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DETERMINATION OF SOIL NUTRIENT BALANCE ON BARLEY FARM LAND IN CHENCHA DISTRICT, SOUTHERN ETHIOPIA

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This is to certify that the thesis prepared by Yewubdar Melese, entitled: “Dermination of Soil Nutrient Balance on Barley Farmland in Chencha District, Southern Ethiopia. Submitted in partial fulfillment of the requirements for the Degree of Master of Art in Geography and Environmental Studies, specialization: Land resources Management complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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Abstract

Soil nutrient depletion is fitting one of the major challenges of agricultural production for the small holder farmers in Ethiopia. The objective of this study was to determine the nutrient; nitrogen (N), phosphorus (P) and potassium (K)) flows at barley land in gadha ditta village, chencha district southern Ethiopia. Throughout stratified random sampling three farm wealth groups (rich, medium and poor) were distinguished based on farm size. From a total of 323 households 129 Households were surveyed using structured questionnaire. Soil organic fertilizer sources, crop yield and crop residue samples were collected and analyzed for their nutrient content. The inflow nutrients are chemical fertilizer and manure while the outflow resources were crop yields and crop residues. The result of this research was the nutrient balance for barley land was -4.3 kg N, 13.6 kg P and -12.39kg K/ha/yr. The study noticeably recognizes the must for the development of included nutrient management systems to reduce the high rates of nutrient depletion. The achievable actions can be recommended foremost reduce crop residues removal from barley land and the farmers receive knowledge about application of more chemical fertilizer to the field.

Keywords: soil fertility, nutrient flow, nutrient balance, nutrient depletion,

Table of Contents

List of Table

List of Figures

List of Acronyms

AV.P	Available Phosphorus
CEC	Cation Exchange Capacity
COoA	Chencha Office of Agriculture
DAP	Diammonium phosphate
HI	Harvest Index
LCD	Least Significant Difference
NH4+	Ammonium Ion
NPK	Nitrogen Phosphorus Potassium
Nr	Crop Residue
OC	Organic Carbon
SAS	Statistical Analysis Software
SPSS	Stastical Package For Social Science
SSA	Sub Saharan Africa
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
SNNPE	South Nation Nationality Peoples of Ethiopia
TLU	Livestock Holding Size
TN	Total Nitrogen
WFNM	Whole farm nutrient balance

CHAPTER ONE: INTRODUCTION

1.1 Background

In Africa soil fertility declination is one of the main restrictions of agricultural production (Sanchez *et al*, 1997), whereas food production in the tropics and subtropics frequently relies on offered soil nutrient accumulation (Sheldrick*et al*., 2002).Here is rising need of using reliable indicators of soil nutrient mining and related land degradation (Sheldrick *et.al* 2004). Soil fertility decline can be accessed via expert knowledge systems, the observing of soil chemical properties over time at different sites and the calculation of nutrient balances, with the last one being the most used and cost-efficient technique. Nutrient balances are calculated by the difference between nutrient inputs and outputs of a system with predefined spatial-temporal boundaries (Bindraban *et al*., 2000). Thus, they are generally expressed in amount of nutrient(s) per unit of area and time. Negative nutrient balances indicate that a system is losing nutrients; on the contrary, nutrients are apparently accumulating. The main assumption with regards to the nutrient balance approach is that a system in severe or continuous disequilibria is not sustainable in the long term (Smaling *et al* 1993).

Soil erosion and soil nutrient mining through continuous cultivation of crops coupled with low application of external and internal sources of nutrients is singled out as the major cause of nutrient depletion in the region (Stoorvogel and Smaling, 1990). The average intensity of fertilizer use throughout SSA remains much lower than to another place (Jayne, 2003).A quantitative knowledge on the depletion of plant nutrients from soils helps to understand the state of soil degradation and may be helpful in devising nutrient management strategies. Nutrient-balance exercises may serve as instruments to provide indicators for the sustainability of agricultural systems.

Barley is one of the most important cereal crop, mainly grown by smallholder farmers at mid and high altitudes Ethiopia, It is one of the most important small cereal crops, which ranks fourth after wheat, maize and rice in the world and 5th in Ethiopia both in terms of area and production after Teff, Maize, Sorghum and Wheat. Food barley is commonly cultivated in stressed areas where soil erosion, occasional drought or frost limits the ability to grow other crops. Low soil fertility has been recognized as one of the major biophysical constraints affecting agriculture in sub-Saharan Africa. Soils in the highlands of Ethiopia exhibit low levels of essential plant nutrients and organic matter content. This is largely consequence of the cereal dominated cropping history of most fields and continuous nutrient mining by crop removal, which eventually leads to depletion of soil nutrients. Soil nutrient depletion has been exacerbated by low levels of chemical fertilizer usage. Due to both high cost and constraints to timely availability of the fertilizer input. Application of organic materials alone or in combination with inorganic fertilizer helped in proper nutrition and maintenance of soil fertility.

Ethiopia is the second biggest barley producer in Africa, next to Morocco, accounting for about 25 percent of the total barley production in the continent (FAO, 2014). Although barley is not among the top cereal crops in Ethiopia, its importance is rapidly growing in terms of production, potential for poverty reduction, as well as for the country's coffers and the current balance of payment situation. Barley yields are stagnant or declining in many parts of the highlands of Ethiopia (Icarda, 2003), which could be the result of a decline in the natural supply of one or more crop nutrients. On the other hand, population is growing at an annual rate of2.7% (Irin, 2003) and land holdings in the area are less than 2 ha per household (Abegaz*et al.*, 2007a).

The most common fertilizers used in Ethiopia are diammonium phosphate (DAP) and urea. Such unequal and permanent application of limited fertilizers both in amount and type may aggravate the depletion of other important nutrients such as K, Mg, Ca, S and micro-nutrients not supplied by the chemical fertilizers and may also lead to chemical soil degradation (Dibabe*et al.*, 2007). Chemical fertilizers are also costly for farmers to apply the recommended rates. On the other hand, sole application of organic matter is constrained by access to sufficient organic inputs, low nutrient content, high labor demand for preparation and transporting. For instance, the low P content of most organic materials indicates the necessity of external sources of P to sustain crop productivity. Thus, the integration of organic and inorganic sources may improve and sustain crop yields without degrading soil fertility status.

Ethiopia is one of the countries that are affected by soil nutrient depletion (Elias *et al*., 1998; Haileslassie *et al*., 2005). As a result, productivity per hectare has been declining over the past several decades. It is less likely that increasing food production without employing integrated soil fertility management practices allied with adoption of improved crop varieties (Sanchez *et al*., 1997)

In Gamo Gofa Zone, declining agricultural productivity per unit area due to soil fertility reduction is fetching a challenge for smallholder farmers. hence, this survey will be carried out to decide the effects of current soil fertility management practice on soil nutrients status through nutrient balance analysis via nutrient in and out flow monitoring and to observe the role of farmers' intervention in sustaining and advancing soil nutrients balance to improve agricultural productivity.

1.2 Statement of the problem

The word soil nutrient decline refers to all nutrient losses from a soil through natural processes. Dynamically, it is the process by which the soil nutrient stock is shrinking for the reason that of permanent nutrient mining without adequate replacement of nutrients collected in agricultural products. Soil erosion is mainly a natural process and usually treats as an independent issue and the nutrient loss from leaching is also driven by a natural process although it is exacerbated by application of fertilizers, especially Nitrogen.

Nutrient depletion in Ethiopia has several causes. Application of organic fertilizer like crop residues and manure is limited because of competitive uses. Also problems in the fertilizer sector have restricted the wider use of inorganic fertilizers. Fertilizer subsidies were eliminated since 1997 (fertilizer subsidies were 15% in1993, 20% in 1994, 30% in 1995, 20% in 1996, 0% in 1997) and consequently costs of fertilizer went up. At the same time, low grain prices on the market probably discouraged farmers from using fertilizer (Demeke *et al.*, 1998). Additionally inadequate soil conservation practices and reduced fallow periods contributed to the problem (Wood, 1990).

The annual nutrient deficit in Ethiopia has been calculated to be -41 kg N, -6 kg P and -26 kg K ha-1 yr-1 (Stoorvogel and Smaling 1990). However, a more diversified picture of nutrient mining appears when studying the nutrient balance at the farm, field and plot level as compared to the national level. It is obvious that the national facts are hard to relate to a specific farming system. This is particularly important for Ethiopia since the agricultural landscapes and production systems are variable with regard to topography, agro-ecological characteristics, ethno-history and culture that influence agricultural practices and nutrient management (Balesh. 2005: Haileselassie, 2005).

Nutrient depletion has a far reaching impact that extends beyond the soil and farming household into community, regional, and national scales; it concerns the environment and the agricultural sector, for it reduces yields, income, and food security. In fact, nutrient depletion decreases food security through lower production and leads to higher food prices, lower employment, and increment of government expenditures on health, more famine, and reduction of government revenue due to fewer taxes collected on agricultural goods. (Drechsel, *et.al* 2001)

In point of fact, the socio-economic factors that directly influence soil nutrient flows are: fertility management practices, level of crop-livestock interaction, (De Jager, *et al.*, 1998a; Keeney) and the level of importation and exportation of soil nutrients through crop and livestock product sales and purchases. Other socio-economic factors that are likely to affect soil nutrient balance household endowment, household income activities, land tenure, market access, population pressure; and policies and institutions (Sserunkuuma, *et al*.2001). The socio-economic factors interact with the biophysical processes, thereby influencing the nutrient flow directly and indirectly.

Ethiopia faces a wider set of issues in soil fertility beyond chemical fertilizer use, which has historically been the major focus for extension workers, researchers, policymakers and donors. If left unchecked, this wider set of issues will limit future output and growth in agriculture across the country and in some areas they already limit the effectiveness of chemical fertilizer. These chemical, physical and biological issues interact and include loss of organic matter, macronutrient, and micronutrient depletion; topsoil erosion; acidity; salinity; and deterioration of other soil physical properties. In addition Ethiopia has soil types with inherent characteristics which can be problematic for crop production and need special management. (Asnakew W. 1989)

In general Soil nutrient mining is the leading causes of land degradation in Ethiopian (Zake, *et al.* 1997) and Gamogofa Zone in particular. Land degradation results in declining crop yield (Bekunda, *et* al.1999). But the degree to which soil mining and other related factors affect the soil nutrient balance of Gamogofa Zone has not been so far investigated.

So this study is projected to fill the gap in presented of soil nutrient mining by mainly focusing on determination of nutrients balance and the impacts of nutrient depletion on sustainable agricultural production of barley land of Gadha Ditta *villag*e chencha, District, southern Ethiopia.

1.3 Objective

1.3.1 General Objective

The general objective of the study is to determine Nutrient balance in Barley land of Small holders Of MAXO *District* GadhaDitta *Village* in ChenchaDistrict, GamoGofa Zone Southern Ethiopia

1.3.2 The Specific objectives are to:

- Recognize nutrient flow into and out of the barley land
- Investigate current soil fertility status of the study village.
- Evaluate the role of farmers' wealth diversity in maintaining and improving soil nutrients

1.4 Research question

This research intends to answered the following basic question which are derivatives of the above mentioned research objectives

- What amount of nutrients flowing out of the barley land?
- Soil fertility amendment inputs to your barley land?

- What types of inputs do you use to barley land?
- Identify the role of farmers that maintaining soil nutrient?
- Recognize the responsibility of farmers to facilitate rising soil nutrients?
- What is the current soil fertility status of the study village?

1.5 Scope of the study

The study was conducted in Gadha Ditta *village,* Chencha *district,* Gamo Gofa zone, SNNPE Ethiopia. It is carried on determine soil nutrient flow in barley production of small holders of Maxo *Kebele* The study was also accepted exposed to estimate nutrient balance focus on NPK. The study is enclosed only to partial nutrient balance investigation.

1.6 Significance of the study

Determination of soil nutrient flow in barley production to study at farm level is a device for assessment of particular farming systems from the awareness of sustainable nutrient management and agricultural production. It is besides valuable for allowing farmers to handle their soil nutrient balance and sustainable agricultural production. In this survey the output of the research may provide as it indicate the amount and flow of nutrients which take place among at barley lands. Finally it may initiate other researchers who are interested in carrying out further research in the area.

1.7 Limitation of the study

Like some research this study was carried out through some constraint. The first constraint was time. The second constraint was the study focuses on only partial nutrient flow analysis that only considers the nutrient import through chemical fertilizer and organic sources as and crop yield harvest and residues, manure as. This study does not consider full nutrient flow analysis that should consider all possible sources of nutrients in to and out of the barley land because of there is no any fund to work and, the limitation of available data and skill.

