UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

SUSTAINABLE INTENSIFICATION AGRICULTURE FOR CLIMATE CHANGE ADAPTATION AMONG SMALLHOLDER FARMERS IN NORTH-WESTERN GHANA

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SUSTAINABLE INTENSIFICATION AGRICULTURE FOR CLIMATE CHANGE ADAPTATION IN NORTH-WESTERN GHANA

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MARCH, 2019

DECLARATION

Students'

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere:

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ABSTRACT

Climate change and climate variability have had a profound effect on agriculture in Developing Countries, adversely affecting smallholder farmers the most. Farmers are responding in diverse ways but the response that is the subject matter in this thesis, is, how smallholder farmers are practicing Sustainable Intensification Agriculture (SIA) for adapting agriculture to climate change and climate variability in north-western Ghana. The study employed a mixed research design involving the application of qualitative and quantitative methods of data collection and analysis. In particular, focus group discussions, in-depth interviews, household case studies and a household survey were the primary methods of data collection and analysis. First, the results reveal a shift from the cultivation of large bush farms to smaller compound farms, valley fields and gardens for supporting smallholder farmer practices of SIA for climate change adaptation. Secondly, the results also show that farmers employ Integrated Soil and Water Management, comprising the application of manure and compost, ridging and bunding for improving the moisture retention capacity of soils. Finally, the results also reveal a shift from the cultivation of indigenous crop varieties to a mix of indigenous and early maturing crop varieties for the purpose of adapting production to climate change. To support farmer efforts at adaptation through SIA, the study recommends the promotion of integration of crops and livestock production, diversification of cropping, and farmer training in compost making and application to improve soil and water management in agriculture.

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DEDICATION

This work is highly dedicated to my sibling, Prosper Naazie of blessed memory.

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ACRONYMS

IPCC = Intergovernmental Panel on Climate Chang

UN = United Nations

SPSS = Statistical Package for Social Sciences

ODK = Open Data Kit

FGDs = Focus Group Discussions

KIIs = Key Informant Interviews

GHG = Greenhouse Gases

AR4 = Fourth Assessment Report

CO_2 = Carbon Dioxide

WMO = World Meteorological Organization

CFCs = Chlorofluoro Carbons

N_2O = Nitrogen Oxide

O_3 = Ozone

SIA = Sustainable Intensification Agriculture

U.S.A = United State of America

FAO = Food and Agricultural Organization

TEK = Traditional Ecological Knowledge

ISFM = Integrated Soil Fertility Management

AFFRITC = the Agriculture, Forestry and Fisheries Research Technology Centre

MoFA = Ministry of Food and Agriculture

YiAP = Youth in Agriculture Programme

P.F.J. = Planting for Food and Jobs

F.A.O.U.N. = Food and Agriculture Organization of the United Nations

N.G. O s = Non-Governmental Organizations

I.F.D.C = International Food Development Corporations

^{O}C = Degree Celsius

SADA = Savannah Accelerated Development Authority

SITAM = Sustainable Intensification Trade-Off Agriculture Management

NPP = New Patriotic Party

PPMV = Part per Million Volumes

CH_4 = Methane

SI = Sustainable Intensification

CSA = Conservation Smart Agriculture

IFPRIR = International Food Policy Research Institute Report

PHC = Population and Housing Census

UNDESAPD = United Nations, Department of Economic and Social Affairs, Population Division

CC = Climate Change

CCA = Climate Change Adaptation

MS = Microsoft

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The adverse effects of climate change/variability are numerous as such threaten the sustainability of people's livelihood both at the global, regional and local economic scales. Climatic stressors and shocks such as drought, flooding, pest infestation, rising temperatures, unpredictable rainfall are increasingly steadily (Christensen et al., 2007). It was added that, the climate in Africa is warmer in the 21st century than it was in the 20th century yet expected to increase in the upcoming years Among all sectors of global, regional and local economy, the agricultural sector maybe the most affected with the advent of climatic stressors due to the sector's relation with nature. Though the change in the climate equally affects other sensitive sectors like drinking water (Kurukulasuriya & Rosenthal, 2013). The IPCC (2012) observed that high frequencies of heat stress, drought and flooding are projected to affect human development especially the agriculture sector for the rest of this century (ibid). Given that there is a negative relationship between climate change impacts and agriculture production, economies that rely heavily on the agrarian sector of production may be adversely affected by the climatic stressors and shocks. Worse of all, smallholder farmers' maybe the most disadvantaged under the global changing conditions of the climate. For instance, global maize production has reduced by 3.8% and wheat 5.5% while soybeans and rice are the same in the production chain due to production losses (Lobell, et, 2011), and the

exposure of most cropping regions and growing seasons to rising seasonal temperatures (ibid)

However, under the declining food production levels and increasing seasonal hunger, there is rising human population of late. Global human population is projected to increase from 9.8 billion in 2050 to as much as 11.2 billion by 2100 (IPCC, 2001). Comparatively, about 70% increase in food production will be required to meet the food consumption needs of the projected global population of 9.8 billion in 2050 and 11.2 billion populations in 2100 respectively (IPCC, 2001; Bacci, 2017).

Climate change and its variability have negative impacts on countries which developmental agenda, especially African countries is dependence on the agriculture sector for growth, with an equally predominate smallholder farming practices. In sub-Saharan Africa, air temperature is projected to rise by an average of 2.1°C by 2050 (Cairns et. al. 2013). This projected increase is expected to influence rainfall changes and subsequent decrease in cereals production (Cairns et. al., 2013). It is hypothesised, that lack of intervention and adaptive measures may thwart the progress of Sub-Saharan African countries against the realisation of the Sustainable Development Goals by 2030 especially the goal 2 which seeks end hunger, achieve food security and improved nutrition and promote sustainable agriculture (FAO, 2016).

Within the Sub-Saharan African region, Ghana is not exempted from the threats of climatic shocks and stressors. Over the years, Climate Change/Variability have affected agriculture production and pose severe threat to food security particularly in smallholder farming

households and growth of the economy. Agriculture in Ghana is the largest contributor to Gross Domestic Product (GDP) and more than half of the population are employed in the sector (Acquah, 2011). Out of the 14,009 farmers in lawra district, about 13,610 (97.2%) are into crop farming (GSS/GPHC, 2010) and Upper west is one of the regions experiencing Climate Change (CC)/variability effects on Agriculture (Antwi-Agyei, et al., 2012). It is projected that by the end of the 21st century, cereals/grains production will be reduced by 20% due to rainfall variability and unfavourable weather such as heavy rain or low rain as well as unpredictable rain pattern (Adhikari, et al., 2015).

Climatic stressors and shocks such as unpredictable patterns of rainfall, drought, flooding and erosion due to excessive raining and increasing temperatures commonly hinder agriculture production particularly in the northern part of the country where seasonal production abounds (Deryng et al., 2014; Kotera et al., 2014; Enenkel et al., 2015). In respond, the smallholder farmers have devised local adaptation measures manifesting in farmer-based cultivation practices to sustain production and subside hunger including the Sustainable Intensification Agriculture (SIA). It is an emerging innovation seeking to address challenges in smallholder agriculture production including climate associated problems. According to Strantuff et al. (2011), poor rainfall patterns affect the production of food crops such as maize, millet and sorghum in the three northern regions of Ghana, subsequently affects food availability in farming households (Nyantakyi-Frimpong, 2013; Amikuzuno & Donkor, 2012). Contemporarily, there are intermittent variations in temperature and precipitation in Ghana as a result of climate change/climate variability. The duration between the start and stop of rainfall has shortened and in the dry season,

temperature has increased to about 1^0C, while in the rainy season, temperature increases to about 2^0C (Kunstmann & Jung, 2005). Sustainable Intensified Agriculture has been adapted by smallholder farmers to cope with the menace of climate change (ibid). Given that climate change/variability influence all aspects of crop production, cropping area and crop intensity (Reynolds et al., 2015), this study seeks to understand how Sustainable Intensification Agriculture help smallholder farmers adapt to food crop production.

