring PAs. This could have a serious impact on the efficiency and timely operation of farm activities. Generally, most areas are highly undulated and there is almost no means of transportation.

Livestock holding and crop production

Livestock production in the study area is a complement to crop production. Households keep only a few livestock to supplement their income and to facilitate their farming activities. Unlike the three study districts and other parts of the country where farmers use ox as the only source of draught power in plowing land, farmers in Sekela District use primarily horses. On average, when livestock holding is expressed in terms of tropical livestock unit (TLU), sample households owned an average of 6.2 TLU with a standard deviation of 3.5 TLU. Deteriorating and common grazing land in all study areas is the major obstacle to livestock production.

Crop production is the major source of income and food. Farmers produce diversified food crops in any given year for various reasons, such as: the suitability of land, to meet the household's food demand, the interest of the land owner (for share-cropped land), to distribute the scarce resources of labour and ox power across seasons, and to minimize various risks. Factors such as price risk, production-related risk hazards and theft are some of the risk factors compelling farmers to produce diverse crops in any given year. Teff, wheat and maize are the dominant crop in all

Districts of the study areas, while barley and vegetables are widely cultivated in the highland areas of the sample Districts (mainly in Machakel and Sekela). In general, all the above crops are not location specific, except teff, which is dominantly grown in mid- to low altitude areas of the zones. On average, a household generates Birr13,696.6 per annum with a standard deviation of Birr9,226.9. In addition to crop and livestock production, sample households also participated in non-farm/off-farm activities. These activities' productivity in terms of value is shown in Table 5.

Table 5: Income earned from other non-farm income sources in 2010

Variable	Obs	Mean	Std. Dev.	Min	Max
Crafts	15	2918.5	4911.2	440.0	20000.0
Microbusiness	62	3011.5	4467.0	60.0	30000.0
Casual labour	33	3100.9	6583.3	30	36000.0
Wage	13	2323.4	1841.6	200.0	6050.0
Rent	10	686.9	837.8	18.8	2860.0
Sale of charcoal and wood	22	533.7	884.4	16.7	3000.0
Transfers from others*	7	126.3	59.3	66.0	200.0
Income from others sources	5	6316.0	8925.5	220.0	22000.0
Total non-farm/off-farm income	116	3569.8	6736.1	18.8	51600.0

* Note that transfer income is not considered non-farm income

As described in Table 5, farmers participate in many other non-farm/off-farm activities. About 53% of the sampled households participated in various non-farm activities. These activities serve as important sources of income to supplement their farm incomes. In particular, microbusiness activities and casual labour were important sources of income for many sample households. In addition, sales from charcoal and wood contributed a meagre amount to household income. Sample households indicated during the survey that these activities are expanding with the expansion of rural towns in recent years.

Farmers use fertilizer intensively and the use of fertilizer has been increasing over time. DAP and Urea fertilizers are the only fertilizers used in the area. They also make use of hired labour and ox power in peak cropping seasons. Table 6 presents the cash revenue and expenditures on input. The average net cash income earned by a farmer amounts to Birr11,840.4, with a range of Birr422.7 and Birr 90,733.0 for both minimum and maximum profits, respectively. Revenue from crops constituted the major portion of farmers' income, and livestock contributed only a small portion. On the cost side, fertilizer cost, mainly DAP, constituted the largest portion of total farm costs. Since livestock production is a supplement to crop production, the costs and revenue earned from it is much lower compared to crop production.

Table 6: Net cash income, revenues and cash expenditures

Variable	Obs	Mean	Std. Dev.	Min	Max
Net cash income from agri. activities	208	11840.4	9901.6	422.7	90733.4
Crop revenue (imputed price)	208	12569.6	8109.6	369.0	38269.2
Area operated	208	1.4	0.8	0.1	4.1
Livestock value revenue	175	704.5	1051.4	22.0	5600.0
Livestock value expense	199	306.0	444.9	2.0	2760.0
Rental cost	50	1617.1	1653.3	8.0	7000.0
Hired labour costs	89	376.6	543.1	20.0	4278.0
Fertilizer costs	208	2165.7	1468.9	60.0	6030.0
DAP costs	208	1145.1	847.8	30.0	5386.5
Urea costs	148	580.7	460.3	9.0	1942.5
Seed value	208	1419.7	982.6	69.3	5741.7
Total labour in person days	208	128.6	60.8	12.0	394.4
Total ox days	208	3.5	0.8	0.7	4.8

Analysis of poverty

An analysis of poverty starts with identifying the poor within the population of interest. The most common objective method of identifying the poor is by using a poverty line. The poverty line for a given individual can be defined as the money the individual needs to achieve the minimum level of "welfare" to not be deemed "poor", given the circumstances (Ravallion, 1994). This study combines the FEI and CBN approaches to compute the poverty line that defines the minimum "welfare".

Using the FEI method, the total calories a household derived from the consumption of food products was calculated. Using the daily calorie requirement developed by the FAO (2001) for each age and sex group, and taking the calorie requirement for moderate activity level, the study calculated the total calorie requirements for each sample household.