1.8 Organization of the Thesis

This thesis is divided in to five chapters. In the first chapter, the introduction of the paper is presented. This covers background of the study, statement of the problem, objectives of the study, research questions, scope of the research, significance of the study and organization of the thesis. Chapter two presents the literature review which encompasses theoretical literature review and the conceptual framework of the study. Chapter three provides research methodology. Chapter four discusses with results and discussion of the thesis and finally, chapter five presents conclusion and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical perspective of soil nutrient in farm land

Plants draw the nutrients from the soil through their roots. These nutrients are grouped into Macronutrients and Micronutrients**.** Macronutrients are needed at high levels in the plants, and consist of the familiar Nitrogen, Phosphorus, and Potassium, usually abbreviated "N-P-K". Micronutrients are just as essential as macronutrients, but in lesser quantities**.** Soil nutrient demands are specific for each crop, and should be measured through a soil nutrient test. If the soil is deficient in a certain nutrient, critical life stages will not be completed or the deficiency can lead to plant stress or death (Pierson, *et.al* 2001).

2.1.1 Macronutrients

Macro-nutrients are elements which plants use in large quantities for growth. The most important macro nutrients are nitrogen, phosphorus and potassium, all of which are commonly used as fertilizers and they are called primary macro nutrients. Calcium, sulfur and magnesium are also macro nutrients, but they are less important as fertilizers and they are also called secondary macro nutrients (Samuel *et al*, 2000). Macro elements refer to the main elements that are required by the plant for its basic functioning such as development, chlorophyll, flower and fruit formation, increased resistance of the plant to disease and insect attack (Andrew, 2008). If there is deficiency of these nutrients in the soil the plant will show deficiency symptoms like stunted growth, pale green and yellow leaves, reduced root growth, increased disease susceptibility, etc., (Buruah and Barthakur, 1997). Macro nutrient depletion in Ethiopia mostly caused by continuous cropping without replenishing, leaching, crop residue removal, low level fertilizer use, deforestation, and inadequate run-off management (Chilot *et al* ; 2002).

A. Total nitrogen

Management of nitrogen availability is vital to achieve optimal yields and quality in barley crop. The level of nitrogen and plant available water will impact strongly on yield and protein having potentially a major impact on crop return. Unlike wheat where premiums are available for high protein barley premiums for malting require moderate proteins of 9-12%.

Nitrogen occurs in soils in both organic and inorganic compounds of which plants absorb N in its cationic form (NH4+) and anionic form (NO3-) and obtain readily available N forms from various sources. The total N content of a soil is directly associated with its OC content and its amount on cultivated soils is between 0.03% and 0.04% by weight (Tisdale *et al.,* 1995).

Because of their low SOM content, most of the Vertisols in Ethiopian highlands have low total N content and there is a high crop response to N fertilizers in these areas (Desta, 1986). On account of rapid nitrification, most of the N added as fertilizer containing NH_4 or NH_2 is subject to leaching or denitrification soon after application.

Nitrogen is available to plants as either ammonium (NH_4^+-N) or nitrate (NO_3^--N). Animal manures and other organic wastes can be important sources of N for plant growth. The amount of N supplied by manure will vary with the type of livestock, handling, rate applied, and method of application. Since the N form and content of manures varies widely, an analysis of manure is recommended to improve N management. Crop residues from non-leguminous plants also contain N, but in relatively small amounts compared with legumes. Nitrogen exists in crop residues in complex organic forms and the residue must decay before N is made available for plant use. Soil organic matter is also a major source of N used by crops. (Nash *et.al* 2007).

All the effects from applied nitrogen contribute to an increased yield. To determine the actual required nitrogen rate/hectare then dose response trials can be conducted to calculate the optimum. Excess nitrogen applications can give problems with lodging and increased disease levels. Average total N decreased with increasing depth from surface to subsurface soils (Nega, 2006). The considerable reduction of total N in the constantly cultivated fields could be attributed to the rapid turnover (mineralization) of the organic substrates derived from crop residue (root biomass) whenever added following intensive cultivation (Donagh *et al*., 2001).

Organic matter is composed primarily of rather stable material called humus that has collected over a long period of time. Easily decomposed portions of organic material disappear relatively quickly, leaving behind residues more resistant to decay. Soils contain approximately 2,000 pounds N in organic forms for each percent of organic matter.

B. Available phosphorus

Phosphorus is considered to be the second most important nutrient after nitrogen in terms of its influence on plant growth and development. After the crop has developed two to three leaves it will begin to rely on soil available phosphorus for continued leaf and shoot numbers growth. Phosphate availability in the soil is influenced by many factors including pH, other nutrients such as aluminum, iron and calcium, soil moisture and temperature. (Nash, *et.al* 2007)

Phosphorus is unique among the anions in that it has low mobility and availability, which is determined by soil pH and the consequent reactions of P with Al^{3+}, Fe^{3+} and Ca^{3+}. It is difficult to manage because it reacts so strongly with both solution and solid phases of the soil. While P occurs in a multitude of inorganic and organic forms in the soil, the plant available forms of P are limited primarily to solution HPO_4^{-2} and $H_2PO_4^{-}$, with the dominant forms determined by the soil pH (Tisdale *et al.,* 1995).Studies show that the total P status of some representative major soil types in Ethiopia is low (Piccolo and Huluka, 1985).

Crop use of any nutrient depends on a two-step process: soil supply of that nutrient in an available form, and uptake of that available nutrient by the crop. There are certain constants involved that the crop manager cannot change. The soil solution is the key to plant nutrition because all phosphorus that is taken up by plants comes from phosphorus dissolved in the soil solution. Because the amount of soluble phosphorus in the soil solution is very low, it must be replenished by as many as 500 times during a growing season to meet the nutritional needs of a typical crop. Although very little phosphorus is in the soil solution at any time, there is a large amount of phosphorus in most soils. The bulk of the soil phosphorus is either in the soil organic matter or in the soil minerals. A large proportion of the phosphorus in both of these fractions is in very stable, unavailable forms, while a much smaller proportion is in available forms that can dissolve in the soil solution and be taken up by plants. The dynamic and available phosphorus in these fractions, such as phosphorus added in fertilizer or manure, can be quickly fixed into stable, unavailable forms in the soil. This is why, even with optimum management, the efficiency of plant uptake of phosphorus is very low usually less than 20 percent. (Pierson, *et.al* 2001)

It is important therefore to ensure that recently available phosphate is applied to avoid this limiting early shoot growth. In barley there are two timings that are important to consider. When it is growing rapidly with shoots and roots developing, and secondly as spring growth commences. In the period from March to May 70% of phosphate will be taken up, so applications of phosphate fertilizer should be targeted to meet this demand. (Burkitt, *et.al 2002)*

Organic phosphorus availability depends on microbial activity to breakdown the organic matter and releases this phosphorus into available forms. Thus, availability of organic phosphorus is very dependent on conditions in the soil and on the weather, which influence microbial activity. The mineralization of organic phosphorus to inorganic forms is favored by optimum soil pH and nutrient levels, good soil physical properties, and warm moist conditions. The inorganic phosphorus is bound with varying adhesiveness to iron and aluminum compounds in the soil. Replenishment of the soil solution with phosphate from inorganic forms comes from slow dissolution of these minerals. The solubility of the compounds holding phosphorus are directly related to the soil pH. The pH range of greatest phosphorus availability is 6.0 to 7.0. At a lower pH, when the soil is very acidic, more iron and aluminum are available to form insoluble phosphate compounds and, therefore, less phosphate is available. At very high pH, phosphorus can react with excess calcium to also form unavailable compounds in the soil. (McKenzie *et,al 1999)*

C. Available potassium

Potassium is the third most important essential element next to N and P that plants require in the largest amounts (Marschner, 1995). Potassium (K) is involved in photosynthesis, sugar transport, water and nutrient movement, protein synthesis and starch formation (Zublena, 1997). It also helps to increase disease resistance, tolerance to water stress, winter hardiness, tolerance to plant pests and uptake efficiency of other nutrient .Its behavior in the soil is influenced primarily by soil cation exchange properties and mineral weathering rather than by microbiological processes. Unlike N and P, K causes no off-site environmental problems when it leaves the soil system. It is not toxic and does not cause eutrophication in aquatic systems (Brady and Weil, 2002).

Potassium that is dissolved in soil water plus that held on the exchange sites on clay particles is well thought-out readily available for plant growth. The exchange sites are found on the surface of clay particles. This is the form of K measured by the routine soil testing procedure. Plants readily absorb the K dissolved in the soil water. As soon as the K concentration in soil water drops, additional K is released into the soil solution from the K attached to the clay minerals. The K attached to the exchange sites on the clay minerals is more readily available for plant growth than the K trapped between the layers of the clay minerals.

2.1.2 Micronutrients

Micronutrients are nutrients that are essential for plant growth, but which are only needed in small quantities. Iron, Zinc, Manganese and Copper are some of the micro nutrients and others like boron (B), molybdenum (Mo) and chlorine (Cl). Copper is most likely deficient, Zn contents are variable and, Fe and Mn contents are at an adequate level in Ethiopian soils (Desta, 1982; Fisseha, 1992; Abayneh, 2005; Alemayehu, 2007). They are required in very little amount but their importance for the growth of the plant is no way less than those of major elements. If there is deficiency of these minor elements, leaves, branches, and fruits may not properly grow and they may even affect the fruits quality as well as production (Alloway, 1990). These elements also help in development of hormones, enzymes, chlorophyll and in the absorption of major elements (Andrew, 2008). Micro nutrient depletion is also one of the most common problems of Ethiopian soils.

The main causes of micronutrients deficiencies are intensive cultivation, higher requirements of modern crop cultivars (varieties) due to higher yields, loss of topsoil layers by soil erosion which contain higher OM, use of liming in acid soils, which reduces their concentration due to increases in soil pH and adsorption of these elements, low rates or no application of fertilizers by farmers, especially in developing countries, increased use of high-analysis fertilizers with low amounts of micronutrients, low rate of application or no use of organic manures, involvement of natural and anthropogenic factors that limit adequate plant availability and create element imbalances, sandy soils low in OM content, which may become deficient because of leaching losses and no recycling of crop residues (Fageria *et al*., 2002).

Although the role of micronutrients in balanced plant nutrition is well established, information regarding their status in most Ethiopian soils is very little. Even, the current fertilizer recommendation for major crops in Ethiopia is only for macro nutrients; continuous application of one or two macro nutrients may in due course deplete the soil reserve of other nutrients and limit the crop yield (Yifru andMesfin, 2013).

2.1.3 Nutrient Deficiency

Nutrient deficiencies in field crops generally occur because of low nutrient levels in the soil. Consider nutritional problems in relation to all conditions affecting plant growth, not exclusively in terms of the amounts of nutrients contained in or added to the soil.The presence of adequate quantities of plant nutrients in the soil is no guarantee that they will be absorbed by the plant roots. Nutrients may be present in forms not available to the plants, or other factors may prevent plant uptake. Unusually low or high soil pH levels can affect nutrient availability. Poor growing conditions, excessively wet or dry soils, cold weather, or soil compaction can significantly restrict root growth and access to soil nutrients. (Dorivar A. Ruiz Diaz *et al*., 2011)

2.1.4 Excess nutrient

Plants with excess N turn a deep green color and have delayed maturity. Due to N's positive effect on vegetative growth, excess N results in tall plants with weak stems, possibly causing lodging. New growth will be succulent and plant transpiration high (Jacobsen and Jasper, 1991). N toxicity is most evident under dry conditions and may cause a burning effect. Plants fertilized with ammonium (NH4+)-based fertilizers may exhibit NH4+ toxicity, indicated by reduced plant growth, lesions occurring on stems and roots and leaf margins rolling downward, especially under dry conditions. Excess P indirectly affects plant growth by reducing Fe, Mn and Zn uptake; thus, potentially causing deficiency symptoms of these nutrients to occur. Zn deficiency is most common under excess P conditions. Due to a cation imbalance, K toxicity can cause reduced uptake and subsequent deficiencies of Mg, and in some cases, Ca. (Ann McCauley, 2011)

2.2 Soil Fertility Management

Soil fertility management is managing nutrients to improve crop production. Farmers use different types of soil fertility management practices and agronomic practices to respond for the depletion in soil fertility. According to Barry and Ejigu (2005), the decline in the fertility status of Ethiopian soils is largely caused by extra pressure on land due to increased population, decline in the amount of manure available for soil fertility. However, farmers are responding to the decline in the fertility level of soils in various ways. Some are shifting their social behavior or adapting their farming system, whereas others are replying through action to improve the soil itself (Barry and Ejigu, 2005).

Barry and Ejigu (2005) and Fairhurst (2012)stated major types of soil fertility management practices applied commenly by farmers such as; commercial fertilizers, manures, waste products, and composts to add nutrients and organic matter to the soil.

2.2.1 Fertilizer

Fertilizers are substances that added to the soil inorder to correct the deficient nutrents in the soil.Use of fertilizers to replace soil nutrients is one of the major ways of correcting low soil fertility. Fertilizers also could be part of a solution to correct environmental degradation and properly address rising food demands. However, average use of fertilizer in Africa is very low (about 8 kg/ha, i.e. only 1/10th of world average) (Wopereis andMaatman, 2002). According to Ezekiel,2004 fertilizers are divided in to two. These are namely chemical fertilizers and organic fertilizers (Ezekiel, 2004).