Sustainable Intensification Agricultural (SIA) provides means for food crop farmers to increase production with the limited available resources. This concept is underpinned by production efficiency with limited resources not necessarily increasing cultivated land. Sustainable Intensification Agricultural (SIA) is a new concept in the terrain of agriculture that enables global agriculture to achieve a doubling in world food production while environmental integrity and human wellbeing is maintained. Sustainable intensification looks at producing more outputs with efficient and effective inputs usages while reducing the adverse environmental impacts to promote resiliency (Montpellier Panel, 2013). "Smallholder farmers produce more with less impact on the environment while also improving agriculture's sustainability" (Juma et al., 2013, pg. 2). This makes them keep on trying various farming practices in the name of intensification. Within the area of organic agriculture as applied in Sustainable Intensification agriculture, it is the "maximization of primary production per unit area without compromising the ability of the system to sustain its productive capacity" (FAO, 2009 cited in Doré et al., 2011pg 2).

This study was conducted as part of a larger/ongoing research project from 2017 to 2019 in Lawra and Nandom Districts entitled: Sustainable Intensification Trade-offs in Agriculture

Management (SITAM Project). SITAM Project seeks to Supporting smallholder farmers' decision-making: Managing trade-offs and synergies for sustainable intensification. As part of the project, this study focused on the role of Sustainable Intensification Agriculture (SIA) for Climate Change Adaptation (CCA) among smallholder farmers. However, this study looked at Sustainable Intensification Agriculture (SIA) as an innovation way for climate change adaptation under environmental change and poverty in the Upper West Region of Ghana. Major concern is on climate change/variability and how smallholder farmers' production of food crop, basically cereals and legumes are coping with environmental changes in the North-Western part of Ghana. North-Western Ghana here refers to the extreme North-Western corner of the country and covered the following administrative districts in the Upper West Region of Ghana, Nandom and Lawra and some selected communities were used for the studies. Smallholders Farmers are people who cultivate to sustain their households with minor sale of their produce and make use of low technologies in their activities. Smallholder Farmers are those who mainly use family labour, with small farm sizes not more than three hectares, living within or closely to absolute poverty and undernourished (IFPRIR, 2006).

1.2 Statement of the Problem

Agriculture constitutes the highest land use among other land uses across the globe. It is estimated that about 1.2–1.5 billion hectares are cropping lands, 3.5 billion hectares as grazed field and 4 billion hectares of forest are used by humans in varying degrees (Howden et al., 2007). Yet the world counts about one (1) billion hungry people today and further projected to reach nine (9) billion by 2050, with high possibility of increasing food demand

(ibid). Global attention is on climate change/climate variability because it's direct biophysical effects on agricultural production (Nelson et al., 2014).

Also, among the many improved agriculture technologies, sustainable agricultural technology has become prominent in recent times for addressing extreme environmental and climatic shocks and stressors in agriculture production. Sustainable intensification emerged from 1990s–2000s as one of the innovations and include, agroforestry and soil conservation, conservation agriculture, integrated pest management, and novel policies and partnerships. Thus, by early 2010, 10.39 million farmers and their families attained some benefits and manifesting approximately 12.75 million hectares increased in production (Pretty et al., 2011).

In Ghana, more than 60% of the national population depend on agriculture for their livelihoods. The Upper West Region has approximately 84,931 households that are into agriculture and 81,251 (95.7%) are food crop farmers. Out of the 14,009 farmers in the Lawra and Nandom Districts, about 13,610 (97.2%) are into food crop farming (PHC, 2010). This implies that the livelihood of people in Ghana, especially in the North-Western part depend directly on rainfall-fed agriculture showcasing their vulnerabilities in the midst of the changing climate. The three Northern Regions are more vulnerable to climate change/climate variability (Antwi-Agyei, et. al., 2012). This is due to the fact that farming practices are not capable of coping with the changing climatic stressors. Smallholder therefore keep on experimenting various methods to intensify agriculture and there are uncertainties as to what the livelihood outcomes are. Intensification in agriculture has been adopted for food crops production**.** Given that climate change/variability is intrinsically linked

to agricultural activities, there is the need to investigate its impacts on smallholder farmers. This study seeks to understand how Sustainable Intensification Agriculture **(**SIA) helps smallholder farmers in the Lawra and Nandom districts adapt to climate change stressors and shocks in their annual production. The question then is, are the farming practices among smallholder farmers' climate smart and environmentally friendly in the age of climate change/ variability?

1.3 Research Questions

1.3.1 Main question

How has Sustainable Intensification Agriculture practices among smallholder farmers improved adaptation to Climate Change?

1.3.2 Sub-questions

1. What are the dynamics and trends in the types and sizes of farms in Sustainable Intensification Agriculture (SIA) Practices for Climate Change Adaptation (CCA)?
2. What are the dynamics and trends in types of crops and yields in Sustainable Intensification Agriculture (SIA) for Climate Change Adaptation (CCA)?
3. How are Smallholder Farmers (SFs) employing Soil and Water Conservation Management (SWCM) Practices in Sustainable Intensification Agriculture (SIA) for adapting to Climate Change Adaptation (CCA)?

1.4 Research Objectives

1.4.1 Main Objective

To examine how Sustainable Intensification Agriculture (SIA) practices improved smallholder farmers' adaptation to Climate Change

1.4.2 Sub Objectives

1. To explore the dynamics and trends in types and sizes of farms in Sustainable Intensification Agriculture Practices (SIA) for Climate Change Adaptation (CCA).
2. To determine the dynamics and trends in types of crop and yields in Sustainable Intensification Agriculture (SIA) for Climate Change Adaptation (CCA).
3. To assess the Soil and Water Conservation Management (SWCM) practices smallholder farmers are employing in Sustainable Intensification Agriculture (SIA) for Climate Change Adaptation (CCA).

1.5 Significance of the Study

Many works on agricultural intensification look at agronomic practices such as farming methods (land rotation, shifting cultivation, intercropping etc.), the use of improved seeds, mechanized agriculture (irrigation), and the use of chemicals, manure regaining and other soil conservation techniques. The study therefore, contributes to broaden knowledge in agriculture intensification. The study provides information that maybe useful for policy making on agriculture production and programming particularly, targeting smallholder farmers, who constitute the majority of the farming population of Ghana. Some of these policies by government of Ghana are; the Savannah Accelerated Development Authority (SADA) in 2009 and the recent Planting for Food and Jobs Programme (PJP) started in January 2017. It can also serve a reference material for readers and researchers.

1.6 Scope of the Study

Geographically, the study was conducted in North- Western Ghana with specific focus in the Nandom and Lawra Districts of the Upper West region. In the Nandom District, Ko community was selected while Tanchara community was selected in Lawra District. These districts are chosen in line with the on-going research project; Sustainable Intensification Trade-offs and Agriculture Management (SITAM) Project that the study benefited from. Contextually, the focused is on how the operations of Smallholder Farmers food crops intensify agriculture production to adapting to climate change adaptation. The targeted population were smallholder farmer households, opinions leaders of the selected communities and youth groups in the two districts. This lasted for twelve (12) months, from July 2017 to June 2018.