Table 7: Actual and required kcal consumption of sample households

Variable	N	Mean	Std. Dev.	Min	Max
Total calories consumed	208	23009.7	12887.9	2902.8	68715.1
Total calories required	208	14549.5	4529.2	4850.0	26550.0
Calorie deficiencies*	58	(5045.1)	3956.1	(17624.3)	(60.5)

* Refers to households whose calorie consumption falls below the required level

Table 7 shows the summary results of the computed actual calorie intake and required levels. The average actual calories consumed are more or less equal to the recommended 2,200 minimum calorie requirement level. However, there were wide variations across households as can be seen from the larger standard deviation of 12887.9kcal. Given the household size, age and sex of households, on average a household requires 14,549.5kcal with a standard deviation of 4,529.2kcal. The major source of energy in the rural areas is crops, particularly cereals. Survey results from the 1999 HICES survey indicates that the poorest half of the Ethiopian population obtains about two thirds of their calories from cereals (World Bank, 2005). As also shown in Table 7, 58 (27.9%) households were unable to meet the minimum recommended calorie requirement and hence could be identified as food-deprived households. The distribution of the food poverty level in the study area is shown in Table 8.

Table 8 summarizes the distribution of food poverty in the study area. When we compare food poverty between the two zones, sample households in West Gojjam are poorer than in East Gojjam. From the total 58 food-poor households, about 70% of households are found in West Gojjam. Of the total food-poor households, 46.6% are found in Sekela, 13% in Aneded and Burie and only 8.6% in Machakel. Note that the proportion of food-poor relative to the total sample was higher in Burie than in Aneded. However, this analysis is limited to food deprivation and does not reflect the overall poverty level of households. It is therefore important to include other basic non-food items to determine the overall poverty level of households. The CBN approach initially used by Rowntree (1901) and Orshansky (1965) and later developed by Martin Ravallion and others is the most commonly used approach. The approach stipulates a consumption bundle deemed to be adequate for basic consumption needs, and then estimates its cost for each of the subgroups being compared in the poverty profile. First, an estimation is made of the minimal food expenditure necessary for living in good health (in our case the recommended 2,200kcal) and then an analogous estimate of the required non-food expenditures is computed and added to the first estimation to yield a total poverty line.

Table 8: Distribution of food poverty level by zone and wDistrict

Zone	Poverty by zone					Poverty by wDistrict				Total	
	Poor		Non-poor		Districts	Poor		Non-poor			
	n	%	n	%		n	%	n	%	N	% of poor
East Gojjam	18	15.3	100	84.7	Aneded	13	21.7	47	78.3	60	22.4
					Machakel	5	8.6	53	91.4	58	8.6
West Gojjam	40	44.4	50	55.6	Burie	13	35.1	24	64.9	37	22.4
					Sekela	27	50.9	26	49.1	53	46.6
Total	58	27.9	150	72.1	Total	58	27.9	150	72.1	208	100.0

Following the same procedure, the study first estimated the average cost of acquiring one kcal in the study areas (see Tables A.2–A.4 in the Annex). This was done first by computing the total expenditure given the average quantities and prices, and then the expenditure was weighted by the proportion of expenditure to the total food expenditure. The total kcal consumption was derived based on the number of households consuming the product and the average quantity consumed by households. This total kcal was then weighted according to the proportion of kcal items comprising the total kcal. Finally, the aggregate weighted expenditure birr/year/hh was divided by the aggregate weighted kcal/year/hh. The result provides the cost of consuming one kcal, i.e. birr/kcal.

The estimated cost of one kcal was then multiplied by 2,200kcal per person per day – the minimum amount considered to be adequate for a healthy life –- to arrive at the cost of acquiring the minimum amount of food per person per day.

Table 9 summarizes the results of Tables A.2 to A.4 (see the Annex). Column (1) is the aggregate weighted expenditure per household per year and column (2) is the aggregate weighted kcal per household per year using current prices. Dividing column (1) by column (2) provides the average cost of acquiring one kcal (column (3). Multiplying this by the minimum requirement of 2,200kcal/head/day gives the minimum cost of food in birr per day per head (column (4). Multiplying column (4) by 30 days provides the monthly poverty line (column (5).

The next step is deriving the non-food expenditure. Based on the 2004 Ethiopian Household Expenditure Survey results, households in Amhara region spend 64.2% of their income on food items and the remaining 35.8% on non-food items. The non-food poverty line was then estimated based on this fixed proportion. The result shows that the average food poverty line of the study area is Birr119.6 per person per month and the non-food poverty line is Birr66.7 per person per month. The sum of the two provides the overall poverty line which is equal to 186.3 per person per month.

The next step was to compare the actual per capita consumption expenditure on food and non-food items with the poverty line to identify the poor from the non-poor. Table 10 describes the actual food (produced and purchased) and non-food per capita consumption expenditure per month. While the mean food

Table 9: Derivation of food and non-food poverty lines

District	Weighted expend. on food (birr/ household/ year[a] (1)	Weighted kcal per household per year[a] (2)	Average cost in birr/ kcal (3)	Cost of acquiring 2,200 kcal (birr) (4)	Food poverty line per month per head (5)=(4)*30	Non-food exp. (37.8%) (6)	Poverty line in birr (7)=(5) +(6)
Aneded	3173.8	1353257.2	0.0023	5.16	156.9	87.5	244.5
Machakel	2856.5	1595382.6	0.0018	3.94	119.8	66.8	186.6
Bure	3359.4	1992372.4	0.0017	3.71	112.8	62.9	175.7
Sekela	966.3	594823.5	0.0016	3.57	108.7	60.6	169.3
Overall	2708.1	1435225.0	0.0018	3.71	119.6	66.7	186.3

[a] The values are weighted according to the proportion of the various crops in the expenditure

consumption expenditure is higher than the estimated poverty line of Table 9, the mean per capita non-food expenditure is less than its estimated value. On average, about 88% the expenditure of households in the study area was on food and the remaining 12% was on non-food goods and services. There seems to be quite a variation when it is compared with the national survey result mentioned earlier.

