QUANTITATIVE ANALYSIS OF THE IMPACT OF AGRICULTURAL INTENSIFICATION ON SOIL FERTILITY IN ARABLE LANDS, GHANA

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ABSTRACT

The study examined the impact of agricultural intensification on soil fertility in arable lands within five farming districts in the Ashanti Region Ghana. The study is based on the premise that the current agricultural intensification practices have not contributed to increased productivity but instead, have impacted cultivated lands negatively. Two hundred farmers were selected randomly from the five districts within Ashanti Region. A questionnaire was developed based on the objectives of the study to collect data on farmers land use activities, production cost and their perceptions of the challenges facing agricultural intensification. Soil testing was undertaken to determine the soil fertility status of fields under intensified systems using non-intensified fields in the study area as control. Data collected was analyzed using SPSS version 20. The results show that fields under intensified cultivation systems had significant reduction in soil available water, soil nutrients and microorganism presence. Also, the results indicate that 95% of respondents face the problem of high production cost (resulting from high cost of agricultural inputs) and a decline in yields even with the use of agricultural intensification methods and improved crop varieties. Thus, the premise of the study was valid. The results suggest a need for the capacity of farmers to be built to implement sustainable forms of agricultural intensification to be able to the reduce impact of current practices on fertility and by so doing increase their agricultural productivity.

Key words: Degradation of agricultural lands, land use intensification, rice fields, soil nutrients status.
FOREWORD

Improving Ghana’s agriculture is pivotal in ensuring food sufficiency for the country as a whole. Doing this would require the maximum use of arable lands with sufficient fertility levels. The study is to clearly ascertain how using intensive practices of farming has affected the fertility of soil and yields in the study area based on quantitative analysis and local farmers perceptions. The study contributes to the data required by the Ministry of Food and Agriculture of Ghana to understand and support local farmers in the implementation of sustainable forms of agriculture and soil management.

I would like to thank Dr. Mark Appiah, who is the main supervisor of my thesis, for his guidance throughout the study. I would also thank Dr. F.M. Tetteh for assisting me with the analysis of the soil.

I thank my husband Mr. Roland Andy Adapaura for his moral and financial support throughout the study.
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LIST OF ACRONYMS

AI Agricultural intensification
FAO Food and Agriculture Organization
FC Forestry Commission
MoFA Ministry of Food and Agriculture
GDP Gross domestic Product
INGER International Network for Genetic Evaluation in Rice
WARDA West Africa Rice Development Association
1. INTRODUCTION

1.1 Background of the Study

An average of 70% of Africa’s population live in rural areas and their livelihood is through agriculture. About 40% gain foreign currency from trading internationally with agriculture and a greater portion of their Gross Domestic Products (GDP) is from agriculture (Frederick, et al 2010). There is much evidence that agriculture contributes to both local and national economic growth (Frederick, et al 2010). In an agriculture-based economy like Ghana, agriculture contributes about 32 percent of GDP growth. But, agricultural activities in Ghana are still being conducted with simple farm tools and equipment and limited fertilizer inputs consequently productivity is low. In contrast, in transforming countries like China, India, Indonesia, and Morocco, agriculture activities are heavily mechanized even though, the sector does not contribute much to the growth of their economies. Agriculture contributes just about 7% of their GDP.

In the case of some Latin American countries, agriculture provides below 5 percent of GDP growth (Gobind, 2009). In these two groups of countries agricultural mechanization has contributed to increased agricultural output enabling them to achieve sufficiency in food production. Thus, to achieve a higher level of agricultural productivity and agricultural development, policy has to embrace agricultural intensification (AI) which has been defined by Ruthenberg (1980) as designs of land-use that includes a higher usage of resources that are fixed usually because of continual usage of the same area of land (Binswanger, et al. 1993).

AI increases the worth of its outcome (Tiffen, et al. 1994) and this happens because of a high portions of materials that are added without a change in technologies (Frederick, et al 2010). However, AI can also reduce the productive potential of agro-ecosystems if not properly managed. As agriculture has become specialized and intensified, there have been landscape level trends for a reduction in biodiversity and soil (FAO, 2011). Continues process of cultivation of the land and low use of organic materials on fertilization significantly contributes to the depletion of soil nutrients (e.g. Purvis & Bannon, 1992; Pedro, 2002). Also, land degradation, deforestation and drying up of rivers are side effects of agricultural intensification (Vitousek et
al. 1997; Tilman et al. (2001). Some effects which takes time to be evident include salinization, loss of biodiversity, high carbon levels released into the atmosphere, loss of soil organic matter which in the long run affect global climate.

Increased reliance on chemicals, which are often used under AI, also may have negative effect on the environment and thus sustainable agriculture is very necessary (Pretty et al. 1996: 16). This means that improved AI programmes including appropriate utilization of fertilizes are needed (Tilman, 1999). The AI can be improved if ecological and soil conditions of farming known and are assessed from time to time (MEA 2005). The aim of this study is to assessing the interface between intensifying agriculture and its subsequent impact on soil fertility.

1.2 Problem Statement

Whilst population increase in Ghana demands greater amount of food to feed the populace through mechanize agriculture and agricultural intensification, soil and its fertility is largely affected. Yields are gradually dropping throughout Ghana including the study areas (Adansi South, Atwima Mponua, Asante Akim Central, Asante Akim North and Ahafo Ano North) according to MOFA SRID, (2010) due to continue cultivation without appropriate conservation practices and soil improvement measures. An increased shortfall annually in the levels of N and P in soils that have been continuously cultivated with crops that demand those nutrients. Most frequently cultivated soils also become susceptible to erosion. Furthermore, biodiversity within agro ecosystem are also affected as a consequence of declined soil fertility.

Different studies have results showing impacts of agriculture on biodiversity and soil fertility. This include how agricultural intensification practices influence species abundance and richness (Vickery et al. 2001, Fuller et al. 2005 (Krebs et al. 1999; Tilman et al. 2001). The fertility of the soils changes in reaction to the type of agricultural intensification practice (Chamberlain et al. 2000). The effects that results from agricultural intensification practices within agro ecosystems are poorly documented, particularly for Africa. This study was designed to fill in the gap in knowledge by assessing the soil conditions and examining farmers’ perception of the effect of intensification on the soil fertility using less intensively managed systems as control. The study attempts to answer the following research questions:
1.3 Research Questions

1. What are socioeconomic background of rice producers in the study area and impacts on cultivation practices?
2. What are the impacts of intensive practices of rice farming on soil fertility?
3. What are the farmers’ perception of the problems facing the intensification of the agricultural practices, in this case being rice farming?

1.4 Research Objectives

**General Objective**

1. The general objective of the study is to generation information on the impact of agricultural intensification on soil fertility. This information could be useful for developing appropriate strategies for conserving soils within landscapes used for rice farming.

**Specific Objectives**

- Determine farmers’ socioeconomic conditions affecting the choice of land use practices in the study area and the challenges facing agricultural intensification.

- Assess the soil fertility status of rice farms under intensive management systems through laboratory soil analysis.

1.5 Significance of the Study

Our understanding of soil fertility changes in small-scale agricultural system in Ghana and Africa as whole remains poor. In fact Soil fertility are highlighted as major issues for agricultural
development in Ghana and Africa as whole. This study offers information that could be useful in soil management decisions. Expected outcomes of the study include the following:

- The characteristic of farming systems and their association with soil fertility determined
- The extent of soil fertility status and loss determined for selected fields
- Recommendations for management and policy decisions proposed.

1.6 Organization of the Study

Chapter one covered the introduction of the study, followed by chapter two which reviewed relevant literature on agricultural intensification agricultural practices, and soil fertility. Chapter three also focused on the methodology of the study. The chapter looked at the research design and sampling framework. This is followed by chapter four where the results are analyzed and discussed. Lastly chapter five presents the study conclusion and management recommendation.