1.7 Organization of the Study

The study is organised into five chapters. Chapter one comprises of the background of the study, problem statement, research questions and objectives, significance and scope of the study. The second chapter reviews literature related to the study and conceptual/theoretical framework was arrived at. Chapter three outlined the research methods and description of study area. Chapter four presents the results and discussions of major issues. Areas considered include; the trend and dynamics of types of farms by generations, methods of soil and water conservation and the dynamic and trends in type of crops and yield by generation in Sustainable Intensification Agriculture and Climate Change Adaptations. The final chapter presents summary, conclusion and recommendations for further studies.

CHAPTER TWO

REVIEW OF RELEVANT LITERATURE

2.1 Introduction

In this section, literature is reviewed on thematic areas, concepts and theoretical perspectives relevant to the study. The review considered Climate Change/Climate Variability, Incidence of Climate Change/Climate Variability and effects of Climate Change/Climate Variability on Smallholder Agriculture. Others areas cover included the Concept of Smallholder Agriculture, Effects of Climate Variability on Smallholder Agriculture, Sustainable Intensification Agriculture (SIA) and Climate Change Adaptation and Concept of Climate Change Adaptation. Drawing on this review, a conceptual framework was put forward to guide empirical analysis.

2.2 Climate Change and Climate Variability

2.2.1 Concepts and Differences

Climate change/climate variability concepts have become an important point of discussion in this 21st century due to its perceived impacts on development especially on the area of agriculture as in crop production. Climate Change is the change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC, 2007 cited in UN, 2015). And added that, the change in climate is over time, whether due to natural variability or as a result of human activities. The concept of climate change has been defined variously by many people. For instance, Climate Change is defined as long-term

weather patterns that describe a region through studies … and global climate change indicates a change in either the mean state of the climate or in its variability, persisting for several decades or longer (Rosenzweig et al., 2011). It was added that, it is due to climate variability which is the variations in the current state of the climate on both spatial-temporal bases beyond the normal weather changes. This shows that the weather can either change in negatively or positively. Climate variability is "the way climate fluctuates yearly above or below a long-term average value" and Climate change is the "long-term continuous change (increase or decrease) to average weather conditions or the range of weather" (Dinse, 2009, page 8). Most at time climatologists take thirty (30) years or more to measure climate change but climate variability is lessor than that (Nicholls et al., 1996). Climate Change is a term that "refers to major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer" (Wells, 2010). Burch Jr (2016) defined climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

Climate variation has three (3) components; the one directly driven by purely periodic external forces like seasonal cycle of insolation (easiest to predict), variation due to non-linear interplay of feedback in the climate systems (difficult to understand and predict) and variation associated with random fluctuations in physical and chemical factors (very hard to predict details) (Ghil, 2002). Climate variability can be determined by means of short-term changes in weather and it components (IPCC, 2012). Climate variability can be observed through comparing the average temperatures within two years and that of the standard

deviation, with a normal variation of 68% or more in variation and when this is studied for thirty (30) years or more, climate change can be concluded (Hansen, et al., 2011). The emission of about 58% of nitrous oxide (N_2O) is from soil and the application of fertilizer and methane (CH_4), about 47% from livestock and rice cultivation and these are some of the gases that causes climate change (Brundtland, 1987). Operationally, climate change is defined as the state of unfriendly weather elements and water deficit or over-sufficiency of water for agricultural purposes due to changes in weather elements observed over a period of time, not less than thirty years. And climate variability on the other hand is positive or negative changes in weather elements in a short-time leading to unpredictable rainfall pattern.

This study therefore laid more emphasis on the concept of climate variability than climate change concept. The reason is that, the investigation is looking at the inter-annual changes in the weather elements typically rainfall and temperature. This has been established in less than thirty (30) years and does not qualify to be climate change but rather climate variability.

2.2.2 Incidence of Climate Change and Climate Variability

Comparing the 20th and the 21st centuries, annual average temperature will rise by 2^{o}C or more globally, especially in the Asian continent; and the effect if it is, timing and quantity of precipitation (IPCC. 2014). The third U.S.A National Climate Assessment indicated that, global climate is changing and this is apparent across the United States in a wide range of observations. The global warming of the past fifty (50) years is primarily due to human activities, predominantly the burning of fossil fuels (McCarthy, et al., 2001). The sub-Saharan region is said to be vulnerable to climate change impacts at all levels, there is

between 2°C and 4°C warming effects on Africa of late which has negative impacts on the livelihood of people (Niang et al., 2014). Africa is experiencing multiple stresses of climate change and climate variability and its effects, which make farmers developed several adaptation options to cope with it (Parry et al., 2007). Africa is likely to be severely compromised by climate change and climate variability because the length of growing season is likely to reduce further, smallholder farmers' yields are projected to reduce by 50% by 2020 and crop net revenue will fall as much as 90% by 2100 (Parry, et al., 2007). This is likely to affect development as developing countries heavily rely on agriculture to develop. According to Collen & Scholes, (2015), African countries are vulnerable to climate change and climate variability because the continent is exposed to droughts, flooding and storms with low adaptive capacity due to poverty, financial, technology and heavy reliance on rain-fed agriculture.

The average annual temperature in Ghana is predicted to increase by about 1.0 to 3.0^{o}C between 1970 and 2060, average precipitation is decreased by 2.4% per decade between 1960 and 2006 and droughts are expected to be more frequent and intense than now in the country (Dumenu & Obeng, 2016). The annual average temperature in Ghana is ranging from 24°C to 30°C but temperature can be 18°C in the southern part and 40°C in the northern part with general rainfall decreasing from the south to the north due to climate change and variability (Asante & Amuakwa-Mensah, 2014). The incidence of climate change has led to a declined in rainfall amount in the three northern regions; it has reduced from about 1,122mm in 1900 to about 964mm in 2014 which affect smallholder farmers' production (Abbam et al., 2018). Climate change and climate variability affect the production of food

crops such as groundnuts, sorghum, rice, yam and tomatoes in the three regions of northern Ghana over the past decade (Müller-Kuckelberg, 2012).

2.3 Effects of Climate Change and Climate Variability on Smallholder Agriculture

2.3.1 Concept of Smallholder Agriculture

The term agriculture is seen differently and has gone through transformation to the current system which most people regard as resilient agriculture. “A resilient agricultural system is one that continues to provide services, such as nutrient cycling and food production, despite the presence of external stressors, such as extreme climatic events or the presence of pests” (Lin, 2011, as cited in McCord, et al., 2015, pg. 3). Smallholder farmers are those people who cultivate family size farms; their production pattern is usually dependent on agro-ecological and soil conditions (Lowder, et al., 2016). Smallholders are small-scale farmers … who manage areas varying from less than one (1) hectare to ten (10) hectares; they are characterized by family-focused motives such as favouring the stability of the farm household system, using mainly family labour for production and using part of the produce for family consumption (FAO, 2012). The working definition is that, Smallholder farmers are defined by the characteristics it possesses such as the use of family labour, managed by family, with a small farm size and have generational linkages (Garner & de la O Campos, 2014).

2.3.2 Effects of Climate Variability on Smallholder Agriculture

Higher maximum global temperatures during the day increase the risk of crop damage and minimum decrease the risks of crop damage and more intense precipitation causes soil erosion and leaching (McCarthy & IPCC, 2001). Understanding the future of environmental

impacts on global crop production can be done through good agronomic practices that will not affect environmental variables (Tilman, et al, 2011). Developing countries depend heavily on rain fed agriculture, typically the tropics suffer environmental disturbances such as poor soil cover that affects grains and legumes production and their inability to use agricultural practices to mitigate the impacts of global warming (Apata, et al., 2009). In Africa, Climate change impacts is on major food crops such as wheat, rice, maize and other cereals notably in the tropical and temperate regions (Porter et al., 2014). They added that, local temperature will increase to 2°C or more above late-20th-century levels which vary across crops and regions and the kind of adaptation scenarios, more severe impacts will increase by 2050. Environmental challenges that affect agriculture are among seasonal rainfall variability caused by climate change (Rockström & Barron, 2007; Cooper et al., 2008). Climate variability has negative effects on some classes of crops such as tubers, grains, legumes and vegetables in Africa, especially in the case of Nigeria (Oluwasegun & Olaniran, 2010). Smallholder farmers' crop yields of sorghum, maize and groundnuts are decreasing over the years due to poor rainfall distribution caused by climate change in Southern Mali (Sultan, et al., 2013). Climate variability is having negative effects on the yields of food crops of smallholder farmers, especially on cereal crops (Poudel & Shaw, 2016). The prevalent of climate change on Africa led to changes in weather patterns and this affects agricultural production and food security (Besada, et al., 2009).