The overall poverty incidence in the study area is 35.6 and is higher in the West Gojjam zone (Table 11). This is consistent with the result obtained using the FEI method. It was found that more than 50% of households in both districts of the West Gojjam zone were poor. The poverty gap provides somewhat different result vis-à-vis poverty incidence level. The poverty incidence and poverty gap are comparable in all except the Aneded District, where the poverty gap is higher than in other Districts. These measures of poverty are, however, relative. To see the absolute poverty level using the international standard of US$1 a day, the consumption expenditures were converted into US$ using the average annual official exchange rates. Table 12 shows that the absolute poverty level in both zones is much higher than the preceding relative poverty incidence. About 76% of the total sample households were found to be poor in absolute terms.

Table 10: Food and non-food expenditure in birr; households per annum in 2010

Per capita expenditure per month	N	Mean	Std. Dev.	Min	Max
Food expenditure	208	257.1	158.7	31.7	1009.3
Proportion of food expenditure	208	87.9	7.7	60.4	97.9
Non-food expenditure	208	33.9	28.8	2.2	152.0
Proportion of food expenditure	208	12.1	7.7	2.1	39.6
Food and non-food expenditure	208	291.1	173.8	36.7	1060.0
Food and non-food expenditure in US$*	208	.74	.4	.1	2.2

* Using the average annual official exchange rate of US$ 1 = Birr12.8909 (National Bank of Ethiopia, 2010)

Table 11: Distribution of food and overall poverty incidences using CBN method

Zone	Poverty by zone				Districts	Poverty by wDistrict				Total		Poverty gap	
	Poor		Non-poor			Poor		Non-poor					
	n	%	n	%		n	%	n	%	N	% (poor)	Mean	Std. Dev.
East Gojjam	24	20.3	94	79.7	Aneded	18	30.0	42	70.0	60	30.0	67.5	9.6
					Machakel	6	10.3	52	89.7	58	10.3	37.3	11.6
West Gojjam	50	55.6	40	44.4	Burie	21	56.8	16	43.2	37	56.8	30.8	5.6
					Sekela	29	54.7	24	45.3	53	54.7	59.2	7.2
Total	74	35.6	134	64.4	Total	74	35.6	134	64.4	208	35.6	51.4	4.4

Table 12: Absolute poverty level in the zones using US$1 per day

Zone	Poor		Non-poor		Total
	n	%	n	%	N
East Gojjam	75	63.6	43	36.4	118
West Gojjam	84	93.3	6	6.7	90
Total	159	76.4	49	23.6	208

Subjective measurement methods were also used in the study to compare the results obtained using the objective measures. Sample households were asked to indicate if their current food consumption was adequate or not. As shown in Table 13, about 26.5% of households indicated that their food consumption was not adequate. This result was consistent with the result obtained using objective poverty measures as there was no significant difference between the proportions of the two results.

Table 13: Adequacy of food to sample households, 2010

Adequacy of food for the household	N	%
Less than adequate	56	26.5
Just adequate	141	66.8
More than adequate	14	6.6
Total	211	100.0

Households were also asked about their perception of being poor or rich. Although the response rate was low, households considered working hard and access to resources as the main reasons for being rich (Table 14). The ranking of respondents showed working hard as the primary source of being rich, which can indicate the role of inefficiency in determining the poverty status of households in the study areas. Similarly, households rated failure to work hard as the primary reason for being poor (Table 15). Access to resources was rated as the second main reason for being poor. This result, however, suggests that resource endowment is not the primary source of poverty but one of the important factors, hence strongly supporting the original proposition of this research. Other reasons were, however, given less emphasis by sample households.

Table 15 shows that the primary reasons for being poor, as indicated by the perception of households, were failure to work hard, lack of resources, not using improved technologies and management incompetence, in descending order of importance. All these are important indications that inefficiency in the use of existing resources was an important source of poverty of farm households. Nevertheless, there is a need for further evidence on whether a link exists between inefficiency and poverty, which is the main purpose of this study.

Analysis of efficiency

The study estimated the efficiency levels of households using the stochastic distance frontier method. The stochastic distance function is suited to considering multiple-output and multiple-input cases. Due to missing data problems (as all farmers do not grow all crops in any given year), all crops were aggregated into one – value of crops. This reduced the output variables to two: crops, and livestock plus others. Since the parameter estimates are not affected by the choice of the normalizing output (Coelli and Perelman, 2000), value of crops was used as a normalizing variable.

Table 14 Descriptive assessment of households' perception for being rich

Perception of households about reason for being rich	First main reason		Second main reason		Third main reason	
	n	%	n	%	n	%
Hard working	42	65.63	4	19.0	2	13.3
Have more resources	14	21.88	5	23.8	2	13.3
Have better technology access	4	6.25	5	23.8	6	40.0
Good at saving	4	6.25	1	4.8	4	26.7
External assistance			1	4.8		
Educated			3	14.3		
Lucky			2	9.5	1	6.7
Total	64	100	21	100	15	100

Table 15: Descriptive assessment of households' perception for being poor

Perception of households abou causes leading to poverty	First main causes		Second main causes		Third main causes	
	n	%	n	%	n	%
Fail to work hard	90	51.7	6	9.1	1	3.0
Lack resources	67	38.5	36	54.6		
Not using improved technologies	6	3.5	5	7.6	8	24.2
Lack saving culture	1	0.6	8	12.1	19	57.6
Risk aversion and management incompetence	6	1.2	7	3.0		
Unlucky	1	0.6	2	3.0		
Other	3	1.7	2	3.0		
Total	174	100	66	100	33	100

To identify relevant input variables, the plot of the distribution of variables with the dependent variable was inspected (see Figure A3 in the Annex). All variables seem to have a correlation with the dependent variable (value of crops).