2 LITERATURE REVIEW

2.1 Agricultural Intensification (AI)

Increasing population growth in Ghana has led to continual usage of farm land so as to cater for the high food and other agricultural products demands (Benites & Vaneph, 2001). The use of intensified farming requires mechanized farming with effective and efficient machinery. As a result, land area under cultivation has increased with a gradual shift to the cultivation on one crop continuously. Also crop rotation is least practiced reducing fallow periods on lands that are cultivated.

Tillage associated with intensive farming impacts on the structure of the soil which does not encourage favourable crop development because of degradation of the structure of the soil (Huwe, 2002). The level of modification of the soil and the extent of negative damage depends on the type of soil, organic matter contend, soil moisture and the time of ploughing. Generally,
soils with high levels of silt and low clay and organic matter content mostly sandy and sandy loam soils are at a greater risk of damage mechanically.

Most AI practices specilises in crops and livestock species with high management involvement. Different forms of Agricultural intensification at varying levels. These include shifting cultivation where land is utilized in less than a year out of a total of ten years. For fallow systems land is utilized between one and two-thirds at a time and this can be viewed as systems of varying intensity Ruthenberg, 1980. With this increasing level of land use, intensification replaces manual labour with mechanized machinery also organic manure with agrochemical usage. Levels of agricultural input utilized can change significantly at different levels between internally regulated systems to externally regulated systems. Also can vary from sustainable methods to unsustainable systems within a short time duration. Another factor used to identify the level of intensification is the season within the year thus dry or wet season’s management is required through irrigation or wiers (Flohre, 2011).

2.2 Agricultural Intensification Measurements

Grace Carswell, (1997) explained that agicultural intensification processes involved an increase in the number of times of cultivation for the same piece of land, a higher labour cost as well as technological changes. There should also be prove of the usage of chemical fertilizer, animal traction, machinery, improved seed and soil conservation methods. This would imply intensification is evident. Therefore for Agricultural intensification to occur, there should be a higher inputs on a fixed area of land, the number of times the soil is cultivated and total productivity.

Cropping times can be determined by the period of time that a piece of land is used for farming activities viewing an increased number of cropping to be immediately after intensification. But a move from crops that have higher yield that mature within 100 days within a year to crops with low yield that mature in about 250 days a year would not be described as intensification even though the move may result in increased labour. Also an area could be intensified but would be without fallows like in Kabele, Uganda (Lindblade et al. 1996).
When there is an increase in the output per hectare of an intensified area is a possible increase in the quantity and quality of the livelihood as well as livelihood sustainability. Opposite of TFP as a measure tool by Binswanger, et al. (1993), Ruthhenberg, (1980) gave a different measurement perspective to agricultural intensification. Another criteria that is used to identify the extent of intensification in areas that are arid by seasons, wet climates and in production systems is how water is managed through drainage or irrigations systems. Thus intensification is associated not only with land use intensity, labour inputs and nutrient usage with internal recycling, but also with pest management and water management (Ruthenberg, 1980). For intensification practices to impact soil biodiversity positively, these factors must be available in sustainable levels and appropriate management options developed for the management of these factors.

2.3 Economic Aspects of Agricultural Intensification

Agricultural Intensification can be considered as justifiable economically and also sustainable if the perceived economic cost can be lower than economic benefits in its long term. The cost of Intensification can include using improved varieties of seed or plants, farm consumables like fertilizer and fuel, investments made in mechanization, cost of labour in maintainace, operational and other repairs (Dbowen, 2012). The advantages can be an improvement in yield, pest resistant plants, drought resistant plant which means there would be crop reliability. Therefore if the benefits obtained in the long term does not satisfactorily outweigh the cost involved, intensification would be considered unsustainable and not a venture that should be promoted. This if the benefits supersede the input cost, then farmers should bear the cost of intensification and achieve a very significant output (Dbowen, 2012).

Farming has a very high level of uncertainty and as such the risk is very high and affects the profits involved. Some of the risks include drought, insect infestation, diseases, political and unstable markets. Under traditional farming methods, seed are saved from seasonal harvest and family labour is utilized. On the other hand, intensification requires investments directly in fertilizers, herbicide, mechanized techniques, improved seeds etc. Benefits would only be obtained after these investments are made even though similar farming risk such as drought,
disease infestation presents itself. Notwithstanding, intensification has potential loss of indebtedness or increased production cost (Dbowen, 2012). Therefore, if there is a move from traditional farming to intensification, farmers will have the extra risk of intensifying farming risk to the extent that a trade-off cost upfront and future perceived benefit in yield may not be attractive. For farmers to be convinced of intensification practiced, donor organizations usually supply inputs like seed, improved technologies of farming, chemical fertilizers at a reduced cost or in some cases at no cost. Although this approach could also lead to continual dependency on donors (Dbowen, 2012).

2.4 Soil Fertility and Agricultural Intensification

The maintenance of soil fertility and access to water are essential to food production according to Westarp, (2002). This is of particular relevance to the subsistence-based farming systems of the Sub Saharan Africa especially in Ghana, which face tremendous pressure to feed a rapidly growing population and the need agricultural intensification to increase food production. Agricultural intensification will require that soil fertility level are good. However, soil fertility is declining in most of the agricultural landscapes in Ghana.

Westarp, (2002) study investigated if soil fertility has been compromised through agricultural intensification by comparing the soil status and inputs in intensively managed sites (sampled in 2000) to those of less-intensively managed sites (sampled in 1994). Nutrient budgets for nitrogen (N), phosphorus (P), and potassium (K) were developed to examine if inputs of these nutrients are sufficient to meet crop uptake. It was found that intensive farms utilize significantly more fertilizer and compost than less-intensive sites (Westarp, 2002). He concluded that cropping rotation under intensive agriculture have higher nutrient uptake than rotations under less intensification. He added that the intensification of agriculture in the area altered the soil fertility dynamics of phosphorous and potassium.

A great number of living organisms of diverse origin are contained in the soil and they are classified into complex and varying communities in which they live. The FAO (2002) underlines that biodiversity found in the soil indicates the varying living organisms in the soil and they
could range from those microorganisms that cannot be seen including bacteria and fungi to those macro fauna that can be seen like earthworms and termites. The roots of plant could be said as part of soil organisms because of their symbiotic relationships and the way they interact with the various components of the soil (Anderson & Domsch, 1989; Oades, 1993; Smith et al., 1994; Kennedy & Papendick, 1995). The varying organisms interact in different ways with the plants and animals found in the ecosystem which forms a complex form of biological activity (FAO, 2002). Those factors that affect the environment like temperature, moisture, acidity and other anthropogenic factors like agricultural and forest management activities tend to affect the various soil biological communities as well as the way they function. Thus affecting the health and quality of the soil. But soil quality are needed in either within the natural or ecosystems that are managed with boundaries in order to hold on to plant and animal production, and thus enhance the quality of water and air as well as support the health of humans. Soil health includes ecological contribution of the soil, which include beyond the quality and capacity to produce a particular king of crop (FAO, 2002).

2.5. Rice farming in Ghana

There has been a fast change in the diet of Ghanaians especially within the urban communities after the country’s independence in 1957. This change has largely been attributed to rising income levels, favourable government policies, better storability of rice and its ease of cooking (Nyanteng, 1987). The per capita per annum rice consumption in Ghana increased form 7.4kg to 13.3kg between 1982 and 1985. This resulted in the total annual consumption of 23900 tonnes of milled rice at and estimated population of 18 million. Between 1991 and 1996, consumption increased to 119000 tonnes over the previous figure. The core of the motivating factor which is governmental policy was attributed to the Medium Term Agricultural Development Policy which involved exploring the vast inland valleys and swamp areas in the country, reducing emphasis on conventional irrigation schemes, and at the same time researching into rice production as well as increasing the engagement in technological transfer to make production efficient (Nyanteng, 1987).
In Ghana, rice is cultivated in all ten administrative regions of the country which covers all the major ecological zones including the savannah zone, high rain forest zone, semi deciduous forest and coastal savannah. Each ecological zone has a distinct rice ecosystem which could be Rainfed, dryland, Rainfed lowland, inland and valley bottom and irrigated paddy fields (Nyanteng, 1987). Rainfed ecology accounts for about 75 percent of production area whilst irrigated fields contribute about 10 percent with inland valleys adding about 15 percent.