A. Organic fertilizer

Organic fertilizers are naturally occurring fertilizers and nutrient enhancers of the soil. Therefore every substance that occurs naturally and is easily bio-degradable is organic and if this organic material enhances the richness of the soil, it is termed as organic fertilizer. It includes animal manure, slurry waste, peat, seaweeds, sewage, guano waste and other bio-degradable wastes. Mine rock phosphate, sulphate, potash and limestone also fall under the same category. Decomposing crops also make up for a naturally occurring organic fertilizers.

i. Manure

Out of the organic fertilizers the good quality manures, which consist of the solid and liquid feces and litter, are at the first place. The fresh manures from the stock-yards cannot be used immediately, because the good quality is provided by the suitable storing and curing. Fermentation is done by micro organisms and during the process the high temperature sterilizes the manure, at the same time the contents will get more favorable indicated by the adequate (20:1) ratio of C: N as well as the water content reduced down to 60-70 %. At the beginning the manure is harmful for man, animals and environment this is why its fermentation and storage are regulated by strict laws in the EU member states. These also apply to transport and distribution. Besides the physical-chemical-biological effects the absorbable nutrient contents cannot be neglected either.

ii. Compost

Compost is a poor short term supplier of nitrogen to the soil because the mineralization process in the compost takes a longer period of time. Compost can be produced from the waste originated from food industry, industry or agriculture as well as organic materials from farms. Consecutive compost application is to raise the amount of soil organic nitrogen and the potential to mineralize nitrogen (Mark et al, 2007). Compost changes waste materials into nutrients and restore soil nutrients (Doug et al, 2013).Using compost as organic matter is highly economical and can offer both macro and micro nutrients. Depending on the material differences to be composted, the method of composting and its maturity of nutrient content of compost differs (William, 2005). While applying compost, it is important to know about its components and to determine how to use it effectively.

Compost is better than chemical fertilizer due to its balanced chemical composition and has a high water holding capacity and develops the structure of the soil (Laura and Rienke, 2004). As compared to manure and crop cover nutrient delivery by compost is slow and this is because the higher degree of decomposition leading to the production of humic substances resulting in a slower release of nutrients, particularly nitrogen (William, 2005).

B. Inorganic Fertilizer

A chemical Fertilizer is known as inorganic fertilizer when its constituents are originated through synthetic means making them non degradable. To sustain reliable and hastened growth, these fertilizers are added to the soil. Generally chemical fertilizers are manufactured keeping in mind the natural elements needed by the plants for healthy and convenient growth. They contain one or more of the essential growth nutrients such as nitrogen, phosphorus, and potassium and various others. Once added to the soil, these nutrients fulfill the required demands of the plants and provide them the nutrients they naturally lacked or help they retain the lost nutrients.

Inorganic fertilizers are primarily made from non-renewable sources like petroleum products. They help plants by providing the nutrition needed but do nothing to promote soil health; this result in the soil being rendered useless after repeated applications. It destroys all the beneficial micro organisms in the soil by changing the pH, so in the end nothing can be grown on the soil without chemical inputs. Over a long period of farming by using inorganic fertilizers, there may even be a toxic buildup of harmful or poisonous chemicals like arsenic - that can make their way into the food crops grown. Fruits and vegetables grown using inorganic fertilizers may be large in size and appear good, but that's all. They do not taste half as good as the ones grown using organic fertilizers

2.2.2 Soil organic matter

Soil organic matter forms complexes with micro nutrients and prevents them from being lost through leaching (Ilaco, 1985).During anaerobic fermentation process, about 25-30 % of the OM from the manure is converted into biogas while the rest becomes available as residual manure (Chendu, 2006). Foth (1990) has indicated that the distribution of soil organic matter, expressed as organiccarbon, is 38% in trees and ground cover, 9% in the forest floor and 53% is in the soil including the roots plus the SOM related with soil particles.

Most cultivated soils of Ethiopia are poor in SOM contents due to low amount of organic materials applied to the soil and complete elimination of the biomass from the field (Yihenew,2002), and due to severe deforestation, steep relief condition, intensive cultivation and excessive erosion hazards (Eylachew, 1999). SOC is a complex of organic carbon compounds in the form of SOM. In agricultural soils, soil organic Carbon content is usually less than 5% and decreases with soil depth (Baldock and Skjemstad, 1999).

2.3 Nutrient Imbalance in Agricultural Development

Nutrient cycles link agricultural systems to their societies and surroundings; inputs of nitrogen and phosphorus in particular are essential for high crop yields, but downstream and downwind losses of these same nutrients diminish environmental quality and human well-being. Agricultural nutrient balances differ substantially with economic development, from inputs that are inadequate to maintain soil fertility in parts of many developing countries, particularly those of sub-Saharan Africa, to excessive and environmentally damaging surpluses in many developed and rapidly growing economies.

National and/or regional policies contribute to patterns of nutrient use and their environmental consequences in all of these situations. Solutions to the nutrient challenges that face global agriculture can be informed by analyses of trajectories of change within, as well as across, agricultural systems. (Vitousek *et al* 2009)

2.4 Barley production and Productivity in Ethiopia

Ethiopia is ranked twenty-first in the world in barley production with a share of 1.2 percent of the world's total production (Usad, 2014). According to Usad reports on assessments of commodity and trade, Barley cultivation is widely distributed across the country on over one million hectares of land and by more than four million small holder farmers. Currently, it is grown exclusively for the domestic market and is neither imported nor exported. Barley is a high-opportunity crop, with great room for profitable expansion, particularly when connected with the country's commercial brewing and value-added industries. It is the fifth most important cereal crop in Ethiopia after teff, wheat, corn, and sorghum.

2.5 Factors affecting Nutrient failure

Soil erosion and associated nutrient transport is driven by surface runoff, which is generated disproportionately from soils that have low infiltration capacity as a consequence of such factors as high clay content, surface crusting, high water table, or shallow bedrock. Phosphorus transport in runoff tends to increase with increasing phosphorus concentration at the soil surface and increasing runoff (Sharpley*et al*. 2003). Thus, practices that reduce phosphorus concentrations in the soil surface and/or reduce surface runoff are most effective in controlling P transport.

When tillage is reduced or eliminated, particulate phosphorus loss in surface runoff usually declines, but dissolved P losses may increase if phosphorus becomes more concentrated near the soil surface unless P fertilizers or manure are injected or incorporated into the soil. Thus, timing and methods of application of P fertilizer become more important to controlling phosphorus transport in runoff from reduced tillage systems.

Conservation tillage practices that leave crop residue on the soil surface protect fine textured soils from forming surface crusts, and thereby have the potential to reduce runoff in soils where crust formation is a major limitation to infiltration. There are some reports of dramatic reductions in runoff from continuous no-till on well drained soils, where after three or four years, accumulations of organic matter and/or earthworms develop and maintain high porosity at the soil surface (Shipitalo*et al*. 2000). But in some settings, no-till has not had much influence on runoff (Gihdey and Alberts 1996). Residue cover also reduces evaporation from the soil surface, thereby increasing soil moisture content, which may increase runoff.

2.6 Socio-economic factors and their role in nutrient balances

Much of the soil nutrient dispute ignores the role that farmers play in determining the processes of environmental change. However, despite broadly similar access to resources and opportunities, marked differences often exist within a single setting in which soil fertility is handled by different farmers. Among different farmers and between areas, the relative value of land, labour and capital endowments over time may have important implications for the form and efficiency of any farm-level nutrient cycle. Although reasonable solutions may be unclear, soil nutrient-balance studies do explain the consequences of farming for soil fertility. What is further required, and possibly more relevant, is a time-scale plan for external interventions based on a sound policy framework; this in addition to a more simple and reliable model/approach that is readily adaptable to various situations(vanlauwe,*et.al* 2002).

2.7 Nutrient Flow and Balance

Nutrient flow analysis can be used to give insight into the impact of farmer management decisions on soil fertility in his or her farm. Farmers transport material that contains nutrients - be it harvested products, manure, fertilizer or straw that is used to build roofs. Some processes may lead to a loss in nutrients, e.g. burning of straw will result in complete loss of carbon and nitrogen. Estimating nutrient flows is a useful way to find out if farmers‟ crop management practices are sustainable, i.e. are outputs of nutrients balanced by a sufficient level of inputs (FAO. 2003).

Nutrient balances are partial when they only consider flows of inputs and outputs that are easy to measure, and are normally regarded as more useful for farmers. Other balances cover a wider range of inflows and outflows, including atmospheric deposition of nutrients, fixation, sedimentation, erosion, leaching and gaseous losses, among others. Such types of balances are calculated in the multi-scale nutrient called full scale nutrient balance.

2.8 Whole farm Nutrient balance

Whole farm nutrient management (WFNM) includes the consideration of import of nutrients to the farm, movement and transformation (including losses) of nutrients within the farm operation, and export of milk, meat, crops, or manure. In order to understand WFNM, it is necessary to consider all sources of nutrients, their movement within the farm, and how they might move to the environment. On most dairies, feed represents the largest import of nutrients, with fertilizer as the second largest import of nutrients. Feed Management practices currently exist to reduce imports of nutrients (particularly nitrogen and phosphorus) or decrease their excretion.

Nutrient management is a process of planning for manure and fertilizer applications to individual crop fields. Whereas whole farm nutrient balance considers the location and flow of nutrients onto, within and off the entire farm. Whole farm nutrient balance involves taking a step back and also comparing the amount of nitrogen (N), phosphorus (P), and potassium (K) and other nutrients entering the farm as purchased feed, fertilizer, animals etc. with the amount of nutrients leaving the farm as milk, animals, crops, manure exports to other farms, etc. Such a comparison can help in determining the economic and environmental impacts of nutrient management on `dairy and livestock farms (Doug Beegle, 2015).

2.9 Conceptual Framework

The conceptual framework of the study is designed based on the literature reviewed on the estimation of soil nutrient balance in farming system. The same nutrient flows in the crop production system and their movement to and from the household and animal production systems. Each flow has been subdivided according to whether it is inside or outside the farm system. Mineral fertilizer (IN1) obtained from outside of the farm and Organic fertilizer *(IN 2)* can be obtained outside the farm (*IN 21*) or produced inside it (*IN 22*), and a further distinction can be made between what is produced by livestock (*IN 22)* and what is produced by the household and its members in the form of household waste and compost (*IN 222*).

Output processes can be similarly subdivided. We can distinguish between crop produce sold on the market (OUT 11) and crop produce that remains on the farm (OUT 12) and is consumed by the farm's livestock (OUT 121) or by household members (OUT 122). If a farmer leaves crop residues (OUT 2) in the field there is no flow from the field. Part of the crop residues left there will be eaten by termites and the rest will be incorporated into the soil when the land is prepared for the next season. However, when crop residues are burned some nutrients do leave the field and the farm in soot and ash (OUT 21).