Table 16 presents the ordinary least square (OLS) results of the input distance function while using variables provided in Equation 27. As shown in the table, all the independent variables (i.e.the value of livestock per value of crops and the input variables), with the exception of ox power, were found to be significant. The question then is whether the production structure can be represented by this average response function (OLS regression) or by the stochastic frontier distance function (SFDF) as a result of production inefficiency. This question is answered by comparing the estimation results of the SFD function with the OLS regression using a log-likelihood ratio (LR) result given by:

$$LR = -2[LLR_0 - LLR_1] = -2[-127.1 - (-122.5)] = 9.3 \tag{28}$$

The test result shows that there is inefficiency among producers in the study area because the LR of 9.3 is greater than the table chai-square value of 6.63 at a 1% significance level. It follows that the stochastic distance function explains the production differentials observed among farmers in the study areas more adequately.

Table 16: Result of OLS regression of the input distance function

Negative of Ln value of crops	Coef.	Std. Err.	t-value
Constant	-4.738***	0.57	-8.28
Ln of livestock & nonfarm value per crop value	0.297***	0.04	6.94
Ln of plot size value	-0.167*	0.08	-2.01
Ln of labor	-0.294***	0.09	-3.42
Ln of ox power	0.051	0.04	1.16
Ln of fertilizer	-0.313***	0.05	-6.71
Ln of seed value	-0.142***	0.04	-3.37
R-squared	0.670		
Adj R-squared	0.66		

log likelihood function = -127.1

The results of the variable return to scale (VRS) and constant return to scale (CRS) specifications of the SFDF in Tables 17 and 18 shows that all the independent variables, except ox power, determine distance function. The positive coefficient value of livestock and non-farm income indicates the competitiveness between crop production and livestock enterprises for the given input factors. This implies that there is trade-off between crop production, and livestockand other non-farm activities. However, to see if normalizing all variables by one of the input variables will impose a restriction on the return to scale, the constant return to scale specification of the SFDF was ran while a test result using the log-likelihood ratio was carried out for both specifications (VRS and CRS) to determine which of the specifications best explained the production behaviour of farmers.

Table 17: Result of the SFDF under VRS specification

Negative of crop value	Coeff.	Std. Dev.	t-value
Cons.	-5.482***	0.55	-9.91
Ln of livestock & non-farm per crop value	0.255***	0.05	5.60
Ln of plot size value	-0.176**	0.07	-2.36
Ln of labour	-0.339***	0.08	-4.13
Ln of ox power	0.055	0.04	1.41
Ln of fertilizer	-0.245***	0.04	-5.46
Ln of seed value	-0.125***	0.04	-3.42
sigma-squared	0.425***	0.07	5.6
gamma	0.834***	0.08	11.09

log likelihood function = -122.5

Table 18: Result of the SFDF under CRS specification

Negative of crop value per ha	Coeff.	Std. Dev.	t-value
Constant	-4.097***	0.56	7.38
Ln of livestock & non-farm value per crop value	0.267***	0.04	-6.62
Ln of labour per ha	-0.368***	0.08	4.67
Ln of ox power per ha	-0.044	0.04	-1.01
Ln of fertilizer per ha	-0.319***	0.05	6.90
Ln of seed value per ha	-0.172***	0.04	4.30
sigma-squared	0.281***	0.03	10.64
gamma	0.000	0.01	0.00

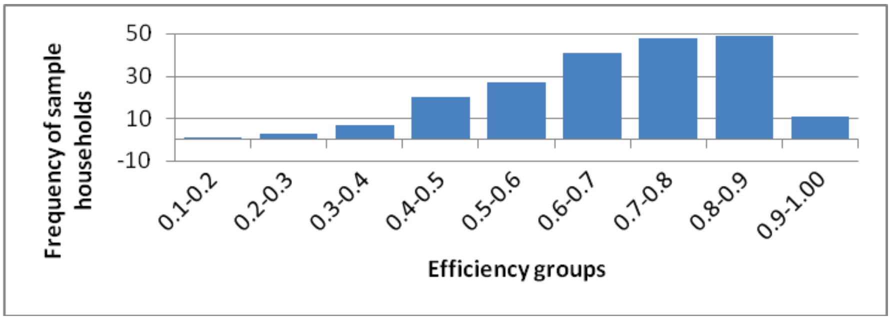
log likelihood function = -130.1

The result of the LR test (calculated value of 15.2 and critical chi-square value of 6.63, as per Equation 29) which was significant at the 1% level led to the rejection of the null hypothesis, which states that the production structure exhibits CRS. This implies that the VRS specification better explains the production structure of the sample farmers.

$$LR = -2[LLR_0 - LLR_1] = -2[-130.1 - (-122.5)] = 15.2 \quad (29)$$

Using the VRS specification, the efficiency level of individual farmers was estimated. The result shows that there was substantial inefficiency variation among farmers. The mean technical efficiency was found to be 62.8%, implying that farmers in the study areas have the potential to increase output by 37.2% without increasing the existing levels of input. The distribution of inefficiency among farmers is shown in Figure 2.

Figure 2: Technical efficiency distributions of sample households



As Figure 2 shows, the majority of sample households fall in efficiency range levels of between 0.6 and 09. More than 70% of households scored below the 0.8 efficiency level and only a few scored higher than 0.9. Suppose households have the potential to increase output without increasing the existing level of inputs, the question is then what will the implications be for poverty. This requires firstly assessing what relationships exist between poverty and efficiency. If a relationship does exist between efficiency and poverty, it can be hypothesised that households could get out of poverty just by improving their efficiency. Using the classical mean comparison t-test, a test was carried out to see whether or not efficiency has a relation to poverty. Based on the test score presented in Table A.5 (see the Annex), it can be concluded that significant differences exist in the mean efficiency levels between the poor and non-poor households. As shown in Table 19, the mean efficiency of non-poor households was significantly higher than those of poor households at a 1% significance level.