### 2.5.1 Rainfed dryland ecology

According to (Nyanteng, 1987), this ecology is characterized by higher slopes within the toposequence where crops cultivated obtain their water requirement mainly from rainfall and not from high underground water table. Weed competition is very high in this ecology making it favourable for upland weeds like *Rottboelia exaltata*, *Tridax procumbens*, *Cleome viscose*, *Commelia spp* etc to grow. When rainfall levels are low and inconsistent, weed growth are enhanced and making weed control the major issue within this ecology. As such controlling weeds in this ecology is a basic requirement if rice cultivation is to be successful. Cultivation of low yielding variety such as *Oryza glaberrima* is very common in this ecology.

Some of the traits that have favoured the continuous cultivation of these local varieties include their tall nature of growth making it a good competitor with weeds, its tolerance of some adverse soil conditions such as drought, low fertility and high acidity. Also they better withstand diseases and insect pest as well as having a good aroma when cooked.

Much emphasis should be placed on cultivating improved varieties such as Basologo (GR 19) and Faro 15 Gr 21. Some of the above mentioned varieties are being tested for release to farmers by the crop research institute and savannah agricultural research institute. Common pest found here are rodents and bird. Thus it becomes necessary to fence the fields in order to protect them from large rodents, grass cutter so that the crops are not destroyed. Low inherent soil fertility and erratic rainfall as well as the low technological know-how are some of the other challenges in this ecology (NARP 1994).
2.5.2 Rainfed lowland ecology

The flood plains of rivers dominate this ecology and are located interior of the savannah where the topography is gently undulating. Water availability is higher than the rainfed dryland. Water levels differ with the height of flood and as floods decrease, the crop obtains its required water from the high water table. Sixty percent of rice area in Ghana is covered by the rainfed lowland ecology and more than 80% of rice area in the interior savannah are also rainfed lowland where rainfall season is once a year.

The rainfall pattern is between May and November which leaves most rice field under water for extended periods. The flash floods usually affect field activities such as application of fertilizer, weed control, bird scaring and harvesting which tend to reduce yields. Weed and water management, use of low yielding varieties as well as poor soil conditions is the major defect of this ecology (Nyanteng, 1987).

2.5.3 Inland valleys

A wide area of land is represented by inland valleys and they remain unexploited for rice cultivation. About 30% of cultivable inland valleys are yet to be effectively cultivated.

2.5.4 Irrigated ecology

The irrigated area under cultivation is lower than that of rainfed lowland and inland valleys. But the reliability and sustainability of production is much higher than that of rainfed ecology because production is under control and the output per unit area is around 3.5-7 ton/ha. Irrigated area can be said to be of superior importance than the remaining ecologies which have an average of 2tons/ha or even less.

Extensive education and research has gone into irrigated ecology development by the University of Ghana Agricultural Research Station in collaboration with West Africa Rice Development Association (WARDA). This has resulted in the development of several improved varieties for
farmers’ trial. This ecology is also associated with a high level of improved technologies application (WARDA 1986).

The main constraint within this ecology is the high bird and rodent population which reduces yield resulting to the poor participation of farmers in rice production in this ecology. Continuous mono-cropping of rice is a common feature in this ecology because of a lack of sustainable option within the rice basins. Unfortunately, this results in depriving the soil of the needed nutrients and increasing diseases and consequently adding up to the challenges of this ecology.

Weed control is also said to be a problem within this ecology. Some of the common weed found under irrigated fields are *Ischaemum rugosum*, *Echinochloa colonum*, *Cyperus rotundus* and *Phyllanthus* spp. The withdrawal of subsidies on inputs has increased the challenge of weed control especially farmers resorting to hand weeding which causes reduced farm sizes. Low infrastructure of agricultural inputs like reapers, threshers, transplanters, combine harvesters, power tillers also affect the output within this ecology (Nyanteng, 1987).

### 2.6 Land preparation for rice production

Land preparation is a very vital activity in rice cultivation. The land is prepared adequately in a way that reduces weeds, nutrients can be reused, a good surface which can be used for direct sowing etc. Preparing the land could involve farming practices such as zero tillage or minimal tillage which reduces the disturbance of the soil to a well puddle field which could destroy the structure of the soil. The process of land preparation could include tilting, harrowing and land leveling. Harrowing the field helps break down the lumps of the soil formed after ploughing as well as return the plant residue into the soil which helps improve upon the structure of the soil. Leveling the land also help in equal distribution of water and nutrients on the paddy field. Land preparation could take about 3weeks before planting is done (Oteng 1994).

**Land Till/Tillage:**

According to (Oteng 1994), the method of conservation tillage involves crop residue from previous planting season that is left on the fields before the next cropping. The method helps to
reduce soil erosion by conserving the top soil. For this benefit to be achieved, about 30% of the field should be covered with plant residue. This method is appropriate for areas where the soil is prone to erosion.

The following are different types of conservational tillage that are practiced.

1. Strip till
2. No till
3. Ridge till
4. Mulch till.

Strip till and No Till:
This include the cultivation of crops into the residue left on the field without any tilling or only tilled narrowly at the edges and the rest of the field left.

Ridge till:
Planting on permanently mounted a ridge which is about 4-6 inches horizontally in height. The residue from the previous season is usually cleared from the top to the ridge in order to make way for the new plants.

Mulch Till.
About a third of the field is covered with the crop residue or mulch.
3 METHODOLOGY

3.1 Study Area

The study was carried out in Ashanti Region involving five (5) selected farming districts namely; Adansi South, Atwima Mponua, Asante Akim Central, Asante Akim North and Ahafo Ano North (Figure 1). The region and selected districts falls within the semi-deciduous agro-ecological zone of Ghana. The region can be found of the latitude of 6°52’N and longitudinally at 1°51’W. Also the altitude of the region is about 280m above sea level.

The region has two rainy seasons within a year with the first starting from May – June. The Second season is around October every year. The rainfall averages within the region are between 1100mm and 1800mm. The average temperature daily is about 27°C. The region is densely populated with the average density being 148.1 per square kilometer and which is after the Greater Accra Region. A greater part of the region lies within the wet forest zone. As a result of anthropogenic factors, the northern part of the region has been changed into savanna.
Figure 1. Location of study area in Ghana- Source: (Survey Department, 2009)
Adansi South District

The population of the district as per 2006 information gives a density of 110.4 person to 59 kilometers. This means a greater population pressure on resources especially land. The number of communities’ totals 1767 and households totaling 17032. The population practices mainly monocropping, plantation cropping and mixed farming. Traditional farming tools are mainly used with slash and burn being the main land preparation method. Also shifting cultivation is the most common farming method used within the district.

Atwima Mponua

The most common farming system in practice here is the Monocropping. Other form also practiced is the mixed farming. The use of the hoe and cutlass are dominate as the farming tools used for cultivation. A period of between 1 and five years are usually left between cultivation in which the land is allowed to fallow. The main vegetation here is the Semi-deciduous. There is diversity in the soil fauna and flora. Some of the economic trees present within this district include Wawa, Sapele, Esa and Asafena. The vegetation of the District has been extensively disturbed by human activities depriving the District of valuable tree species and other forest products. Soils are generally very suitable for cultivation and can be categorized into two. The moderately suitable soil and marginally suitable soils.