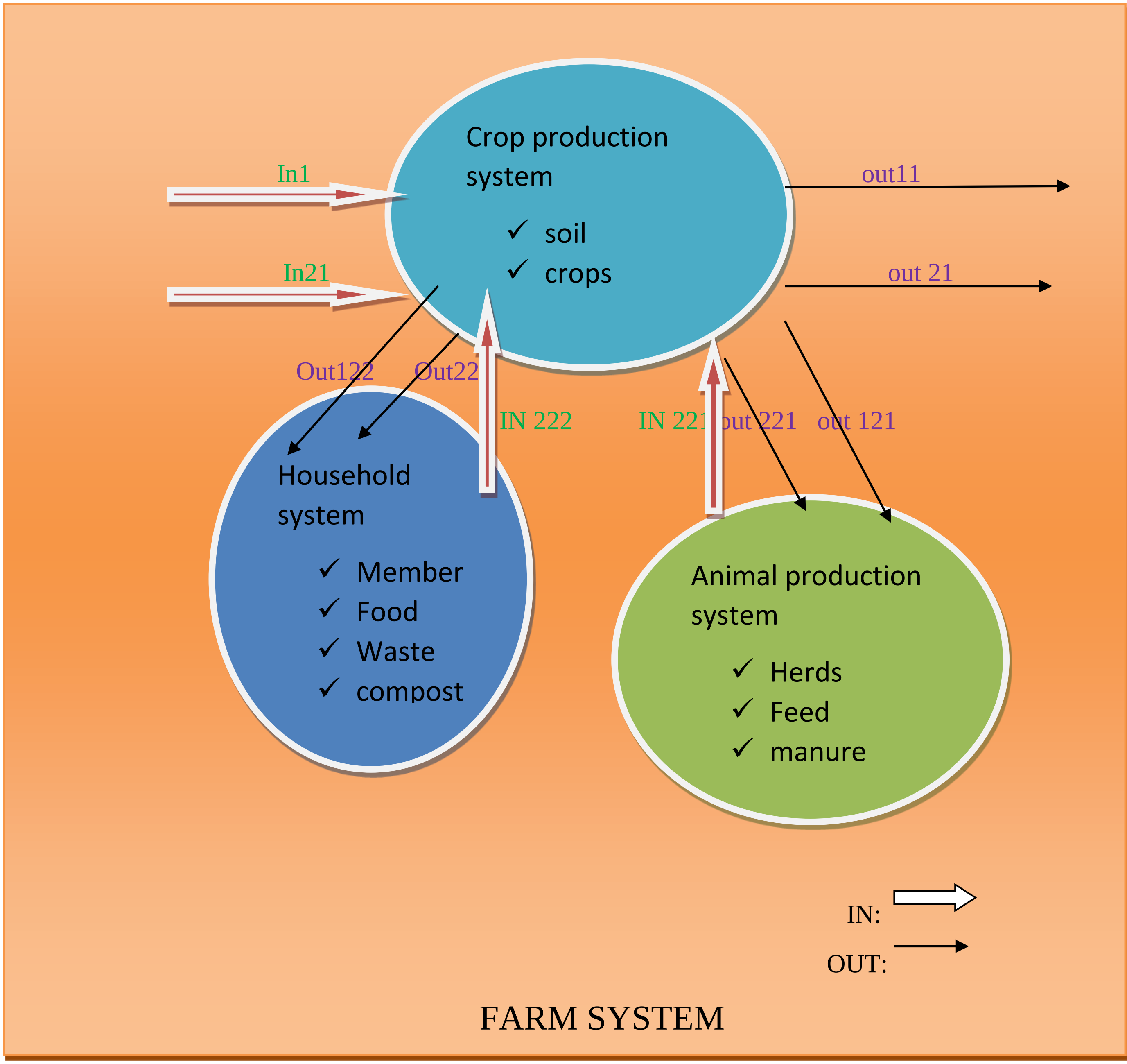

Fig 2. 1: the whole farm nutrient flow in the farming system

Crop residues also leave the farm when they are sold as fodder or when animals from a neighboring farm come and graze them but defecate elsewhere. The crop residues that are used as outputs on the farm (OUT 22) can be divided into those which go into the animal production system as fodder or bedding in the kraal (OUT 221); and those used in the household system for composting or for roofs (OUT 222).

CHAPTER THREE: DESCRIPTION OF THE STUDY AREA AND RESEARCH METHODS

3.1 Description of the Study area

The study was conducted at Chencha District, which is located in the Gamo Gofa administrative zone of the Southern Nations, Nationalities and Peoples' Regional State (SNNPR) of Ethiopia. The district encompasses 50 *districts*, the lowest administrative level in Ethiopia. The altitudes of the district range from 1600-3200 masl. It has two agro-ecological zones: '*dega'* (2300-3200 masl, 82%) and '*woinadega*' (1500-2300 masl, 18%); with total area coverage of 37,650 ha. The population of the district is 138,373 (Female: 74,936 and Male 63,437). It is one of the most populous districts in the zone. The major means of livelihood for the district is subsistence agriculture followed by traditional weaving and causal labor employment. (CSA, 2016)

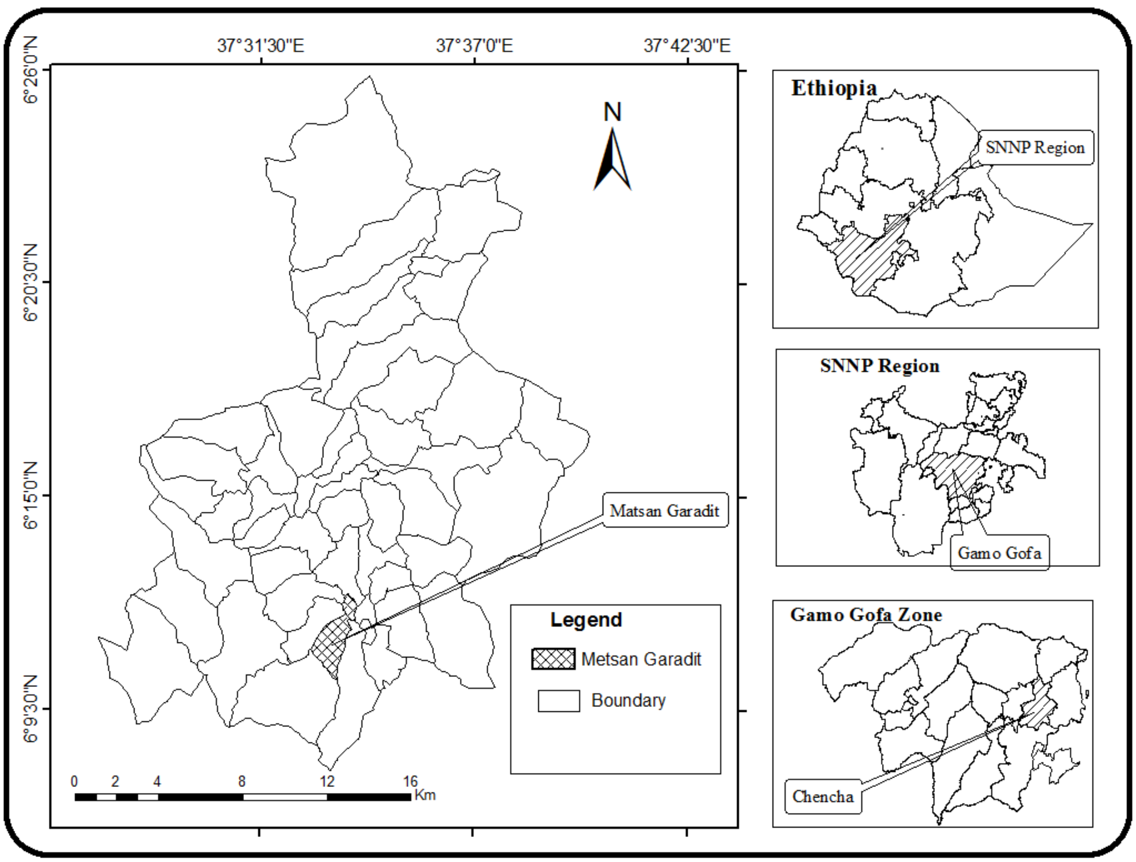

Fig: 3.1 Map of the study area (constructed based on Ethio GIS, 2009)

3.1.1 Topography

Chencha *District* is situated between 1,300 m and 3,250m above sea level. It forms the upper rectangular landmass of the highland. Astronomically Chencha *District* is located between 37o 29' 57" East to 37o 39 36 West The *District* is bordered by Kucha and Boreda- Abbaya *districts* in the North, Arbamich Zuria *District* in the South, Boreda *District* in the East and Dita Deramalo in the West. Due to a high altitudinal range, the area is characterized by diverse agro-climatic distribution and vegetation cover. The *District* is divided into two agro-ecological zones, namely, *Dega* and *Woinadega*, which account for about 82 and 18% of the total area respectively. Due to its rugged topography the highland area is very vulnerable to soil eroding forces.

3.1.2 Soil

The soils of the *District* are primarily clay or clay loams which have evolved from volcanic rocks (basalt) and volcanic tuff in the higher altitudes of the study area. The dominant soil color is reddish brown to dark brown. The principal soil types are Cambisols and Nitosols. Lithosols are specially confined to severely erode steeper parts of the district. These soils are very shallow and generally agriculturally unproductive (CSA, 2012).

3.1.3 Rainfall and temperature of the study area

Chencha's climate is classified as warm and temperate. There is significant rainfall throughout the year in Chencha. Even the driest month still has a lot of rainfall. In Chencha, the average annual temperature is 14.0 °C. In a year, the average rainfall is 1353 mm. The least amount of rainfall occurs in December. The average in this month is 24 mm. Most precipitation falls in May, with an average of 190 mm. The temperatures are highest on average in February, at around 15.3 °C. In August, the average temperature is 12.2 °C. It is the lowest average temperature of the whole year. The variation in the precipitation between the driest and wettest months is 166 mm. The average temperatures vary during the year by 3.1 °C. (CSA, 2003)

3.1.4 Natural resources

The soils in the study area were developed on highly weathered volcanic rocks (basalts) and they are shallow to moderately deep and reddish brown in color. The very shallow and unproductive, lithosols, are confined to the severely eroded steeper parts of the district (Teshome, 1999). The natural forest except in sacred places has dwindled due to population pressure that caused increased demand for arable land, fuel wood and other uses. Although natural forests on privately used lands are almost depleted, one can see here and there patches of natural forest areas. Usually top of hills are used as grazing lands. These resources under traditional resource management system have cultural and spiritual value to people. Groves on graveyards, meeting places and others are considered as sacred places. Recently, as informants explained it, forest area in the *district* increased significantly but all in all of eucalyptus afforestation. It is explained that people are increasingly dependent on eucalyptus trees for fuel and construction. But everybody underlines the negative effect of eucalyptus trees on crop productivity and there is trend of negligence to other tree species. Many informants noted that woodlots or eucalyptus planting has increased in the *district* while the land size under other uses has declined.

3.1.5 Land use and land cover

Much of the district is under crop cultivation (54.4%). The table 3.1 shows land use/land cover in the district. Out of the total area only 7.7% is grazing land. The private and state forests are dominated with exogenous species while natural forest is dominated by indigenous varieties. Natural forest is only 5.6% of the district territory.

Table 3.1 Land use/land cover of Chencha district

Land use	In hectare	Percent
annual crops	24,420.54	54.8
permanent crops	3,102.51	6.9
Grazing areas	3,446.85	7.7
Natural forest	2,510.5	5.6
Cooperative forest	1,668.7	3.6
state forest	695	1.6
Private forest	1,311.85	2.6
rugged areas	7,137.85	16
Others	707.00	1.6
Total	**45,000**	

Source: district rural development Main Coordination Office (2014).

In terms of land holdings Chencha District has households possessing mostly in the range between 0.5-1.2 hectares. According to agricultural Census (CSA, 2003) based on 20,072 households, there was no holder with landholding size above two hectares.

3.1.6 Population

According to the S/N/N/P/R State's Statistics and Population Office demographic abstract the total population of the district is 138,373 as of July 2015. Out of this population, 63,437 are males and 74,936 are females. The same document indicated that Ninety-five per cent of the *district* population lives in rural area while only 9.5 % of the people are residents of urban areas. Agriculture is the mainstay of the economy of the district. However, a significant amount of people in the *district* are engaged in weaving within the district or as migrant weavers in major urban areas all over the country. (CSA, 2015)

3.1.7 Farming system

The Gamo highland is characterized by a very intensive system of agriculture. The intricate combination of field, pasture, and forest indicates centuries of human use and settlement. Agriculture in the highland is mainly subsistence oriented and is mainly aided by traditional farm implements and rich endogenous farming and land management techniques which are accumulated over many generations.

The altitudinal variation in the highland allows the cultivation of different types of crops. Cereals, pulses and horticultural crops of various types are cultivated on the highland. Barley is the most dominant cereal in the upper *dega* areas followed by wheat in lower altitudes. The pulses cultivated in the highland include faba bean and chickpeas, which are of a great value in soil fertility maintenance by crop rotation. Horticultural crops like falso banana (*enset*), *Koltso*, Potatos and taro are also cultivated on the highland to various degrees.

Agriculture in *Chencha* highlands is all round the year job. There are two cropping season in a year, which are locally known as *Gebba* and *Silla* seasons. *Silla* crops are planted in August and harvested in January, whilst the *Gebba* crops are planted in February and harvested in July. In the *Dega* region *Silla* crop is the most important. The *Gabba* crop consists only of barley and the yields are usually low.

The farming system in the *District* is a mixed farming system where the crop sub-system and the livestock sub-system are equally important to each other. Due to low natural fertility, low amount of available nutrients and low permeability of the clay or clay loam soils of the highland, soil fertility maintenance is the number one priority to every farmer in the highland.

In general agriculture in Gamo highlands is highly labor intensive all through the year. Labor is required to level fields, create and maintain terraces, cut and carry fodder to animals, turn the soil of fields to be shown several times rather than once, carry all available manure to the fields, move the houses in which animals are penned in order to plant *ensete* on the wall manure floors of the animal pens, plant and tend the crops and herd the animals. The shortage of agricultural labor force in a household has severe implications on the agricultural production and natural resource management effort in any household. **(**Beletegeberu, 2006)

3.1.8 Crop production

In Chencha District different crops were grown in two cropping seasons, which receive different amounts of rainfall. Common crops included cereals, pulses, root and tuber crops, vegetables, fruit crops and oil crops. On average, about nine crops (range: 5–13) were grown per household. The most widely cultivated crops were *enset*, barley, potato, wheat and apple. Improved varieties were used for production of mainly potato and wheat and in a few cases for barley whereas local varieties were used for the other crops. The most common crops grown in the Belg season were potato and barley which could also be grown in Meher season, along with other annual crops. (CSA 2012)

3.2 Research Design

The study followed both qualitative and quantitative method of data handling and analysis. Research instruments such as sampling, household questionnaire, personal observation and key informant interviews, were used to get reliable data. Laboratory sample analysis and document reviewing were also used.

