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Demand and perception of fertilizer - among small-holder farmers in Kenya
Småskaliga kenyanska bönders efterfrågan av, och uppfattning om, mineralgödsel

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Uppsala, June 14 2012

Madelene Casselbrant & Siri Lindqvist Ståhle

Abstract

Hunger is a problem in some parts of the world (www, FAO 1, 2012). The lack of food is often a result of insufficient knowledge in soil fertility management (Röing de Nowina, 2012). Ongoing hunger and malnourishment are quite prevalent in Sub-Saharan Africa and are often combined with poverty (www, FAO 1, 2012). Farming is the most common occupation in this area and the farms are often small-scale farms with subsistence crops and a few cattle. The farmers who operate these small-scale farms are economically a weak group. They do not have a steady income, as one example. Additionally, in Sub-Saharan Africa, there is a problem with a negative soil nutrient balance; which means that more nutrients are taken from the soil than what is added (FAO, 2003). The lack of nutrients could be related to the economic situation of the farmers, whom often do not have the economic means to buy inputs, such as chemical fertilizer (Ariga *et al.*, 2008).

The overall main objective in this study is to get comprehension for the economic situation for small-holder farmers in Kenya. The specific objectives are to determine what influence their perception on different methods to improve soil fertility and their willingness to pay, (WTP), for the fertilizer Diammonium Phosphate, DAP. The reasons behind the use of a certain product method are such as the factor demand and the profit maximization problem. However this is not expected to give the whole picture, but only a part of the explanation. Therefore the perceived value of a method, from the farmers' perspective, will as well be taken into consideration.

The method chosen for the study was empirical interviews; 27 farmers in Central Kenya, Embu, and 29 farmers in Western Kenya, Bondo, participated in the study. The basis for the interviews was a questionnaire in which the farmers were to relate to different statements about soil fertility management. During the interviews a payment card was also presented to the farmers. Through the payment card the farmers' WTP for DAP was measured.

The farmers in Embu gave a high importance to the combined use of chemical fertilizer and livestock manure. These two methods were the most frequently used in the area. In Bondo, on the other hand, the highest importance was from the use of crop residues for mulching and from crop rotation with legumes. The most used technologies were the use of livestock manure and crop residues, whereas chemical fertilizer was rarely used in the area.

The WTP for DAP was determined to be 44 Ksh/kg which is about half of the actual price in year 2012; however, the farmers in Embu could not afford to use a sufficient amount for their farming. Nevertheless, they could afford to use a small amount. In Bondo nearly none of the farmers could afford any use of the fertilizer.

How the farmers perceive a certain method to improve soil fertility depends on their economic situation, the effort connected to the use of the method, the supply of the input and the knowledge about the method. Those factors are assumed to have an impact on the demand of an input.

Sammanfattning

I vissa delar av världen är hunger ett ofta förekommande problem (www, 1 FAO, 2012). Svåra produktionsvillkor samt avsaknad av, eller otillräcklig teknik för, god markbördighet är i många fall bakomliggande orsaker till bristen på mat (Röing de Nowina, 2012). I Afrika söder om Sahara är det vanligt att inte kunna äta sig mätt varje dag. Hunger är ofta kombinerat med fattigdom (www, 1 FAO, 2012). En stor andel av befolkningen i denna region har jordbruk som huvudsaklig sysselsättning. Gårdarna är ofta små med grödor för självhushåll och ett fåtal djur. Dessa jordbrukare är en ekonomisk svag grupp. De har ofta ingen regelbunden inkomst och saknar, i stor utsträckning, likvida medel. Ett vanligt problem i området är även negativ näringsbalans i marken, vilket betyder att mer näring tas från jorden än vad som tillsätts (FAO, 2003). Bristen på näringsämnen kan kopplas till den finansiella situationen för bönderna, de har inte ekonomisk möjlighet att köpa insatsvaror som mineralgödsel (Ariga *et al*,. 2008).

Fokus i denna studie är småskaliga jordbrukare i Kenya och deras ekonomiska situation. Syftet var att fastställa orsaken bakom böndernas val av olika markförbättrande tekniker samt deras betalningsvilja för gödningsmedlet diammonium fosfat, DAP. Bakomliggande orsaker tros vara faktorefterfrågan och vinstmaximeringsproblem. Detta tros dock inte vara hela bilden. Därför studerades även böndernas uppfattning om olika metoder för god markbördighet. Det övergripande syftet med studien var att förstå den ekonomiska situationen för småskaliga jordbrukare i Kenya.

Den metod som valdes för studien var empiriska intervjuer. 27 jordbrukare i Embu i centrala Kenya och 29 stycken i Bondo i västra Kenya deltog i studien. Intervjun baserades på en enkät där bönderna i en del fick relatera till olika påståenden kring arbete för god markbördighet. En annan del av intervjuerna utgjordes av ett payment-card. Detta användes för att mäta jordbrukarnas betalningsvilja för gödningsmedlet DAP.

Bönderna i Embu såg ett stort värde av ett kombinerat användande av mineralgödsel och stallgödsel. Dessa var även de två mest använda metoderna i området. I Bondo ansåg bönderna att det högsta värdet uppnåddes då växtrester användes som marktäckare samt när en växtföljd med baljväxter applicerades. De mest använda insatsvarorna för en god markbördighet var stallgödsel och växtrester.

Betalningsviljan för DAP fastställdes till 44 Ksh/kg, vilket är omkring hälften av det aktuella marknadspriset år 2012. Bönderna i Embu kunde använda en liten mängd mineralgödsel, men hade inte råd att använda den mängd som egentligen skulle behövas på gården. I Bondo hade nästan ingen av bönderna råd att överhuvudtaget använda mineralgödsel.

Hur bönderna uppfattade en viss metod för att förbättra markbördigheten påverkades av deras ekonomiska situation, graden av arbete som krävs för att applicera metoden, tillgången på insatsvaran samt kunskap om metoden. Dessa faktorer tros ha en påverkan på efterfrågan av en insatsvara.

Abbreviations & Terminology

Abbreviations

CIAT	International Centre for Tropical Agriculture
CV-method	Contingent Value-method
DAP	Diammonium Phosphate; 18 % nitrogen, 46 % phosphoric acid (www, IPNI, 2012)
GDP	Gross Domestic Product
Ksh	Kenyan Shilling
Sida	Swedish International Development Cooperation Agency
SLU	Swedish University of Agricultural Sciences
WTP	Willingness To Pay

Terminology

Acres	measurement for area; 1 acre equals approximately 0,41 hectare (www, metric-conversions, 2012)
Agriculture extension officer	provides consultation for farming-improvements and sells agro-industrial products
Agro-industrial by-products	rest-products from agro-industrial factories, such as coffee husks from coffee factories
Chemical fertilizers	industrially compounded fertilizer, applied to increase soil fertility
Crop residues	parts of crops that are rest-products from the harvest
Crop rotation	the rotation of crops from one field to another between seasons
Fallow cropping	leaving a field to rest for some time so that the land will recover nutrients
Green manure	crops that contributes nutrients to the soil when cultivated; local examples are Tithonia, Calliandra
Intercropping	cultivating two or more crops in the same field during the same season
Mulch	applying e.g. crops residues at the top of soil to protect the soil fertility
Rural broker	makes a living off collecting harvests from farmers and distributing it to factories or markets
Subsistence crops	crops cultivated for home consumption and not for sale

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1 Introduction

In the following chapter the background to the study is presented. Furthermore the problem, the aims and the delimitations of the study are stated.

1.1 Problem background

Food production could be considered as one of the most important branches of production in the world, as every person needs to eat to survive. Mal-nourishment, hunger and even, in some cases, famine is a problem in many developing countries (www, FAO 1, 2012). A large percentage of the world's population is living off farming, and produces food to maintain the peoples on earth. In some parts of the world, the produced amount of food is sufficient to nourish the population; in other parts of the world the amount of food produced is not enough for everyone to still their hunger. The lack of food is often combined with poverty (www, FAO 1, 2012). In developing countries a majority of the farmers are small-holder subsistence farmers and have limited financial resources. With a small-holding farming means a small farm mostly supporting only one family. On the farm there are often a mixed production with a few livestock and cultivation of subsistence crops. A way to combat hunger in the world could be to strengthen those small-scale farmers and increase their production so that it could feed more people (www, FAO 1, 2012). This is also something that could lead to an improvement of the economic situation of the farmers, since they then would be able to sell a larger percentage of their total production.

Kenya became independent from the United Kingdom in 1963 (www, CIA, 2012). Since then, the country has developed to be one of the strongest economies in east Africa. About 50 % of the population is however living below the poverty line (www, CIA, 2012). According to the Swedish International Development Cooperation Agency, Sida, a way to improve this situation is to develop the agricultural sector. Progress in the sector could lead to a more efficient food production. That would benefit public health and mal-nutrition in the country. In Kenya the food-producing sector is the largest one, employing 75 % of the residents (www, CIA, 2012). Agriculture accounts for 19 % of Kenyan GDP. Most of the population is living in rural areas; only 22 % lived in urban areas in year 2010 (www, CIA, 2012). Furthermore one fifth of total land is cultivated. Most of the cultivated area is found in the western, southern and central parts of the country.

The agricultural sector in Kenya mostly consists of small-holder subsistence farmers. The most common crops produced are maize, beans, sugar cane, fruits and vegetables (www, CIA, 2012). In some areas cash crops such as tea and coffee is also commonly produced. The small-holder farmers are the bases of the agricultural sector in Kenya. An improvement of the production methods would strengthen the agricultural sector since it could lead to a stronger economy of the farm. One way to make the sector more effective could be an increasing use of fertilizer (UNDP, 2010). If more fertilizer were used it could result in higher yield for the farmers which directly means more food produced. That could strengthen the economy of the farm since the farmers then could be able to sell more of their production. In a broader perspective, a more frequent use of chemical fertilizer in developing countries could be a small part of the solution to eliminate the hunger in the world. Today the use of fertilizer is limited. This due to the economic situation as well as the knowledge level; the chemical fertilizer may be too expensive, and further, according to knowledge on soil fertility management, the farmer may not know how to use and apply chemical fertilizer (Matsumoto & Yamono, 2009).

Prof. Carl Johan Lagerkvist who was supervising this project, has ongoing projects concerning preferences and risk assessment in relation to cultivation of vegetables in the Nairobi area. He

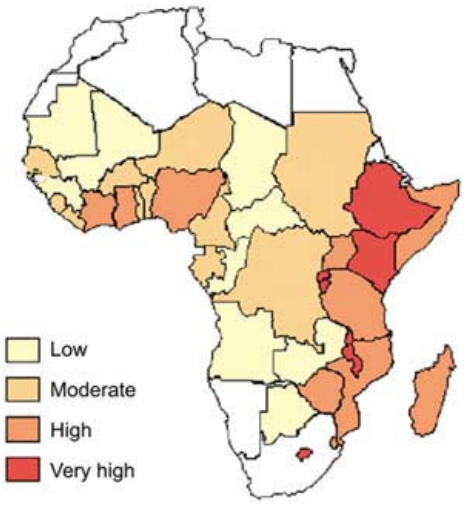
also conducts a study about the reasons behind the behaviour and choices that farmers make. Dr Kristina Röing de Nowina, the second supervisor to the study, conducts projects on soil fertility among small-holder farmers in Kenya. The results from this study will relate to the research of both supervisors. The formulation of the study and the objectives were however developed by the authors.

Focus in this study will be on how small-holder farmers in Kenya relate to soil fertility management and especially to chemical fertilizer. The study will be of interest for persons interested in willingness to pay, WTP, for fertilizers, and factor demand for inputs to soil fertility, which are the main focus in this study. The study could also be of interest for persons concerned in the situation for the small-holder farmers in Kenya. This could be such as international development agencies, researchers and companies.

1.2 Problem

Lack of resources is common problem among small-scale farmers in Kenya (Ariga *et al.*, 2008). It could be shown as deficiency of financial means as well as of land, labour and material. The lack of inputs, such as fertilizer and seeds, could be closely related to the shortage of money. Many of the farmers are subsistence farmers. Therefore it is essential that the yield is sufficient to nourish the family. The crop production is also often the only source of income for the farmers. To increase the income and to have a cash flow, the yield must be large enough so that the farmer both can sell some of the harvest and nourish the family. To have an appropriate yield, the use of some kind of fertilizer is recommended; otherwise a lack of nutrients in the soil is most probable. Lack of nutrients in the soil impacts the possibility to optimal growth and the quality of the crop (www, SJV, 2012).

Diammonium Phosphate, DAP, is the world's most used chemical fertilizer; it is compounded of 18 % nitrogen and 46 % phosphoric acid (www, IPNI, 2012). A large advantage with this fertilizer is the high nutrient concentration. With a higher concentration, a smaller amount has to be applied, something that reduces the transport costs per unit of nutrient. The DAP granule should not be applied too close to seedlings of the crops, since the pH increases when the granule dissolves. If applied too close, this could be negative for the plant (www, IPNI, 2012).



In Kenya the use of chemical fertilizers, such as DAP, has increased since 1990 (Mathenge, 2009) and compared to other countries in East Africa, Kenya has a high use of DAP (www, FAO 2, 2012). Even though the use of fertilizer is increasing, the nutrient balance in the soil is negative (FAO, 2003). The negative balance is due to a high population level and high and frequent cultivation of the soil (FAO, 2003). The geographic characteristics, such as sloping hillsides, and erosion contributed as well to the lack of nutrients in the soil. In figure 1 the condition due to nutrient depletion rate is shown. Kenya has a very high level of nutrient reduction.

Figure 1 Nutrient depletion rate. Source FAO

Table 1 shows the nutrient balance in Kenya year 2000 and 1982-1984. The nutrient balance is measured as kg/ha/year. As shown in the table there is a negative nutrient balance, more nutrients are taken from the soil compared to what is added. To reduce the negative balance, additional nutrients need to be added. One way of adding nutrients to the soil is to use chemical fertilizers. Table 1 also shows the use of nutrients in Sweden and respectively Kenya in 2009.

Table 1. Nutrient balance in Kenya. Source FAO

Nutrient/Year	1982-1984	2000	Use in Kenya 2009 (tonnes of nutrients)	Nutrients per hectare in Kenya	Use in Sweden 2009 (tonnes of nutrients)	Nutrients per hectare in Sweden
N	-42	-46	27 372	1 kg	142 400	46 kg
P	-3	-1	93 168	3 kg	18 600	6 kg
K	-29	-36	14 674	0,5 kg	21 800	7 kg

As seen in table 1 the amount of nutrients used are higher in Sweden compared to in Kenya, with phosphate as an exception. The total area for cultivation is however nearly nine times as large in Kenya as in Sweden, 27 350 000 ha in Kenya compared to 3 079 000 ha in Sweden (www, FAO 2, 2012). The reasons why farmers decide to use, or not to use, fertilizer are various but some factors are the fertility of the soil and the knowledge the farmer has on soil fertility management (Ariga *et al.*, 2008). To study methods to improve soil fertility used by small-scale farmers and their perception of those methods could help to understand why farmers chose to use, or not to use, chemical fertilizer. It would therefore be of importance to investigate the perception of soil fertility management among small-holder farmers in order to understand the use of chemical fertilizer. This could also be connected to the demand of different farming inputs.

One of the most important reasons why farmers do not use fertilizer is however caused by economic constraints, if the farmer has enough income to afford to buy fertilizer or not (Morris, 2007). The price of chemical fertilizer is assumed to be too high; the farmers cannot afford to use a sufficient amount of fertilizer needed for their farming (Matsumoto & Yamano, 2009). To investigate how a sufficient quantity of fertilizer could be used regularly in the long run, it is important to know at which price the farmers could afford to buy fertilizer. Asking about the farmers' WTP for fertilizer would give an estimate of at which price the fertilizer would be affordable. WTP is connected to the utility of the good; a high level of utility should generate a high WTP (Brännlund & Kriström 1998). The measurement also indicate the price the consumer is prepared to pay to remain at the same level of utility in case of a price change and to avoid a price change. WTP are often measured for non-marked goods. In this study, the WTP is however estimated for DAP, which is an obvious market-good. The expected WTP among the farmers that actually buy DAP should therefore be just below the actual market price. But the farmers that buy fertilizer at present do not buy as much as they need to get balanced soil fertility (Ariga *et al.*, 2008). When asking the farmers about their WTP they will be asked to choose between two scenarios. Either they can choose their present scenario where the majority cannot afford a sufficient amount of DAP. Otherwise the farmers can choose the second scenario where they are able to buy as much DAP required for their whole farm to have a balanced soil nutrient.