Table 19: Comparison test of mean efficiency between poor and non-poor households

Group	n	Mean	Std. Err.	Std. Dev.
Non-poor	134	0.744	0.01	0.13
Poor	74	0.583	0.02	0.17
Combined	208	0.686	0.01	0.16
diff		0.161	0.02	t = 7.81

The logistic regression result (Table 20) using poverty as a dependent variable and the level of estimated efficiency scores as independent variable, reveals a similar result as described in the preceding table.

Table 20: Result of the logistic regression on poverty and efficiency

Poor or non-poor	Coef.	Std. Err.	z
Efficiency levels	-7.279***	1.19	-6.13
Constant	3.918***	0.74	5.26
LR chi2(1)	50.58		
Prob> chi2	0.000		
Pseudo R2	0.187		

The result in Table 20 shows that there is a strong association between poverty and efficiency levels. For instance, one can predict that the average risk of being poor may decrease by about 4% if a household can improve its efficiency by 10%. However, the relationship between poverty and efficiency does not rule out the fact that households will get out of poverty just by attaining a 100% efficiency level. This is because the percentage of observed output differentials among farmers is attributed to inefficiency. And given that the gamma value of 0.834 cannot be directly interpreted as the percentage of deviation from the frontier that can be attributed to inefficiency[1], accordingly it can be calculated that from the observed total deviation of output from the frontier, 65% of the deviation is attributed to inefficiency and the remaining 35% to noise.

To see the potential contributions of possible improvements in technical efficiency to the reduction of the poverty gap, the poverty-equated net income proposed in Equation 15 was computed. This poverty-equated net income is a net income that a household identified as poor needs to generate from production activities in order for the household to get out of poverty. The summary of this computed value is provided in Table 21.

Table 21: Summary of poverty-line equated net income of poor households

	n	Mean	Std. Dev.	Min	Max
Poverty-equated net income	74	15298.4	7510.2	-23395.7	32780.4
Actual net-income'	74	9352.4	7124.5	369	43336
Poverty-equated net income	74	5946.0	8618.3	-42412.1	19254.9

On average, poor households need to generate more than Birr152,98.4 per annum (Table 21) from production activities for them to be above the poverty line and to be deemed not so poor. The negative minimum value was only for those individuals who were able to generate sufficient income (have positive income gap), but whose consumption expenditures were found to be below the minimum levels. These households may not be considered poor according to the capability approach that was introduced by Sen (1992).

1. $\gamma^* = \gamma/[\gamma+(1-\gamma)\pi/(\pi-2)]$. This is because the variance of u_i is equal to $[(\pi-2)/\pi]\sigma^2$ not σ^2(Coelli et al., 1998).

Given the estimated poverty-line-equated net income in Table 21, it is possible to see the income gap that a household needs in order to meet its minimum basic needs. The simulated result in Table 22, obtained by improving the efficiency of households, shows by what percentage households could get out of their poverty. This demonstrates the potential impact of improving efficiency on the poverty incidence of sample households, assuming that the causes of inefficiency are known and that investments are made to improve efficiency.

Table 22: Simulation result of the impact of efficiency improvement on poverty

Percentage improvement in efficiency	Poor (n=74)	%	% reduction in poverty
Inefficient but have sufficient income*	10		
Given current inefficiency	64	100.0	0.0
10%	63	98.4	1.6
20%	58	90.6	9.4
25%	55	84.4	14.1
30%	54	85.9	15.6
40%	49	76.6	23.4
50%	44	68.8	31.3
75%	31	48.4	51.6
90%	23	35.9	64.1

*Not so poor in terms of income gap

The first row shows the number of households who were identified as poor by the consumption measure of poverty, but who were able to generate sufficient income. These households may not be considered poor in the real sense. The remaining 64 households lack the necessary income and hence face a positive income gap. If all poor households reduce their inefficiency by 10%, the poverty incidence will decline by 1.6%. Similarly, if they reduce their current inefficiency by 25%, 14.1% of poor households will get out of their poverty. A 50% reduction in inefficiency results in a 31.3% decline in poverty, and so on. This result shows the important potential effect of efficiency improvement in reducing poverty.

7. Conclusion

The result obtained from objective approaches to poverty measurement, (the FEI and CBN approaches) and other self-rated subjective poverty measures revealed that the levels of poverty were generally high in the study areas. The level of food poverty measured using the FEI and self-rated measures was found to be 28% and 27%, respectively. On the other hand, while 35.6% of the households were found to be poor in relative terms (using the CBN approach), 76.4% were found to be poor in terms of the one-dollar-a-day absolute measure of poverty. Whereas there was a statistically significant difference between the objective measure of food poverty using FEI and self-rated subjective judgements of respondents, the general poverty measure using CBN and self-rated subjective measures were found to be different at a 10% significance level. Moreover, test results from the poverty results obtained under subjective and objective approaches shows that the result of subjective measures is highly sensitive to the type of question asked. The study also found that the level of poverty was generally higher in the West Gojjam zone than in East Gojjam, while differences exist in the level of poverty between the sample Districts.