3.2.1. Selection of the study sites

Gadha Ditta is the village where inappropriate distribution of the agro-ecological condition of the potential Barley production. so this village is one of the areas where nutrient mining is expected. Therefore, it is important to conduct this research to assess nutrient flow out of and into the barley farmland of the specified village.

3.2.2. Sampling technique

Households of the village were classified in to three different wealth categories (rich, medium and poor), depending on the local community's criteria and the socio-economic conditions of the households in the village. The criteria used were land holding size, oxen number and the stock of grain for seed. Farmers in the rich group possessed land > 2 ha, oxen ≥ 4, and had excess production in stock to cover the requirements for seed, farmers in the medium group possessed 1-2 ha, 2-3 oxen and sufficient production in stock to cover the requirements for seed, and the poor group possessed land holdings <1 ha and owned one or no oxen, and had insufficient grain in stock for seed. Through stratified random sampling proportionally 39 households from the rich, 55 from the medium and 35 from the poor group were selected from the households of the village. The community's classification has been validated with the data collected during the direct survey.

Table 3.2: Total households and Sample size by wealth category, Gadha Ditta village, chencha district, southern Ethiopia, 2017.

Wealth category	Total number of household heads			Number of sample households					
	MHH	FHH	TOTAL	MHH	%	FHH	%	TOTAL	% of the sample size
Rich	70	18	88	36	31.85	3	18.75	39	25.3
Medium	93	44	137	48	42.5	7	43.75	55	43
Poor	57	41	98	29	25.66	6	37.5	35	31.58
Total	220	103	323	113	100	16	100	129	100

3.2.3. Data sources and data collection Instruments

Both primary and secondary data were generated by employing quantitative and qualitative methods. The quantitative methods involve the use of household survey while the qualitative methods used include key informant interview and direct personal observation.

Primary Data collection

Household Survey

Questionnaires developed for this purpose was used after pretesting to generate reliable data. During the household interviews, information was obtained on the family size, land holding size, number of cattle, amount of inorganic and organic fertilizer used, amount of crop and labour. Farmers also gave information on different land utilization type, and their major farm products and destinations. Nutrient flows were quantified by asking farmers and through direct observation on the Barley farmland. The inflows were investigated by asking farmers the quantities of mineral fertilizers (IN1), organic inputs such as manure (IN2) entering the barley farmland annually. The outflows included harvested crops (OUT1) and crop residues (OUT2. Also all classes of farm animals will be counted and converted to TLU for each farmer; a field observation was conducted randomly to check the different land utilization type, the number of plots under each farmer, and the surface area of each plot that was owned by the farmers.

Key Informant Interview

A key informant interview is important in getting information relevant to soil nutrient management practices. Through such instrument, information regarding the views of experts from chencha district Agriculture office was collected.

Personal Observation:

Field survey of the area was carried out by using Global Positioning System (GPS) read to identify the geographical locations and the coordinate system where data was taken. The observation encompassed visit of topography, vegetation cover, settlement pattern and the overall aspects of farm management practices and of the study area.

Sample collection for laboratory analysis

From the selected households, composite samples of soil, household's organic materials (cattle manure and compost), farm products (barley yield and barley residues) were collected so as to analyze the nutrient contents of these farm land. Thrty composite soils samples, 0-20 cm depth, were collected from representative land utilization types of barley for the analysis of organic carbon, NPK contents. Ten composite samples five samples from each of cattle manure and compost were collected and analyzed for NPK and OC content. Ten composite samples from barley yields and ten composite samples of barley residues were collected and analyzed for their NPK and OC content. All collected samples were analyzed at Debrezit Agricultural research center plant analysis laboratory and Addis Abeba University the soil analysis laboratory using standard procedure.

Soil organic carbon was determined by the wet oxidation method (Walkley and Black 1934). Available P was determined with the Olsen method (Bray and Kurtz 1945), while total N was determined by Kjeldahl digestion, distillation and titration. Exchangeable K was analyzed using an atomic absorption spectrophotometer following an ammonium acetate extraction. Bulk density was determined by the measurement of the wet weight of each core and converting to dry mass equivalent per unit volume of the soil using moisture data and the known volume of the core. Plant P and K were analyzed by dry ashing method using spectrophotometer and atomic absorption and TN was analyzed by Kjeldahl digestion, distillation and titration and organic carbon was calculated from the ash (Sahlemedhin and Taye, 2000). Nutrient input from mineral fertilizer was calculated using data obtained from the village. Both DAP and Urea was taken into account for farm household input estimation. Urea is chemically composed of 46% of N, while DAP contains 18% of N and 46% of P (FAO, 2008).

3.2.4. Administration of the Questionnaire

The questionnaires were administrated by trained data collectors and the researcher who are speakers of the local language of the study area. A brief orientation and training was given for data collectors before the actual data collection. During data collection strict supervision and control was done to increase the quality of the questionnaire.

3.2.5. Data-analysis

Nutrient balance study follows starting by the identification of the key inputs and outputs in barley farmland. The nutrient inputs and outputs were defined through analysis of farmer estimation. Flows of nutrients (Nitrogen, Phosphorus and Potassium), and Organic Carbon were calculated through analysis of flows nutrient content.

To assist the analysis of nutrient flows in barley farmland, the subsequent steps were pursued: The major resources in the barley farmland were identified, the estimated amount of matter within barley farmland was translated into quantities of nutrients based on data base collected from the study site nutrient content analysis, and then estimated nutrient flow was done

The data obtained from household interview, field observation, and laboratory analysis was analyzed and summarized in to tables and graphs by using Microsoft office excel spreadsheet and Statistical Package for Social Studies (SPSS) version 20 to measure and characterize the production factors available on the farm *i.e.*, overview and characteristics of land size, livestock, barley yield and barley residues, nutrient balance per barley and fertilizer use. Qualitative data generated from key informant interview, and secondary sources was analyzed by account description.

Chapter Four: Results and Discussion

4.1 Socio-economic and demographic Characteristics of the Sample

4.1. 1 Sex and age of the respondents

Members were collected of both sexes chosen from the whole three farmers‟ wealth categories (Rich, medium and poor). About 88% and 12% of members were male and female headed Farmers respectively. The smallest age of the members was 25 while the highest age was 63. The modal age group of members is 35-44 years old, accounting for 42.42% of the members male and 6.1% of the members are female(Fig 4.1). About 18.18%, 18.18%, and 9.1% of the members of male were from the age groups between 45-54, 55-64, and 25-34 respectively and about 6.1% of the members of female were from the age groups between 35-44 and 45-54.

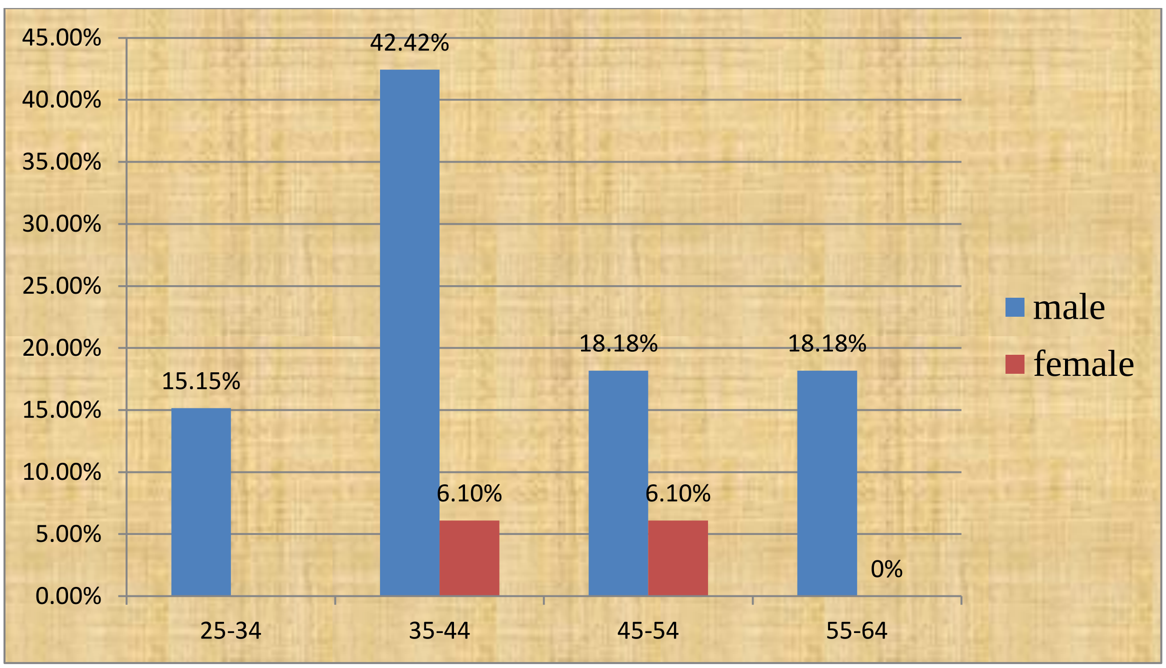

Fig 4.1 Percentage distribution of the respondents by their sex andage group, gadhaditta , 2017
Source: Field survey, 2017

The average age of the respondents is 44 years. That means on average the respondents are in the category of active labour force, which could have positive implication in terms of coordinating family labor and soil fertility management. Like many other rural villages of the country, most households of Gadha Dita *village* are dominated by male headed households.

Therefore, decision on soil fertility management is done by male than females. But there is no difference on use of resources and nutrients between male and female headed households.

4.1.2 Marital status

About 81.8% and 18.2% of the members are married and widowed respectively .But there are no single and divorced members, because of culture of the society. That means if one women come be divorced, she never have the chance to get the resource.

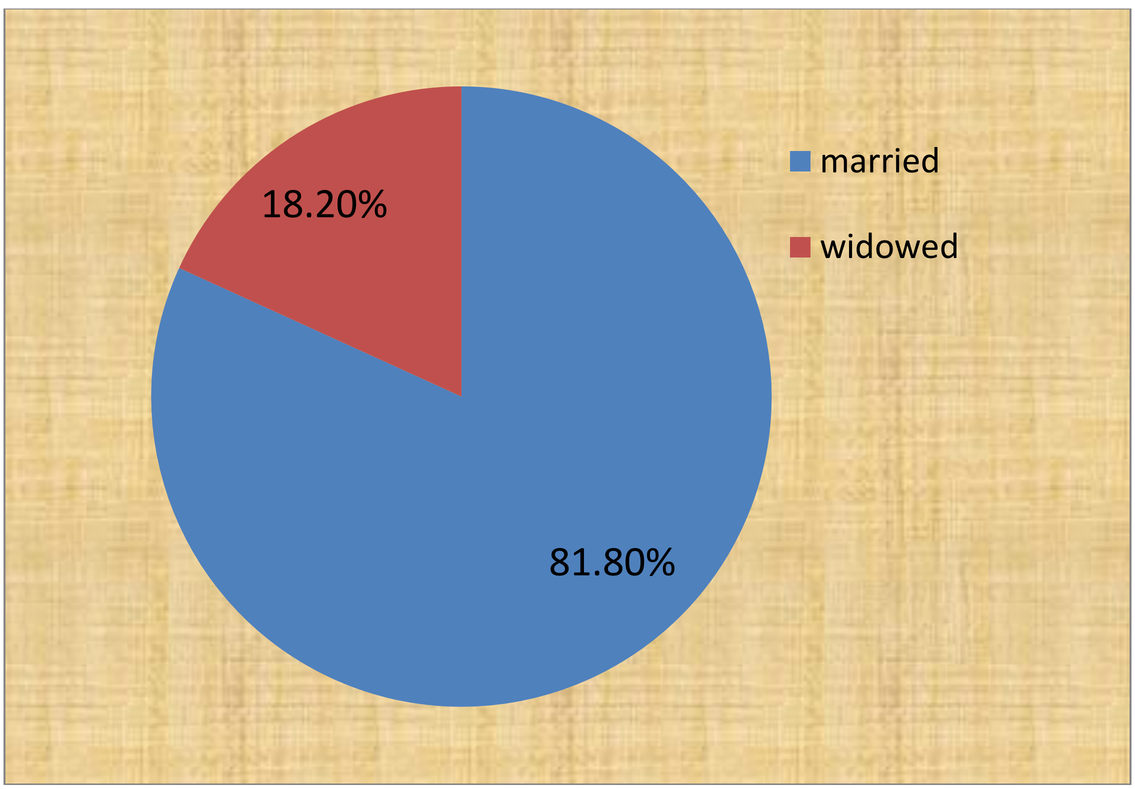

Fig 4.2 Percentage frequency distribution of marital status of the member's gadhaditta, 2017 Source: Field investigation, 2017