After conducting the study, the farmers stated WTP could be compared to the present market price. If the market price is shown to be much higher it would strengthen explanation that the low demand of DAP is caused by the too high market price. It would give incentives for the market price to be adjusted to the price that the farmers states (through governmental or institutional intervention as an example). Then the price would be at a level where demand equals supply, and the demand of using chemical fertilizer as a factor of production would increase. An increased demand is important to amplify the food production and strengthen the farmers' economic situation. Therefore it is important to investigate the WTP for fertilizer among small-holder farmers. The WTP is as well an important quantitative estimation to have in

the future in order to see if the economic situation for the farmers is improving, and if the perception of fertilizer is changed.

The purpose with this study is to identify what factors that influence the demand of inputs used to improve soil fertility. These attitudes in combination with determining the WTP for DAP will be used to further understand the low use for chemical fertilizers among small-holder farmers in Kenya.

1.3 Objectives and delimitations

The overall main objective with this study is to understand the economic situation for small-holder farmers in Kenya. More on, the aim is to investigate how the farmers WTP corresponds to the actual price of DAP in year 2012. The specific objectives of this study are stated below:

- *What is the willingness to pay for the chemical fertilizer DAP among small-holder farmers in central and western Kenya?*
- *How do small-holder farmers in Kenya perceive different methods to improve soil fertility, and has this an effect on the demand of inputs?*

The first point will be estimated with a payment card. The second point will be investigated through theories about factor demand and analysis of soil fertility practices on the farm. The methods are explained in detail in section 3.

The study was delimited by area; the interviews were not conducted in whole Kenya but in selected parts of the country. The parts were the Central parts, particularly Embu, and the Western parts, particularly Bondo. In these districts there were some ongoing research projects conducted by Dr Kristina Röing de Nowina. The results coming from this study will be complementary to previous research, which was why the districts of Embu and Bondo were chosen. Another limitation was that the WTP only was estimated for the fertilizer DAP. The reason why DAP was chosen for the study was that it was one of the chemical fertilizers that were used in both Embu and Kisumu. The farmers in the both areas could therefore relate to the product and have an opinion about the value and utility of the product. Another fertilizer that was used in both areas was Double Superphosphate, DSP. But since DAP is the cheapest of the two it was considered more attainable for the farmers and therefore selected for the study. The decision was made after discussion with, and on recommendation from, Kenyan master students doing studies in the same areas as this study. The last limitation was that the income of the farmers only was measured from the last season, September 2011 – January 2012. This because it could have been hard to receive appropriate answers on income from earlier time periods, as the basis of this study were interviews with farmers, thus depending on their memory. None of the farmers kept records. Collecting information on income from several seasons could therefore give a misleading picture of their economic situation. Income level from only the last season was judged to give a somewhat adequate picture of the economic situation and therefore it was decided to be sufficient for this study.

This study was one of three complementary projects investigating soil fertility management and economic situation among small-holder farmers in Kenya. While this study focused on demand and WTP in relation to chemical fertilizer, there was one study in the project focusing on the economy on the farms and another one concerning demand and WTP connected to improved seeds. In figure 2 the three different groups within the project are presented. This study is thus Group B. The studies are partly financed by the Swedish International Development Cooperation Agency, Sida.

The three groups all conducted interviews in both Embu and Bondo. Group A and B used the same questionnaire as basis for the interview. Group A and B did not interview the same farmers. Group C conducted a study about the economy of the farms, and they interviewed partly the same farmers as group A and B in order to be able to do a deeper analysis.

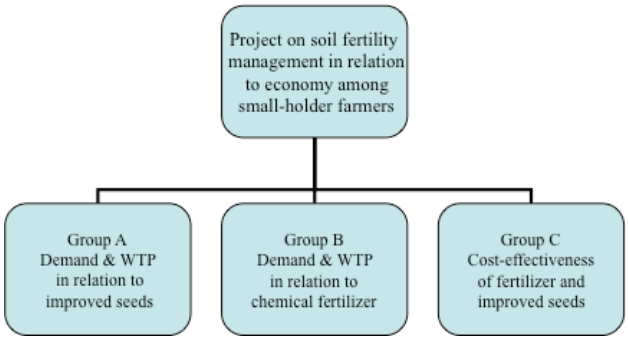


Figure 2, The three different project groups in relation to each other

2. A theoretical perspective

Chapter 2 is a theoretical review of the specific theories included in the study. These are factor demand and willingness to pay, WTP. A part of this study is to greater understand if there are other factors than price affecting small-holder farmers demand for the production factor chemical fertilizer. To identify which different factors it might be, a perception-method within benefit-perception analysis theory will be implemented in the study.

2.1 Production theory

A firm uses different techniques and methods to transform inputs to outputs, which create revenues to the firm (Perloff, 2011). In the case of the farm, the inputs could be such as seeds and fertilizer while the outputs are the crops grown. The production methods vary between crops, but do often include ploughing, weeding and fertilizing. Methods to have good soil fertility are essential for the production. The input could be fixed or variable, in the short run all variables could be seen as fixed except labour. In the long run, on the other hand, all inputs are variable. The relation between input and output could be seen in equation 1, the production function, where q = output, K = capital and L = labour.

$$q = f(L, K) \qquad (1)$$

When making a production decision, it may be of interest to know to which extent the use of one additional unit of input affects the production. The cost to produce one additional unit of output is described through the marginal cost function. The marginal cost (MC) is the derivative of the variable cost function (Perloff, 2011). The effect that the increased use of inputs has on the output is however the marginal product, which is the derivative of the production function (Perloff, 2011). The marginal product (MP) of labour is shown in equation 2.

$$MP = \frac{\partial q}{\partial L} = \frac{\partial f(L.K)}{\partial L} \qquad (2)$$

In the case of the farm, this could be implied as the extra unit of crops that follows with the use of one additional kg of the input fertilizer. In the use of fertilizer, the nutrient balance in the soil has however as well an impact. The marginal product increases most rapidly when going from a very low amount (Pindyck & Rubinfeld, 2009). After a while the marginal production is however declining. If the farmer goes from using no fertilizer at all, the effect of the first kg of fertilizer will be of importance, on the contrary – adding a too high level of fertilizer will have a negative effect on the crops. This could be described as the law of diminishing returns, the marginal productivity of the fertilizer declines.

Factor demand

As described above, different inputs are necessary in the production of output. The inputs are provided at a factor market, such as the labour market or the capital market (Perloff, 2011). For the firm it is important to combine the inputs so that profit is maximized. Both the price of the input as well as the price of the output is important when the firm makes a production decision, and choses which quantity of the inputs to use. The factor demand varies in the short- and the long run. This due to the fact that only labour is a variable input in the short run, while any input could be variable in the long run (Perloff, 2011). In this specific study the long run scenario will be of interest. The inputs under consideration are capital, such as chemical fertilizer, and not labour force. The objective is as well to see how the farmers in Kenya could implement better farming techniques in the long run. Specific theories about factor demand in the short run will therefore not be presented in this section.

To maximize profit, a firm choses the ultimate combination of inputs with respect to the prices of the input and the output. This could be described by equation 3, where w = wage and r = rental cost of capital.

$$\max \pi = R\big(q(L,K)\big) - wL - rK \qquad (3)$$

Equation 3 state profits to be revenue minus the costs. This could be further developed by the concepts of marginal productivity and marginal cost. The firm should set the ultimate level of input so that the extra cost that follows with the last additional unit of input used equals the revenue that follows with the increased production from the input. In the case of labour, this could be that the revenue from employing a worker should be the same as the wage. This revenue is called the marginal product of labour (MRP_L). This is shown when stating the first order conditions for profit maximization for a firm, equation 4. It is shown that the firm adjust the marginal revenue of capital to the rental price of capital, and the marginal revenue of labour to the wage.

$$\begin{aligned} \frac{\partial \pi}{\partial L} = \frac{\partial R}{\partial q} * \frac{\partial q}{\partial L} - w = 0 \Rightarrow MRP\ L = MR * MP\ L = \frac{\partial R}{\partial q} * \frac{\partial q}{\partial L} = w \\ \frac{\partial \pi}{\partial K} = \frac{\partial R}{\partial q} * \frac{\partial q}{\partial K} - r = 0 \Rightarrow MRP\ K = MR * MP\ K = \frac{\partial R}{\partial q} * \frac{\partial q}{\partial K} = r \end{aligned} \qquad (4)$$

The price of each input affects its marginal productivity as well as the demand of the input. The demand for the input decreases when w and r increases, meanwhile when the demand increases when p increases. On a competitive market, when the price of the factor falls, the firms will use more of the input. This will give a higher level of output. Since all the firms on the market will react in the same way, there will be an increased supply of output on the market, something that will result in a fall of the market price. The lower price of output has an effect on the revenues and will lead to a lower demand for input.

Cost minimization

Cost minimization is a necessary prerequisite for profit maximization. In such case the firm choses the combination of inputs depending on the iso-cost line, and is therefore dependent on a chosen level of output (Gravelle & Rees, 1992). The level of output is dependent on the factor prices, the relation is shown in equation 5, where *p* = price and *z* = quantity of input.

$$\underset{z1 \dots z\,n}{\boldsymbol{minC}} \sum_{i=1,\dots,n} \boldsymbol{p\ i, z\ i\ \ s.t\ (i) f(z1, \dots, z\,n) \geq y} \qquad (5)$$

To be able to fully explain the level of input use it is important to motivate the chosen level of output (Lagerkvist, 2012). For the small-holder subsistence farmers in Kenya the level of output must typically, at least, be primarily enough to feed the family. This base-line objective is then different from the assumption of profit maximization.

The cost function has the following general properties (Gravelle & Rees, 1992):

- Increasing with y, when output increases the cost increases as well and non-declining with p_x, if $p'_x \geq p_x$ then $C(p'_x, y) \geq C(p_x, y)$
- Linear homogeneous for p_x; $C(tp_x, y) = tC(p_x, y)$
- The cost function is continuous and concave for p_x, when the price changes, the firm will react with respect to its use of the input. The minimised cost for the production of a given level of output is a function that increases in p_x but at an decreasing rate.

- Shepard's lemma: the conditional factor demand for a given input factor, *x*, is obtained as the marginal change in the cost function for a marginal change in the price of the input factor, p_x.

For each output level there is a cost minimizing optima (Perloff, 2011). The optima is where the isoquant tangents the isocost curve, giving the optimal allocation of inputs. A line could be drawn from origo that connects the optimal point at each output level. In order to expand the production in a cost-effective way, the firm most follow this line, the expenditure path.

To conclude, when taking a production decision the objective is often to maximize the profit or to minimize the costs of production for a given level of sought output. Which input a firm choses is thus dependent on the price of the input as well as the price of the output. For the purpose of this study it is relevant to relate both the empirical findings on WTP for fertilizers to the factor demand conditions to provide an understanding on the reality/theory gap that seems to be present. It could be expected that Kenyan farmers actually would chose an output maximization solution to the production planning problem i.e. to produce as much output as possible. This according to the non-sufficient food production in the region.

Demand, supply and equilibrium

Above it has been explained how the demand for an input can be derived either from profit maximizing or the cost-minimizing function of production. If the input factor is a market good there should exist a supply function for the factor as well. The supply is the quantity of the good that the market can supply at a given price; the quantity of the good is a function of the price, which can be seen in function 6, where Q_s = quantity supplied and P = price.

$$Q_s = Q_S(P) \qquad (6)$$

Assuming a perfect market exists, the price will be set in the equilibrium, where the quantity demanded is equal to the quantity supplied. This relationship can be seen in equation 7, where Q_D = quantity demanded and P* = equilibrium price.

$$Q_s = P^* = Q_D \qquad (7)$$

The consequence of the price for a good not being set in the equilibrium will be the existence of either consumer or producer surplus. If the market price is set higher than the equilibrium price it will result in a producer surplus. The consumption of the good will be less than the demanded quantity. When it is set lower than the equilibrium price it will lead to a consumer surplus and a shortage of the quantity supplied. Therefore the market mechanism on a perfect market is to seek to set the market price equal to the equilibrium where the consumer and producer surplus is zero (Pindyck & Rubinfield, 2009).

2.2 Willingness to pay

The basic principle for willingness to pay is that consumers get to estimate how much they are willing to give up in money or goods for an incremental change in their utility, i.e. how much to pay for acquiring a specific good or condition. An important reason to investigate a person's WTP is that it will reveal if there is a large difference between how much a good is worth to a customer and how much the present market price is. In other words, this can be described as estimating the consumer surplus set it in relation to the producer surplus. This is important information for example a company to know when they are setting their price. If the price is overestimating how much the majority of their consumers are willing to pay, there will be a smaller demand for the product, and the producer surplus will be larger than the consumer

surplus. It would therefore suggest that the price should be adjusted down to a price that equals the product's value for the consumers. On the other hand, if it is shown that the average WTP is much higher than the present price, the companies can increase the price and gain a larger profit, and still keep most of their consumers (www, ecosystemvaluation, 2012). When asking for the WTP, individuals are asked to give up as much as they can in money and still keep their utility constant (www, FAO 3, 2012). This is what the economist Hicks would describe as *equivalent variation*, since the utility stays the same even though the consumers' price changes (Brännlund & Kriström, 1998). Another possibility is that the WTP measure capture the *compensating variation*, i.e. the amount that the individual is willing to forego to obtain a higher utility level (Brännlund & Kriström, 1998).

In environmental economics, WTP is especially used to attach monetary values to non-market goods. National recreational sites are an example of such non-market goods (Bockstael, 1980). Commonly the WTP is measured through interviews by using the Contingent Value method, CV. It is considered to be a *direct method* since the WTP is stated directly by the respondents and not from another source. Furthermore, since the respondents' WTP is stated by the respondents, and not revealed by their consumption patterns, the CV study is also categorized as a *stated preferences method* (Brännlund & Kriström, 1998). An example of how the CV-method has been used is a study conducted in Holland, where it was used to appraise the WTP to pay for management of peat meadows. In the study, questionnaires were sent out to households by mail. Each questionnaire provided the respondents with information about the problem. Furthermore, scenarios were given to them, one where meadows were managed in order to preserve the wildlife and in the other scenario they were not. A crucial part in the questionnaire was to include pictures to further illustrate the issue. After being given the information about the environmental situation, the respondents were asked to state their WTP. This was done buy providing them with a card where different price intervals were presented. They got to tick the price intervals that they were ready to pay, and cross the levels they were not willing to pay (Brouwer, 1999). Cards that present price levels are called payment cards. Another name for payment cards is "ladder" due to the way they presents increasing price intervals (Common *et al.*, 2011). Even for this study a payment card was designed and used during the interviews (see appendix 2).

A large disadvantage with the CV method being based on questionnaires is that it is hard to get enough participants. This could be seen in the study mentioned above, where 3100 questionnaires were sent out by mail but only 909 could be used as results (Brouwer, 1999). To increase the response frequency the questionnaire could have been carried out in person. However, this brings extra expenses and logistics. Another weakness with the CV method is its' hypothetical nature. Because the respondents simply state their WTP it is difficult to confirm that this is the actual price they would pay. It is therefore important how the questionnaires are designed to convince the respondents to be as honest as possible. Furthermore, if interviewing in person, the interviewer can try to *cheap talk* the respondents, which means to explain and stress upon the importance of giving the most realistic price (Common *et al.*, 2011).

2.3 Measuring perceptions

The value of studying different perceptions of benefits and risks is to better understand what factors and circumstances affects the trade-off between the two, this according to an introductory paper to the BEPRARIBEAN-project (Verhagen *et al.*, 2012).[1] In a study valuing Swedish farmers' risk preferences, a specific method was applied to measure risk and benefits. The study first asked 25 statements about which factors would provide a more stable economy of the farm. In the second set, the farmers were asked if each of these factors were not used, would lead to a less stable economy of the farm. To each statement the respondents had the choice between seven answers, from "completely unimportant" to "to a large extent". The answers of the two sets of statements were used to analyse the risks and benefits connected to using and not using these practices (Hanson & Lagerkvist, 2012). The general idea behind this theory is that the producer (in this case the farmer) sees a value of using one method or input. According to the farmer, one input could have a higher perceived value compared to another. This implies different levels of marginal utility between the inputs. The farmer could therefore see a higher benefit from the use of one input, and would more keenly choose this product. The method used could be implemented in a simpler way to this study in order to capture if there are other explanatory factors than the price affecting farmers' choices of inputs.

[1] A cross-disciplinary benefit-risk analysis-project on food consumption, called Best Practices for Risk-Benefit Analysis: experiences from out of food into food.