Asante Akim Central Municipal and North

The district was divided from the Asante Akim North Municipal Assembly. The capital of the district is Konongo Odumase. The location of the district is between Latitued 60 30’ North and 00 15’ longitude. It shares boundaries with Sekyere East, Kwahu South, Asante Akim and Ejisu Juaben Municipal on the West. Some of the common forest trees are Wawa, Ofram, Sapele, Sanfina, Okyere, Onyina etc. There has been forest degradation in the district and as such primary forest has been lost.
Ahafo Ano North

The geographical location of the district is at latitude 6° 47’N and 7° 02’N and longitude 2° 26’W and 2° 04’W. It lies in the north western part of the region. The surrounding districts include Ahafo Ano South, Atwima, Asutifi and Tano South districts. Farmers in the district are predominately cash crop farmers due to the high fertility of soils in the district (DDP, 2006).

3.2. Data collection

The study used different methods to address the different research questions including laboratory tests and qualitative methods (direct observation, and interviews). Field data were collected in 2013. Desktop study was also done to review relevant literature from current articles, journals and other published and non-published data related to agricultural intensification, soil fertility losses, rice farming, and general information on districts. The main sources of secondary data were technical reports obtained from the Ministry of Food and Agriculture (MOFA), Forestry Research Institute of Ghana (FORIG), Forestry Commission, District Assemblies and from the Environmental Protection Agency (EPA) of Ghana.

3.2.1. Soil Sample Collection

In order that fertility could be measured, soil samples were collected in at least two types of fields (i.e. intensified fields and non-intensified fields) from each study area. To avoid sampling error and ensure uniform sampling areas, the soil samples were collected from fields with similar slopes, slope length and farming. Other criteria used for selection was land-use intensity and the type of crop grown. During the soil sample collection process, the owners of the plots were interviewed for specific information such as agricultural practices and past land-use.
A soil auger and a soil probe was used as sampling tools to take soil samples at a depth of 30cm of top soil and sub soil. Plastic bucket and rubber was also used for the collection of the samples. Twenty samples of top and sub soils were collected to assess physical and chemical properties. The co-ordinates of the soil sample locations were also recorded by a GPS (Table 1).

Table 1. The areas where soil samples were collected in Ghana

<table>
<thead>
<tr>
<th>District</th>
<th>Community</th>
<th>Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adansi South</td>
<td>New Edubiase</td>
<td>N 06 39 16.4, W 001 1243.7</td>
</tr>
<tr>
<td>Atwima Mponua</td>
<td>Kensah Krom</td>
<td>N 06 06 58.0, W001 28 76.3</td>
</tr>
<tr>
<td>Asante Akim</td>
<td>Atonsu</td>
<td>N 06 39 14.4, W001 12 38.8</td>
</tr>
<tr>
<td>Ahafo Ano North</td>
<td>Tepa</td>
<td>N 06 04 48.0, W001 24 56.3</td>
</tr>
</tbody>
</table>

3.2.2. Interviews

Data on tree resources and perception on soil fertility was obtained by asking farmers questions using both closed and open ended questions. The questionnaires were administered to 200 farmers (out of a total population of 3350 rice farmers) selected from the 5 selected districts of the region. Purposive sampling was used to select the rice farmers based on the intensification practices. After which a random and proportional sampling was done to ensure that every respondent have the equal chance of being interviewed within the study. Using ratios and proportions, the sample size was derived as follows in (Table 2).
Table 2. The number of individual rice farmers sampled from the respective districts Study

<table>
<thead>
<tr>
<th>Districts</th>
<th>Farmer Population</th>
<th>Sample Size (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahafo Ano North</td>
<td>687</td>
<td>41</td>
</tr>
<tr>
<td>Adansi South</td>
<td>1500</td>
<td>90</td>
</tr>
<tr>
<td>Atwima Mponua</td>
<td>594</td>
<td>35</td>
</tr>
<tr>
<td>Asante Akim North and Central</td>
<td>569</td>
<td>34</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,350</strong></td>
<td><strong>200</strong></td>
</tr>
</tbody>
</table>

3.3. Analysis of the fertility levels in the laboratory

3.3.1 Sample Preparation

Prior to the soil physical and chemical characterization, sampled soil were air-dried, later crushed and sieved through a 2 mm sieve.

3.3.1.1 Characterization of soil (Physical properties)

Particle size analysis

In measuring the percentages of primary soil separates, Bouyoucous hydrometer method was adopted (Day 1965). Each sampled horizon was analyzed for its particle size distributions (i.e. clay, sand and silt content).

The weight of a beaker was taken using a weighing balance and fifty grams (50 g) of the 2 mm sieved soil was weighed and 20 ml of H$_2$O$_2$ was added to oxidize the organic matter. 100 ml of Calgon solution (Sodium hexametaphosphate and sodium hydrogen carbonate) was added to the
mixture in the beaker and stirred. The mixture was then heated for the first sigh of boiling while stirring and thereafter poured through the 53 µm sieve into a settling cylinder and topped to the 1000 ml mark with distilled water. The retained material on the sieve was then washed off into a beaker and allowed to settle for 24 hours. Water on top of the settled mixture was then poured off and heated to evaporate all moisture to obtain the dried sand fractions. After agitating the soil suspension with a plunger, the time was noted immediately. A hydrometer (ASTM 15 2H) was then placed into the soil suspension and the first and second readings recorded after 5 minutes and 5 hours respectively. Thereafter, the soil suspension in the cylinders was poured onto a 53 µm sieve. Retained soil particles on the sieve was thoroughly washed with water into a beaker of known weight and dried in an oven at 105 °C for 24 hours.

The oven dried samples were then placed in desiccators and weighted to represent the sand fraction. Equation (Eq) 1 – 4, represents the formulae used in determining the particle size distribution of each soil horizon sample.

\[
\text{Silt \%} + \text{Clay \%} = \frac{\text{5 minutes hydrometer reading}}{\text{Weight of soil sample}} \times 100 \quad (1)
\]

\[
\text{Clay \%} = \frac{\text{5 hours hydrometer reading}}{\text{Weight of soil sample}} \times 100 \quad (2)
\]

\[
\text{Silt \%} = \% (\text{Silt} + \text{Clay}) - \% (\text{Clay}) \quad (3)
\]

\[
\text{Sand \%} = \frac{\text{Oven Dry Mass (g) of Particle Retained on the 53µm Sieve}}{\text{Weight of soil sample}} \times 100 \quad (4)
\]

The texture triangle as indicated in Figure 2 was further used to determine the textural classes (primary soil separates sand, silt and clay) of each soil sample.
Figure 2. Texture Triangle

**Determination of Gravimetric Soil Water Content**

Samples collected with the cylindrical core sampler was weighed and transferred into a moisture can of known weight. The samples were then oven dried for 24 hours at 105 degrees and later weighed after cooling it in a desiccator. Eq. 5 represents the formula used to estimate the gravimetric soil water content of each sample.

\[
\text{% Moisture Content} = \frac{B - C}{C - A} \times 100
\]

Where A is the mass of empty container in grams, B is the mass of empty container and moist soil sample in grams and C is the mass of empty container and dry soil sample in grams.
3.3.1.2 Characterization of soil (Chemical properties)

Determination of Soil pH (1:1)

Twenty five grams of the soil sample was weighed into a 50 ml beaker. In a ratio of 1:1, 25 mls of distilled water was then added. The soil suspension was then stirred for 30 minutes at 5 minutes interval. The suspension was then allowed to stand for an hour to allow the entire suspended particles to settle. A glass electrode pH meter was standardized with two aqueous solutions of pH 4 and 7. The pH of the prepared suspension was then measured and recorded by dipping the glass electrode into the soil suspension.

Determination of Total Nitrogen

Determining soil percentage total nitrogen involved three (3) stages; (1) digestion, (2) distillation and (3) titration. 0.2 g of air-dried soil sample was weighed into a 250 ml Kjeldahl flask followed by addition of digestion accelerator, selenium catalyst and 5 ml of concentrated sulphuric acid (H₂SO₄). The mixture was allowed to digest until the digest was clear. It was then allowed to cool and then transferred with distilled water into a 50 ml volumetric flask and made up to the volume. A 5 ml aliquot was pipetted from the digest into a distillation flask and 20 ml of 10N sodium hydroxide (NaOH) was added with 150 ml distilled water. The sample was then distilled and collected in 25 ml of boric acid. The distillate was then titrated against 0.02 N HCl (Bremner, 1965) to attain the end point. The amount of N (%) was then calculated.