4.1.3 Educational level

Educational rank of 36.36%and 9.1% of the members cannot read and write and read and write respectively, while 15.15% and 30.30% of the members attended Junior high school and elementary school. Those with Secondary high school and higher education (diploma) educational level were only 3.03% and 6.06%% of the members respectively (Fig 4.2)

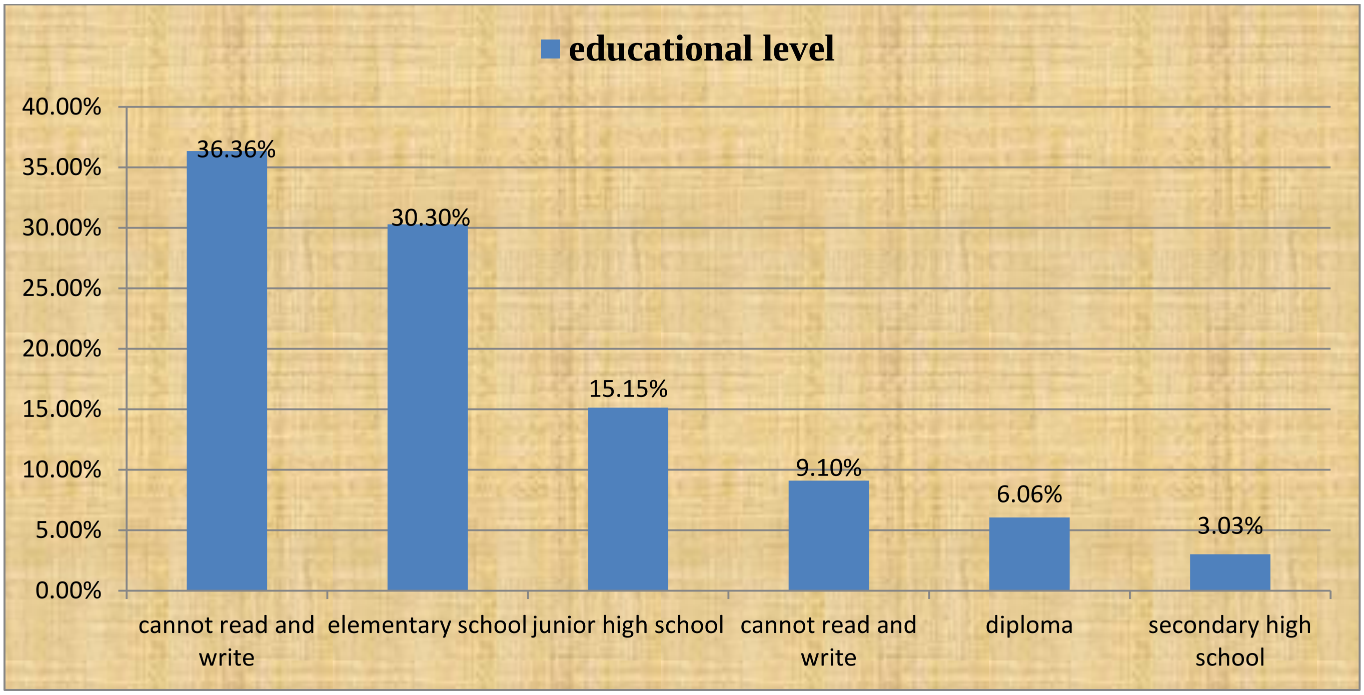

Fig 4.3 Percentage frequency distribution of members by their educational level, Gadha Ditta village 2017 Source, Field survey 2017

4.2 Determination of selected resource flows

4.2.1 Labour force

In the study village about 58% (16-60 years old) represents active labour force (Fig.4.4). This is greater than the national average which is about 52% (CSA, 2007). The families in the age group between 6-15 years (52%) can also perform some activities. They look after cattle, collect firewood, fetch water and perform similar agricultural activities.

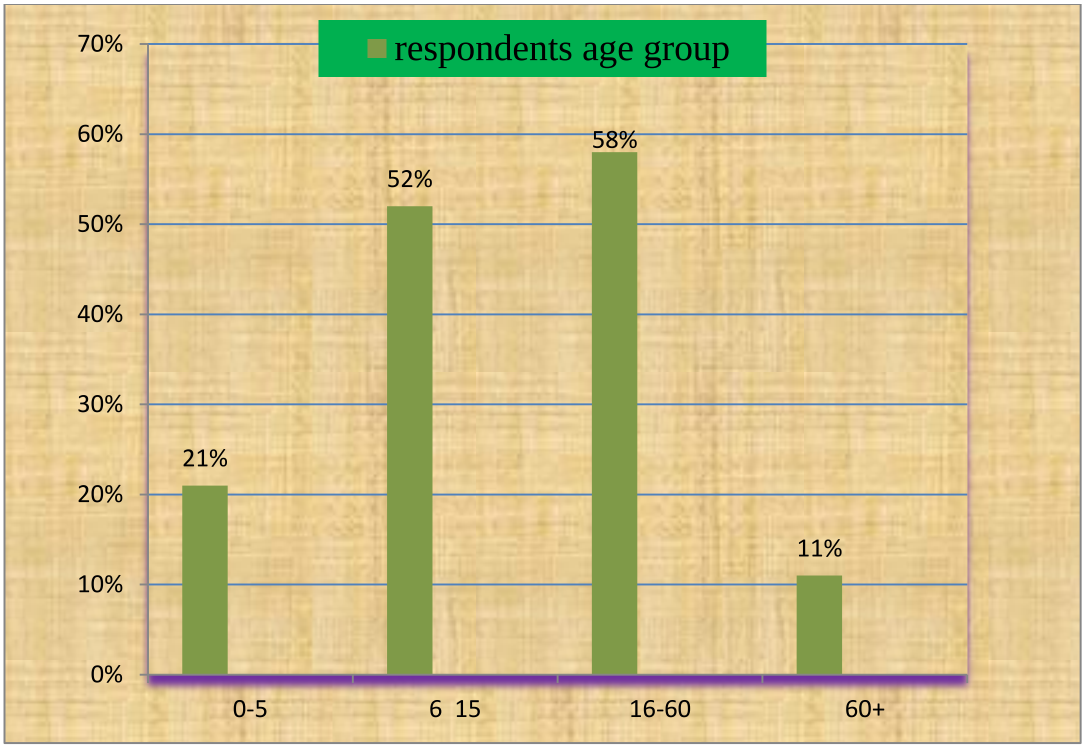

Fig. 4.4 labour force of the respondents in Gadha Ditta *village*, January, 2017
Source field survey, 2017

Labour is one of the most important socio-economic characteristics that manipulate soil fertility management. Transportation and application of organic fertilizer such as manure and compost to the distant plots require human labour and transportation.

4.2.2 Land holding size

The average land holding size for the poor, medium and rich farm group is 0.66, 1.19 and 2.47 hectares respectively, and these differences are statistically significant ($P< 0.05$). The average land holding size of the respondent's is 1.44 hectares. This is larger than the national average land holding size, which is nearly one hectare (CSA, 2007).

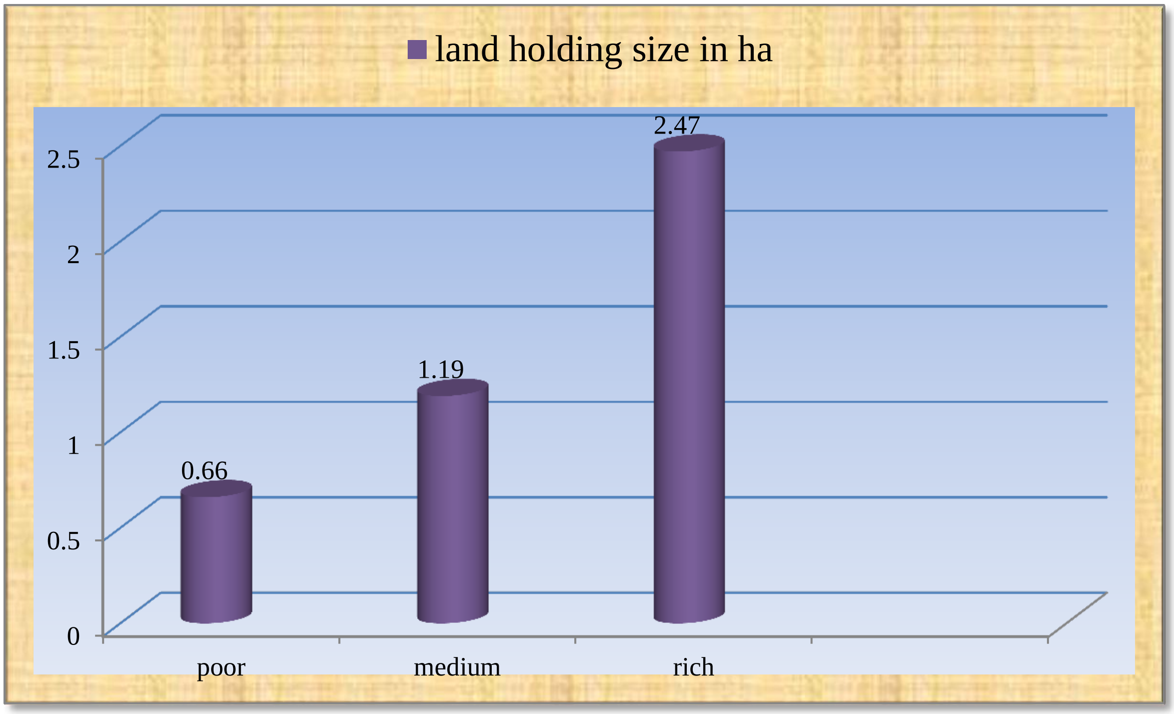

Fig 4.5 Average land holding size (ha) by farm wealth category, gadhaditta village
Source: Field survey, 2017

There is significant variation among the different wealth categories of the village in terms of Land holding sizes. Rich households have significantly highest holding size than medium and poor wealth farm groups, and land holding size of medium wealth farm group is significantly higher than land holding size of poor wealth group ($P < 0.05$). The land holding size influences the wealth status of the households. Those households that have large land size are rich because they produce more crop yield than those households that own smaller land sizes. The resource and nutrient outflow and inflow to the farm systems of rich households are high compared to the medium and poor households.

4.2.3 Livestock holding size

A Tropical Livestock Unit (TLU) is an animal unit used to aggregate different classes of livestock. One TLU equals an animal of 250 kg live weight (FAO, 1987). To convert different animals to TLU, the numbers of different animals were multiplied by the corresponding conversion factors as follows: cattle 0.7, sheep/goat 0.1, and horse=0.8, donkey=0.5 and chicken=0.01(http://www.fao.org/wairdocs/ILRI).

In the study village the average livestock (TLU) holding for rich, medium and poor farm groups was 13.5%, 6.05%.and 3.24% respectively, and the differences are statistically significant ($P < 0.05$)

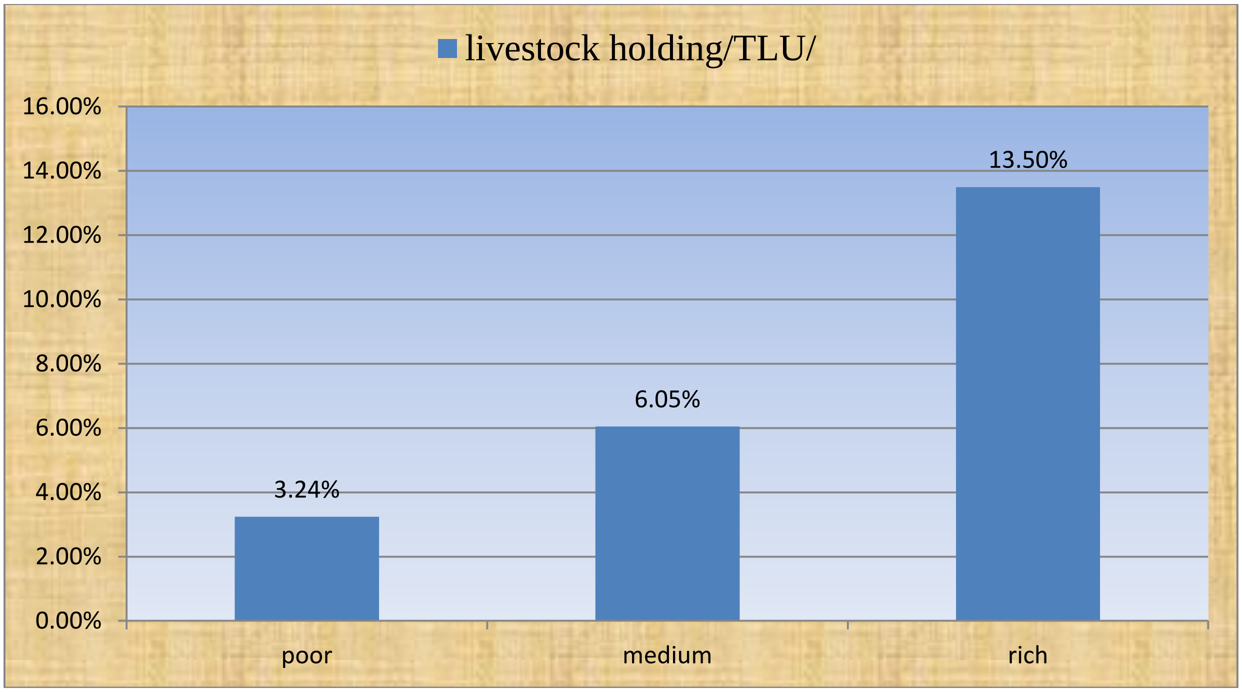

Fig 4.6 Average livestock holding (TLU) by farm wealth group in Gadha Ditta *village*
Source: Field survey, 2017