The VRS specification revealed that all input variables except ox power significantly determined the efficient level of output. The estimated mean efficiency was found to be 62.8%, indicating that a substantial technical inefficiency exists among farmers in the study areas. Of the total deviation of the actual output from the frontier, 65.5% of the deviation was due to inefficiencies and the remaining 35% due to noise. While the mean efficiency score of non-poor households was found to be 74.4%, it was only 58.3% for poor households. This result implies that households that have equal access to land and other inputs, could differ in their poverty levels. More respondents rated inefficiency than access to resources as an important source of poverty. The logistic regression also revealed that efficiency levels significantly explain poverty levels, while the prediction of the marginal effects of a 10% improvement in efficiency reduces the probability of being poor by about 4%. Simulation results of the effect of improved efficiency on poverty indicates that 14.1% of the poor households could get out of poverty by attaining a 25% improvement in their existing efficiency levels, while a 90% improvement in efficiency could result in a reduction of poverty by about 64.5%, implying that other sources of poverty such as access to resources, technologies, markets could also have an important effect. We can therefore safely conclude that other than access to resources, the efficiency in using existing resources is equally important in explaining poverty. The policy implication is that improving access to resources without ensuring their efficient utilization would not have the desired impact in reducing poverty.

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Annex

Figure A1: Per capita expenditure per month in birr, 2010

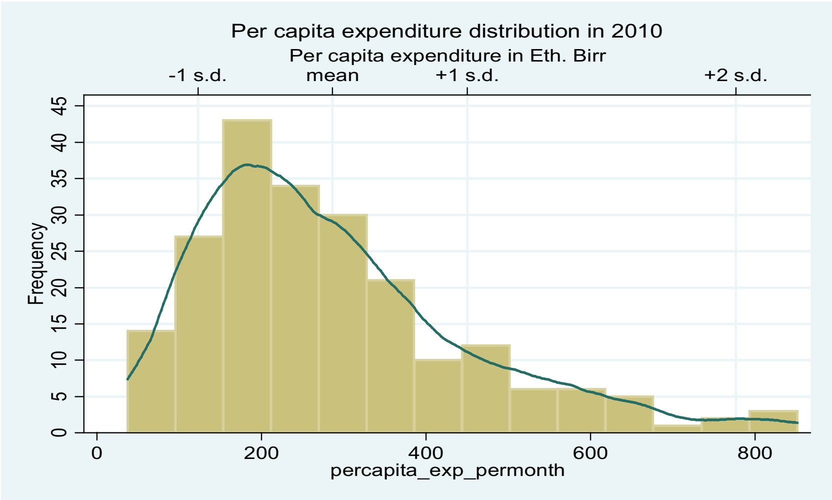

Figure A2: Absolute p**overty distribution of the two z**ones

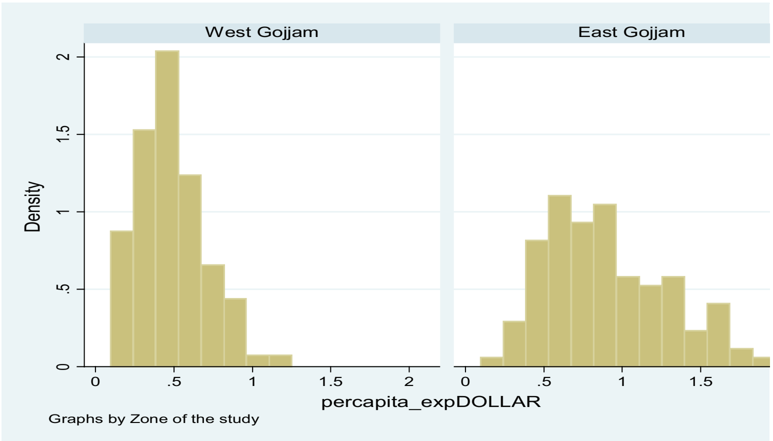

Table A1: Calories by age and sex groups

Age group (years)	Average kcal per day Male	Female
<1	650.0	600
1–2	950.0	850
2–3	1125.0	1,050
3–4	1250.0	1,150
4–5	1350.0	1,250
5–6	1475.0	1,325
6–7	1575.0	1425.0
7–8	1700.0	1550.0
8–9	1825.0	1700.0
9–10	1975.0	1850.0
10–11	2150.0	2000.0
11–12	2350.0	2150.0
12–13	2550.0	2275.0
13–14	2775.0	2375.0
14–15	3000.0	2450.0
15–16	3175.0	2500.0
16–17	3325.0	2500.0
17–18	3400.0	2500.0
18-30	3050.0	2375.0
30-60	3000.0	2375.0
>60	2475.0	2125.0

This annex presents updated average energy requirements recommended by the 2001 expert consultation on human energy requirements convened by the United Nations University, the World Health Organization, and the Food and Agriculture Organization of the United Nations. The requirements are meant to be applied to population groups, not individuals. Those for older children, adolescents, and adults are reported for three activity levels – light, moderate, and heavy – which are defined in the consultation report (UNU, WHO, and FAO 2004), available on the Internet.