Determination of Organic Carbon and Organic Matter

Wet combustion method of Walkley and Black (1934), was used to determine organic carbon. In this method, One (1) gram of soil sample was weighed and 10 mls of 1N potassium dichromate (K₂Cr₂O₇) solution added. Twenty (20) ml of 98% concentrated sulphuric acid (H₂SO₄) were added to the prepared mixture and allowed to stand for 2 hours to ensure complete digestion. A
30 mls blank solution was then prepared at a ratio of 1:2 (i.e. 1 ml K₂Cr₂O₇ solution is to 2 mls of H₂SO₄) and the blank factor determined by Eq. 8.

\[
\text{Black factor (bf)} = \frac{10}{\text{Titre value of the blank solution}}
\]  

(8)

Further on, the remaining unreacted K₂Cr₂O₇ in the solution after the digestion was titrated against 0.2 M ferrous ammonium sulphate using barium diphenylamine sulphonate as the indicator to give the end point. The titre value was used to calculate the % C and Organic Matter (Table 3)

**Table 3.** Titre value table used to calculate the percentage Carbon and Organic Matter

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>O.C.</td>
</tr>
<tr>
<td>Titre value</td>
<td>A x bf</td>
<td>10</td>
<td>C - B</td>
<td>D x K</td>
</tr>
</tbody>
</table>

Where K is a constant (0.39), T is 1.724 (i.e. there is about 58% of O.C. in O.M.)

**Determination of Available Phosphorus**

Available P of the soil was determined using Bray-1 solution. Five (5) grams of soil sample was weighed into the extraction bottle and 35 mls of Bray I solution added. It was then capped and shaken for 30 min on a mechanical shaker. The extracts were filtered using Whatman’s No. 125 filter paper to obtain clear filtrate. Five (5) mls aliquot was taken into a test tube and then ten (10) mls of colour reagent (colour reagent was prepared from 40 grams of ammonium molybdate, 4 grams of bismuth sub carbonate, 300 mls of sulpharic acid and distilled water) added. A pinch of ascorbic acid was then added to reduce the P to form the blue colour. The mixture in the test tubes was swirled for colour development and phosphorus analysis. Concentrations of P in the mixture was then determined using the spectrophotometer. Available phosphorus content of the soil was calculated by Eq. 9.

\[
\text{Avail. P} = \frac{X}{0.0878} \times 7
\]  

(9)

Where X is the absorbance and 7 is the extraction ratio (i.e. 1:7, 5 g soil: 35 mls of Bray I solution).
Determination of Effective Cation Exchange Capacity

Ammonium acetate (NH$_4$OAc) pH 7.0 method was adopted to determine the CEC of the soil. To mimic field conditions, leaching tubes were used. Leaching tubes were filed with cotton and 2.5 grams of soil sample weighed into them. Fifty (50) mls of NH$_4$OAc at pH 7 was measured and poured into the cotton filled leaching tube with soil sample. The setup was allowed to stand for 2 hours to ensure maximum leaching of exchangeable bases. The leachate was then taken for elemental analysis. Here, atomic absorption spectrophotometer (AAS) was used to determine the concentrations of Magnesium (Mg) and Calcium (Ca) and further used the flame photometer to analyze the leachate for the concentrations of Sodium (Na) and Potassium (K).

Determination of Exchangeable Acidity and Hydrogen

In determining Exchangeable Acidity, as indicated by Mclean, E. O. (1965), three (3) grams of soil sample was weighed unto a folded filter paper placed on an extraction cup. 50 mls of 1.0 N KCl solution was measured and gently poured into the soil on the filter paper for filtrate to be collected. Five (5) drops of phenolphthalein indicator was then added to the filtrate and titrated with 0.05N NaOH to obtain a pink end point. The titre volume (in mls) of NaOH used was then recorded. Eq. 10 below was used to calculate the exchangeable acidity of the soil sample.

\[
\text{Exchangeable acidity} = \frac{V \times 0.05 \times 100}{W}
\]  

(10)

Where V is the titre volume of NaOH used (ml), 0.05 is the normality of NaOH, W is the weight of soil sample in grams.

In addition, exchangeable aluminium was later determined by the addition of four (4) mls of 3NNaF to the titrated extract and the mixture titrated again with 0.05N HCl to obtain a pink end point. The titre value of HCl used was the recorded and exchangeable aluminium in soil calculated from Eq. 11.
\[
\text{Exchangeable aluminium} = \frac{V \times 0.05 \times 100}{W}
\]  

(11)

Where \( V \) is the titre volume of HCl used (ml), 0.05 is the normality of HCl, \( W \) is the weight of soil sample in grams.

### 3.4 Analysis of interview data

The data collected were subjected to descriptive and quantitative analysis with the use of bar charts, percentages and frequency distribution tables. SPSS and Microsoft excel sheets were used for the analysis. Pre coding of data was also done to assist in the analysis. Chi square test was used to measure differences of the variables for observed and expected intensification impacts on the ecosystems, biodiversity and soil fertility levels in the study areas. Qualitative and quantitative methods such that respondent answered in a nondirective manner (McCracken 1988, in Hoggart, Lees and Davies, 2002). Thus the benefit of using the quantitative approach is to make research easier and fast so as to cover a large area within where the situation pertains. (Amaratunga et al 2002).

#### 3.4.1 Analytical Framework of Measured Study Variables

Several measurable variables were used in the analysis of the primary data linking farmers experience as bio-data to environmental and biophysical factors. The Table 4 below indicates the category and types of variables used in the analysis for this study.
Table 4. Variables used in interview data collection

<table>
<thead>
<tr>
<th>Variables</th>
<th>Levels of Measurements</th>
<th>Method of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Interval</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Gender</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Education</td>
<td>Ordinal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Farm size/Acreage size</td>
<td>Interval</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Household size</td>
<td>Interval</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Household head</td>
<td>Ordinal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Number of dependants</td>
<td>Ordinal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Farming experience</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Household expenditure</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Source of agricultural water</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Agricultural inputs</td>
<td>Interval</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Technologies used</td>
<td>Ordinal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Forest cover availability</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Number of years cultivated</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Soil compaction and fertility</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Methods of cultivation</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Types of crops cultivated</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Rainfall pattern</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Agricultural practices</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Biodiversity loss</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
<tr>
<td>Conservation practices</td>
<td>Nominal</td>
<td>Frequency, percentages, tables and graphs</td>
</tr>
</tbody>
</table>
3.8 Ethics

Ethical issues were addressed by explaining to participants about the nature of the study and their expected roles in answering the researchers’ questions. They were, needless to say, not under any obligations to answer questions they did not like or wish. Participants consent forms were given to them to sign and they were assured of confidentiality and protection of their identity in accordance with the University ethical standards.

4. RESULTS AND DISCUSSION

4.1 Socioeconomic/demographic characteristics

The majority (164) of the respondents were male farmers representing 82% of total respondents. The rest were (28 representing 14% of total respondents) were female respondents (Table 5). This shows that the rice farming sector in the study areas is largely dominated by men and confirm the statistics reported by Danso et al. (2002). This could be attributed to the culture in the areas, economic situation and the drudgery nature of the agricultural activities. Again, it could also be linked to the intensification practice as more of the women cannot be fully engaged to practicing all year farming to the detriment of household marketing activities.