4.3 Nutrient inflow analysis to the barley land

i. Chemical fertilizer

For all three farm groups, inflows into the crop land include chemical fertilizer and manure. Inflows of the inorganic fertilizers, Urea and Diammonium phosphate (DAP), restricted to barley fields. 34.8 kg/ha urea and 68.8 kg/ha DAP (28.4 kg N and 31.6 kg P ha-1) for the rich, 37.8 kg /ha urea and 78 kg/ha DAP (31.4kg N and 36 kg P ha-1) for the medium; and 29.6 kg/ha Urea and 70.4 kg/ha DAP (26.3 kg N and 32.4 kg P ha-1) for the poor farm group, respectively.
There is deference in fertilizer consumption among the farm wealth categories. Because of the farmers limitation of knowledge about fertilizer and not take sufficient for land

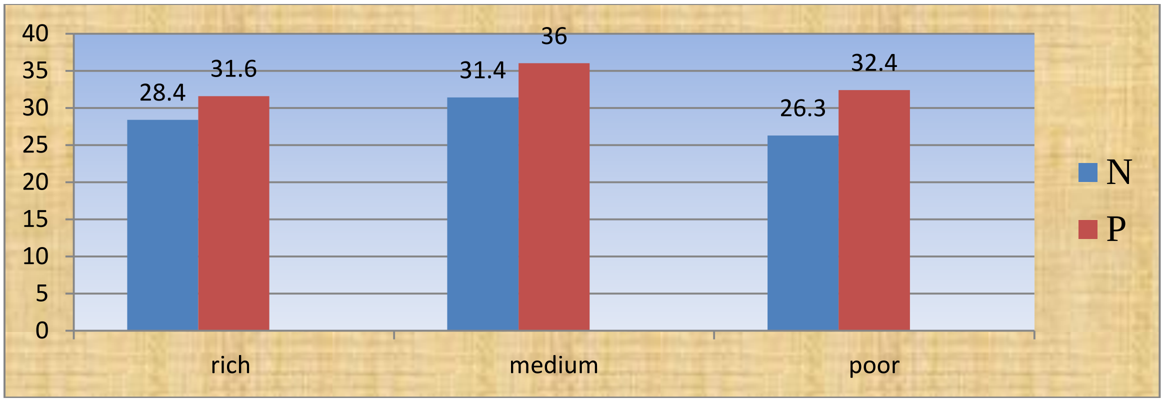

Fig 4.7 Inflow of nutrients through chemical fertilizer and manure to the barley crop land in Gadha Ditta *village*.

Source: laboratory result, 2017

i. Manure

Farmers in gadha ditta rarely use animal manure to improve soil fertility. On average, 2.7% (137.7Kg) of manure was used to apply near the homestead. This is equivalent to 2.07 kg N, 0.56 kg P and 2.81 Kg K per annum. The rest 97.3% (4962.3kg) per household per annum was used as others. This is equivalent to74.6 Kg N, 20.18 kg P and 101.3 kg K per household per year. This amount of N was not recycled because of loss through other purpose.

4.4 Nutrient out Flow Analysis from the Barley Land

Crop yield: The average amount of barley yield out from the land totally was 983 kg/ha. (28 kg N, 5 kg P and 9 kg K ha-1) for the rich; 1,062 kg/ha (31 kg N,5.5kgP and 9.7kgK ha-1) for the medium; and1074 kg (30.6 kg N, 5.4kg P and 10kgKha-1) for the poor farm group per household per year respectively. This is due to limitation of fertilizer use by farmers.

Crop residue (Nr): In the study village, nutrients are also exported from farm fields through the removal of crop residues. the amounts of crop residues were estimated using crop yieldmultiplied by harvest index set as 0.45 averagely for most crops in developing countries derived from Gallagher et al. (2012) and the percentage of residue left on the field after harvest set as 30% because Nearly 70% of the crop residue is removed from the field. It could be calculated as follow.

$$Nr = Cp\ (1\text{-}HI)\ NI\ Ref$$ ……………………………………………..

Where:

Nr = nutrient uptake by the residue.

HI = harvest index.

Ref = the approximated percentage of residue left on the soil after crop harvesting.

Therefore the average amount of crop residue exported to other purpose was 162 kg. (10.2 kg N, 1.3 kg P and 20.6 kg K ha-1) for the rich; 175 kg(11.8 kg N, 1.6 kg P and 23.8 kg K ha-1) for the medium; and 177kg (7 kg N, 0.8 kg P and 18.2 kg Kha-1) for the poor farm group per household per year respectively.

Fig 4.8 barley field left bare land Photo by the author, 2017

4.5 Determination of Nutrient Flows in Barley land

In agricultural activities, nutrients are added to the systems via organic and/or inorganic fertilization. On the other hand nutrients are exported from the systems via harvesting yields or collecting crop residues. Hence, by calculating the net difference between the amounts of nutrients that are entering a system (i.e. inputs) and the nutrients that are removed (i.e. outputs) a nutrient balance i.e. (Σ IN+IN2 inputs – Σ OUT1 +OUT2).

4.5.1 Nutrient balance analysis in barley land

The total N imported (IN1 and IN2) into The barley Land system on average was 15.4 kg/ha/yr, while the export of the same nutrient (OUT1 and OUT 2) was 19.77 kg/ha/yr. Thus, the partial balance was -4.3 kg N/ha/yr. Similarly the total P imported (IN1 and IN2) into the crop land on average was 16.9 kg/ha/yr, while the export of the same nutrient (OUT1 and OUT 2) was 3.3 kg/ha/yr, yielding a partial balance of 13.6 kg P/ha/yr. The balance for K was (-12.39 kg/ha/yr). The negative balance for N was seen, because on average farmers in the study area are applying insufficient inorganic fertilizer for barley field. And also the negative balance for K was due to the fact that K was not a component of common inorganic fertilizer that is usually applied in the village as well as in Ethiopia. But the positive balance of P was seen because of the of the high nutrient inport to external through barley yield

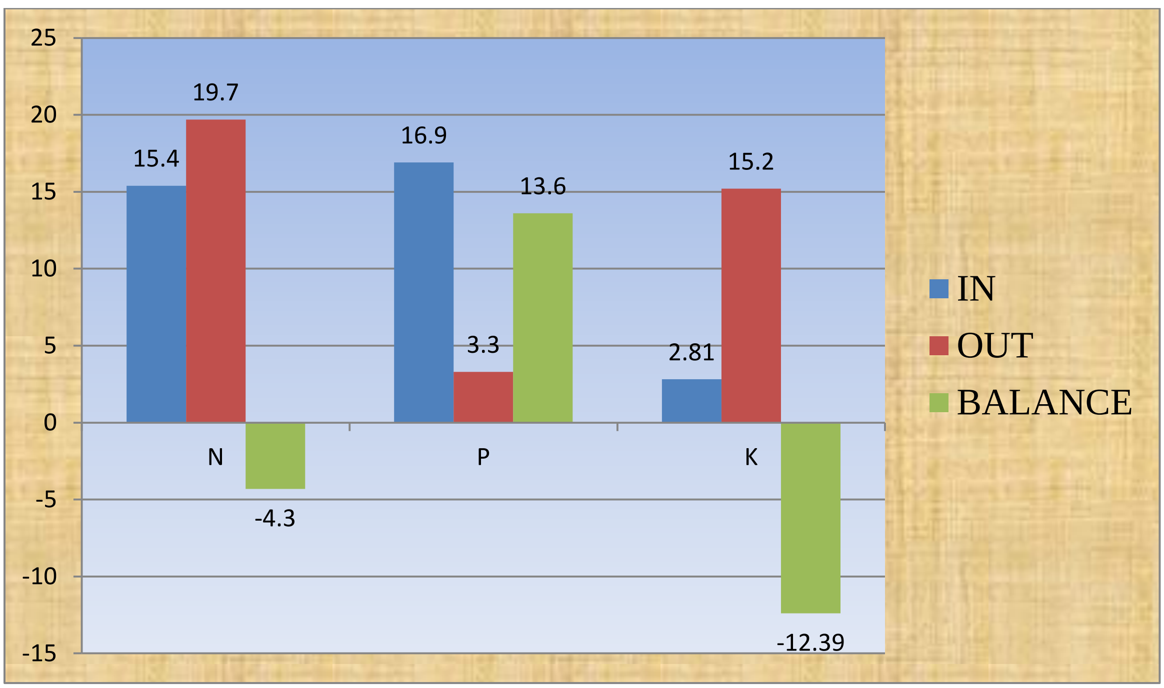

Fig 4.9 Farm Scale NPK balances in Gadha Ditta *Village*
Source: Laboratory result, 2017

4.5.2 Nutrient Balance Analysis across farm wealth groups

For all the three farm groups, inflows into the farm include chemical fertilizer, and manure. In this study, chemical fertilizer (DAP and Urea) purchased from the market was common for the three farm groups, but the amount of chemical fertilizer taken by the three farm group was little compared on land size. In barley land outflows consisted of in all farm groups, were crop products and crop residue. P was positive for the three farm groups and the N and K are negative because of the high nutrient export to external through barley yield and residue. That means the farmers not use sufficient chemical fertilizer per hectare for land.

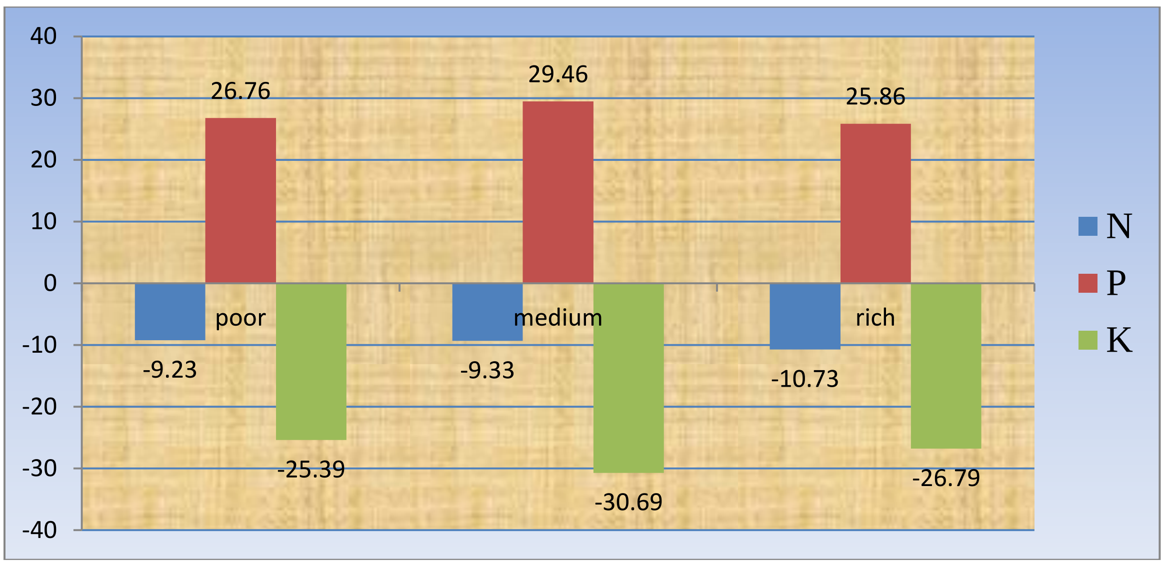

Fig 4.10 Farm Wealth groups Partial Nutrient Balance Analysis for Gadha Ditta *village*
Source Laboratory result, 2017

4.5.3 Organic Carbon flow Analysis

Organic carbon is one of the most important components of crop yield, crop residue and other organic sources such as manure. In crops and crop residue the proportion of organic carbon content ranges from 50-55 %.Organic carbon depletion rates differ significantly among different farmer wealth groups. The highest amount were recorded for the rich farm group (12,323kg/hh/yr), followed by the medium (7513 kg/hh/yr) and poor farm group (4576 kg/hh/yr). These differences are associated with the differences in crop production