3. Method

In this chapter the conceptual framework for the study is presented. Thereafter follows a section about the hypothesis. Then comes a presentation of the methods of the study, such as a literature review and empirical interviews. A brief part about the performance is found in section 3.4.

3.1 Conceptual framework and hypothesis

The theoretical basis for this study is theories about factor demand and WTP. The following text will present how those theories are applied in this study.

Willingness to pay

In this study the utility of using chemical fertilizer (DAP) was measured in comparison to a situation where the farmer does not make use of (bought) fertilizers. There is currently a widespread underutilization of fertilizer in African agriculture. Reason for this is mainly that farmers cannot afford to buy fertilizer at the existing market price. Therefore, although a current market price for DAP is established, the use of a stated preference method is applicable to measure the threshold value which could induce an uptake of fertilizer use among farmers. As Brouwer (1999) recommends, a payment card was developed (see appendix 2). The farmers were asked about the highest amount that they were prepared to pay for one kilogram of the fertilizer DAP in a situation where they could afford a sufficient amount for their farm on regular basis. In the first scenario they had to imagine not using any kind of fertilizer or any other method for increasing soil fertility. In the second scenario, DAP was applied as the only fertilizer. Before starting to ask questions about the prices, the interviewers always implemented *cheap talk* (Common *et al.*, 2011). Thereafter the farmers were asked how much they would pay to stay in the second scenario. Different intervals in Kenyan shillings, ranging from 0 to 120 Kenyan shillings, were presented to the farmers. Each interval added five shillings to the previous level, this according to the theory about the ladder (Common *et al.*, 2011). It had to be a price that the farmers could afford on regular basis, according to their present economic situation. If the price for DAP would increase beyond the selected interval, the farmer would not be willing to pay the amount demanded to stay in scenario two. Which means that the price was too high in relation to the utility of using the fertilizer.

Demand of an input

Asking the farmers about their perception, i.e. their given importance to different soil fertility managements, would give a broader picture of how the farmers perceive different techniques, such as mulching, intercropping, different types of organic manure and chemical fertilizer. The analysis could indicate why a farmer chooses a certain input. The implementation in this study was the same as in the case of Hanson and Lagerkvist (2012). The farmers were asked which methods they used and then thereafter they evaluated the importance of the method. The perceived importance of the method, and the inputs that follows with the choice of method, should have an impact on the demand for the input. Through analysing the use and perception of the methods it may be possible to draw conclusions about factors affecting the demand for fertilzer, other than the price.

Hypothesis
According to the objectives in section1.3 there are three different hypotheses to be made. Those are as follows:

H1: The farmers WTP are lower than 2012 price of DAP.

H2: The perceived importance of a method to improve soil fertility depends on the characteristic of the farm and the socio-economical situation of the farmer.

The first hypothesis was based on the theories in the work of Ariga *et al.* (2008). Ariga states that the reason to use or not to use a certain input depends on the educational level and the economic situation of the farmer. The characteristics of the farm, as crops produced and type of livestock kept was as well assumed to have an impact on the perceived importance of a certain method. It could as well be related to producer theory where the farmer choses the input that contributes the most to the profit. The second hypothesis was made after reading reports that indicated that there was not a sufficient use of fertilizer in the area (FAO, 2003) and that animal manure was a common input for good soil fertility (Probert *et al.*, 1995). The fact that chemical fertilizer was used indicated nevertheless that the farmer did see some benefit of the use. The law of diminishing returns could also be related to the hypothesis; an infinite use of chemical fertilizer is not beneficial. The same reasoning was also the basis for the third hypothesis. In some reports, such as Matsumoto & Yamano (2009) it was indicated that the farmers were unable to use a sufficient amount of chemical fertilizer, this as a result of lack of economical resources. The price was assumed to be too high and the estimated utility too low compared to the price demanded.

3.2 Literature review

Before starting with the questionnaire and in order to have a proper picture of agriculture in developing countries in general, notably in Kenya, a literature review was conducted. The review was a base for the problem background. The literature was mostly rapports from organisations such as Food and Agriculture Organization, FAO, and United Nation Development Programme, UNDP. Some basic facts about Kenya were found on Central Intelligence Agency, CIA. Other reports that were used were from different universities as Tegemeo and University of Nairobi. In order to have an as realistic and trustworthy picture as possible different sources were used. Dr. Kristina Röing de Nowina at the Tropical Soil Biology and Fertility program of the International Centre for Tropical Agriculture, CIAT-TSBF, in Nairobi, provided information on Kenyan agriculture.

Further literature studies were done to better comprehend the main theories behind WTP and production theory. The books *Natural resources and environmental economics* and *Miljöekonomi* were used to attain basic understanding of the theory of WTP. For the production theory several well-recognized microeconomic books were used, such as Perloff's '*Microeconomics with calculus*'. Another source for the readings were articles published in different academic journals, such as the journal *Food and Chemical Toxicology*. In addition, reports from ongoing researches carried out at the Department of Economics at Swedish University of Agricultural Sciences, SLU, were used. One of them was the study *'Measuring farmers' preferences for risk: a domain-specific risk preference scale'* (Hansson & Lagerkvist, 2012).

3.3 Interviews

The method chosen for this study was empirically based interviews. The respondents were randomly picked farmers in different sites in Kenya. All respondents in the study were small-holder farmers. Madelene Casselbrant and Siri Lindqvist Ståhle, students in agricultural economics at SLU, conducted the interviews. In the list below the standard format of how an interview was conducted is presented. In section 3.2.2 the different parts in the questionnaire will be further explained.

- Presentation of the study and the purpose
- Description of context and connection to SLU and CIAT
- Explanation of the questionnaire
- Questions about the farm and the farming techniques used (Part 1 & 2)
- Change of interviewer in order to give some new energy and remain focused
- Benefit-risk analysis and payment card (Part 3 & 4)
- Questions from the respondents to the interviewers

An interview took between 45 minutes and 1h30 minutes, depending on barriers of language and how talkative the respondent were, this includes as well a transect walk on the farm. Since not all the farmers spoke English, interpreters were used during the interviews. Before starting the interviews a meeting with the interpreters was held in order to assure that the interpreter understood the meaning and purpose of each question.

3.3.1 Location of the study

The western part and the central part of Kenya were selected for the study. The base for the field work was Embu in the central parts and Kisumu in the west, see figure 3 for location of the sites. The choices of district were based on factors as if the farmers used chemical fertilizers or if they have some basic knowledge in English. For this study Bondo in the western parts and Embu in the central parts were chosen. In Bondo there were as well some other students, supervised by Dr. Kristina Röing de Nowina, which conducted projects concerning soil fertility management. The fact that having other project in the area were judged to be useful since the results from the different studies could be compared and a deeper analysis would be possible.

Figure 3 Map of Kenya, Source Nations online, 2012

In each district some locations were found. In Embu the locations Kibugu, Nguviu and Karumiru were selected. The locations in Bondo were North Sakwa and Bondo Township. Maps of the districts will be presented in chapter 4. The locations were divided into sub-locations. The sub-locations were selected on the basis of the experience of CIAT staff and students, as well as the interpreters. That means that the interpreters were asked about their experience of working in the sub-locations according to accessibility, number of

habitants and familiarity in the area of the interpreters. Five to eight farmers in each sub-location were selected to be interviewed. Total number of farmers to be interviewed in the study was between 50 and 60. This number was estimated to give sufficient material to do a statistically acceptable analysis. The farmers where chosen on the basis of distance from each other, the farmers were picked randomly but with a distance between the farms of at least 300 meters.

3.3.2 The questionnaire

The base of the interview was a questionnaire (see appendix 1). The basis of the questions in the questionnaire where provided by Prof. Carl Johan Lagerkvist. It is however important to point out that the questions were adapted to this study by the authors. The adaption was made through test interviews with Kenyan farmers on a randomly picked farm in Kikuyu, in Nairobi area. The reason behind the test-interviews was to see how well the questions gave relevant information for this study. It was essential that the authors did the adaptions corresponding to this precise study, since the basis of the questionnaire initially was developed for another study. One part of the questionnaire, the payment card, was completely the work of the authors.

In the questionnaire the respondents answered basic questions about themselves and the farming that they undertook as well as a statement part where the attitude towards soil fertility management was measured. In the list below the different parts of the interview are stated.

- Part 1 – Basic fact about the farmer and the farm
- Part 2 – A statement section in three parts
    - Part 2.1 – The methods used on the farm
    - Part 2.2 – The implementation of the methods
    - Part 2.3 – Importance of a certain technique
- Part 3 – A risk benefit analysis divided into two parts

In the second part the farmers first had to state, which soil fertility techniques they had ever used and in which way they implemented a certain technique. Thereafter they had to relate to statements and indicate whether they agreed or disagreed. 31 statements were presented to the farmers that had to answer on a five-graded scale where 1 stood for “strongly disagree” and 5 was “strongly agree”. This part indicated how important the farmers think that a certain technique was. In the questionnaire there was also a benefit-risk analysis on different techniques used to improve the fertility of the soil. The answers from this part of the questionnaire will not be further presented or analysed within this paper. To complement the questionnaire a payment card (see appendix 2) was developed. The purpose of the payment card was to estimate the WTP for the fertilizer DAP.

3.3.3 Data analysis and feedback

Descriptive statistic analyses were made on the data collected in the interviews. As an example the following values were used to analyse the data collected; mean, mode, median and standard deviation. The analyses were basically made in Excel.

After all the interviews were made, the data was briefly analysed to get some preliminary results. The results were then presented to the farmers, both orally and in text (see appendix 3), the feedback part of the study. The text was originally in English but a translated version to Swahili was as well made available. The feedback was given in order to not only take information from the farmers but as well give them something back, as well as to have an opportunity for follow-up questions.

3.4 Performance

Between 12/4 and 8/5 2012, interviews were conducted first in Embu and thereafter in Bondo. In Embu 27 interviews were made and in Bondo the number of 29 was achieved. Thus 56 interviews took place and the goal of 50-60 interviews was reached. See table 2 for allocation between the sub-locations.

Table 2. Sub-locations in Embu and Bondo.

EMBU			BONDO		
Location	**Sub-location**	**Farmers interviewed**	**Location**	**Sub-location**	**Farmers interviewed**
Kibugu	*Ngerwe*	6	**North Sakwa**	*Abom*	8
	Kiunyu	5		*Bar-Chando*	4
	Gicherori	1			
Nguviu	*Kiaweru*	6	**Bondo Township**	*Ajiko*	8
	Kirungu	4		*Bar-Kowino*	9
Karimuru	*Kiandome*	3			
	Ndunduri	2			
	Total	**27**		**Total**	**29**
		TOTAL 56			

Interpreters were always used during the interviews. The level of English varied however among the respondents, some of the interviews were held without, or with very little, help from the interpreter while other were held with the translator as intermediary along the whole interview. In Embu three and in Bondo one interpreter was used.

In Embu it was harder to maintain the distance of 300 meters between the farmers since there were two other groups, in the same project as this, conducting interviews in the same area. This may impact around 5 of the 56 interviews. Some days in field the hard rain prevented the interviews, it was impossible to walk the distance between the farms. This gives that the numbers of interviews in each sub-location in Embu are inconsistent. The farmers where however perceived to give answers independent of each other and therefore the interviews were judged to be valuable for this study even though there was not a distance of 300 meters between all the farms.

At the time for the feedback, the farmers were invited to come to an assembly point. A brief presentation of the results was then held and the farmers received a document with the preliminary results (appendix 3). The farmers then had the possibility to ask questions.

4 Results

In the following chapter the results from the interviews with the farmers will be presented. In the first section comes a presentation of results in Embu and in the second section there is a presentation of the answers from Bondo. The third section will be a more general comparison between Bondo and Embu and the differences found. The forth part is about the WTP for chemical fertilizer. All the results are based on answers received during interviews with the farmers.

4.1 Results from interviews in Embu

Embu is situated in the Central parts of Kenya, 131 km from Nairobi and close to Mount Kenya, see figure 3 for location of the town. A map over the area can be found in figure 4 and 5.

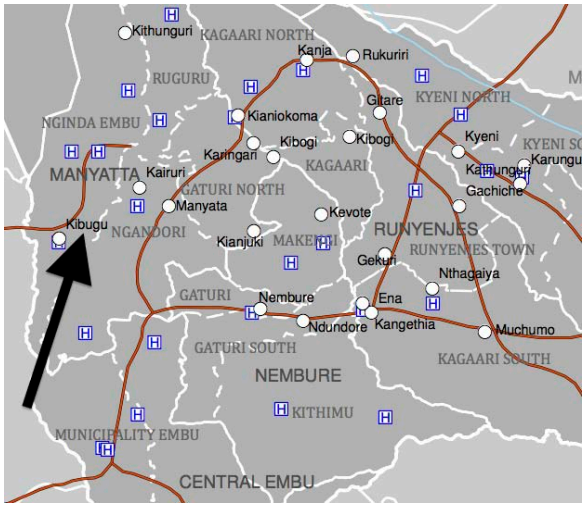


Figure 4 & 5, Map over Embu district where the location Kibugu is indicated and map over Kenya showing the location of Embu. Source OCHA Online

4.1.1 Characteristics of the farmers and their farms

In Embu 27 farmers were interviewed. Most of the farmers interviewed were women (59 %), nevertheless the head of the household was often a man, frequently the husband of the respondent. Every farmer taking part in the questionnaire in Embu had received at least some years of schooling; the majority part had reached secondary school. Only two had received some higher education. In general the household consisted of two parents and a number of children. In table 3 some more characteristics of the farms are shown.

Table 3. Some characteristics of farmers and location of farms in Embu.

Characteristic:	
Gender of respondent	40,7 % men
Gender of head of the household	77,8 % men
Average age	47 years
Average years of schooling	10,19 years
Average number of household members	4,17 persons

In figure 6 below is shown a sketch of a typical farm in Embu. Hedges surround the house and the cow is kept in a simple stable.

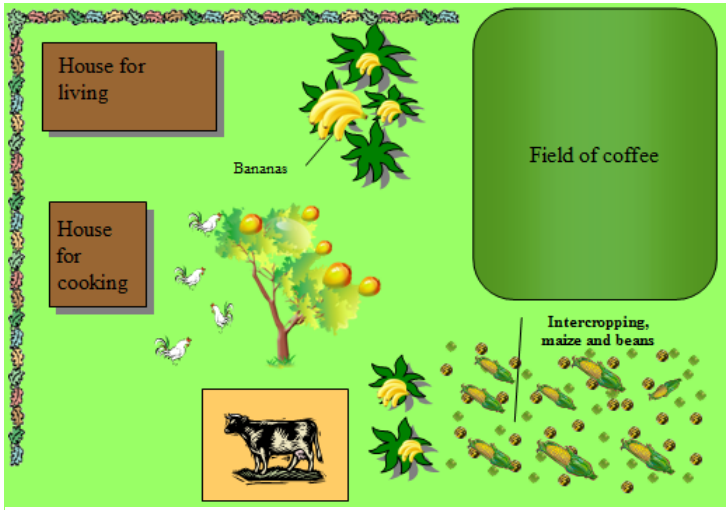


Figure 6, Diagrammatic sketch over farm in Embu

The crops grown in the area were mostly cash crops and subsistence crops. Examples of cash crops are coffee *(Coffea canephora and Coffea arabica)*, tea *(Camellia sinensis)* and macadamia nuts *(Macadamia integrifolia)*. Subsistence crops could be maize *(Zea mays)*, beans *(Fabaceae)*, bananas *(Musa ssp)*, and Irish potatoes *(Solanum tuberosum)*. Some of the farmers cultivated pineapple *(Ananas cosmosus)*, passion fruit *(Passiflora edulis)*, mango *(Mangifera)*, sugarcane *(Saccharum)* and avocado *(Persea americana)*. Of the farmers, 92,6 % cultivated tea, coffee or both. Every farmer also cultivated some kind of subsistence crops. In figure 7 the percentage of farmers that cultivates a certain crop is shown.