Ghana is vulnerable to climate change effects because of its biophysical and socioeconomic conditions which change with respect to time and some poor adaptation strategies, for example, the case of Afram Plains (Westerhoff & Smit, 2009). The agricultural sector in

Ghana which is the largest employer suffers the most from climate change and variation, particularly on stallholder agriculture (Kalame, et al., 2011). Empirical evidences proved that climate change is negatively affecting subsistence agriculture, however, adapting to climatic effects are not entirely beyond farmers' control due to fact that some adaptation measures are employed (Nyong & Osman, 2007). Study in Afram Plains District of Ghana shows that impacts of climate change and climate variability on food crop production affects rural food production (Codjoe & Owusu, 2011). In northern Ghana, crop farmers depend on rainfall, but heavy precipitation as typified by wet years, leads to low-crop productivity (Derbile & Abudu, 2012). This means that more rains does not mean more yield in some cases, heavy and irregular rainfall pattern can affect crops production negatively.

2.4 Sustainable Intensification Agriculture (SIA) and Climate Change Adaptation

2.4.1 Concept of Climate Change Adaptation

In the age of agricultural production, intensification practices include; halting agricultural expansion, closing 'yield gaps' on underperforming lands, increasing cropping efficiency and reducing waste, "Chemical fertilizers, manure and leguminous crops have also been key to agricultural intensification" (Foley et al., 2011 pg.340). Climate change adaptation means taking steps to prepare and respond to the effects of the changing climate (Prober, et al., 2015). Adaptation is seen "as an adjustment in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects" (Smith et al, 2001). In Malawi, Tanzania and Zimbabwe for instance, many strategies and approaches to adapting to climate change are used to enhance intensification of agriculture including; applying Traditional Ecological Knowledge (TEK), observed changes, harvest rainwater, change

tilling practices and the use of appropriate crop varieties (Majule et al. 2013 & Kalanda-Joshua et al, 2011).

Knowledge, experiences and perceptions of smallholder farmers and the adaptation measures in Ghana stands that farmers have good ideas of indicators climate change as it affects their farm productivity and livelihoods with lower adaptation capacities, they attached divine explanations to climate change, that it is a punishment from God through our immoral acts (Yaro, 2013). The interconnectedness between the world Climate change adaptation strategies and geo-politics cannot be underestimated, because, "local innovations and adaptations are thus increasingly interlinked with global policy and intervention indicative of a profound global interconnectedness between institutions and actors" (Rodima-Taylor, et al., 2012 pg. 3). Poverty is contributing to the ability of farmers to undertake intensification practices; poor households with larger family members employed locally as agricultural labourers but small family size has less labour force and wealthier farmers do better (Rusinamhodzi et al., 2012).

2.4.2 Concept of Sustainable Intensification Agriculture (SIA)

Sustainable Agricultural Intensification as a form of Conservation agriculture has been in existence for barely two decades ago and is conceived differently by many people in terms of operationalization. This concept presumes that there is the need to satisfy the ever-expanding population with the highly fixed arable land with efficient utilization of resources to preserve the ambient quality of the environment (Cook et al., 2015). In agriculture intensification, yields are increased without adverse environmental impacts and without the cultivation of more land (The Royal Society, 2009 cited in Cook et al., 2015). Sustainable

Intensified Agriculture aims at, maintaining the actual land size while producing to meet the current global demand for food, according to (Foley et al. 2011). The main aim of intensification agriculture paradigm is to enable large-scale change in terms of policy advocacy groups, stakeholders and government systems in improving people livelihoods while protecting the environment in the context of growing food to satisfy current and future food demands (Godfray & Garnett, 2014). There is correlation between agricultural intensification and land sparing especially in the developing world which Africa is among where there is likelihood of food crops yields increases with expanding farm size (Ewers *et al.*, 2009).

Sustainable Intensification Agriculture (SIA) is related to households' characteristics such as age, sex, level of education, household size, farm implement ownership, and related variables in the form of implement ownership and herbicide use by smallholder farmers (Andersson & D'Souza, 2014). In many cases, the concept of Sustainable Intensification is defined as "a process or system where agricultural yields are increased without adverse environmental impact and without the conversion of additional non-agricultural land" (Pretty & Bharucha, 2014). Water availability is one of the problems confronting agricultural production in recent times, intensification therefore tries to reduce and manage the risk associated with agriculture by reducing water use or quantity through changing the input use such as nitrogen and phosphorus fertilizer (Bouwman et al., 2017). In the work of Smith et al., (2017) sustainable intensification concept was broaden to include issues of human conditions such as nutrition and equity in identifying measurable indicators because the current static indicators cannot be used to evaluate sustainability.

Sustainable intensification involves increasing output levels from the same area of land while decreasing the negative environmental impacts of agricultural production and increasing the provision of environmental services (Cook, 2015). SIA has been criticised as not favouring access and distribution of resources, lack of political analysis in agriculture, favour technological approach and focus is on crop production only instead of looking at farming system holistically. The study made use of the working definition of Sustainable Intensification Trade-Offs for Agriculture Management (SITAM) project. In this, Sustainable Intensification Agriculture is seen as means of increasing food production from existing farmland while minimising pressure on the environment including social and economic dimensions. The sustainability is focus on the concept of "leaving no one behind". Thus, ensuring poorer smallholder farmers who are food insecure such as women and youth to be part of decision-making regarding trade-offs and synergies.

2.4.3 Sustainable Intensification Agriculture for Climate Change Adaptation Practices

Sources of Water for SIA

Sustainable agriculture can be achieved through water harvesting which could be a key strategy to achieving sustainable intensification in sub-Saharan Africa (Dile, et al., 2013). The use of irrigation agriculture helps to enhance agro-biodiversity, because crops that are having different maturity periods can be cultivated as the growing season is extended (Zimmerer, 2014). There is still the possibility of crop failure if the design of the irrigation facility does not reflect the community interest (Zimmerer, 2011). In the past, farmers' adaptation measures were centred on diversification of production and migration but in recent times, they are adopting the usage of shallow underground water for irrigation in

vegetables gardening, this act is called a Farmer-driven Small-scale irrigation (Laube & Awo, 2012).

Agricultural Inputs Use

Considering the high rate of population growth in the Africans continent, interest is geared towards getting extra food without converting new lands into agricultural lands but rather through intensification of the current lands (Bekunda, et al., 2010). The Africa Fertilizer Summit in 2006 recommended that, increasing soil moisture holding capacity and building soil nutrients in agricultural lands can make farmers to sustainably and reliably supply food as well as fertilizer usages. Fertilizer use and intensity is low in Sub-Saharan Africa and soil fertility has been declining over the years and has potentially been contributing to low crop yields particularly for smallholder farmers (Chapoto, et al, 2015). Agricultural intensification can be attained through increasing agricultural inputs use to increase per-hectare yields either than expanding cultivation land and this goes a long way to protecting forest (Phelps, et al., 2013). Sometimes back, farmers' adaption measures were entered on movement from unfertile lands to fertile ones. Similarly, smallholder farmers' adaptation measures to cope with rainfall variability include migration (Murali & Afifi, 2012). The findings show that migration takes place to improve livelihood and access to food.