Fig: 4.11 of Analysis of soil organic carbon at Addis Ababa University soil laboratory.
Source: photo by the author, 2017

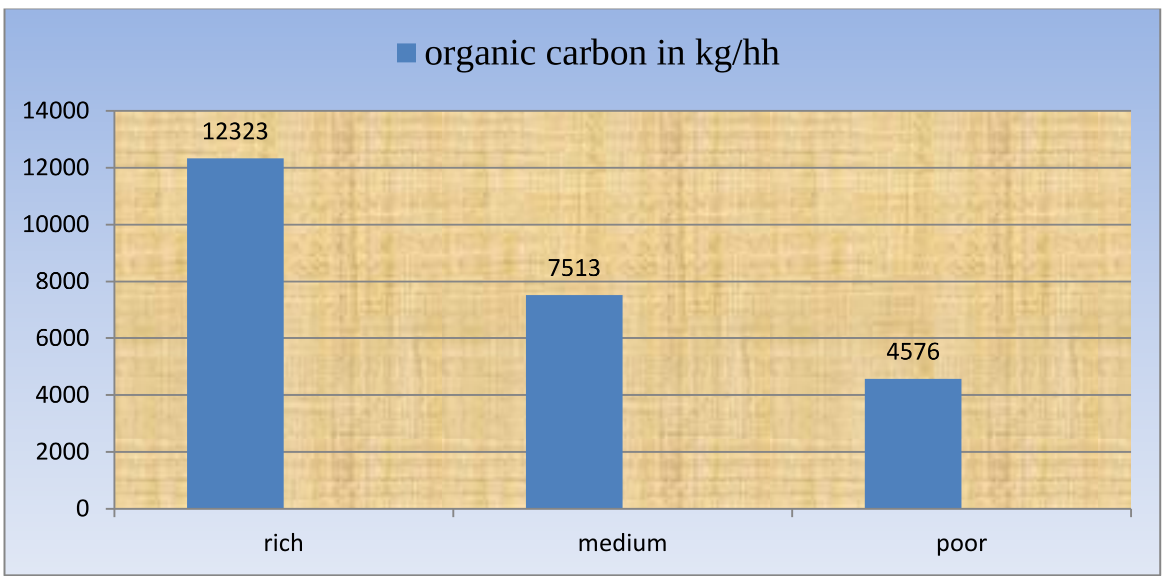

Figure 4.12 Organic Carbon flow analysis in Gadha Ditta *village*
Source: Laboratory result, 2017

4.6 Soil fertility status of the study area

It should be noted that there is no worldwide accepted single criterion used for interpretation of analytical soil data. It all depends on the methods used and procedures followed in the determination of the properties in the laboratory and the intended use of the land or crops to be cultivated. Different field crops have different nutrient requirement and toxicity tolerant levels, which makes the definition of single criterion difficult. For this particular study the following criteria edited by J.R Landon (Booker Tropical Soil manual, 1991) was used as a reference to evaluate the natural soil fertility status of the study area.

Table 4.1 Critical values of Organic Carbon (OC), Total Nitrogen (N), Available Phosphorus (P) and exchangeable Potassium (K)

Nutrient Rating	Nutrients			Exch.K Cmol/100 g soil
	OC%	TN%	AV.P(ppm)	
Very High	>20	>1	>22	>0.8
High	10-20	0.5-1	13-22	0.5-0.8
Medium	4-10	0.2-0.5	6.5-13	0.3-0.5
Low	2-4	0.1-0.2	3-6.5	0.15-0.5
Very Low	< 2	< 0.1	<3	< 0.15

Source: Booker Tropical Soil Manual, 1991

Table 4.2 Organic carbons (OC) Total Nitrogen (TN), available P and Exchangeable K content of the surface soil (0-20 cm) land utilization types in Gadha Ditta, Southern of Ethiopia, 2017

Crop	Nutrients			
	OC (%)	TN (%)	Av. P (ppm)	Exch.K (Cmol/100g)
barley	1.4%	0.10%	3.89ppm	1.91Cmol/100g

Source: Soil laboratory analysis, 2017

In general from this data it can be concluded that the contents of Organic Carbon and total Nitrogen are very low in barley crop fields while available Phosphorus is low and exchangeable Potassium is very high. The soil of the area is dominated by clay soil. The area is continuously not cultivated. Therefore applying these nutrients to crop fields is necessary to counterbalance the deficiencies, while potassium was sufficient as it was generally accepted that most Ethiopian soils are rich in Potassium.

Soil fertility decline was identified as one of the serious problems that have affected the agricultural land in the high-lands, as expressed by the majority of respondents. Almost all respondents thought that the fertility of their cultivated land was very low as compared with the situation 30 years earlier. They characterized low soil fertility as resulting in a low plant performance and low yields even during a good rainy season. Farmers stated that soil erosion was also a factor for the decline of soil fertility, as it caused removal of fertile surface soil.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In the preceding chapter, nutrient balances and soil fertility status results have been presented and discussed. The most important findings of the study have been summarized and concluded below: Nutrient that flow in to the barley production includes chemical fertilizer and organic fertilizer. In barley production outflows consisted of barley yields and barley residues.

Barley yields and barley residues were flow from barley land and Manure flows from animal production. The calculation of NPK in barley land was negative for N and k, while p was positive. This is because of potassium is not applied as chemical fertilizer in crop fields of the study area also the N content would be reduce because of the farmers use insufficient chemical fertilizer per hectare. This is the case of farmers do not know about significance of chemical fertilizer and the case of incomes. This is due to the farmers and the agriculture sector was not work together.

The result of organic carbon per house holding the three farm group of barley land was very differ, this is because of the number of livestock of the rich is greater than medium that is also greeter than poor. But for rich land holding size is greater than for other two groups. There for the amount of organic carbon per hectare for rich farm group is less than the other two farm groups

Soil fertility analysis for the study area shows that organic carbon and, total nitrogen were very low and available phosphorus was low in barley crop fields while exchangeable potassium was very high. Therefore, application of inorganic and organic fertilizer sources is important to replenish the low content of nutrients in the study area. And farmers to not get more knowledge about soil fertility management in that sector.

5.2. Recommendations

Among the efforts made by the government, natural resource conservation and soil fertility management for sustainable agricultural production are the most important practices of the government. Despite the efforts made by the government, still crop productivity is greatly hampered by inadequate application of soil fertility amendments, removals of nutrients through crop harvest and crop residues, use chemical fertilizer properly. In line with this the following recommendation were forwarded to strengthen the government effort so far on practices:

- Soil fertility management problem in the study village can be addressed both through the use of adequate soil fertility amendment inputs and minimizing organic nutrient losses.

This can be done through application of chemical fertilizers and organic sources such as: manure, crop residues and domestic waste to the field.

- To feed the increasing population, the crop yields need to increase beyond the current level. This cannot be achieved without increasing the nutrient input. Both organic and mineral fertilizers have a role to play. Chemical fertilizers are expensive, hence it is better if future researches focus on how to increasing the use of organic fertilizer in smaller farming systems.
- Provision of continuous training and awareness to the farmers on soil fertility management is advisable to improve the awareness of farmers for sustainable soil fertility management.
- The farmers know about the significance of chemical fertilizer and reduce the price of the fertilizer.
- The Chencha Office of Agriculture and Cooperatives could facilitate timely delivery of fertilizers. In addition, the COoA and microfinance institutes could facilitate access to credit. Some farmers are not sure whether they can produce enough to repay their loans; they require training on how to maximize the effectiveness of their production systems.

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Appendix 1

House Hold Survey Questionnaire

November 2017

Structured survey questionnaire

Addis Ababa University

Graduate Studies

College of Social sciences

Department of Geography and Environmental studies

A Questionnaire to be completed by Farmersof Gadha Ditta *village* chencha District,

Dear Farmers, This questionnaire is designed to gather information for a study on small holder‟s farming Systems of chencha District to determine nutrient flows on barley farmland.

Please note your individual responses will be kept confidential, and only aggregated results from the whole survey will be used for the purpose of the study.

Yours faithfully

Yewubdar melese

Read the questions and use tick mark (√) or circle your choice

Questionnaire for gadha ditta Farmers to determine nutrient balance and flow, in small farming systems of, chencha District

Date of interview: ----------------------

GPS coordinates at / near the farm of respondent

a. Latitude: ---------------- b. Longitude: ------------------- c. Altitude ----------------

1. General information

1.1 Gender of the respondent: 1) Male 2 Female

1.2 Age of the respondent ______________________________

1.3 Marital status of the household head

1) Single 2) Married 3) Divorced 4) Widowed

1.4. Educational status of the household head

1) Cannot read and write 2) can read and write 3) Elementary school

4) Junior secondary (7-8) 5) Secondary high school (9-12)

6) Diploma (or equivalent)

1.5 Is the respondent head of the household?

1. Yes 2 No

1.6. The household family size with Age and sex

No.	Age	Male	Female	Total
1	0-5			
2	5-15			
3	15-30			
4	30-60			
5	60+			
	Total			

2. Overall land holding and land use characteristics

2.1. Total size of land you own in ha (or in local unit) __________________

2.2. In how many plots is your total land situated? __________________

Plot	Area of plot		Current land use	Means of owning the land	Distance away from the home (in km or hr)
	Area	Unit			
1					
2					
3					
4					
5					

2.3. Do you have serious problem of land shortage?

1) Yes 2) No

2.4 If Q 2.3 is yes how do you solve the problem?

1) Rented 2) Crop Share 3) Gift 4) Other, please specify

2.5 .How far the barley farmland is distant from your home?

a. around the home b. Around 200 m c. 500 m d. >500 m

3. Sources and utilization of fertilizers

3.1. Do you use soil fertility amendment inputs to your farmland?

1) Yes 2) No

3.2. If the answer for question 3.1 is yes, what types of inputs do you use? Multiple responses are possible.

1) Chemical fertilizers 2) Manure 3) Compost 4) crop rotation 5. Incorporate crop residues in the soil/field 6) specify, if any other _______________

3.3. Rank your preference for the following inputs/ as per your preference to apply in your farm field (1 = most preferred and 5=least preferred)

No.	Input/inflow type	Rank	Reason for your preference
1	Chemical fertilizers		
2	manure		
3	compost		
4	Incorporate crop residues in the soil/field		
5	if any other		

3.4. Do you face any problem in applying these inputs to your field?

1) Yes 2) No

3.5. If the answer is yes, what is the problem?______________________________________

3.6. Please specify the type and amount of fertilizer used on different crops last season?

plot	Crop grown	Area allocated in ha	Fertilizer used		
			Type of fertilizer	Amount Used kg/ha	Price /Qt
1			Urea DAP Manure Compost		
2			Urea DAP Manure Compost		
3			Urea DAP Manure Compost		
4			Urea DAP Manure Compost		

4.1 How much crop yield and residue you produced last season?

Plot	Crop grown	Area allocated (ha/)	Total yield in kg	Total crop residue in kg
1				
2				
3				
4				

5. Crop and residue utilization

5.1. For what purpose do you use the crop produced?

Plot	Crop grown	Utilization of crop product in kg		
		Used as house hold food	sold to market	Other uses
1				
2				
3				
4				

6. Household animal production

6.1. What type and amount of animals do you own?

Animal type	Number of animals
cows	
Oxen	
Calve	
Heifers	
sheep	
goats	
horses	
donkeys	
poultry	

6.2. Does your household graze animals away from the house?

1. Yes 2. No

6.3. If Q 6.2 is yes where do your animals graze?

1. On communal lands 2. On own pasture land

3. On own crop land residues 4. Others, specify

Appendix 2. Interview Questions for Key informant (with experts)

Dear Experts of agriculture in chencha District

This questionnaire is designed to gather information on nutrient balance and flow in small

holder‟s farming systems of chencha wereda Please note that your individual responses will be kept confidential, and only aggregated results from the whole survey will be used for the purpose of the determinant of soil nutrient balance.

Yours faithfully

Yewubdarmelese

1. Name ----------------------------------

2. Position/profession------------------------------------

3. Is there any form of soil nutrient depletion in your district?   A)yes   B)No

If, 'Yes, please explain it**.**

4. Did farmers use organic fertilizer such as: manure and crop residues for soil fertility? If not why?

5. Do farmers get training on soil organic source and their application? if yes how often?

6. What problems farmers face to use organic fertilizer sources?

7. What are the roles of institutions like NGOs in facilitating the management of soil fertility in your *Kebele*?

8. Do local communities take part in making decisions with regard to appropriate soil fertility?

how to aplay it?   A.Yes   B.No

If yes, how, please explain it

If not why Please explain it

13. Do farmers in the area have alternative sources of income? A)Yes B)No

What percentage of farmers relies only on farm income? ....

Thank you for your cooperation!!!