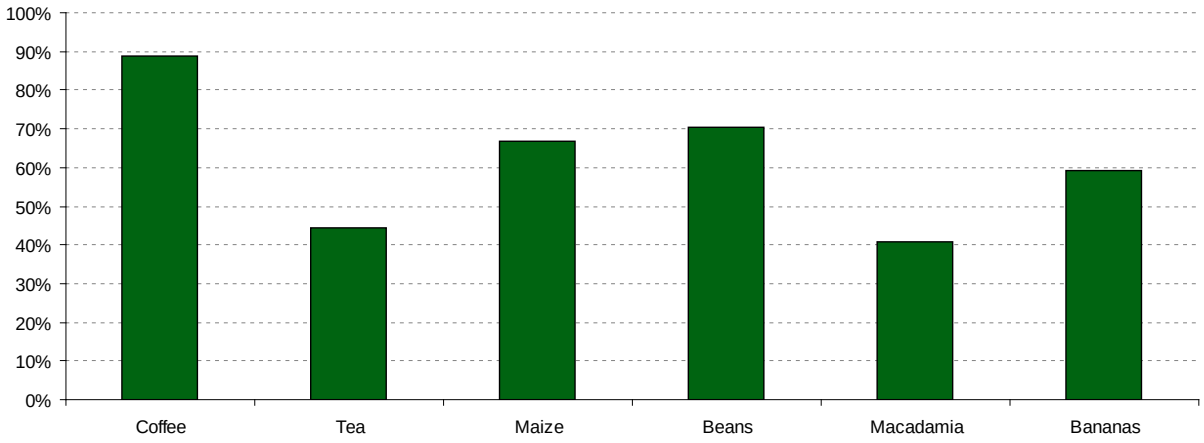


Figure 7, Percentage of farmers cultivating a specified crop

The subsistence crops were only for home consumption; very few of the respondents were selling their production. Those who were selling did it only if they had got an occasionally high yield. The subsistence crops were sold to local traders or rural brokers. The coffee and tea were distributed to factories in the nearby area. Sometimes the farmers sold their production themselves and sometimes the sale was conducted by cooperatives in which the farmer took part. 30 % of the farmers interviewed were members in some kind of farmer group dealing with fruits or vegetables. The purposes with the farmer groups were such as savings and credits and crop production. Membership in cooperatives for producing bananas, tea or coffee was common among the farmers in Embu.

Table 4. Income source for the farmers

Crop revenue	93 %
Livestock revenue	30 %
Off-farm income	26 %
Pension	15 %
Income from several sources	56 %
No income at all	7 %

The farmers were asked about their income during the last season, September 2011 – January 2012. For many of the farmers it was hard to estimate the income, none of them kept records. However, it was noted that crops such as coffee or tea bring a major income to the household. Some of the households also received income from selling milk and meat from the livestock. A few of the

farmers had off-farm incomes; yet it was hard to get an appropriate estimate of the salary. The difficulties could be according to culture; the interpreters found it difficult to ask questions on salary level. There are as well farmers that have income from several sources such as from crop production and from livestock in the same season. In table 4 it is shown the source of income for the farmers. Another determinant that the farmers found hard to estimate was the farm size. On average the farms could be assumed to be somewhere between one and two acres, equal to between half of to one hectare. The farmers had production on the total area of the farm; the plots were not in fallow. Many of the farms were located in valleys or on the hillsides. The sloping was beneficial for the cultivation of tea since the tea preferably could be cultivated on sloping hills. With the slopes there may however be a problem with erosion.

89 % of the responding farmers kept some kind of livestock. Most common were one cattle and some poultry. Many farmers also had a calf. In table 5 the percentage allotment of animals is shown. The livestock was mostly kept in some kind of simple stable, the poultry was often kept as free-range.

Table 5. Allocation of animals

Poultry	74 %
Cattle	59 %
More than one cattle	33 %
Calves	19 %
Goats	19 %
Sheep	11 %
No animals	7 %

4.1.2. Results on soil fertility management

In the following section the methods used in Embu and how the farmers perceived the different methods will be presented.

4.1.2 a) Methods used

In the questionnaire, see appendix 1, the farmers were asked whether they had ever used a certain soil fertility management technique and if they had used the method during the last season. The most common methods to improve soil fertility used in Embu were the use of livestock manure and chemical fertilizer separately. A large percentage of the farmers did as well practice intercropping, especially when combining cereals and legumes. The most common combination of crops was maize and beans, but many farmers also combined bananas with other crops, such as coffee. Table 6 demonstrates what percentage of the farmers that used a certain method.

Table 6. Methods used for increasing soil fertility. The first column gives which percentage that has ever used the method. The second column describes the percentage that used the method during the last season, September 2011 – January 2012.

	Ever used	Last season
1. Livestock manure	96 %	93 %
2. Chemical fertilizer	96 %	96 %
3. Intercropping	89 %	78 %
4. Cereal – legume intercropping	81 %	74 %
5. Crop residues	78 %	78 %
6. Crop rotation	70 %	52 %
7. Green manure	41 %	37 %
8. Agro-industrial by-products	19 %	7 %
9. Other	19 %	19 %

In the category “other” were methods to avoid erosion, see figure 8, and mulching. A method applied to avoid the effects of the rains and protect the soil from erosion was to dig a trench. The rainwater was collected in the trench so that the erosion was diminished. Sometimes crop residues were as well put in the trench in order to produce compost manure.

Figure 8, Technique applied to avoid erosion. Photo S. Lindqvist Ståhle

Livestock manure was highly used among the respondents in Embu. In the list below it is stated how the farmers used the manure.

- Livestock manure was used by 89 % of the farmers
- 37 % collected the manure from neighbours
- The livestock manure was composted before it was spread, only 4 % spread it fresh
- 81 % of the farmers incorporated the manure into the soil
- Many of the farmers hired labour to apply the livestock manure
- Techniques to facilitate the collection of animal manure were frequently used

Farmers that collected livestock manure from their neighbours were mostly farmers that did not keep livestock of their own. To get livestock manure from neighbouring farms it was common to make arrangement so that the farmer supplied the neighbouring farm with fodder, labour force or money. A reason not to incorporate the livestock manure into the soil was lack of labour force. Many farmers found that family labour was not enough to apply a sufficient amount of livestock manure, many hired additional labour. 30 % of the farmers had dug a furrow from the livestock stall in order to easily collect the livestock manure. In most cases the furrow led to a compost hole, in a few rare cases directly to the crops. In figure 9, a furrow between the livestock stall and a compost hole is presented. Please note the stable in the upper side of the photo. From the stable a small furrow was dug. At the bottom of the picture is the compost pit to which the furrow leads.

Figure 9, Furrow that leads to a compost pit. Photo S. Lindqvist Ståhle

Another important source of nutrients to the soil was chemical fertilizer. The farmer did mostly apply the chemical fertilizer in micro-doses at the root zone, 85 % of the farmers applied this technique. In other cases the farmers practised topdressing, which means that the fertilizer is widely spread all over the field and not only at specific plants or part of the plant. 89 % of the farmers combined chemical fertilizer with organic manure.

After the use of chemical fertilizer and livestock manure, the most common management technique to influence soil fertility was the practice of intercropping, practised by 89 % of the farmers in the study. The most common reason to practice intercropping was related to the farm size. Many farmers found their farm small, and in order to receive a sufficient yield to nourish the family intercropping was necessary. The most common crops that were part of the intercropping in Embu were maize and beans. Some farmers stated that if beans were included in the intercropping it had a beneficial impact on the yield and lead to higher fertility of the soil.

Many of the farmers used crop residues to improve the soil fertility. The residues were often used for mulching. Sometimes the farmers used them for lining the floor in the livestock stall; the residues absorbed the urine and were then applied to the plots as manure.

Only the most frequent used methods are presented in the text, for a complete list of the answers see appendix 4 and 5.

4.1.2 b) Importance of the methods

The farmers participating in the questionnaire were asked how important they thought a certain technique was according to their farming. In table 7 below the two statements that received the highest level of agreement respectively the two statements with highest level of disagreement are presented. Answers to all statement are presented in appendix 6.

Table 7. Presentation of statements and received answers in Embu.

Statement	Mean	Median	Standard deviation
It is important to first compost livestock manure before spreading it to the soil surface.	4,93	5	0,27
It is important to me to seek training from agricultural extension officers on how to prepare and apply compost manure.	4,78	5	0,8
It is important to spread fresh livestock manure to the surface of the soil.	1,3	1	0,82
I apply livestock manure only at plots close to the place where I store it.	1,67	1	1,49

Many farmers found it important to receive training on soil fertility management as well as on how to prepare compost manure. Nevertheless only 41 % of the respondents in Embu stated that they had received such training.

The importance given to a certain method could be connected to the actual practice of the method in the area. A large quantity of the farmers did compost the livestock manure before spreading it and many of the farmers found this practice important. In other questions the actual practice and the perceived importance were not connected. Many of the farmers in the questionnaire found it very important to line the floor in the livestock stall with concrete. Yet very few of the farmers, only 22 %, applied this technique in reality.

Together with livestock manure, chemical fertilizer was the most used soil fertility management technique. The farmers agreed with the statement that it was important to spread the chemical fertilizer in micro-doses at the root zone of the plant. To combine chemical fertilizer with organic manure was as well quite essential according to the respondents.

Concerning crop residues, the farmers agreed that it was important to use the residues for mulching and that it was not necessary to collect residues from other farms. Another product that could be used to improve the soil is agro-industrial by products. Those products were however not frequently used in the area, only 7 % used by-products as a complement to livestock manure and chemical fertilizer. The farmers stated as well that the method had less importance to improve the soil fertility. The agro-industrial by-products were more frequently used as animal feed, 22 % of the respondents used those products as fodder. The farmers found it more important to use the by-products as fodder rather than putting the material on the soil.

4.2 Bondo

Bondo is situated outside Kisumu, Kenya's fifth largest city (www, geonames.org, 2012). The district is within short distance of the eastern shore of Lake Victoria. The sub locations, in which the study was carried out, can be seen in figure 10.

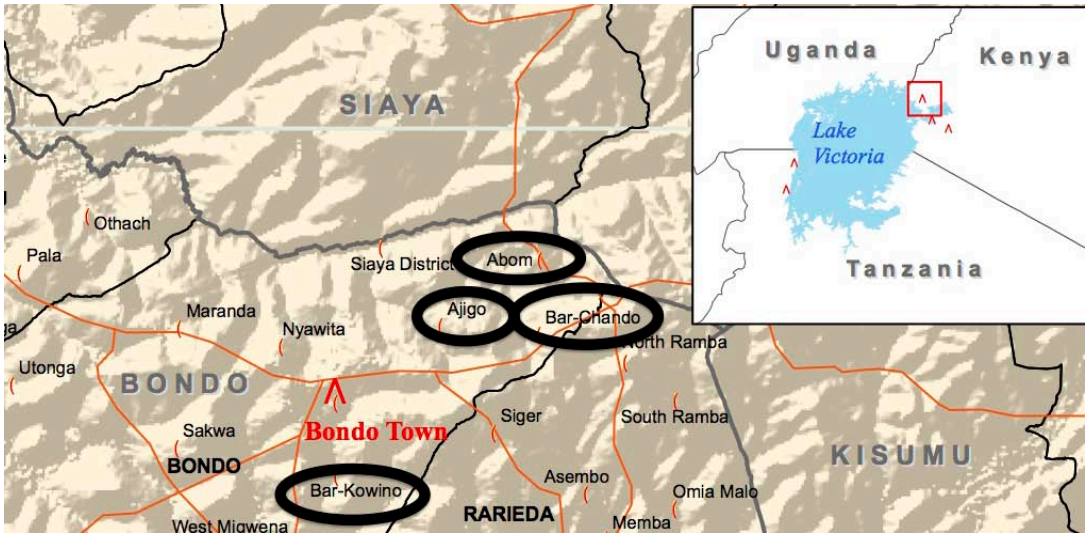


Figure 10, Map of Bondo, with the four sub-locations marked, source UNEP

4.2.1 Characteristics of farm in Bondo

In table 8, several characteristics about the farmers interviewed in Bondo and their farms are presented. The heads of the households were in majority the husbands even though the majority of the respondents were female. Another cultural phenomenon was that in several households the husband would have more than one wife, resulting in a larger number of household members. The average years of schooling were 8,45 years. However five of the respondents stated that they had had no schooling at all. Figure 11 is a sketch of a typical farm in Kisumu. Usually the homestead was separated from the fields, and the livestock would live outside, not in a stall.

Table 8. Characteristics of farms in Bondo

Characteristics	Percentage
Gender	69 % female, 31% male
Household status	41 % female head, 59% male head
Average years of schooling	8,45
Average number of members in households	6,97 persons
Farmers with more than one cattle	59 %
Farmers with revenues from crop production	48 %
Farmers with revenues from livestock production	41 %
Farmers with other income than from the farm	41 %
Farmers with no income at all	24 %

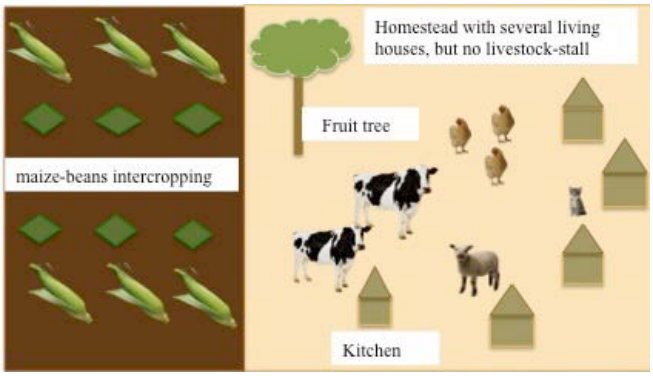
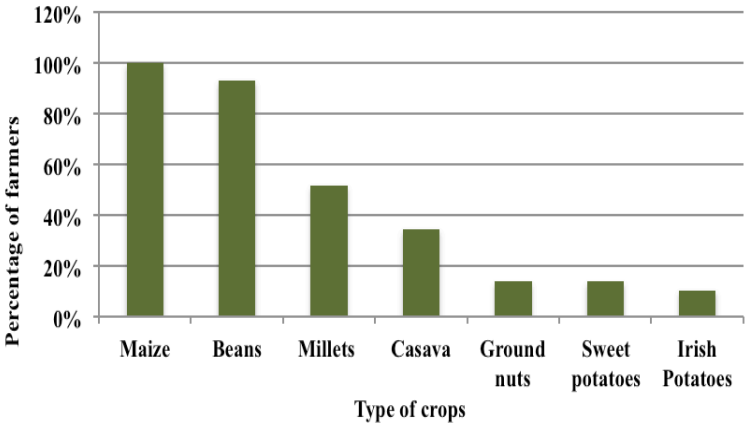


Figure 11, Sketch of typical farm in Bondo district

The crops cultivated in Bondo were mainly for home consumption and more than half of the farmers did not sell their crops. The different crops that occurred can be seen in figure 12. To get monetary means 41 % farmers had alternative income such as having their own shop or selling local pastries or craftworks. Close to a fourth of the interviewees said that they did not have any income last season. Almost half of the individuals could estimate some kind of income from their livestock previous season. Only one farmer did not keep any animals at all. The types of animals that most of the farmers kept are presented in figure 13.

Of the respondents that did sell their goods, it was common to sell the crops themselves at the local market and not to local brokers. 24 % of them were members in farmers groups, commonly for crop production or to produce marketing.



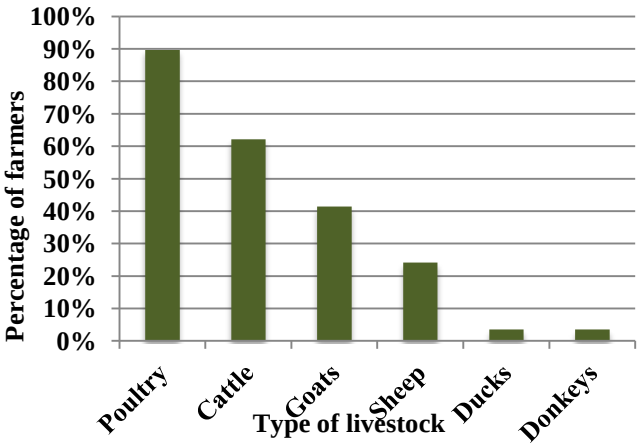


Figure 12 & 13. Percentage of farmers that cultivated each crop and kept livestock

4.2.2 Soil fertility management

Under section 4.2.2, in part a, the methods that the farmers in Bondo stated that they used to increase soil fertility will be presented. Part b will show the methods farmers thought were important to use.

4.2.2 a) To what extent different methods are used to increase soil fertility

All the interviewees were asked what methods out of ten different ones they used to increase soil fertility. The results can be seen in table 9.

The method that was most used was intercropping and more specifically, cereal-legume intercropping, since nearly everyone would combine maize and beans. Even though the practise was rather used due to shortage of land, 66 % stated that they either used intercropping or crop rotation because they thought this would fit the different needs of the crops, and therefore benefit the soil fertility.