Soil Fertility Management/Nutrients Retention Method

In conservation farming systems, legumes play crucial role in ensuring food security in developing countries as a result of its nitrogen fixation ability but in many regions of the world it is affected by drought, the amount of water reduction is positively related to yield reduction but the extent of the impacts are not the same among different spices and the state

of the drought (Daryanto, et al., 2015). The use of synthetic fertilizers in soil nutrients management leads to nitrate pollution and eutrophication; the alternative environmentally friendly act is practicing intercropping with legumes as a way to sustainably introduce biological nitrogen fixation (Fustec et al., 2010; Lithourgidis et al., 2011). The major problems facing farmers in Integrated Soil Facility Management (ISFM) were lack of access to information and improved technologies, poor and declining soil fertility and weakening local institutions, this can be enhanced by means of strengthening and revitalizing local institutions to improve smallholder farmers' adaptive capacity (Mapfumo, et al., 2013).

The goals of most soil fertility restoration are based on agronomic, socioeconomic and environmental factors and in Sub-Sahara Africa, smallholder farmers do not benefit from agricultural technologies (Woomer, 2007). This is because their operations are subsistence instead of market-driven agriculture, with that few soil management techniques are adopted, because it has high cost relative to crop prices and economic returns are still low (ibid). In northern Ghana, sustainable agriculture is done using improved innovations in transplanting sorghum and millet (local and improved varieties), and mulch/ organic matter and compost, farmers (Asante, et al., 2012).' He further explained that, adaptive capacity can be built using education approach and technology broaden the gap between different kinds of adaptive capacities but this is sometimes affected by financial accessibility Farmers use composting to reclaim barren lands with no penetration by burying compost, the seeping of rain run-offs soaks the compost in which the moisture further seeps to enrich the soil, meanwhile, farmers still prefer to plant traditional crop varieties such as the local maize which they belief has

good taste, easily cultivated, accessed and stored than the hybrid and synthetic ones (Nyantakyi-Frimpong, 2013).

Research had it that nitrogen fixation, water use sufficiency and the use of improved seeds can avoid agricultural land expansion into the natural ecosystems at the same times meeting current human needs which some scholars such as Perfecto & Vandermeer (2010) viewed as not being possible because that is a very simple model that leads to land sparing. Nutrients application takes the form of livestock manure, crop residues in situ or transferred from other production areas and compost which is a value added product of a collection of a range of organic compounds that have been incubated for a period to allow for their decomposition" (Bekunda et al., 2010, pg. 24).

Soil Moisture Conservation or Restoration Methods

In the Sahel, Soil moisture is managed through contour stone bunds and soil water moisture but very wet years have effects on the field and sediments very rich manure on the farm (Jalloh, 2013). carbon soil sequestration can be better promoted through the application of organic manures, use of intercroping and green manure, higher shares of perennial grasslands and trees or hedges, etc. which has higher potential of improving soil structure (Müller, 2009). In Africa, studies show that using crop residues in no-tillage systems of farming helps to increase crop yield per plot and in situations where there are no crop residues in no-tillage systems, there is a significant reduction of yield compared with yields of conventional tillage by about 50% (Andersson & D'Souza, 2014; Thierfelder et al., 2013).

The long-term impacts of climate change on crop production can be mitigated through water resource development such as small-scale irrigation system and water harvesting using affordable means (Adhikari & Woznicki, 2015). Climate change and variability have impacts on farm households in terms of poverty and food security, this can be managed by expanding irrigation facilities, however a remarkable change in food security can be attained by using irrigation, shifting planting dates and adopting early majoring crops (Wossen, et al., 2014). In Ethiopia, famers harvest water from the Ephemeral Rivers, roadsides and hillsides using stone and embankments to irrigate crops and pasture which has doubled the production of sorghum and vegetables in both raining and dry seasons (Binyam & Desale, 2015).

Crop Diversification and Crop Rotation Method

Smallholder farmers who intercropped cereals with legumes generate high quality of organic matter inputs at a larger amount to improve production benefits comparatively with regular maize mono-cropping (Rochester, 2011) but Farm-level climate adaptation measures in Africa indicate that the agricultural practices that are most vulnerable to climate change is crop specialization and irrigation farming (Hassan, et al., 2008). Intercropping maize with grain legumes is an effective means to improve food security and income as it reduces the risk of crop failure, improve productivity and income at the same time increase food security in systems that are vulnerable in nature and is a feasible entry point to ecological intensification (Rusinamhodzi, et al., 2012 & Meyer, 2010).

Crops can be diversified through, agroforestry and crop rotation systems and these evidence are of many forms (e.g. genetic, species, structural), function (e.g. pest suppression,

increased production), and scale (temporal and spatial) (Lin, 2011). The advantages of crop diversification are that it promotes ecosystem functioning and resilience such as duplicative functions, redundancy is built into the system (Lin, 2011). Practicing crop rotation is a good way of controlling or suppressing disease on farms (Smith et al. 2008). Polycultures (growing two or more crop species and wild varieties) helps in the suppression of diseases, climate change buffering and increase production (Tilman et al., 2011 and Mitchell et al., 2002).

Crop diversification systems have the possibility of natural process of nutrients recycling; intercropping with leguminous crops and trees has been noted to improve space utilization, rooting and water use efficiency, and field nutrient consumption with poor soil quality (Lithourgidis et al., 2011). "Grain Maize, sorghum, rice, millet, wheat intercropped with nitrogen-fixing crops to increase production; large biomass producing cover crop; extensive rooting structure; staple food crop and legumes such as groundnut, soybeans, mixed beans, Bambara nuts, cowpeas, velvet beans, peas contribute to nitrogen fixation; used as cover crop to reduce water loss; pest suppressing properties; staple food crop" (McCord, et al., 2015, pg. 6).

Checking Soil Erosion by Smallholder Farmers

In Africa, soil erosion management is done through the use of on-farm tree planting by smallholder farmers (Ligonja & Shrestha, 2015). Conservation agriculture adoption by smallholder farmers increases when there are trainings on previous experience in minimum tillage for members of farmer organizations and ownership of Conservation Agricultural tillage equipment (Nyanga, 2012). Information on climate change adaptation strategies on

improve soil fertility take place at social and public places such as market places, hospitals, schools and water collection points of which government extension workers and non-governmental organization play active roles in information dissemination (Chaudhury, et al., 2012). Farmers use cut-off drains and tree planting to prevent soil erosion, this has prevented further expansion of area affected by erosion, others are; contour ridges, mixed cropping and strip cropping (Ligonja & Shrestha, 2015).

Soil erosion by water is determined by the nature of tillage system (depth, direction, timing and the type of equipment used), less soil disturbances reduces the rate and severity of soil erosion and some conservation tillage practices include; ridge tillage, vertical tillage and strip tillage (Panagos, et al., 2015 & Giller, et al., 2011). In preventing soil erosion on farms, farmers can plant trees to conserve soil and water because the falling leaves enriching organic matter in the soil and the trees also blocks the flow of water (Agriinfo, 2015). Soil erosion has greater effect on the quality of soil and may even lead to desertification which has an impact on the growth and production of staple food crops (Bashir, et al., 2017). "Soil erosion can be checked through the use of bunds and trenches as well as the creation of ponds to collect excess water for later usage" (Hiscock, 2014). The use of various methods to improving soil fertility should be geared towards enriching the soil without contaminating streams and underground water (Barrow, 2012).