Figure A3: Correlation plot between input and output variables

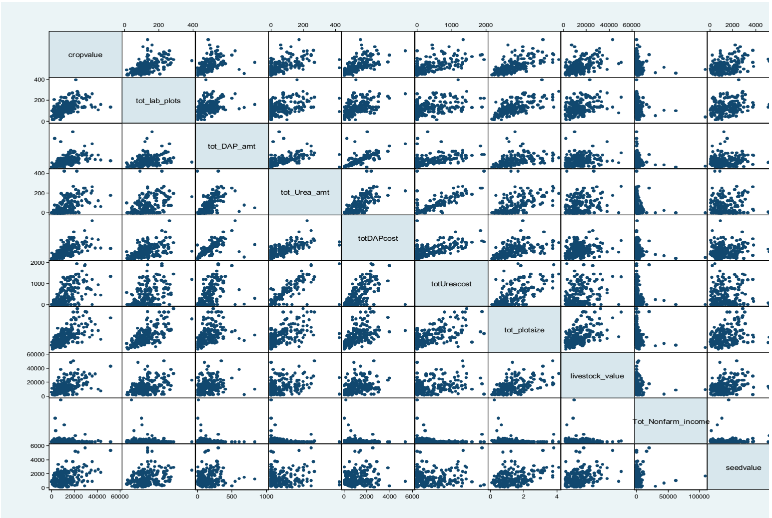

Table A2: Kcal conversion factors for major crops

No.	Crop/livestock product	Kcal/100g
1	Teff	350
2	Barley	365
3	Wheat	346
4	Maize	342
5	Sinar/oat	365
6	Millet, raw	350
7	Horse bean	347
8	Pea	315
9	Chick pea	315
10	Potato	97
11	Guaya/vetch	315
12	Onion	50

Table A 3 Description of consumption bundle by households of major crop products

District	Aneded=59			Machakel=37			Burie=36			Sekela=52		
	n	mean	sd	n	mean	sd	n	mean	sd	n	mean	sd
Whte_teff	37	1117.6	625.8	1	1000.0	.	14	310.5	200.4	0	.	.
Mixed_teff	24	1115.7	758.4	55	579.1	271.4	15	420.3	113.5	39	105.3	67.3
Barley	13	883.2	559.3	9	433.3	308.2	2	117.0	117.4	23	111.3	90.9
Wheat	51	694.7	609.8	42	381.7	272.7	25	601.7	376.2	39	250.5	250.8
Maize	48	529.3	374.5	47	953.6	881.9	33	1325.2	1148.2	51	237.1	134.8
Sinar	20	987.9	571.6	48	934.4	554.4	0	.	.	19	117.5	103.2
Millet	0	.	.	7	292.9	179.0	26	494.2	324.1	8	54.7	25.5
Horse bean	3	193.4	230.4	45	398.6	1340.0	15	71.0	30.0	16	25.8	12.6
Peas	12	571.2	563.9	13	7.5	4.5	1	50.0	.	33	39.7	30.3
Chickpea	0	.	.	3	135.0	150.6	7	405.0	595.6	0	.	.
Potatoes	7	337.6	468.1	31	933.9	722.2	2	783.3	117.8	46	1390.8	1032.4
Guaya/vetch	4	31.0	46.4	10	318.3	596.3	17	71.0	26.8	7	130.1	65.6
Onion	28	25.1	15.5	41	78.2	192.0	10	53.4	51.4	39	51.2	105.8

Table A 4 Computation of average cost of kcal

Crop product	Kcal/100g	Average prices		Aneded						Machakel					
		East	West	Expend.	Weight for exp.	Weighted exp.	Total Kcal/kg	Weight for kcal	Weighted tot kcal	Expend.	Weight for exp.	Weighted exp.	Total Kcal/kg	Weight for kcal	Weighted tot kcal
Teff	350	7.36	7.79	304.4	0.3	88.5	115.8	0.2	28.5	7.4	0.0	0.1	2.8	0.0	0.0
Teff	350	7.18	6.75	192.2	0.2	35.3	75.0	0.2	11.9	228.6	0.2	51.3	89.2	0.2	16.2
Barley	365	5.49	5.49	63.1	0.1	3.8	33.5	0.1	2.4	21.4	0.0	0.5	11.4	0.0	0.3
Wheat	346	5.70	4.80	201.8	0.2	38.9	98.1	0.2	20.4	91.3	0.1	8.2	44.4	0.1	4.0
Maize	342	4.24	4.83	107.8	0.1	11.1	69.5	0.1	10.3	190.2	0.2	35.5	122.6	0.3	30.7
Sinar/oat	365	4.76	2.38	94.1	0.1	8.5	57.7	0.1	7.1	213.6	0.2	44.8	131.0	0.3	35.0
Millet, raw	350	2.92	2.92		0.0			0.0	0.0	6.0	0.0	0.0	5.7	0.0	0.1
Horse bean	347	7.69	6.50	4.5	0.0	0.0	1.6	0.0	0.0	137.9	0.1	18.7	49.8	0.1	5.1
pea	315	9.88	9.88	67.7	0.1	4.4	17.3	0.0	0.6	1.0	0.0	0.0	0.2	0.0	0.0
Chick pea	315	6.41	7.00		0.0	0.0		0.0	0.0	2.6	0.0	0.0	1.0	0.0	0.0
Potato	97	2.67	2.24	6.3	0.0	0.0	1.8	0.0	0.0	77.4	0.1	5.9	22.5	0.0	1.0
Guaya/vetch	315	6.17	6.17	0.8	0.0	0.0	0.3	0.0	0.0	19.6	0.0	0.4	8.0	0.0	0.1
Onion	50	6.87	6.87	4.8	0.0	0.0	0.3	0.0	0.0	22.0	0.0	0.5	1.3	0.0	0.0
	Total			**1047.6**	**1.0**	**190.4**	**470.9**	**1.0**	**81.2**	**1019.0**	**1.0**	**165.7**	**489.9**	**1.0**	**92.5**