Table 9. Most used methods for increasing soil fertility in Bondo

Management practise	Ever used	Used last season
1. Intercropping	97 %	90 %
2. Cereal-legume intercropping	97 %	90 %
3. Animal manure	93 %	76 %
4. Crop residues	76 %	69 %
5. Crop rotation	62 %	59 %
6. Green manure	48 %	48 %
7. Chemical fertilizer	31 %	17 %
8. Agro-industrial by-products	7 %	3 %

The second most common method was to use livestock manure. All the farmers that kept livestock said that they in first hand used their own livestock manure. When this was not sufficient 66 % said that they would collect livestock manure from their neighbours. Several in Bar-Chando said that they bought livestock manure from the same neighbour who was a poultry producer. Close to half the respondents said that they made arrangements with their neighbours to receive livestock manure in exchange for money or fodder. One farmer said that in their neighbourhood, situated in Ajiko, it was common to get livestock manure in exchange for farming services such as providing help with weeding. Barely a fifth of the farmers said that they travelled more than three kilometres to get livestock manure.

It was not common to use specific methods to facilitate the collection and spreading of livestock manure. Of the 18 farmers that kept cattle:

- Seven had put crops residues at the floor in the livestock stall to collect urine.
- Three had constructed a furrow from the livestock stall to a compost pit.
- None had lined the floor in the stall with concrete.

After collecting the animal manure, 86 % stated that they would put the manure in a compost pit for decomposing before spreading and 38 % would spread the manure fresh. This suggests that some farmers did both. As many as 90 % of the farmers said that they incorporated the manure into the soil. When applying the manure, 48 % would use their families as labour, and thought this would be enough without having to hire. 41 % thought it was easy to get help from neighbours, even though some would pay their neighbours to do so.

The use of crop residues for surface mulching was practiced by 59 % of the farmers. Most of the crop residues used were from the interviewees' own farms, while 17 % would get crop residues from their neighbours. However several said that it would be necessary to collect crop residues from their neighbours to have sufficient amount for their own farming, but that the neighbours had no excess to supply.

About a third of the farmers had sometime used chemical fertilizer, but it was only 17 % that used it during the last season. Several of the farmers had experienced or heard that chemical fertilizers would only increase the yield the first seasons used, but that consistent use of chemical fertilizers would decrease the soil fertility. A particular farmer said that to use chemical fertilizer would lead to excess of salt in the soil. One farmer did not know anything about fertilizers but would use it if she could receive more training. Only one farmer combined organic with chemical fertilizers. Several respondents explained that they would not use this method since chemical fertilizer was too strong and would ruin the organic manure. A farmer told that he had been given training where they had been told that it was not good to use chemical fertilizer, and it was preferable to use organic material.

Of the respondents in Bondo, 24 % had received training on soil fertility management while 45 % had sought training on how to prepare and apply compost manure. No one had used agro-industrial by-products as supplement to other fertilizers but 17 % had used it as fodder.

4.2.2 b) Importance of soil fertility management practices according to the respondents

The result in this section is from when the famers in Bondo were asked to rate to what extent they agreed to statements about soil fertility management. The three statements that received highest respectively lowest ratings can be seen in Table 10.

Table 10. The statements with highest and lowest ratings

Highest rating		**Lowest rating**	
Statement	*Grade*	*Statement*	*Grade*
It is important to seek training on how to prepare and apply compost manure.	4,66	I apply livestock manure only at plots close to the place where I store it	1,59
Understanding cropping patterns on my farm is important for crop rotation	4,48	I travel for several kilometres (more than 3 km) to get livestock manure.	1,83
It is important for me to have received training on soil fertility management	4,45	It is important to combine chemical fertilizers with organic manure	2,32

For the livestock manure the importance of letting it decompose before spreading was graded 4,45. The statement about the importance of spreading the manure fresh scored, 2,32, which was much lower. If it was necessary to collect the manure from neighbours got on average 3,76. To make arrangements with the neighbours in exchange of manure received a slightly lower rating of 3,69. In the reality it was easier for the farmers to get livestock manure from neighbours if they first made a deal with them. To hire transport to get the manure from a source that was far away got 3,41, and was therefore graded almost as important as the previous two statements. Even though few farmers were applying wood shavings to the floor in the livestock stall, had lined the floor with concrete or had dug furrows, these methods received 3,93, 3,71 and 3,54 respectively. The median for each one was a 4. Therefore most farmers considered that these methods were important for assisting the collection of the livestock manure. Less important was to combine organic manure with chemical fertilizers, which was graded 2,32.

The practice concerning crop residues that got highest rating, 4,17 was the one about recognizing what crop residues that were high in nutrient and easy to decompose, closely followed by applying crop residues as mulch, 4,14. It was not considered necessary to get crop residues from neighbours. To receive training on how to prepare and apply compost manure was graded 4,66 and therefore seen as very important. The importance to add agro-industrial by-products as supplement to manure scored 3,35, while to use them as fodder to the livestock in order to get higher nutrient level of the livestock manure got 3,32. It was not important to hire transports to get these products, since it only received 2,89. One aspect that was perceived as very important for good soil fertility was to get training on soil fertility management, which the farmers graded to 4,45.

4.3 Comparison of results from Embu and Bondo

There were some differences between Embu and Bondo. Some of the major differences and similarities will be presented in the forthcoming part.

4.3.1 Differences in characteristics of the farm

The geographical premises differ between Embu and Bondo, the landscape and the weather conditions are not the same in the two districts. This has an impact on the farming in the area; the methods used and the crops grown. In Embu there were good conditions for cultivation of cash crops as coffee and tea. The environment in Bondo was not beneficial for production of such crops. One similarity between the districts was however that all the farmers cultivated subsistence crops. During the interviews it was hard to get an appropriate estimation of the income since none of the farmers kept records. Nevertheless the farmers in Embu had a higher

estimated income, this as a result of selling coffee and tea. In Bondo on the other hand there were 62 % of the farmers that did not sell any of their production. The farmers in Embu mostly sold their crops to factories and there was a system for the trade. Crops that were not sold to factories were traded to rural brokers or local traders; none of the farmers did sell the products themselves. Contrary, this was something that was common in Bondo; the farmers that did sell something of their production were selling it themselves on the local market. In Bondo there were a larger number of the farmers that had an additional non-farm income compared to in Embu.

In both Embu and Bondo a larger percentage of the respondents were women and they had about the same average age. An explanation to the higher number of women responding could be drawn from a cultural context. Women more often stayed working on the farm compared to men, and furthermore the women were obliged to stay at home preparing food for children coming home from school during the lunch break. The households had however more members in Bondo. The average education level in Embu was higher compared to in Bondo where some of the farmers not had attended some schooling at all, and the average had reached a lower level of education. Fewer of the farmers in Bondo were members of some kind of farmer group.

In both Bondo and Embu it was hard to estimate the size of the farm. On average the farms in Bondo were estimated to be bigger than in Embu. The whole farm was however not used with the same intensity, there was more common with fallow cropping in Bondo. The farmers in Bondo had a larger number of cattle, nevertheless there were several farmers that did not have any livestock at all, and thus only had crop production. In Embu none of the farmers had more than 3 cattle but the majority kept livestock. The livestock in Bondo walked freely on the farms or were tied to a tree while the animals in Embu were kept in stables.

4.3.2 Soil fertility management methods used in Embu and Bondo

The methods used to improve soil fertility differed between Embu and Bondo. The frequency to which a certain method was used is presented in table 12.

Table 12. Percentage of farmers using a certain technique.

	Ever used Embu	Last season Embu	Ever used Bondo	Last season Bondo
1. Crop residues	78 %	78 %	76 %	69 %
2. Green manure	41 %	37 %	48 %	48 %
3. Intercropping	89 %	78 %	97 %	90 %
4. Cereal – legume intercropping	81 %	74 %	97 %	90 %
5. Crop rotation	70 %	52 %	62 %	59 %
6. Livestock manure	96 %	93 %	93 %	76 %
7. Compost manure	41 %	37 %	52 %	48 %
8. Chemical fertilizer	96 %	96 %	31 %	17 %
9. Agro-industrial by-products	19 %	7 %	7 %	3 %
10. Fecal sludge	0 %	0 %	3 %	3 %
11. Other	19 %	19 %	7 %	3 %

Which method that was the most used differs between the districts. Very few of the farmers in Bondo used chemical fertilizer, which is a big difference from Embu where 96 % of the farmers used it. Most significant is however the practice of combining livestock manure and chemical fertilizer. In Embu 89 % the farmers did combine it while only 3 % of the farmers in Bondo did that. In both Embu and Bondo the use of agro-industrial by-products was low, the percentage was however slightly higher in Embu.

The use of crop residues was equally high in Embu and in Bondo. In both Embu and Bondo 59 % of the farmers used the residues for mulching. A low percentage of the farmers in the two districts did collect residues from the neighbours. When it comes to livestock manure there was however a distinct difference: 66 % of the farmers in Bondo collected livestock manure from the neighbours while only 37 % of the farmers in Embu did so. The farmers in Bondo did furthermore not use specified techniques to collect the livestock manure. A very low percentage had dug a furrow from the livestock stall, a larger percentage of the farmers used crop residues on the floor in the livestock stall in order to collect urine. The number of farmers that practised this method in Bondo was however lower compared to the number in Embu, 24 % compared to 56 %. None of the farmers in Bondo had concrete on the floor of the livestock stall. When it comes to the application of livestock manure, the respondents in Embu did, most of them, compost the manure before spreading it. In Bondo it was conversely only 17 % that composted the manure. Contrarily 38 % spread the livestock manure when it was fresh while only 4 % did that in Embu. In Embu it was as well much more common to hire labour to help out in the application of the livestock manure.

4.3.3 Perceived importance in Embu compared to Bondo

When it comes to the perceived importance of implementing a certain technique, the answers were quite similar between Embu and Bondo. The largest differences were detected in questions concerning how to apply livestock manure. In Embu the respondents stated that it was not important at all to spread the livestock manure when fresh meanwhile the farmers in Bondo found this practice quite important. To hire labour was perceived as more important in Embu than in Bondo, which can be related to the frequency of hiring labour. The farmers in both districts agreed however on the importance of incorporation of the livestock manure into the soil. Besides, the farmers in Bondo found it more important to make arrangements with the neighbours to obtain a sufficient amount of livestock manure. The farmers in Embu on the other hand recognized a higher importance of digging furrows in order to collect the livestock manure.

There were as well some differences of the perceived importance of chemical fertilizers. In Embu the farmers found it important to apply chemical fertilizer in micro-doses at the root zone, this practice did not receive as high grade of importance in Bondo. To combine chemical fertilizers with organic manure was agreed to be important in Embu, with an average of 4,37 and a median of 5. In Bondo the same statement got an average of 2,32 and a median of 2.

In both districts the farmers gave a high importance to training on soil fertility management. A larger number of the farmers in Embu, 41 %, had received such training compared to Bondo. There were nevertheless a few more farmers in Bondo, 45 % compared to 44 %, which had received training on how to prepare compost manure.

4.4 Willingness to pay for fertilizer

In this section the results from the part of the study investigating the farmers' WTP for the fertilizer DAP is presented. In table 13 it is possible to observe the results, as well as some descriptive data, from the study for Embu and Bondo together, and the separate results for the two areas. As can be seen, the difference between the average WTP for one kilogram, of DAP in the two areas is about one Kenyan shilling apart. However, there was a larger spread in Bondo of how different respondents answered. In Bondo the standard deviation was 12 shilling higher compared to Embu. Furthermore, the difference between the highest and lowest WTP stated in Bondo was 115 shilling, while the difference was 65 shilling in Embu.

Table 13. Descriptive statistics of the results for the willingness to pay for 1 kg DAP in both Embu and Bondo in Ksh

	Mean	Standard dev.	Median	Mode	Max	Min
Embu	44,63	17,97	40	50	90	25
Bondo	43,45	29,97	50	10	120	5
Total	44,02	24,71	45	50	120	5

In Kenya fertilizers are commonly sold in bags of 50 kg. As an approximate recommendation for the amount of DAP that should be applied to 1 acre 153 kg was used, a recommendation used in a study in western Kenya (Kipcoech, *et al*, 2010). In the study is suggested that it would require approximately 378 kilograms DAP for one hectare. In table 14 the average WTP for one kilogram of DAP in Bondo, Embu, and the result from the two areas combined, has been used to calculate the total WTP for one bag of 50 kilograms and the total WTP for applying the recommended amount for one 1 acre. The last column indicates the present market price for 1, 50 and 150 kilograms.

Table 14. Average willingness to pay in Ksh for 1 kg, 50kg and 153 kg of DAP
***** *Source: Kimutai, G, 2012*

	Mean Ksh/kg DAP	Mean Ksh/bag DAP, 50 Kg	Mean Ksh/DAP needed for 1 acre, 153 kg
Embu	44,63	2231,48	6694,44
Bondo	43,45	2172,41	6517,24
Total	44,02	2200,89	6602,69,
Market price*	84	4200	12600

5 Analysis and discussion

In the next chapter an analysis of the results will be made. The analysis will relate to the two specified objectives presented in the introduction. Thereafter there will be a section concerning the possible sources of error for the study. The last part is a discussion part.

5.1 Analysis of Willingness to Pay

Below the results from the study on the farmers WTP will be discussed, with regards to what this means for their possibility to use fertilizer at the market price of 2012.

The result show that the total average WTP was 44,02 Kenyan shilling per kilogram of DAP. The average in each district was less than a shilling apart from the total average. This means that on average farmers in Embu and Bondo afforded to pay close to 44 Ksh per kilogram DAP and be able to buy enough of it for their whole farms each season. Their WTP average was about half the market price in 2012 and therefore showed that the present market price was too high for the farmers to afford on regular basis. The results indicate that the farmers' demand for DAP was lower than, and did not intersect with, the market's supply. At the present market price of 2012 there was no equilibrium between the supply and the demand of DAP, and there was an excess of producer surplus. A market failure is assumed at the market for chemical fertilizer.

The small differences between the averages in both areas were slightly surprising result. What the previous parts of the study has shown was that since the farmers in Embu had larger income they were buying chemical fertilizers to some extent, even at the present market price, while the farmers in Bondo expressed suspicion towards it and did not consume it. This knowledge suggests that farmers in Embu should have been much more willing to pay for fertilizers. The difference in the average WTP should therefore have been more apparent. A reason why the averages were closer than expected to each other could be that the average WTP in Bondo was less representative for the whole group than in Embu. This argument could be supported by the other descriptive data presented in the result. The standard deviation was much larger in Bondo than in Embu. The larger variation in Bondo was obvious when comparing the average of 43,45 Ksh in Bondo with the mode that was just 10 Ksh. In Embu the mode was 40 Ksh and much closer to the average.

Since the mode in Bondo was much lower compared to the average it suggests that there could have been one extreme value in the data that brings up the average. There was in fact one farmer who stated her WTP to be 120 or more. This value was 70 Ksh more than the median, and 110 Ksh more than the mode. If her estimated WTP would be considered as an extreme value and omitted from the average, the new average would be 40,17 Ksh. By omitting the extreme value the average becomes slightly more representative for the whole group and confirms that there should have been a larger difference in WTP between Embu and Bondo.

By analysing the data without the highest value in Bondo it enhances the conclusion that the market price in 2012 was too high and was not set in a equilibrium between demanded and supplied quantity of DAP.

5.2 Possible factors that impact demand of inputs

The results gives that there are some major factors that influence the farmers' perceptions. The text is divided into sections, each dealing with a certain factor that are assumed to impact the demand for inputs used to increase soil fertility.

Economic situation

According to basic production theory a firm will choose the output level that maximizes profit at the point where the firm's marginal revenue equals its marginal cost (Pindyck & Rubinfield, 2009). To make profit, the total revenues have to be higher than the total costs. Concerning how the farmers perceived different methods for increasing soil fertility, a method that would enhance soil fertility provided them with higher profit. Good soil fertility is important to generate output, thus revenues. On the other hand a method that involved costly inputs would increase the total cost of production and lower the profit.