Soil Moisture Conservation by Smallholder Farmers

There is a significant loss of soil moisture in the soil during the dry seasons, especially during the transition period of rain and no rain, less moisture loss in the wet seasons yet measures are needed to maintain soil moisture in their age of climate change and its effects on

agriculture production (Lin, 2010). The ability of healthy crops growth and production is highly determined by the availability of moisture in the soil. Soil moisture conservation reduces the rate of water lost from the soil (Brears, 2018). In Southern Mexico, shade trees are used to maintain water availability in the soil; coffee crops are used to prevent soil erosion and evaporation activities in both dry and wet seasons (Lin, 2010). Smallholder farmers can offset the challenges caused by unpredictable rainfall through water harvesting to adapting to climate change which will improved recharge of nearby water-flows or ponds, as well as groundwater (Brears, 2018). Soil moisture conservation can be enhanced through good land management practices such as making of ridges boundary bunds, furrows in preventing the in-flow and out-flow of water on farm lands (Kannan, et al., 2009). There are two basic ways of managing soil; agronomic methods (Contour farming, crop rotation, strip cropping, mulching and dry land Farming) and mechanical methods (Bunds and trenches as well as basins/ponds) (Hiscock, 2014).

Smallholder farmers intercropping maize with grain legumes is an effective means to improving food security and income in the sense that it reduces the risk of crop failure improve productivity and income and increase food security in a system that are vulnerable in nature and is a feasible entry point to ecological intensification. (Rusinamhodzi, et al., 2012 & Rochester, 2011). A study undertaken in Zambia proves that the use of crop residue to improve soil fertility has some kind of confliction on the socio-cultural practices of the people; farmers do not practice crop rotation because maize is the major crop by smallholder farmers and less market for legumes crops (Umar, et al., 2011).

In northern Ghana local knowledge is used to determine the compatibility of crops on soil, rainfall duration and intercropping techniques such cowpea-sorghum and millet- groundnut in years with poor rainfall, and maize-beans, maize-groundnut and maize-millet combined during years with moderate rainfall (Ofori Sarpong, 2001, cited in Nyantakyi-Frimpong, 2013). Intercropping tress do not only help to sustain a green cover on farmlands but also maintains vegetative cover, boost nutrients supply through nitrogen fixation, nutrients recycling, increases carbon storage (below and above ground) and increasing organic matter content (Garrity, et al., 2010). In conservation farming systems, legumes play a crucial role and ensures food security in developing countries as a result of the nitrogen fixation but in many regions of the world it is affected by drought, the amount of water reduction is positively related with yield reduction but the extent of the impacts are not the same among different species and the state of the drought (Daryanto, et al., 2015). Practicing crop rotation is a good way of controlling or suppressing disease on farms (Smith et al. 2008). The rotation of legumes crops such as pigeonpea and beans with cereals crops such as maize increase the yields of crop because of the nitrogen fixation and moisture retention ability of legumes (Adjei-Nsiah, 2012).

The use of Ridges and Bunds by Smallholder Farmers in Soil Management

In sub-Saharan Africa (SSA), farmers heavily depend on nutrients mining rather than fertility improvement, they can thereby make use of good fertilizer management, using improved crops varieties and the application of organic inputs under the integrated soil fertility management system (ISFM) system (Vanlauwe, 2011). Similarly, the Chinese economy faces high increase in population associated with higher demand for food but

environmentally friendly approach is used to increase the yield level of grains and cereals twice the current yields without the use of much fertilizer under integrated crop-soil management system (Chen, et al., 2011). In Malawi, culturally, smallholder farmers' belief that making ridges and furrow system as well as residue burning to hunt for rodents do not affect soil fertility and crop production is possible with that (Ngwira, et al., 2013). A study conducted in Philippines shows that farmers who practice organic farming have high food security with diverse diet, they also produce diverse range of crops and have better health situations than that of conventional farmers (Altieri, et al., 2012).

Smallholder Farmers using Composting and Manure in Managing Soil

Smallholder farmers in Sub-Saharan Africa use integrated soil fertility management to improve soil fertility on the fields which involves the use of inorganic fertilizer, soil organic matter and grain legumes rotation (Vanlauwe et al., 2010). On the other hand, organic farming has the potentials to reduce crop yields and production than conventional agriculture but this depends on the nature and farm characteristics (Seufert, 2012). Soil fertility and health can be increase to enhance crops growth and production through the use of bio-fertilizer and compost (Banerjee, et al., 2011).

In Africa, results from central Kenya proved that, smallholder farmers' production cannot be increased through crops residues retention and minimum tillage on poor fields, rather on the rehabilitation of physical and chemical components of the soil (Guto, et al., 2012). Nutrients application takes the form of livestock manure, crop residues in situ or transferred from other production areas and compost which is a value added product of a collection of a range of organic compounds that have been incubated for a period to allow for their

decomposition" (Panagos, et al., 2015 & Bekunda et al., 2010, pg. 24). One of the basic ways in which smallholder farmers can improve their soil fertility is through artificial means such as using plants residues; sawdust to increase water absorption reduces evaporation (Agriinfo, 2015).

2.4.4 General Farm Sizes and Farm Characteristics

Plot Sizes of Smallholder Farmers and Intensification Agriculture

The world trend and pattern of average farmland distribution shows a decrease in sizes of farms in lowest and lower middle-income countries in Sub- Saharan Africa than the developed countries such as America and Europe (Lowder, et al., 2016). Historical antecedents recorded that during the agricultural revolution in Asia, smallholder farmers were capable of feeding themselves and even the urban populace; still many became net buyers of food and contribute little towards feeding urban populations with no surpluses (Laura, et al., 2016). In many instances plots sizes of farmers reduce in recent times as compared to previous account.

Smallholder farmers in the northern part of Ghana cultivate less than five (5) acres of land and produce diversified crops including cereals, root and tubers, legumes and vegetables with maize cultivation gap between 50% to 80% achievable yield (Wood, 2013). He further indicated that this low yield is due to wrong application of correct agronomic practices. A study underscored the fact that, in the north-eastern part of Ghana especially among the Komkombas, farmers' plots sizes reduce as result of reduction in family/households' composition through migration is having negative impact on food production and households' food security (Nakasone, & Suvedi, 2017). There is an inverse relationship

between plots sizes and yields per plot and management systems such as Terracing, crop rotation, mono-cropping, mixed cropping, the use of irrigation etc. are also determinants of crop yield (Bevis & Barrett, 2016). Farmers who adopt good soil and nutrients management practices are those who have extension visits, experience and training and these are affected by the farms size and distance between farmer and inputs, farmers plant improved seed varieties, make use of fertilizers and sowing in rows to adapt to climate change (Donkoh & Awuni, 2011). The average plot size in the three northern regions is about 4.25 acres with average yields of about eight (8) bags for maize (Zea mays), 19 bags for rice (Oryza sativa) and seven (7) bags for soya beans (Glycine max) in many cases (Amanor-Boadu, et al., 2015). Productivity of cereals crops (rice) farmers is based on the farm sizes and location of the farm (Anang, 2017). The locations of these farms are not specific as where exactly the geographic location refers to.

2.4.5 Types of Farms and its Agricultural Practices

Compound Fields

Home gardens or fields' also called compound farms are farms that are near to the homestead or within the settlements, this is dominant among the many rural savannah farming communities (Vanlauwe, et al., 2010). In northern Ghana, farmers have shifted from traditionally practicing compound farming to feed their families only to farming to sell in recent times; this is as a result of changing the social custom pattern from extended system to individualism (AFFRITC, 30th March, 2018). Land fragmentation does not only reduce the profit margin of farmers but it also makes it difficult to cultivate with machines and man-power, this compel many people to seek for other sources of land to help expand their farm

size (Di Falco, et al., 2010). This method even though could make working on farms laborious but among smallholder farmers, this could not be of much problem.