Adapted from http://sites.google.com/site/foodcaloriesandnutrition/

..cont

Crop product	Kcal/100g	Average prices		Burie						Sekela					
		East	West	Expend.	Weight for exp	Weighted exp.	Total Kcal/kg	Weight for kcal	Weighted kcal	Expend.	Weight Exp.	Weighted exp.	Total Kcal/kg	Weight for kcal	Weighted kcal
Teff	350	7.36	7.79	33.9	0.0	0.0		0.0	0.0		0.1	2.6	12.2	0.1	0.6
Teff	350	7.18	6.75	42.6	0.1	2.8	11.5	0.1	0.9	27.7	0.1	4.1	17.7	0.1	1.3
Barley	365	5.49	5.49	1.3	0.1	0.7	7.5	0.1	0.4	14.1	0.0	0.0	0.7	0.0	0.0
Wheat	346	5.70	4.80	72.3	0.2	8.1	27.0	0.2	5.1	46.9	0.2	11.8	41.6	0.2	7.1
Maize	342	4.24	4.83	211.4	0.2	12.6	33.1	0.2	7.6	58.4	0.5	101.4	119.6	0.5	59.0
Sinar/oat	365	4.76	2.38		0.0	0.1	6.5	0.0	0.3	5.3	0.0	0.0		0.0	0.0
Millet, raw	350	2.92	2.92	37.5	0.0	0.0	1.2	0.0	0.0	1.3	0.1	3.2	36.0	0.1	5.3
Horse bean	347	7.69	6.50	6.9	0.0	0.0	1.1	0.0	0.0	2.7	0.0	0.1	3.0	0.0	0.0
pea	315	9.88	9.88	0.5	0.0	0.6	3.3	0.0	0.1	13.0	0.0	0.0	0.1	0.0	0.0
Chick pea	315	6.41	7.00	19.8	0.0	0.0		0.0	0.0		0.0	0.9	7.1	0.0	0.2
Potato	97	2.67	2.24	3.5	0.3	25.4	49.6	0.3	17.1	83.2	0.0	0.0	1.2	0.0	0.0
Guaya/vetch	315	6.17	6.17	7.4	0.0	0.1	2.3	0.0	0.0	5.6	0.0	0.1	3.0	0.0	0.0
Onion	50	6.87	6.87	3.7	0.1	0.7	0.8	0.0	0.0	13.7	0.0	0.0	0.2	0.0	0.0
	Total			**440.7**	**1.0**	**51.2**	**144.0**	**1.0**	**31.5**	**271.9**	**1.0**	**124.3**	**242.5**	**1.0**	**73.7**

Table A5 Technical efficiency estimates of sample households

No	Effic. score	No	Effic. score	No	Effic. score	No	Effic. score	No	Effic. score	No	Effic score
1	0.614	41	0.837	81	0.854	121	0.510	161	0.838	201	0.44[illegible]
2	0.619	42	0.845	82	0.645	122	0.841	162	0.560	202	0.83[illegible]
3	0.873	43	0.883	83	0.718	123	0.427	163	0.867	203	0.48[illegible]
4	0.766	44	0.721	84	0.830	124	0.613	164	0.191	204	0.43[illegible]
5	0.688	45	0.846	85	0.885	125	0.871	165	0.559	205	0.54[illegible]
6	0.892	46	0.731	86	0.671	126	0.828	166	0.475	206	0.32[illegible]
7	0.566	47	0.810	87	0.592	127	0.700	167	0.773	207	0.43[illegible]
8	0.679	48	0.798	88	0.744	128	0.444	168	0.848	208	0.48[illegible]
9	0.795	49	0.505	89	0.734	129	0.869	169	0.891		
10	0.635	50	0.688	90	0.923	130	0.346	170	0.730		
11	0.743	51	0.893	91	0.527	131	0.854	171	0.474		
12	0.729	52	0.786	92	0.774	132	0.799	172	0.640		
13	0.824	53	0.822	93	0.807	133	0.956	173	0.782		
14	0.591	54	0.742	94	0.842	134	0.633	174	0.573		
15	0.728	55	0.923	95	0.815	135	0.592	175	0.835		
16	0.731	56	0.904	96	0.727	136	0.678	176	0.507		
17	0.478	57	0.666	97	0.580	137	0.694	177	0.972		
18	0.800	58	0.656	98	0.656	138	0.589	178	0.880		
19	0.821	59	0.856	99	0.598	139	0.863	179	0.837		
20	0.654	60	0.791	100	0.645	140	0.489	180	0.622		
21	0.767	61	0.817	101	0.759	141	0.588	181	0.504		
22	0.722	62	0.819	102	0.615	142	0.548	182	0.761		
23	0.833	63	0.866	103	0.676	143	0.604	183	0.893		
24	0.828	64	0.787	104	0.785	144	0.637	184	0.288		
25	0.832	65	0.694	105	0.710	145	0.654	185	0.357		
26	0.444	66	0.734	106	0.720	146	0.770	186	0.562		
27	0.486	67	0.649	107	0.786	147	0.278	187	0.258		
28	0.699	68	0.923	108	0.604	148	0.698	188	0.350		
29	0.376	69	0.732	109	0.651	149	0.856	189	0.333		
30	0.731	70	0.832	110	0.942	150	0.666	190	0.743		
31	0.638	71	0.738	111	0.561	151	0.852	191	0.306		
32	0.409	72	0.913	112	0.475	152	0.863	192	0.914		
33	0.758	73	0.653	113	0.607	153	0.747	193	0.482		
34	0.808	74	0.797	114	0.749	154	0.653	194	0.630		
35	0.581	75	0.760	115	0.724	155	0.608	195	0.787		
36	0.492	76	0.544	116	0.562	156	0.403	196	0.854		
37	0.918	77	0.521	117	0.813	157	0.830	197	0.610		
38	0.826	78	0.748	118	0.651	158	0.920	198	0.444		
39	0.421	79	0.772	119	0.535	159	0.686	199	0.553		
40	0.761	80	0.696	120	0.668	160	0.855	200	0.597		