On average the farmers in Embu have a better economic situation compared to the farmers in Bondo. This is a result from the production of cash crops such as coffee and tea being in the area, which provides additional revenues. Even though the farmers stated that they did not receive an appropriate payment for their coffee or tea, there were however big differences between the farmers selling tea or coffee and the farmers that only sold subsistence crops. In Embu there was also a well-developed system for selling the crops produced. The coffee and tea were sold to factories in the nearby area and other crops as bananas and macadamia nuts were sold to rural brokers. In Bondo the farmers that did sell some of their production sold it themselves on the local market. To sell your own production without an intermediary, such as a rural broker could result in a higher effort/cost. Selling on the market yourself takes time that the farmer could have spent on the farm; it includes many negotiations with customers as well. Using a rural broker, the farmer could spend all the time on the farm and would not negotiate about the price several times. The use of a broker could however have an impact on the profit as the broker takes a share. The lower occurrence of selling crops in Bondo could, to some extent, be explained by the lack of system for trade. Thus both the system for sale and which crops that was grown had a high impact of the income level. Even though the average income in Bondo was lower compared to Embu, there were a larger number of farmers that had some non-farm income. Some of the farmers ran their own small-scale business that provided them some financial returns. This could be interpreted as a tradition of entrepreneurship in the area.

Having an income makes it possible to buy inputs to the farm. Inputs that can be brought are such as chemical fertilizer, livestock manure, seeds, labour etc. How the difference in income was expressed in the different districts is illustrated in the list below.

- Higher income in Embu
- High use of costly inputs as chemical fertilizer and agro-industrial by-products
- High importance given to capital intensive inputs

- Lower income in Bondo
- Low use of inputs that need to be brought to the farm
- Low importance given to capital intensive inputs

The economic situation or the lack of labour retained many of the farmers. That the farmers did not incorporate livestock manure or crop residues into the soil or did not apply livestock manure on all parts of the farm is an example of this. The lack of labour force could relate to the financial situation. The farmer could easily hire someone to help out if there only was sufficient economic means. It is clear that the income is the limiting factor to use some of the methods.

Many of the farmers stated, as an example, that it was very important to line the floor in the livestock stall with concrete. However there were only a few per cent of the farmers that actually had done it. The farmers stated that they did not have the possibility of using concrete in the livestock stall since it was too expensive. The same answer was received on the question about agro-industrial by-products. The farmers found the products too costly to make it possible to use them. In the use of chemical fertilizer the economy probably also plays a major role. The perception of chemical fertilizer will be further developed and discussed under section 5.2.

Knowledge in relation to soil fertility management

The statements concerning education were given high importance in both districts. According to the farmers, it was very important to have knowledge about soil fertility management to be successful in farming. The farmers' own assumptions follow the concept of technological change within microeconomic theory. Training will increase the productivity of the input labour, meaning that with training the farmers' labour will become more efficient, and in it's turn provide economic benefits since the farms' profits should increase (Pindyck & Rubinfield, 2009). Even though training was considered as highly beneficial among the farmers not many of them had received instructions on farming techniques. The farmers often stated that they had searched for training but that it had been unavailable. Either such instruction was not offered in the area, or the agricultural extension officers that should provide the training did not have the time to go to the farmers or simply did not show up when the training was about to be held. Many of the farmers asked even while interviewed how they could receive training or if education was provided in connection to this study. Another reason for the farmers' lack of training was that it could be too costly. The farmers may have to pay a fee to receive the training. Especially in Bondo where both income-level and education-level was low, the economic aspect may be a reason not to undertake training. Time spent on training means as well that less time is spent on the farm, resulting in a risk of loosing farm revenues. There could be farmers that do not have time to spend on training since they have to work on the farm or at an additional job.

The grade of knowledge on soil fertility management varied among the farmers and between different methods. In Embu, nearly all farmers knew how to compost the livestock manure to facilitate the spreading. This was as well a practice that was considered as the most important. Some of the farmers also practiced intercropping with beans since they had knowledge about the nitrogen-fixing capacity. In some cases, the farmers had knowledge about a certain method but they did not have the economic resources or labour force to apply it. The knowledge about a certain method had an impact on the perceived importance and the application of the method.

The supply of inputs

The supply of a certain input may impact the perception of the product. Farmers in Embu gave a higher importance to the use of agro-industrial by-products used as a complement to livestock manure or chemical fertilizer, or as fodder for livestock. The explanation of the perceived higher importance in Embu may be that there was a supply of those products in the area since there were factories producing coffee husks as by-products nearby. In Bondo on the other hand there were no such products produced in the nearby area. There was a sugar factory that had a by-product from sugar cane, but it was quite far away from Bondo. To use those products was therefore connected to higher total cost of production, both from transport and from buying the products.

Both in Embu and Bondo there was frequent use of livestock manure. The practice was as well considered highly beneficial. According to the statements that received the highest grade of importance there was as well many that concerned livestock manure. The farmers that kept animals had a regular supply of livestock manure and it therefore became a cheap source of

nutrients to the soil. In Embu the farmers also had a more developed system to take care of the manure. First, the livestock were kept in stables, something that facilitates the collection. Thereafter there were a larger percentage of the farmers that had systems for collecting manure. This could be such as furrows from the livestock stall to a compost, or use of crop residues on the floor in the livestock stall. In Bondo, the farmers did not seem to care about the collection of livestock manure in the same extent as in Embu. Many of the farmers let the livestock walk freely on the farm and did not have a system to collect the manure were the animals had passed. They did not give methods to help out in the collection of manure as high importance either. Nevertheless the farmers in Bondo gave the impression that they did not have a sufficient supply of livestock manure. If they improved the methods to collect the manure and assured that all manure produced by the livestock were used, there would most probably be a larger supply of animal manure.

The fact that many of the farmers in Bondo did not have any livestock may influence the answers concerning whether it was important to collect livestock manure from neighbours. There was a major difference in perception in this concern between Bondo and Embu. There were more farmers in Bondo that gave a high importance to the collection of livestock manure from neighbours. This may be a result of the animal patterns in the area. In Embu nearly all the farmers kept their own livestock. In Bondo the herds were bigger but not all the farmers kept livestock. This may as well have an impact of the possibility of collecting livestock manure. The farmers that kept many cattle in Bondo, possibly had enough manure to be able to sell to the neighbours, while in Embu the farmers that kept only one cow did barely have an sufficient amount to apply on their own farm. The importance could thus be relating to the actual possibility and frequency of the practice in the area.

Many of the farmers did as well take care of products that they naturally had on their farm, such as crop residues. In Bondo a higher importance was given to the use of crop residues. The use of residues was also a cheap source of nutrients. Both farmers in Embu and Bondo found that mulching and incorporating the residues into the soil were important. The easy access to those products and the fact that using them was not connected to a high cost may be the reason why these practises received such high importance.

The impact of the characteristics of the farm and the farmer

During the interviews there were a difference between women and men answering. When the respondent was a woman it was more common that she searched for the answer from either the interviewer or the interpreter before answering a question. It could be seen as she wanted an indication whether she gave a correct answer or not. When this happened during the interviews the interviewers remained as neutral as possible in order not to indicate an answer. This scenario did not happen when the respondent was a man, the men made impression of being much more self secure compared to women.

The characteristics of the farm were also important for the actual practice on the farm. Many of the farmers gave a high importance to fallow cropping, especially in Embu. Very few of the farmers did however practice fallow cropping. This may be explained by the farm size. An average farm was between one and two acres. The shortage of land was a limiting factor of production for the farmers. The farmers stated that they mostly did not produce enough of subsistence crops to be able to sell some; they just had enough to nourish the family. Leaving some of the plots in fallow would result in lower amounts of crops produced. This is something that was not feasible on many of the farms. Even if fallow cropping were believed to increase soil fertility the farmer could not afford to have a lower production one year.

Another characteristic of the farm was the number of family members. A larger family often means more labour force on the farm. In Bondo the families were bigger compared to Embu.

The larger family size may be a result of polygamy being practiced in the area. It was more frequent that the farmers in Bondo had enough family labour to help out with the work on the farm. In Embu the farmers more often hired labour. A simple explanation to why the farmers in Bondo did not frequently hire labour may be that they had enough family labour. Another part of the explanation may be that the farmers did not have the financial means to hire someone.

Perception of cooperation

In general there were different patterns of cooperation. A larger number of the farmers in Embu did participate in a farmers group and many of the farmers did as well take part in co-operatives dealing with sales of coffee and tea. The cooperation may have had a positive impact on the farming. Within the farmer groups and the cooperatives, knowledge can be spread, something that is positive for the individuals farming and the community as whole. If the farmers have a higher level of education on farming it may strengthen their economic situation, which is beneficial for society. A higher grade of collaboration could as well make it easier for farmers to collect inputs as livestock manure and crop residues from each other something that could be beneficial for both parts. The farmers selling, receives money and the farmer buying will get a sufficient amount of inputs for the farm. Many of the farmers today stated that it was hard to collect those products from neighbours and one of the farmers even stated that he preferred to sell additional amounts of fodder and buy manure from an agro-dealer rather than exchange fodder for manure from a neighbouring farm. How the cooperation between neighbours work could nevertheless differ between sub-locations. To develop the farming systems so that the farmers work together in farm groups could be beneficial for the agriculture sector and a way to reduce poverty. This will be developed further in part 5.4 Discussion.

5.3 Sources of error

There are some possible sources of error in this study. The fact of having an interpreter may be a source of error since it may lead to a non-correct translation of either the question or the answer. The interpreter may as well put some personal values to the questions. To delimitate the possible errors coming from the interpreter, the questionnaire were discussed with, and explained to, the interpreter before starting the interviews. Furthermore there were many languages used by the persons involved in the study such as Swedish, English, Swahili and local languages.

In some questions the respondent had to estimate the answer. This may as well be a source of error. Some estimates are hard to make, and in other cases the respondent may not have been willing to give a correct answer. The error from estimation is most common in questions regarding income, farm size and distances. Concerning the income, the respondents may have indicated lower income in the purpose of receiving economical help from organizations attached to the study, such as Sida.

Some of the statements in the questionnaire may have been hard to understand for the farmers. This problem was handled by extensive explanations. In general the interviewer may not have explained the questions in the exact same words through all the 56 interviews. This may as well be a source of error. The respondent may seem to understand a question even though it was not the case. The expressions were explained as clearly as possible but misunderstanding is however a probable source of error. In some cases lack of knowledge about the practice, from the farmer, may have caused the misunderstanding. Some of the questions in the questionnaire was as well closed which may have had an impact on the answers received. In some other questions the respondent had to give a graded answer from a scale from 1 to 5, in some cases it was hard for the respondent to grade, and answered in terms of yes/no instead. When repeating the question the respondent mostly gave the extreme answers 1 or 5.

Some of the farmers may have given answers not telling their personal thoughts but according to the answers they thought were wanted. This may as well be a possible source of error. This may also be related to the possible sources of error when estimating the WTP. The farmers would maybe not like to state their actual WTP. In some cases the farmer may have thought that the study was going to result in a change of price of the fertilizer DAP to the level that was indicated. This may have had an influence on the answers, probably so that the indicated price is lower than the highest affordable price. To avoid such kinds of misunderstandings the purpose with the question was clearly explained, *cheap talk* was implemented, and the payment card was used as an explanation of the problem. The farmers were also told to give an as realistic price as possible but that it was not a real situation for purchase of fertilizer. In some other cases, the presence of other persons during the interview may as well have an impact on the estimation of WTP. But in those cases the suspected error is that the estimation may have been too high according to the real economic situation. If there were other persons present during the interview the respondent may not have been willing to indicate a severe economic situation and therefore indicated a higher price than he or she could actually afford.

When farmers were asked to state their willingness to pay for DAP, they were asked how much they could afford to pay to buy a sufficient quantity to be used on their whole farm each season. The sufficient quantity was appreciated by the use of a general recommendation per acre. Further development of this study could be that the respondents were asked about how much they were prepared to pay for a specific amount of DAP. The specific amount should be calculated from the area of the farm, nutrient balance in the soil and the need of the crops grown. Basically a more specific recommendation than the general recommendation used in this study, which would provide the farmers with more information before stating their willingness to pay.

5.4 Discussion

In the following section some topics related to the study will be further discussed. One part of the discussion will be how this study can be further developed.

5.4.1 Land reform

While carrying out the interviews, three general limitations of production were observed that hindered the farmers from improving their economic status. These were lack of land, labour and capital. However hypothetically there is a solution to the problem of too small lands. If applied it would provide ease to the other limitations as well. The solution is that neighbouring farms could be merged together, which could provide large-scale advantages. As example it would only be necessary to buy one set for a part of the equipment required. The money saved could be put on attaining modern equipment; getting training to improve the methods used; or hiring extra labour. Furthermore if farms were merged together it would be possible to use mechanical equipment, such as tractors, that are inefficient to use on too small lands. This could increase the efficiency on the farm and enable an expansion, which would provide even more capital.

In both Embu and Bondo it was possible to observe that the farmers were co-operating with each other in certain aspects of their farming. As in Embu many farmers came together to sell their cash crops or to save money to afford production improvements. In Bondo neighbours would to a larger extent than in Embu help each other by supplying excess crop residues and livestock manure to one another. These examples of cooperation provided small mutual benefits for the farmers, but if these neighbourhoods would carry out full land reforms it would likely increase the farmers wealth to a large extent.

5.4.2 Concerns about fertilizer

A topic that often is taken to discussion in developed parts of the world is the use of chemical fertilizer in relation to the environment. A too high level of nutrients in waters near farms due to leakage of nutrients, and eutrophication from the use of chemical fertilizer is a problem in many developed countries. In those countries the use of chemical fertilizer is often too high, resulting in positive nutrient balance. There are often several methods to reduce the use, such as taxation or prohibitions of chemical fertilizer or subsidising organic manure. A study like this that somehow promotes the use of chemical fertilizer would be totally irrelevant and in conflict with goals of protecting the environment in those countries. The situation in Sub-Saharan Africa is however the opposite. There is a lack of nutrients, each year several kilograms disappear from the soil, creating a negative nutrient balance (FAO, 2003). Africa accounts for about 3 % of total use of fertilizer in the world, whether Europe uses around 13 % of all nutrients produced (FAO, 2008). Coming from a developed country with the perception of chemical fertilizer being something bad, this study may seem inappropriate. However when having some understanding of African farming systems, the purpose of the study is relevant. This said, the use of chemical fertilizer could of course be negative for the soil even in developing countries. An example could be too high levels of salt in the soil coming from a very concentrated use of chemical fertilizer.

5.4.3 Further development of the study

One way to widen this study could be to investigate the willingness for DAP in the same areas in the coming years, to get an estimate over a longer time period. Doing this, changes in WTP could be discovered, something that could indicate a better economic situation or a change in perception towards DAP in the area. Since the use of fertilizers is important in order to strengthen and improve the agricultural sector it is central to know the possibilities to buy fertilizer among the farmers over time.

6 Conclusions

Here each of the two objectives of the study presented in part 1.3 will be provided with conclusions reached from the analysis of the study.

What is the willingness to pay for the chemical fertilizer DAP among small-holder farmers in central and western Kenya?
The willingness to pay for the fertilizer DAP was on average for both areas 44,02 Ksh per Kg. This average was about half of the present market price in 2012, and it was therefore possible to conclude that the farmers in Embu could not afford the present market price in order to buy as much as they needed for their whole farm on a regular basis. The WTP points towards there being a market failure on the market of DAP, where the supply is higher than the demand at the present market price. Since the WTP was much lower than the present market price the hypothesis can be confirmed.

How do small-holder farmers in Kenya perceive the importance of different methods to improve soil fertility?
The study has shown that there are four major factors that influence how methods increase soil fertility were perceived, and how these factors were used. Since these factors influence the choice of inputs, they could explain the demand for different inputs, such as the demand for chemical fertilizer. The first factor was the cost of different methods in combination with the farmers' revenue. Since farmers in Bondo had less income than in Embu, they tended to perceive less importance in inputs that involved a higher total cost. In both areas the more expensive methods received lower grades than the less expensive ones. The second factor was the level of training. In both areas many farmers thought it was important with training in soil fertility management but few had received it. There were more farmers in Embu that had received it, and they would therefore use methods that required more training and knowledge to a larger extent than in Bondo. A third factor was the supply of inputs. If there was a greater accessibility to certain inputs these inputs tended to be used more than less accessible inputs. Finally, the last factor was the characteristics of the farmers and their farms. Characteristics such as gender, size of family and farm affected how important certain methods were perceived. Those factors are assumed to affect the demand of the inputs used to increase soil fertility. Therefore, this conclusion confirms the hypothesis, which was that characteristics of the farms and the situation of the farmers would affect the perceived importance of the different methods.

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Appendix 1: Questionnaire

Questionnaire number:_____ Date of interview: _____ Name of the interviewer:

District: Embu/Kisumu Location:_____ Sublocation:_____

Value and perception of fertilizer –

in relation to livelihoods among small-holder farmers in Kenya

The purpose with this study is to estimate willingness to pay for fertilizer. A risk-benefit analysis of the use of fertilizer will as well be a part of the study.