Fertility Management in Compound/Home Fields

The nutrients level on compound/ home fields are higher in the savannah regions, as in Burkina Faso where compound farming is relatively higher among many sections of the countries, especially the smallholder farmers (Vanlauwe, et al., 2010). Similarly, the Chinese economy faces high increase in population associated with higher demand for food but environmentally friendly approach is used to increase the yield level of grains and cereals twice the current yields without the use of much fertilizer through an integrated crop-soil management system (Chen, et al., 2011). The rate of nutrients depletion on alluvial soil is low if not zero because of the continuous deposition of eroded organic materials and this support crop yields for a longer time range (Kumar, et al., 2017).

Bush Fields and Fertility Management

Bush fields are those fields that are furthest away from the homestead and it takes farmers several kilometres to get to the premises (Vanlauwe, et al., 2010). In the past, the cultivation of bush farms was dominant among many farmers than current situations, there is less nutrients status availability in this ecological zone as compared to the compound fields (Vanlauwe, et al., 2010). Soil erosion affects nutrients content in the soils; these emerge as a result of dynamics in vegetative cover, the cultivation of cereals crops, however, tree planting decreases erosion making shrubs and woodland areas better for soil and water conservation (Nunes, et al., 2011). Soil fertility can be improved unimaginably through practicing of strip cropping/strip inter-cropping, thus planting more than one type of crop on

strips made on the same field, for example, planting of cereals and legumes together on the same field where each crop is managed separately (Hauggaard-Nielse, 2010).

Soil Moisture and Water Conservation or Restoration Practices

In the Sahel, soil moisture can be increase through contour stone bunds and soil water moisture depends on the space between the bunds, but very wet years have effects on the field and sediments very rich manure on the farm (Jalloh, 2013. The long-term impacts of climate change on crop production can be mitigated through water resource development such as small-scale irrigation system and water harvesting using affordable means (Adhikari & Woznicki, 2015). There is a significant loss of soil moisture in the soil during the dry seasons, especially during the transition period of rain and no rain and less moisture loss in the wet seasons yet measures are needed to maintain soil moisture in the age of climate change and its effects on agriculture production (Lin, 2010). Traditionally in Africa, smallholder farmers learn their farming skills from their parents rather than external sources which in theoretical perspectives can be true, however, slash-and-burn, reduced fallow periods and plough straight down hillsides causes soil fertility degradation and erosion (Trabacchi, et al., 2014).

2.4.6 Crops varieties cultivated by smallholder farmers

The Cultivation of Improved Crop Varieties

Evidence from the Zangbo river valley in China made it clear that farmers adapt to climate change impacts on agriculture by changing crops species and to some extend making changes in the planting and harvesting time through the application of their indigenous knowledge and experience (Li, et al., 2013). Smallholder farmers are trying hard to increase

production in this era of climate change through the adoption of improved crop varieties among which is determined by farm size, household size, and attendance of demonstration fields' and age of the household head (Danso-Abbeam, et al.,2017). Farmers from the onset of domestication of crop biodiversity to the current era have moved from the cultivation of indigenous varieties to the improved varieties to adapt to climate change, especially in West Africa where rainfall has decreased in the last forty years (Vigouroux, et al., 2011). Farmers who are practicing crop diversification and growing of improved varieties are better off compared to those who do not do that, care should be taken to ensure that these crops are able to much the agro ecological conditions to enhance profitability (Di Falco, et al., 2010).

The Cultivation of Traditional Crops Varieties

The trend of traditional crop cultivation among farmers in the past and present is influenced by decision-taking in relation to environmental, economic and social grounds sustainability. Therefore, in Africa, smallholder farmers still cultivate some cereals, legumes, and tubers such as sorghum, millet finger, rice, cowpea, bambara groundnut and Africa yam which are indigenous in nature (Emmambux & Taylor, 2013). In terms of decision making in agriculture systems, women have a say in the use of improved varieties of crop but have no say in cereals and legumes cultivation as in Ghana (Chaudhury, et al., 2012). Farmers in the contemporary time still grow diverse form of traditional varieties of staple crops due to overwhelming importance they attached to them which improves their livelihoods upon the expectation by many that these varieties are likely to disappear in the system (Jarvis, et al., 2011). Farmers' choice of many crops varieties among many households in the developing world is influenced by their ability to adapt to the environment and sustain yields, their

experience and access to extension services which are considered more important than increased productivity (Asrat, et al., 2010).

In the Sahel region, smallholder farmers cultivated indigenous varieties of staple food crops like millets and sorghum in the past which was resilient than current, this make farmers to shift to the cultivation of improved varieties with high yield under less soil fertility conditions (Sultan, et al., 2013). This means that farmers' choice of crops varieties has changed over the year. Smallholder farmers' cultivation of improved varieties of crops go a long way to increase staple food crops yields than the local varieties, however, farmers who do not make use of organic fertilizer, practice minimum tillage and irrigation are lowering the yields of crops such as maize and other cereals (Abebe, et al., 2013). Many strategies are employed by farmers to substantially increase yield level in the form of planting new crops varieties and the use of inputs like human energy, agrochemicals and the use of irrigation technology in dry season farming just as farmers in Madagascar keep on modifying crop, soil, water and nutrient management systems (Kassam, et al., 2011). The use of improved crop varieties under the agricultural intensification system has gone a long way to increase staple crops yields in modern agriculture in addition to the use of chemical fertilizer, pest-control and irrigation, especially in china (Fan, et al., 2011). This proves that indigenous crops varieties yields are not supported by the current climate. Fertilizer intensity and use are not enough for maintaining and sustaining crop yields but rather in collaboration with cropping systems in many cases, especially for wheat and rice (Amikuzino & Donkoh, 2012).

The Yield Situation of Crops in Smallholder Farming

The low yield of crops has made farmers to adapt to the use of fertilizer to increase production. Climate change brings about higher temperature and reduction in rainfall and this affects crop yields, as such, farmers are adapting to this through timely planting of diversified crops varieties and mulching (Ezeaku, 2014). There are evidence showing that global crop yield in recent times has been categorized into four (4) main types as in the work of Ray et., al (2012). They highlighted them as; situation where yield never improved from the past, yield still is stagnant, yields has decreased over the year, yield has increased and collapsed and yields still on increasing of which some areas are rapidly increasing, others intermediate and some with low yields as compared to the past The issue of sustainability is lacking in instances people belief that yield increases and collapsed with time. Global pattern of crop yields is affected with climate change coupled by bad agronomic managements practices (Licker, et al., 2010). There is a change in crops yields in the past, but this decrease is not through time, it is as a results of non-climatic factors especially among rice, wheat and maize farmers (Osborne & Wheeler, 2013). But Ray et al. (2013) view is that, there is an increase in global crop yields in current era, especially among cereals and legumes crops such as maize, rice, wheat, and soybean. Climate change has seriously threatened food security in world particularly Africa leading to a continuous change in yields over time, especially on cereals crops such as; wheat, maize, sorghum, millets and rice (Knox, et al., 2012). There is an inverse relationship between plots sizes and yields per plot and management systems such as Terracing, crop rotation, mono-cropping, mixed cropping and the use of irrigation are also determinants of crop yield (Bevis & Barrett, 2016).