Farmer’s monthly income from their rice farming activities and other earnings in a month varied among respondents. The majority (66%) earns not less than GHC 500.00($136.46 as at 26/11/15.) a month. 19% of the respondents earn between GHC 1000-1500 ($261-$391as at 26/11/15). Only few (1%) of the respondents earned GHC 2000 ($522 as at 25/11/15.) But the general outcomes from all respondents are that all farmers interviewed are earning more than $60 a month, which is equivalent to the classification of rural income in certain areas in Africa by the World Bank report on average daily and monthly wages. This is reflected in the spending pattern
of farmers as more of the farmers spent less than GHC 500 a month (82%) with 18% spending in a range of GHcC500-1000 (Table 5).

The intensive farming activities in the study areas have resulted in their increased income and expenditures. This agrees with the findings of D Bowen (2012) that intensive farming could lead to an increased benefit in terms of income. The challenge, however, was the dwindling fertility levels of the soils and the higher corresponding cost of inputs and labor for their farming activities. Many of the farmers never added their family labor cost which helps them in the intensification drive seasonally. Often such cost are excluded from the local people’s expenditure and income calculations. However, the cost for labor per day in all the 4 study districts was GH¢ 10 which is expensive based on their intensification levels and the frequency of agronomic activities per crop cycle. This notwithstanding suggests that their intensification farming practices appear profitable to the local people as they could be able to meet their household needs.

One other characteristic of the respondents was that of their educational level. Senior High School (SHS) and Junior High School (JHS) had the highest responses from the farmers with a percentage score of 29% and 26% respectively. Only 1 person had tertiary education and 22% of them had no formal education. With this, it indicates that a large number of the farmers are educated, thus, can read and write.
Table 5. Bio characteristics of household respondents

<table>
<thead>
<tr>
<th>Educational levels of Respondents</th>
<th>Level</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No formal education</td>
<td>44</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>34</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Junior High</td>
<td>52</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Senior High</td>
<td>58</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Tertiary</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sex of Respondents</th>
<th>Sex</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>164</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>28</td>
<td>14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age of Respondents</th>
<th>Age</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18 to 25</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>26 to 35</td>
<td>54</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>36 to 45</td>
<td>68</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>46 to 55</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household Monthly Income</th>
<th>Amount (GHC)</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;500</td>
<td>131</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>500-1000</td>
<td>38</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>1000-1500</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>1500-2000</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>&gt;2000</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average Monthly Expenditure</th>
<th>Amount (GHC)</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;500</td>
<td>164</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>500-1000</td>
<td>36</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>1000-1500</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1500-2000</td>
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<td>0</td>
</tr>
<tr>
<td></td>
<td>&gt;2000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>
4.2 Mode of land acquisition by respondents (Land tenure)

Cultivation of rice has been done for a long time according to Mobil and Okran (1985). Land for rice farming was mostly acquired through hiring (36%), and from family member through inheritance (30%). Others obtained land through direct purchase and lease system. The other forms of land acquisition included annual payments either through cash or in kind. This are common ways of land acquisition in Ghana (Appiah 2001) and this process contributes more to the overall farmers increased cost of production per season thus reducing the income levels of the farmers. It also facilitates intensification as farmers are constrained to the same piece of land without much fallowing of the lands. Migrant farmers usually do not own lands in Ghana. Thus according to Jordan (1995), farmers who practice share cropping are mostly poor and landless and they are allowed to farm for a season where they return part of their harvest to the land owners. Most of the farmers interviewed too were migrant farmers which meant that they were not the custodians of their farm lands leading to the leased, hired and purchase of the lands for production (Figure 3). Majority of the farmers as well earns less than GHc 500 and the cost of land only makes production worse for them.

Figure 3. Mode of Land acquisition in the study area
4.3 Land use characteristics of farmers

The results show that farmers use good agricultural practices to try to increase their yields: practices such as conservative use of organic manure, land fallowing, crop rotation and management of use of water resources (Table 6). This is reflected in the soils showing good signs of soil organic matter contents and activities including soil burrowing that helps in aeration, loosening up soils for easy plant utilization and the decomposition of soil organic matter. When soil microbial organisms are absent in the soil, fertility would be greatly affected and this would in turn affect the healthy growth of crops (FAO 2002). Due to the activities of bacteria, algae, fungus, millipedes etc, organic matter are broken down resulting in its availability to plants for normal development.

The cycling of elements as nitrogen, carbon and phosphorus is crucial for rice growth as they are essential for the growth and development of all crops (Westarp, 2002). When farmers engage in practices such as fallowing, application of organic manure or composting, these elements are able to be retained in the fertile layer of the soil for crop use. As a result, farmers are encouraged to use these conservation techniques for more soil living organism like the earthworms, ants, millipedes to work and burrow the soil for aeration, breakdown of organic matter and enhance soil percolation; this are vital process for developing a healthy soil (FAO 2002). Unfortunately, several years can pass before these elements can be form that are very vital for the growth of plants. For a crop as rice in particular and like other cash crops like cocoa advance land preparations are needed to be able to achieve a good fertility status with such elements present in adequate amount.

As the results show, it is improving the humus and subsequently soil fertility status of the soils that has made these local practices attractive ways of maintaining the soil for higher yields and sustainable production (Table 7).
### Table 6. Characteristics of farmers’ land uses in the study area

<table>
<thead>
<tr>
<th>Land use features</th>
<th>Yes responses (%)</th>
<th>No responses (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop rotation</td>
<td>60</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>Fallowing</td>
<td>80</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Use of organic manures/compost</td>
<td>40</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Tillage</td>
<td>95</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Use of chemicals</td>
<td>60</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>Slash and burn</td>
<td>80</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Water harvesting and management</td>
<td>70</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>Continues cultivation</td>
<td>85</td>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td>Use of fertilizers</td>
<td>90</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Farming far away from river banks</td>
<td>40</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Frequent soil movement (levelling)</td>
<td>30</td>
<td>70</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 7. Perception of farmers on their adopted agricultural practices

<table>
<thead>
<tr>
<th>Land use questions: why do you?</th>
<th>Reasons assigned by respondents</th>
<th>Percentages (%)</th>
<th>No response (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice crop rotation?</td>
<td>Reduce pest and disease</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Allow land to fallowing</td>
<td>Improve soil fertility</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>Use organic manures/compost</td>
<td>Improve soil nutrients</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Grow leguminous crops to help replenish soil nutrients</td>
<td>Cannot be grown on land</td>
<td>15</td>
<td>85</td>
</tr>
<tr>
<td>Practice slash and burn</td>
<td>Improve soil fertility and makes seeding easier</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>Practice water harvesting and management</td>
<td>To ensure water is available to crops in dryer periods</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>Practice continues cultivation</td>
<td>Yes, have not enough land for fallow</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>Use fertilizers</td>
<td>To increase yield</td>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>Farm far away from river banks</td>
<td>To maintain and conserve water</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Frequently move soil (levelling)</td>
<td>Easy flow of water</td>
<td>30</td>
<td>70</td>
</tr>
</tbody>
</table>
4.4 Farmers Nutrient Sources

As the results of this study suggest, the main sources of nutrient available to the majority of the rice farmers is inorganic fertilizer (Table 8). The heavy dependence on inorganic fertilizers, according to the farmers, add to their cost of production significantly thereby reducing the rice production profits. However, a good percentage of the farmers also depend on organic materials and nitrogen fixing crops for soil fertility improvement. This practice should be encouraged as they are relatively cheaper for the local farmers to adopt. Besides, they are environmentally friendly practices (FAO, 2002).

The respondents acknowledge that some of their practices including continuous cropping, slash and burn and siltation of agricultural water sources are input factors that affect the output nutrient levels of the soils negatively as suggested by FAO (2002). The positive aspect is that, fallowing which is a practice some respondents in the study areas provides an external contribution to soil fertility through the decomposition of the plant residue and undisturbed soil structure (FAO 2002).