AGENDA

Before interview

- **Presentation of**: - Our names, origin and reason for visit
  - Our connection to the Swedish Agricultural University
  - The study and the purpose with the interview, a part of Sida, result in our Bachelor thesis, evaluate possibilities of increase in food production
- **Request to farmers**: - Their participation in the interview
  - If photographing is accepted
  - If we can be shown around the farm before the interview, and make a sketch of it.
- **Inform participants**: - We will come back to present our results for the participants after concluding our interviews the end of the study.

Interview

- **Part 1:** Basic facts about the farm and the person answering the questionnaire
- **Part 2:** A statement part – here the respondent will relay to 34 statements. First by answering them with Yes/No and then by ranking them from 1 to 5 according to their importance.
- **Part 3:** The Risk-Benefit analysis. The respondent will here indicate how important certain techniques or failure in techniques are for soil fertility.
- **Part 4:** A payment-card where the willingness to pay for fertilizer is measured. The respondent has to state how much he or she is willing to pay for one kilogram of fertilizer.

Required equipment: Four questionnaires (where three of them are reusable), pens, markers, sodas, SLU-pens, folders, paper-clips

1

Questionnaire number:_____ Date of interview: _____ Name of the interviewer:

District: Embu/Kisumu Location:_____ Sublocation:_____

PART 1

1.1 FARMER AND SITE IDENTIFICATION

1.1.1 Respondent's name (in full).....

1.1.2 Location …… Sub-location ……

1.1.3 Village…… Phone number……..

1.1.4 Household Status…….. 1= Male headed, 0= Female Headed

1.1.5 Distance to the nearest local market (Km) ……

1.1.6 Distance to an agricultural extension office (Km) ……...

1.1.7 Distance to main road (km)……

1.2 FARMER'S SOCIAL AND DEMOGRAPHIC FACTORS

1.2.1 Household Membership list of members:

Please complete the table below for all the people who live in your household

Name of household member (start with respondent)	Gender (Codes A)	Ages (Years)	Martial status (Codes B)	Years of schooling	Main occupation (Codes C)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

"

Codes A	Codes B	Codes C
1. Male	1. Married	1. Full-time farmer
2. Female	2. Single	2. Full-time employee
	3. Widow/widower	3. Part-time employee
	4. Divorced	4. Self-employed
	5. Separated	5. Student
		6. Other *(specify)*……

"

1.2.2 What type of farming do you undertake? ……List the major crops grown

……..

1.2.3 For how many years have you been doing farming? ……

2"

"

Questionnaire number:_____ Date of interview: _____ Name of the interviewer:

District: Embu/Kisumu Location:_____ Sublocation:_____

1.2.4 What percentage of your production is sold? ……..%

1.2.5 What is the size of your farm in acres? .....

1.2.6 What size of your farm is under production? …… acres

1.2.7 Who is the **main** buyer of your production?

1.Local trader	4. Rural assemblers/brokers	7. Urban traders
2. Supermarket	5. Restaurants	8. Exporter
3. City markets	6. Neighbors	9. Others *(specify)*……

1.2.8 Do you irrigate your plots? 1. Yes 0. No

1.2.9 If YES, what is your **main** source of irrigation water?"

1. River / stream"	4. Piped/ tap water"	7. Sewage"
2. Borehole (*kisima*)"	5. Dam"	8. Run-off water"
3. Well (*kidimbwi*)"	6. Roof water"	9. Other (*specify*)……"

1.3 Income sources (*Record from last season September 2011 – January 2012)*

Source of income		**Amount (Ksh)**
Farm income	Crop income	
	Livestock income	
Off-farm income	Non-farm	
Other *(specify, e g pension, remittances)*		

3"

"

Questionnaire number:_____ Date of interview: _____ Name of the interviewer:

District: Embu/Kisumu Location:_____ Sublocation:_____

1.4. Livestock production activities"

1.4.1 Do you keep any livestock on your farm? 1. Yes 0. No

1.4.2 If YES, what type of livestock do you keep on your farm? *(Please do not report livestock that does not belong to this household).*

Livestock type:	**Number:**
1. Cattle	"
2. Calves	"
3. Goats	"
4. Sheep	"
5. Donkeys	"
6. Pigs	"
7. Rabbits	"
8. Poultry	"

"

1.5 Membership to associations/groups

1. Do you belong to **any** farmer group? (*Codes A*)	**2.** Does **any** of the groups you belong to deal with vegetables / flowers*(Codes A)*	**3.** If YES in **2**, what is the **main** function of the group? (*Codes B*)	**4**. How long have you been a member?

"

Codes A
1. Yes
0. No

Codes B
1. Produce marketing
2. Crop production
3. Farmer research group
4. Providing labour for ploughing / weeding/ harvesting
5. Soil and water conservation
6. Input access
7. Savings and credit
8. Others *(Specify)*……

4"

"

Questionnaire number:_____ Date of interview: _____ Name of the interviewer:

District: Embu/Kisumu Location:_____ Sublocation:_____

PART 2

2.1 SUSTAINABLE SOIL FERTILITY MANAGEMENT PRACTICES

2.1.1 Please indicate which of the following soil fertility enhancing practices you use or have ever used on your farm

Management practice	Ever Used?**1. Yes 0. No**	Used last season? **1. Yes 0. No**
1. Crop residues		
2. Green manure [e.g. Desmodium, Lantana*(mushomoro)*, Mucuna, Tithonia (*maroro)*, etc]		
3. Intercropping		
4. Cereal – legume intercropping		
5. Crop rotation		
6. Animal manure		
7. Compost manure		
8. Chemical fertilizer		
9. Agro-industrial by-products (e.g coffee husks, etc)		
10. Faecal sludge 11. Other ……		

"

2.2 Please indicate whether you agree or disagree with the following statements *(tick appropriately).*

Statement	Yes	No
1. I have received training (including demonstrations, informal training) away from my farm site on soil fertility management.		
2. I identify and incorporate in the soil crop residues that are high in nutrients and easy to decompose.		
3. I collect crop residues from my neighbors after harvesting which I add to those I produce from my farm so that I can have enough to use		
4. I sometimes apply crop residues as a mulch		
5. I prune my hedges / boundaries and use the materials for surface mulching.		
6. I incorporate into the soil the materials I get after pruning the hedges and boundary crops.		
7. I collect animal manure from neighboring (max ½ kilometer) farmers in order to obtain sufficient amounts of manure for my production.		
8. I have to travel for several kilometers (more than 3 km) to get livestock manure.		
9. I make arrangements with my neighbors who keep livestock to supply me with animal manure in exchange for fodder.		

5"

"

Questionnaire number:_____ Date of interview: _____ Name of the interviewer:

District: Embu/Kisumu Location:_____ Sublocation:_____

10. I apply straws/crop residues / wood shavings to the livestock stall for insulation and to absorb urine which I later apply on the field		
11. I have dug a furrow through which the livestock urine and dung from the shed flows directly to the farm where I have planted crops		
12. I have to hire a donkey cart from my neighbor in order to transport livestock manure from the source (more than 3 km) to my farm		
13. I hire enough labour to assist in the application of livestock manure		
14. I easily mobilize my neighbors and friends to help me in applying livestock manure to my crops		
15. I spread fresh livestock manure on the surface of the soil		
16. Based on the knowledge I have, I compost livestock manure before spreading to the soil surface		
17. I incorporate livestock manure into the soil		
18. I apply chemical fertilizers in micro-doses (match-box) volume equivalent at the root zone of the crops.		
19. I combine chemical fertilizers with organic manure		
20. I practice crop rotation / intercropping because it fits in my cropping patterns.		
21. I always include legumes in the crop rotations / intercropping		
22. I often apply agro-industrial by-products (coffee husks) from nearby agro-processing factories on my farm to supplement livestock manure and chemical fertilizer		
23. I feed agro-industrial by-products I get from agro-processors to livestock so that I can get quality livestock manure, which I then apply to my soils		
24. I often hire a truck / donkey cart to transport agro-industrial by-products (coffee husks) from agro-processing factories which are far (more than 5 km) away from my farm so that I can apply on my farm.		
25. I seek / have sought training from agricultural extension officers on how to prepare and apply compost manure.		
26. In absence of livestock manure, I make use of human faecal sludge for my production.		
27. I use human faecal wastes on my farm from my own family.		
28. I source for human faecal wastes from my neighbors.		
29. I apply livestock manure, or faecal sludge only at plots close to the place where I store it		
30. I combine human faecal sludge with livestock /compost manure		
31. I have enough family labour to enable the application of compost & farmyard manure.		

6"

"

Questionnaire number:_____ Date of interview: _____ Name of the interviewer:

District: Embu/Kisumu Location:_____ Sublocation:_____

32. I hire labour to enable the application of compost / farmyard manure		
33. I always use deep-rooting green manure crops in my crop rotation in order to recover nutrients from lower soil horizons		
34.I have lined the floor of the livestock stall with concrete to allow regular collection of urine which I apply on the farm		

2.3 Please use the following scale for the next set of statements to indicate the extent to which the following statements describe yourself *(tick appropriately)*

1	Strongly disagree
2	Disagree
3	Neither disagree nor agree
4	Agree
5	Strongly agree

Statement	1	2	3	4	5
1. It is important for me to have received training on soil fertility management provided by agricultural extension services.					
2. Identifying and incorporating in the soil crop residues that are high in nutrients and easy to decompose will improve soil fertility status.					
3. It is necessary to collect crop residues from my neighbors after harvesting to add to those I produce from my farm so that I will have enough to apply on my farm.					
4. It is important for me to apply crop residues as a mulch					
5. For my farming it is important to prune my hedges / boundaries and use the materials for surface mulching.					
6. Incorporating into the soil the materials I get after pruning the hedges and boundary crops will increase soil fertility.					
7. For me it is important to collect livestock manure from neighboring (max ½ kilometer) farmers in order to obtain appropriate amounts of manure for my [ ] production. 8. I travel for several kilometers (more than 3 km) to get livestock manure.					
9. Making arrangements with my neighbors who keep livestock to supply me with livestock manure in exchange for fodder is important. 10. It is important to apply straws and wood shavings to the livestock stall for insulation and to absorb urine to be applied in the field.					
11. It is important for me to line the floor of the livestock stall with concrete to allow regular collection of urine to be applied on the farm. 12. It is necessary to dig a furrow through which the livestock urine and dung from the shed flows directly to the farm where I have planted crops					
13. It is important for me to hire a donkey cart from my neighbor in order to transport livestock manure from the source (more than 3 km) to my farm					
14. It is necessary to hire enough labour to assist in the application of livestock manure					

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Questionnaire number:_____ Date of interview: _____ Name of the interviewer:

District: Embu/Kisumu Location:_____ Sublocation:_____

15. Mobilizing my neighbors and friends to help me in applying livestock manure to my crops is important for me.					
16. It is important to first compost livestock manure before spreading to the soil surface					
17. Applying chemical fertilizers in micro-doses (match-box) volume equivalent at the root zone of the crops is important.					
18. It is important to combine chemical fertilizers with organic manure					
19. It is important to spread fresh livestock manure on the surface of the soil					
20. Understanding cropping patterns on my farm is important for crop rotation					
21. It is important to incorporate livestock manure into the soil					
22. It is important to apply agro-industrial by-products (coffee husks) from nearby agro-processing factories on my farm to supplement livestock manure and chemical fertilizer					
23. Feeding agro-industrial by-products from agro-processors to livestock is important in order to get quality livestock manure to apply to my soils					
24. It is of importance to me to hire a truck / donkey cart to transport agro-industrial by-products (coffee husks, rice husks) from agro-processing factories which are far (more than 5Km) away from my farm so that I can apply on my farm.					
25. It is important to me to seek training from agricultural extension officers on how to prepare and apply compost manure.					
26. It is important to me to make use of human faecal sludge for my production.					
27. It is necessary to use human faecal wastes in my farming because I believe it would release nutrients easily for the crops I grow on my farm.					
28. I apply livestock manure, or faecal sludge only at plots close to the place where I store it					
29. In my farming it is necessary to combine human faecal sludge with livestock /compost manure					
30. It would be of importance for me to hire enough labour to enable the application of compost & farmyard manure.					
31. It is important to me to use deep-rooting green manures in my crop rotation because I believe that they recover nutrients from lower soil horizons					

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Questionnaire number:_____ Date of interview: _____ Name of the interviewer:

District: Embu/Kisumu Location:_____ Sublocation:_____

PART 3.

3.1 A measure of benefits and risks in general soil fertility management

3.1.1 Please use the scale below to indicate how important the following techniques are in enhancing soil fertility

Very important	5
Important	4
Neither important nor unimportant	3
Less important	2
Not important at all	1

Statement	1	2	3	4	5
1. Use of chemical fertilizer alone					
2. Use of livestock manure alone					
3. Combined use of chemical and livestock manure					
4. Crop rotation with legumes					
5. Use of crop residues as mulch					
6. Incorporation of crop residues into the soil					
7. Leaving the farm fallow for sometime					
8. Use of faecal wastes alone					
9. Combined use of faecal wastes and livestock manure					
10. Combined use of faecal and compost manure					
11. Use of compost manure alone					

3.1.2 Please use the scale below to indicate how you think failure to use of the following techniques would lead to low soil fertility

To a very large extent	5
To a large extent	4
I don't know	3
To a less extent	2
To a very less extent	1

Statement	1	2	3	4	5
1. Not using chemical fertilizer alone					
2. Not applying livestock manure alone					
3. Not combining chemical and livestock manure					
4. Not practicing crop rotation with legumes					
5. Not using crop residues as mulch					
6. Not incorporating crop residues into the soil					
7. Not practicing fallow cropping					
8. Not using human faecal wastes alone					
9. Not using combined human faecal wastes and livestock manure					
10. Not using combined faecal and compost manure					
11. Not applying compost manure alone					

9"

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Appendix 2: Payment card

Questionnaire number:_____ Date of interview: _____ Name of the interviewer:_____

District: Embu/Kisumu Location:_____ Sublocation:_____

Part 1: Willingness to pay for the fertilizer Diammonium phosphate, DAP

To grow properly, plants extract nutrients from the soil. With enough nutrients a plant can keep a high quality, grow tall and have the right color.

Examples of necessary nutrients are phosphorus and nitrogen. When nutrients are extracted from the soil, new nutrients need to be added, so that there are enough nutrients for the next planting of crops. This can be done through chemical fertilizers or manure. The advantage in using fertilizers is that when it is used as recommended the soil should receive a perfect combination of different nutrients. Therefore, to have a sustainable and profitable production, the use of fertilizers is recommended if affordable.

Scenario 1: You do not use any fertilizer

Picture of maize cultivated without fertilizer.

Non-use of fertilizers will in the long-run result in lack of nutrition in the soil. When the crops are harvested the nutrients will follow with the crops and leave the soil with a lower level of nutrients. This will lead to decreasing yields in succeeding years.

Scenario 2: Diammonium phosphate, DAP is used to add nutrients to the soil

Picture of maize cultivated with the use of fertilizers.

Diammonium phosphate (DAP) is a widely used non-organic (chemical) fertilizer. The majority of the content is phosphorus and a smaller amount is nitrogen. The use of DAP is expected to improve the yield, and hence increase the production of crops. When you use the recommended amount of DAP, the yield is expected to increase by a quarter. This means that if you produce 100 maize cobs when you are not using any fertilizers, you are expected to produce about 125 maize cobs with DAP, thus 25 more. The amount DAP recommended is 3 bags of 50 kg per acre which is equal to 150 kg per acre.

Use of non-organic fertilizers does not improve organic content of the soil since no new organic material is added. If a high level of fertilizer is applied on the same part of the plot it may lead to a too high level of salt in the soil. In extreme cases nutrients may also leak to the ground water.

We would now like to estimate your willingness to pay for DAP. Please don't agree to pay an amount if you think you can not **afford it on a regular basis** or if you feel that there are more important things for you to spend your money on, or if you are not sure about being prepared to pay or not.

We are asking for your most truly willingness-to-pay here so please provide the sincere response. Thank you

Questionnaire number:_____ Date of interview: _____ Name of the interviewer:_____

District: Embu/Kisumu Location:_____ Sublocation:_____

Estimation of willingness to pay

On this sheet different amounts of money are written, mounting from zero up to more than 120 shillings. Starting at the top of the list and moving down please ask yourself as if you were about to buy DAP: "Am I willing to pay 5 shillings extra for one additional kg of DAP. Or would I rather not pay this amount and then use no fertilizer as in Scenario 1?" If you are almost certain you would pay the amounts of money in the card to buy one additional kg of DAP then place a tick (√) in the space next to these amounts."