Crops respond differently to different levels of nutrient and water intake. For rice, it studies suggest that it consumes and require more water than any of the other cereal crops (Westarp, 2002). This means improved conservation practices that enhances nutrient conservation and that the rainfall pattern and irrigation requirement is critical for rice growing (Westarp, 2002). Interestingly, the study show that farmers have an understanding of the needed nutrient budget for rice growing and can relate those need to practices that can either impede or facilitate the amount of nutrient in the soil. This local knowledge should be a strong basis for building the capacity of local people in soil conservation practices.
Table 8. Farmers’ main sources of fertilizer used in rice production in the study area

<table>
<thead>
<tr>
<th>Input Nutrients</th>
<th>Output Nutrients</th>
<th>% Respondents (Yes)</th>
<th>% respondents (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral fertilizers</td>
<td>Local Market</td>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>Organic Manure (bio char, rice straw&amp; brand and animal droppings)</td>
<td>Crop and animal residues*</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Biological N fixation (rhizobia)</td>
<td>Nitrogen fixing crops#</td>
<td>15</td>
<td>85</td>
</tr>
<tr>
<td>Sedimentation</td>
<td>Erosion</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Fallow period</td>
<td>Nutrient build up</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Ensuring about 5% water retention in the paddy field</td>
<td>Rainwater, river and stream sources</td>
<td>40</td>
<td>60</td>
</tr>
</tbody>
</table>

*Examples include leguminous crops like bambara beans, sorghum. 30% said the plant biomass found on the land during land preparation is incorporated into the soil as the only source of organic matter
# Sources include bio char, rice straw& brand and animal droppings

4.5 Impact of intensification practices on Soil fertility Status

Fertility levels of the intensified and non-intensified fields were different (Table 10) but they fall within the regional average (Table 9). This mean that although AI affects the soil fertility levels in a negative way than the non-intensified practices, the fertility levels of the soils over the years has been relatively steady without AI depleting the soils beyond the regional status. However, differences exist in fertility levels among the districts. Organic matter for instance was low in the Atwma Mponua (1.39%) and Asante Akim (1.43%) districts than the regional average for AI and NI fields. Potassium (K) was very low in Adansi south and Atwima Mponua (Table 10), with Asante Akim showing higher levels of the K.

Respondents indicated that the fields they considered as NI fields were fields left to fallow for a five year period or more. As such the NPK minimal variance noticed in the results for NI and AI could be strongly linked to the soil composition of the study areas, the water management practices and general agricultural practices. There were significant level of intensification as claim by the farmers and their approach to managing the soils was allowing the land to fallow if they had other land to cultivate on.
According to the FAO 2002, when the soil is continuously cultivated without practicing techniques that would restore the soil, sustainable cropping is not being practiced. Thus when soil nutrients are removed without replacement, it is considered as a major part of soil degradation. In reference to the data in Table 9, there levels of fertility are generally low and this evidence is supported, as suggested by the farmers, low yields of their rice produce. These results suggest that more soil conservation practices are needed to improve the soil nutrient status within rice farmers’ fields in the study areas.

Table 9. Fertility Status of soils in the Ashanti region covering also the study

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Soil pH</th>
<th>% Organic Matter</th>
<th>% Available Phosphorus (mg/kg soil)</th>
<th>% Total Nitrogen</th>
<th>Available Calcium (mg/kg soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offinso-Ejura</td>
<td>5.3-7.8</td>
<td>1.5-3.0</td>
<td>0.12-12</td>
<td>0.12-12</td>
<td>50-100</td>
</tr>
<tr>
<td>Kwadaso, Juaso, Obuasi</td>
<td>4.3-7.0</td>
<td>1.5-3.0</td>
<td>0.12-12</td>
<td>0.1-12</td>
<td>50-100</td>
</tr>
</tbody>
</table>

Soil analysis was conducted at Soil Research Institute - CSIR, Kumasi
Table 10. Soil fertility status of Intensified (AI) and Non Intensified (NI) fields of the study area

<table>
<thead>
<tr>
<th>Districts in Ashanti</th>
<th>Types of Fields</th>
<th>Parsec</th>
<th>% Organic</th>
<th>% Total</th>
<th>% Organic</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atwima Mponua</td>
<td>Sub-Plots</td>
<td>H2o</td>
<td>Carbon</td>
<td>Nitrogen</td>
<td>Matter</td>
<td>Ca</td>
</tr>
<tr>
<td>1</td>
<td>AI</td>
<td>5.61</td>
<td>2.11</td>
<td>0.21</td>
<td>3.64</td>
<td>3.74</td>
</tr>
<tr>
<td>2</td>
<td>NI</td>
<td>6.11</td>
<td>1.87</td>
<td>0.20</td>
<td>3.22</td>
<td>3.47</td>
</tr>
<tr>
<td>2</td>
<td>AI</td>
<td>6.52</td>
<td>1.39</td>
<td>0.18</td>
<td>2.40</td>
<td>1.87</td>
</tr>
<tr>
<td>1</td>
<td>NI</td>
<td>6.28</td>
<td>1.55</td>
<td>0.19</td>
<td>2.67</td>
<td>3.20</td>
</tr>
<tr>
<td>Adansi South</td>
<td>1</td>
<td>AI</td>
<td>5.00</td>
<td>2.67</td>
<td>0.24</td>
<td>4.60</td>
</tr>
<tr>
<td>2</td>
<td>NI</td>
<td>4.80</td>
<td>3.79</td>
<td>0.32</td>
<td>6.53</td>
<td>4.01</td>
</tr>
<tr>
<td>2</td>
<td>AI</td>
<td>4.67</td>
<td>2.00</td>
<td>0.21</td>
<td>3.45</td>
<td>3.74</td>
</tr>
<tr>
<td>1</td>
<td>NI</td>
<td>4.44</td>
<td>1.92</td>
<td>0.21</td>
<td>3.31</td>
<td>2.67</td>
</tr>
<tr>
<td>Asante Akim</td>
<td>1</td>
<td>AI</td>
<td>5.60</td>
<td>1.82</td>
<td>0.20</td>
<td>3.14</td>
</tr>
<tr>
<td>2</td>
<td>NI</td>
<td>5.02</td>
<td>2.46</td>
<td>0.23</td>
<td>4.24</td>
<td>6.14</td>
</tr>
<tr>
<td>2</td>
<td>AI</td>
<td>4.87</td>
<td>2.69</td>
<td>0.23</td>
<td>4.64</td>
<td>5.34</td>
</tr>
<tr>
<td>1</td>
<td>NI</td>
<td>5.73</td>
<td>1.42</td>
<td>0.18</td>
<td>2.45</td>
<td>3.47</td>
</tr>
<tr>
<td>Ahafo Ano North</td>
<td>1</td>
<td>AI</td>
<td>5.49</td>
<td>2.46</td>
<td>0.22</td>
<td>4.24</td>
</tr>
<tr>
<td>2</td>
<td>AI</td>
<td>5.62</td>
<td>2.08</td>
<td>0.21</td>
<td>3.59</td>
<td>7.74</td>
</tr>
<tr>
<td>2</td>
<td>NI</td>
<td>5.20</td>
<td>2.06</td>
<td>0.21</td>
<td>3.55</td>
<td>4.01</td>
</tr>
<tr>
<td>1</td>
<td>NI</td>
<td>5.15</td>
<td>1.68</td>
<td>0.20</td>
<td>2.90</td>
<td>2.67</td>
</tr>
</tbody>
</table>

4.6 Challenges of Intensive Farming in study areas

Of the 200 respondents, 190 of them representing 95% of the total respondents indicated they are facing some challenges in their practice of AI (Figure 4). High labor cost, low yields and high cost of inputs were the major challenges they attributed to agricultural intensification (AI). These are common challenges facing many rural farmers (Dbowen, 2012). This, added to the low levels of soil fertility, compounded their production challenges, thus making their yields to be low. Agriculture water resource depletion came as another challenge as a result of the practice. Fields that are highly intensified can have its water resource depleted as suggested by Ruthenberg (1980). Although the study areas are endowed with abundant water resources, very intensified
fields coupled with bad agricultural practices in areas have drastically degraded the rice fields and made rice farming less profitable.