Scenario 1 *You do not use any fertilizer*	**Scenario 2** *DAP is used to add nutrients to the soil*		***Example*** **Total cost** in Ksh for recommended amount 150 kg/acre	***Example*** **Total cost** in Ksh, for a 50 kg bag
In Scenario 1 you do not use any fertilizer. There will be no additional cost in production for the use of fertilizer. However the harvest may be reduced according to lack of nutrients in the soil.	In Scenario 2 you buy and use the fertilizer DAP. This will increase your cost of production. At the same time there will be sufficient amount of nutrients in the soil, resulting in a higher volume and quality of the yield compared to the case without fertilizer. The soil quality will, however, not be improved.			
Indicate by ticking in the appropriate box how much more you are willing to pay extra for DAP in scenario 2 as compared to scenario 1	0 Shilling/kg			
	1-5 Shilling/kg			
	6-10 Shilling/kg			
	11-15 Shilling/kg		150-750 Ksh if you are willing to pay	50-250 Ksh if you are willing to pay
	16-20 Shilling/kg			
	21-25 Shilling/kg			
	26-30 Shilling/kg			
	31-35 Shilling/kg		1-5 Ksh/kg	1-5 Ksh/kg
	36-40 Shilling/kg			
	41-45 Shilling/kg			
	46-50 Shilling/kg			
	51-55 Shilling/kg			
	56-60 Shilling/kg			
	61-65 Shilling/kg		6900-7500 Ksh if you are willing to pay	2300-2500 Ksh if you are willing to pay
	66-70 Shilling/kg			
	71-75 Shilling/kg			
	76-80 Shilling/kg			
	81-85 Shilling/kg		46-50 Ksh/kg	46-50 Ksh/kg
	86-90 Shilling/kg			
	91-95 Shilling/kg			
	96-100 Shilling/kg			
	101-105 Shilling/kg			
	106-110 Shilling/kg		14400-15000 Ksh if you are willing to pay	4800-5000 Ksh if you are willing to pay
	111-115 Shilling/kg			
	116-120 Shilling/kg			
	More than 120 Shilling/kg		96-100 Ksh/kg	96-100 Ksh/kg

Appendix 3: Feedback to the farmers

First, we would like to thank you very much for your participation in our study. It has been very helpful and educational for us! In this sheet is presented the preliminary result from the three groups of Swedish students working in the districts of Embu and Kisumu. In this feedback to you we will make some comparisons between the two areas in where we have been interviewing.

Preliminary results from the study "Observations of soil fertility management among farmers in Embu nd Kisumu"
Madelene Casselbrant & Siri Lindqvist Ståhle

This are results from a study on soil fertility management in Kisumu and Embu. During April and May 2012, 29 farmers were interviewed in Bondo district (Kisumu), and 27 in Kibugu town (Embu). The study shows that the most common methods that the farmers use for increasing soil fertility are the use of animal manure, followed by intercropping and use of crop residues. At the same time, the farmers state that those methods are the ones that are the most useful to them. However it is specified that the crop residues are used for mulching and that cereals and legumes should be combined in the intercropping to give the highest benefit.
If separating the results from each district the result is as follows: In Bondo the use of animal manure and crop residues are most frequent, while in Kibugu, animal manure and chemical fertilizers are equally used, followed by crop residues and intercropping. To use crop residues for mulching and to include legumes in the crop rotation is considered as highly useful in Bondo. According to farmers in Kibugu the largest utility comes from combining animal manure with chemical fertilizer. They also consider fallow cropping and incorporating crop residues into the soil as highly useful.

Willingness to pay for one kilogram of Diammonium Phosphate, DAP
The average amount that the farmers are prepared to pay for one kg of DAP in both districts is 44,02 shillings. This means that most farmers are willing to pay 2200 shillings for a bag of 50 kg. In Embu the average is 44,63 per kg DAP. The sum that the farmers are prepared to pay for a bag of 50 kg is then 2231 Ksh. The average in Kisumu is 43,45 Ksh per kg, resulting in a willingness to pay for a bag of 50 kg is 2172,41 Ksh.

Preliminary results from the study "Soil fertility management and use of improved maize seeds among farmers in Embu and Kisumu"
Anna Lenksjö & Henrik Nordzell

The farms are generally bigger in Bondo then in Kibugu. In both places the farmers think that leaving the plots to rest is very important in increasing crop yield. But due to lack of land it is difficult to implement in Kibugu. It is more commonly used in Bondo. Most of the livestock in Bondo is walking freely and grazing in the nature. The farmers do not have to feed their animals with crop residues, and can use them to increase soil fertility instead. The farmers in Kibugu thinks that crop residues would be good for the soil, but they have to use them as animal feeds.
Animal manure and crop residues are limited resources, and most farmers would like to get access to more if they could.

The most commonly used practices to increase soil fertility were chemical fertilizer, intercropping and composted animal manure. More than half use materials from the hedges for surface mulching and applies crop residues on the stall floors to simplify the collection of animal manure. Almost everyone compost their animal manure because it will work better then when applied fresh. It is also very common to incorporate animal manure in the soil and combine animal manure with chemical fertilizers. The things the Kibugu farmers think is most important to increase soil fertility is;

- to receive training on soil fertility and on how to prepare and apply animal manure
- incorporate crop residues and animal manure in the soil
- use materials from the hedges as a mulch
- compost animal manure before spreading it
- combine animal manure and chemical fertilizers
- to understand cropping patterns when doing crop rotation.

The use of seeds is very differentiated in the two areas. Everyone in Kibugu uses hybrid seeds, while the local seeds is as good as gone. It is the opposite situation in Bondo, where a majority of the farmers still uses the local seeds. The farmers in Kibugu grows coffee and tea as cash crops, and thereby has an income which makes it possible for them to buy seeds. The OPV seed was unknown to the farmers in both Kibugu and Bondo, though the interest of trying it is big after hearing about it from us. The willingness to pay for the seed is between 30-170 KSH/kg, with an average of 98 KSH/kg.
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Preliminary results from the study "Economic situations among small-holder farmers in Kisumu"

Tina Jönsson & Mika Rådman

During the last month we have interviewed 17 farmers in the Embu area about their economic situation. Our aim was to evaluate how the use of improved seeds and chemical fertilizers affects the farm economy. We focused on maize and beans since many farmers grow these crops.
In our preliminary results we found that most farms have 1,5 acres of land, and has an average margin of 37 000 ksh/year. In both the short rains and the long rains the improved maize seeds produced the best yield when both fertilizer and manure was used. The non-improved beans did best when only manure was used in both the short rains and the long rains. No farmer in Embu used non-improved maize seeds or improved bean seeds.

TACK

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We hope this information will be helpful and interesting for you.
Thank you once again for your help!

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Appendix 4: Practices used

Management practise:	Ever used Total	Last season Total	Ever used Embu	Last season Embu	Ever used Bondo	Last season Bondo
1. Crop residues	77 %	73 %	78 %	78 %	76 %	69 %
2. Green manure	45 %	43 %	41 %	37 %	48 %	48 %
3. Intercropping	93 %	84 %	89 %	78 %	97 %	90 %
4. Cereal – legume intercropping	89 %	82 %	81 %	74 %	97 %	90 %
5. Crop rotation	66 %	55 %	70 %	52 %	62 %	59 %
6. Animal manure	95 %	84 %	96 %	93 %	93 %	76 %
7. Compost manure	46 %	43 %	41 %	37 %	52 %	48 %
8. Chemical fertilizer	63 %	55 %	96 %	96 %	31 %	17 %
9. Agro-industrial by-products	13 %	5 %	19 %	7 %	7 %	3 %
10. Faecal sludge	2 %	2 %	0 %	0 %	3 %	3 %
11. Other	13 %	11 %	19 %	19 %	7 %	3 %

Appendix 5: Application of the methods

Statement	Total	Embu	Bondo
1. I have received training (including demonstrations, informal training) away from my farm site on soil fertility management.	32 %	41 %	24 %
2. I identify and incorporate in the soil crop residues that are high in nutrients and easy to decompose.	52 %	48 %	55 %
3. I collect crop residues from my neighbors after harvesting which I add to those I produce from my farm so that I can have enough to use	16 %	15 %	17 %
4. I sometimes apply crop residues as a mulch	59 %	59 %	59 %
5. I prune my hedges / boundaries and use the materials for surface mulching.	59 %	56 %	62 %
6. I incorporate into the soil the materials I get after pruning the hedges and boundary crops.	50 %	37 %	62 %
7. I collect animal manure from neighboring (max ½ kilometer) farmers in order to obtain sufficient amounts of manure for my production.	52 %	37 %	66 %
8. I have to travel for several kilometers (more than 3 km) to get livestock manure.	20 %	18 %	21 %
9. I make arrangements with my neighbors who keep livestock to supply me with animal manure in exchange for fodder.	46 %	44 %	48 %
10. I apply straws/crop residues / wood shavings to the livestock stall for insulation and to absorb urine which I later apply on the field	39 %	56 %	24 %
11. I have dug a furrow through which the livestock urine and dung from the shed flows directly to the farm where I have planted crops	20 %	30 %	10 %
12. I have to hire a donkey cart from my neighbor in order to transport livestock manure from the source (more than 3 km) to my farm	25 %	37 %	14 %
13. I hire enough labour to assist in the application of livestock manure	57 %	78 %	38 %
14. I easily mobilize my neighbors and friends to help me in applying livestock manure to my crops	39 %	37 %	41 %
15. I spread fresh livestock manure on the surface of the soil	21 %	4 %	38 %
16. Based on the knowledge I have, I compost livestock manure before spreading to the soil surface	91 %	96 %	86 %
17. I incorporate livestock manure into the soil	86 %	81 %	90 %

18. I apply chemical fertilizers in micro-doses (match-box) volume equivalent at the root zone of the crops.	50 %	85 %	17 %
19. I combine chemical fertilizers with organic manure	45 %	89 %	3 %
20. I practice crop rotation / intercropping because it fits in my cropping patterns.	57 %	48 %	66 %
21. I always include legumes in the crop rotations / intercropping	79 %	69 %	90 %
22. I often apply agro-industrial by-products (coffee husks) from nearby agro-processing factories on my farm to supplement livestock manure and chemical fertilizer	4 %	7 %	0 %
23. I feed agro-industrial by-products I get from agro-processors to livestock so that I can get quality livestock manure, which I then apply to my soils	20 %	22 %	17 %
24. I often hire a truck / donkey cart to transport agro-industrial by-products (coffee husks) from agro-processing factories which are far (more than 5 km) away from my farm so that I can apply on my farm.	11 %	15 %	7 %
25. I seek / have sought training from agricultural extension officers on how to prepare and apply compost manure.	45 %	44 %	45 %
26. In absence of livestock manure, I make use of human faecal sludge for my production.	2 %	0 %	3 %
27. I use human faecal wastes on my farm from my own family.	2 %	0 %	3 %
28. I source for human faecal wastes from my neighbors.	0 %	0 %	0 %
29. I apply livestock manure, or faecal sludge only at plots close to the place where I store it	20 %	43 %	17 %
30. I combine human faecal sludge with livestock /compost manure	4 %	0 %	3 %
31. I have enough family labour to enable the application of compost & farmyard manure.	52 %	56 %	48 %
32. I hire labour to enable the application of compost / farmyard manure	58 %	63 %	52 %
33. I always use deep-rooting green manure crops in my crop rotation in order to recover nutrients from lower soil horizons	27 %	30 %	24 %
34. I have lined the floor of the livestock stall with concrete to allow regular collection of urine which I apply on the farm	11 %	22 %	0 %

Appendix 6: Importance of the practices

Statement	Mean			Median			Standard Deviation!		
	Tot	Embu	Bondo	Total	Embu	Bondo	Total	Embu	Bondo
1. It is important for me to have received training on soil fertility management provided by agricultural extension services.	4,55	4,67	4,45	5	5	5	0,91	0,88	0,95
2. Identifying and incorporating in the soil crop residues that are high in nutrients and easy to decompose will improve soil fertility status.	4,36	4,56	4,17	4,36	5	4	0,86	0,64	1
3. It is necessary to collect crop residues from my neighbors after harvesting to add to those I produce from my farm so that I will have enough to apply on my farm.	2,32	2,3	2,35	2	2	2	1,49	1,49	1,52
4. It is important for me to apply crop residues as a mulch.	4,23	4,33	4,14	4	5	4	1,01	1	1,03
5. For my farming it is important to prune my hedges / boundaries and use the materials for surface mulching.	3,98	3,96	4	4	4	4	1,04	1,06	1,04
6. Incorporating into the soil the materials I get after pruning the hedges and boundary crops will increase soil fertility.	4,07	3,93	4,21	4	4	4	1,17	1,33	1,01
7. For me it is important to collect livestock manure from neighboring (max ½ kilometer) farmers in order to obtain appropriate amounts of manure for my production.	3,55	3,33	3,76	4	4	4	1,56	1,73	1,38
8. I travel for several kilometers (more than 3 km) to get livestock manure.	1,91	2	1,83	1	1	1	1,43	1,44	1,44
9. Making arrangements with my neighbors who keep livestock to supply me with livestock manure in exchange for fodder is important.	3,45	3,19	3,69	4	4	4	1,58	1,73	1,42
10. It is important to apply straws and wood shavings to the livestock stall for insulation and to	4,05	4,33	3,93	4	5	4	1,29	1,30	1,02

absorb urine to be applied in the field.									
11. It is important for me to line the floor of the livestock stall with concrete to allow regular collection of urine to be applied on the farm.	3,86	4,15	3,71	4	5	4	1,49	1,29	1,51
12. It is necessary to dig a furrow through which the livestock urine and dung from the shed flows directly to the farm where I have planted crops	3,75	4,11	3,54	4	5	4	1,63	1,48	1,62
13. It is important for me to hire a donkey cart from my neighbor in order to transport livestock manure from the source (more than 3 km) to my farm	3,27	3,11	3,41	4	4	4	1,61	1,67	1,57
14. It is necessary to hire enough labour to assist in the application of livestock manure	3,86	4,33	3,41	4	5	4	1,43	1,30	1,43
15. Mobilizing my neighbors and friends to help me in applying livestock manure to my crops is important for me.	3,30	3,26	3,35	4	4	4	1,66	1,83	1,52
16. It is important to first compost livestock manure before spreading to the soil surface	4,68	4,93	4,45	5	5	5	0,72	0,27	0,91
17. Applying chemical fertilizers in micro-doses (match-box) volume equivalent at the root zone of the crops is important	3,77	4,11	3,45	4	4	4	1,28	1,28	1,21
18. It is important to combine chemical fertilizers with organic manure	3,27	4,37	2,32	4	5	2	1,73	1,31	1,39
19. It is important to spread fresh livestock manure on the surface of the soil	1,8	1,3	2,36	1	1	2	1,29	0,82	1,42
20. Understanding cropping patterns on my farm is important for crop rotation	4,57	4,67	4,48	5	5	4	0,5	0,48	0,51
21. It is important to	4,45	4,44	4,45	5	5	4	1,03	1,4	0,51

incorporate livestock manure into the soil									
22. It is important to apply agro-industrial by-products (coffee husks) from nearby agro-processing factories on my farm to supplement livestock manure and chemical fertilizer	3,02	2,67	3,35	3	2	4	1,53	1,69	1,32
23. Feeding agro-industrial by-products from agro-processors to livestock is important in order to get quality livestock manure to apply to my soils	3,38	3,56	3,32	4	4	4	1,57	1,72	1,31
24. It is of importance to me to hire a truck / donkey cart to transport agro-industrial by-products (coffee husks, rice husks) from agro-processing factories which are far (more than 5Km) away from my farm so that I can apply on my farm.	2,96	3,15	2,89	4	4	4	1,62	1,75	1,42
25. It is important to me to seek training from agricultural extension officers on how to prepare and apply compost manure.	4,71	4,78	4,66	5	5	5	0,65	0,8	0,48
26. I apply livestock manure only at plots close to the place where I store it	2,09	1,67	1,59	1	1	1	1,29	1,49	1,09
27. It would be of importance for me to hire enough labour to enable the application of compost & farmyard manure.	4,49	4,11	3,97	4,49	5	4	1,35	1,34	1,38
28. It is important to me to use deep-rooting green manures in my crop rotation because I believe that they recover nutrients from lower soil horizons	4,44	3,96	3,97	4	5	4	1,24	1,48	0,98