Figure 4. Challenges of agricultural intensification practices in the study area
5. CONCLUSION AND RECOMMENDATION

a. About 82% of the rice farmers in the study area were males with the rest being female. Their monthly income from their farming activities are relatively low when production costs are factored into the calculation of farmers profits. Only 1% of the farmers earned GHc 2000 or more per month.

b. Fertility levels were affected by the intensified practices. However, the depletion levels fell within the regional range.

c. Continuous cropping, slash and burn and siltation of agricultural water sources are input factors that affect the output nutrient levels of the soils. Fallowing is seen by farmers as one of the ways to contribute externally to soil fertility improvement through the decomposition of the plant residue and undisturbed soil structure.

d. High labor cost, low yields and high cost of inputs were some of the major challenges farmers attributed to agricultural intensification (AI).

Recommendations

Based the above findings and discussions, the study recommends the following;

a. Government should help to subsidies cost of rice farming inputs for rice farmers to be able to make rice production more economically sustainable.

b. Farmers should be encouraged and supported to build upon their skill in soil conservation techniques such are composting, using of nitrogen fixing crops etc. to help improve the soil fertility levels of their fields for better yields. This should include capacity building in water management in valley farming that are practice by most farmers.
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APPENDIX

Appendix 1 Questionnaire

UNIVERSITY OF EASTERN FINLAND

MSc. in Bio-Economy and Natural Resource Management

Questionnaire for a Study on the Impact of Agricultural Intensification on Soil Fertility and Biodiversity in Agro Ecosystem: Qualitative and Quantitative Reasoning

District……………………………………………………………………………………………………

Community………………………………………………………………………………………………

Date……………………………………………………………Time of recording……………………

A. BIO DATA

1. Name of Respondent………………………………………………………………………………

2. Age of Respondent: a.> 18 b. 18-25 c. 25-35 d. 35-45 e. over 45


5. No. of household dependents a. 0-5 b. 5-10. C. <10.

6. No. of children…………………………………………………………………………………

7. Occupation ……………………………………………………………………………………

8. Home town…………………………………………………………………………………..

9. Main crop cultivated a. rice b. cocoa c. vegetables d. other cereals e. Others

10. Average monthly income of the household
a. GH¢ 500-1000 b. GH¢ 1000-1500 c. GH¢ 1500-2000 d. more than GH¢2000

11. Average monthly expenditure of the household
   a. GH¢ 500-1000 b. GH¢ 1000-1500 c. GH¢ 1500-2000 d. more than GH¢2000

12. Educational Level
   a. Tertiary b. SHS/Middle Level c. JHS/Level d. Primary e. No formal Education

13. What areas are household incomes expended on?
   a. Health care b. Education c. Food d. shelter e. Social events
   d. Others

14. Years of farming experience
   a. 1-5 years b. 5-10 years c. 10-15 years d. >15 years

15. Other source of income other than agriculture
   a. Trading b. Labor c. Government work d. others

B. AGRICULTURAL INTENSIFICATION CHARACTERISTICS

16. What crops do you cultivate?
   a. Rice b. maize c. cocoa d. plantain e. others

17. Why do you cultivate these crops?
   a. Experience b. easy to cultivate c. technology availability d. yields and income e. Others

18. How many times do you cultivate your land in a year
   a. 1 b. 2 times c. 3 times d. 4 times

19. How many years has the land been cultivated?
   a. 1-5 years b. 5-10 years c. 10-15 years d. >15 years
20. How is your land preparation processes?
   a. Clearing and burning of vegetation   b. Ploughing   c. use of weedicide   d. others

21. How many acres of land are you cultivating?
   a. 1-4 acres   b. 4-8 acres   c. 8-12 acres   d. more

22. Land tenure statues
   a. Family   b. purchase   c. hired/leased   d. others

23. If purchased or rented, how much?

   ..............................................................................................................

24. Source of labour for farm works
   a. Family   b. hired   c. communal   d. others

25. Cost of labour per man/day?

   ..............................................................................................................

26. What inputs do you use in your cultivation process?
   a. Seed   b. herbicides/pesticides   c. fertilizer   d. labor   e. others

27. How many liters of herbicides / ha do you use?
   a. 1.1 lit/ha   b. 2lit/ha   c. 3-4 lit/ac   d. <4 lit/ha

28. Types of farming tools used in farming?
   a. Cutlass   b. hoes   c. tractors/power tillers   d. seeders   e. others

29. How many times do you apply fertilizer to your crop?
   a. 1   b. 2   c. 3   d. 4   e. more

30. Why this frequency?
a. Poor fertility  b. want higher yield  c. improve soil composition  d. subsidies

31. What quantity of fertilizer in kg or bags do you apply per acre? (Specify crop).
........................................................................................................

32. Do you use organic manure/compost and weed plough back?
   a. Yes  b. No

33. If Yes why? ........................................................................................................

34. Do you allow the land to fallow?
   a. Yes  b. No

35. If Yes and No why?
........................................................................................................

36. Do you remove all standing trees before cultivation?
   a. Yes  b. No

37. Why clear the vegetation?
........................................................................................................

38. What are the likely impacts of the vegetation cover removal?
   a. Bare land b. drought and less rain  c. heat  d. loss of biodiversity e. others…….

39. Do you think increased fertilization leads to yield increase?
   a. Yes  b. No

40. Why continuous cultivation on the same piece of land?
   a. Has one parcel of land  b. good yield  c. only source of income  d. high fertility  e. other reasons.................................................................

41. Does your use of chemicals and fertilizer pollute the water sources and farm lands?
   a. Yes  b. No
42. Activity and presence of some soil organism and insect pest in the field

[Yes (√)  No (X)]

<table>
<thead>
<tr>
<th>Microbial and Insect Activity</th>
<th>Frequent</th>
<th>Seen in a Long while</th>
<th>Not there at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil burrowing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy decomposition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement of insect pest/worms/crickets others</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of visible soil organisms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piercing and sacking of leafs/plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loose soils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher organic matter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher water retention capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darker soils</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
43. What other observations do you see with soil organisms and insect pest in your field?

................................................................................................................................................

................................................................................................................................................

C. ECONOMIC ASPECTS OF INTENSIFICATION

44.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield/ha (season)</th>
<th>Price (GHc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice (kg/bags)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plantain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cocoa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

45. Inputs Usage and their cost on an acre

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Rates/Quantity</th>
<th>Frequency</th>
<th>Area (ha)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
46. What is the total cost of labor per season per acre?

47. Do you use farming records for your expenditure and income activities
   a. Yes       b. No

48. Are these agricultural practices practiced or not, and why?

<table>
<thead>
<tr>
<th>Agricultural Practices</th>
<th>Yes</th>
<th>No</th>
<th>Good</th>
<th>Not Necessary</th>
<th>Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop rotation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fallowing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of organic manures/compost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero tillage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growing of leguminous crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less use of chemicals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deforestation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No slash and burn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water harvesting and management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continues cultivation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No use of organic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>matter/fertilizers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutting of vegetation (trees shrubs and grasses)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farming close to river banks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over application of chemicals and inorganic fertilizers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No fallowing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequent soil movement (leveling)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## D. TREE RESOURCES AVAILABILITY

49. What trees of socio-economic values are currently available on your farm? List in order of importance

........................................................................................................................................................................................................................................................................................................

........................................................................................................................................................................................................................................................................................................

50. How many trees can be found per acre? .................

51. What trees were available prior to your farming activities

........................................................................................................................................................................................................................................................................................................

52. How many trees were found per acre then? .................

53. What is your assessment of tree species loss from your farm land?

- a. 0-10% lost
- b. 10-20% lost
- c. 20-30% lost
- d. 40-50% lost
- e. 50-60% lost
- f. >60% lost
- g. Others

Thank you