The inter-annual crops yield in savannah and guinea savannah regions of Ghana is affected by rainfall resulting from climate change and variability, meanwhile, a more stable temperature is likely not affect crops yields if any (Amikuzino & Donkoh, 2012). Smallholder farmers who adopt the cultivation of improved seeds and the use of organic manure to increase soil fertility increased their yields (Peprah, et al., 2016). Furthermore, researchers found that the high dependence on rain-fed agriculture in Nadowli/Kaleo District contributes to continued reliance on seasonal migration as a coping strategy because of low yields of crops (Rademache-Schulz & Mahama, 2012). This is an indication that smallholder farmers are doing everything possible to intensify agriculture in the period of climate change and its associated effects on agriculture.

2.5 Theoretical and Conceptual Framework

2.5.1 Ester Boserup Theory of Population Growth

The study presents a framework that blends Boserup's/Qay's theory of agriculture intensification and the concept of Sustainable Intensification Agriculture (SIA). It is necessary to include assumptions of land use intensification to back this research work. It considered one of the earliest theories formulated by an agricultural economist; Ester Boserup who opposed the Malthusians theory which postulates that population growth has an impact on global food production in the sense that population pressure would force the expansion of farm lands which would be exhausted in the long run if the earth reaches its carrying capacity. Agricultural intensification theory formulated by Easter Boserup was the first to explain higher levels of agricultural productivity associated with higher population densities in traditional smallholder agriculture (Ellis et al., 2013).

The Boserup's theory of agricultural intensification also known as Qays's theory posits that population change drives the intensity of agricultural production. This counter the Malthusian theory that agricultural production determines population growth via food supply. Ester Boserup postulated that, agricultural methods depend on the size of the population. The assumptions were that; population will take care of itself (population growth creates the needed innovation and technologies) to boost production. Increase in technology will increase agriculture production through improved farming methods and practices to sustain population growth. She added that Population pressure is the motor of innovation. (Boserup, 1965). The argument that increase in technology and innovation can increase agriculture production with the fixed farmland is relevant to this study, hence, adoption.

However, Nin-Pratt & McBride (2014) have advanced the arguments that in Ghana, agriculture intensification is not driven basically by population growth but rather, through the adoption of labour-saving and land-saving technologies on the part of smallholder farmers. Similarly, Houssou et al (2016) said agriculture intensification has a historical background worldwide but in the case of Ghana, it is through the use of more labour-saving technologies than land-saving technologies. This implies that, smallholder farmers do not have land conservation in mind in terms of their operations.

2.5.3 Conceptual Framework for Sustainable Intensification Agriculture for Climate Change Adaptation

Sustainable Intensification Agriculture helps smallholder farmers contribute adaptation of smallholder agriculture to climate variability. This concept consists of environment elements, sustainable intensification agriculture practices, the outcome of these practices and a feedback (See figure 2.1).

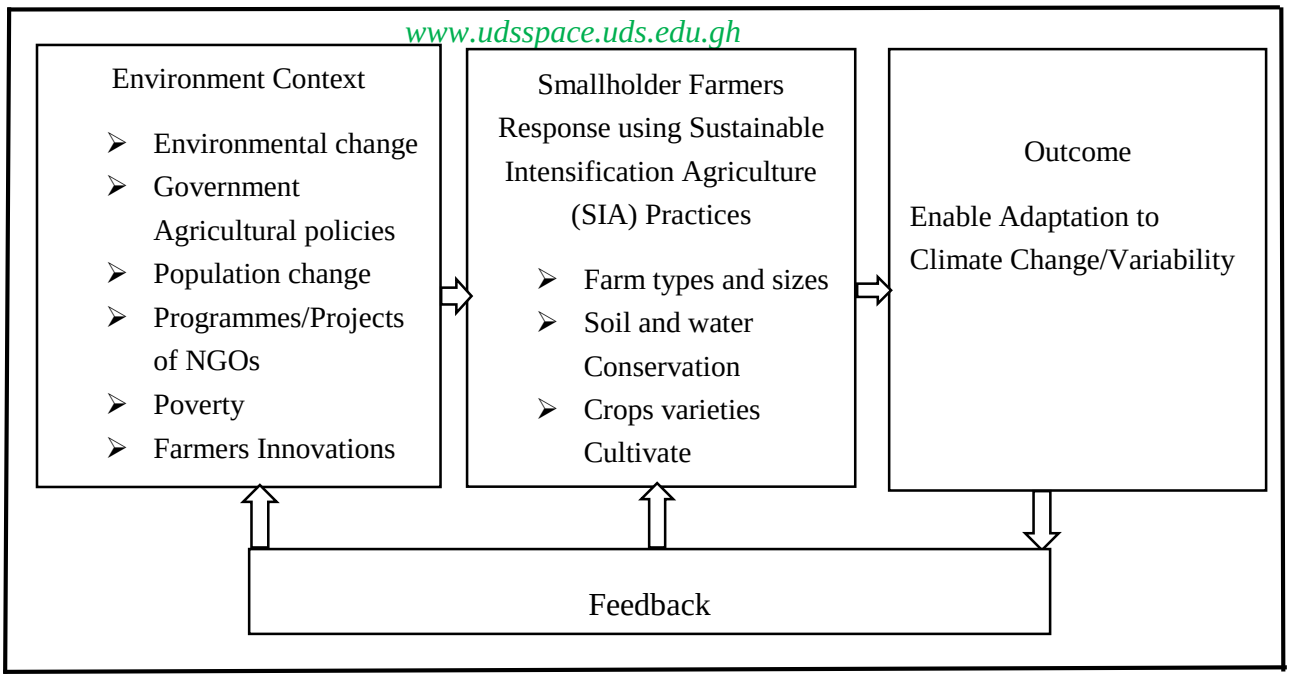

Figure 2.1: Sustainable Intensification Agriculture for Climate Change Adaptation

Source: Author's Construct, June, 2017

In the environment, Sustainable Intensification Agriculture is influenced by components such as environment change, agricultural policies, Population change, programmes/projects of NGOs, poverty and farmers' innovations (See Figure 2.1). Changes in the environment determines agriculture policies governments formulate towards agriculture intensification. Population growth increases food demands coupling with poverty will lead to strategies to increase agriculture production. Based on government agriculture policy agenda and population food demands, Non-Governmental Organizations draw their programmes or projects to facilitate agriculture intensification on the context of smallholder farmers.

Smallholder farmers on their own personal initiatives and innovations choose suitable agriculture practices to increase production. These are mainly in the area of Sustainable Intensification Agriculture (SIA), Farm types and sizes, Soil and water Conservation and Crops Varieties Cultivate. Farmers' innovations and experimentation of SIA practices in the three areas (Farm types and sizes, Soil and water Conservation and Crops Varieties

Cultivate) enhance the resilience of smallholder farming system under climate change. Thus, the ultimate outcome is that, SIA as practiced enables climate change adaptation (See Figure 2.1).

The last component of the concept is the feedback. The nature of this feedback depends on the nature of the outcome. A positive outcome about climate change adaptation means maintaining elements in the environmental context and sustainable intensification agriculture practices. However, a negative outcome about climate change adaptation will lead to reviewing and re-structuring of the process. This can be at the environment level and/or at the level of sustainable agriculture intensification practices depending on where the problem is found. The arrows show the direction of action in attaining sustainability.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 Introduction

This chapter describes the profile of the study area and the research methodology. The Profile comprises of the location, geology and soil, vegetation and climate, natural environment and population. The research methodology presents the research approach and strategy, sampling methods, methods of data collection, tools of data collection, data presentation, and data analysis.

3.2 The Study Districts

3.2.1. Location

The study was conducted in two neighbouring districts, Lawra and Nandom, in the Upper West Region of Ghana. The absolute location of Lawra district is between Latitude 10^0 35 W and 10^0 40W North and latitude 2^0 50W 2^0 and 50W 2^0 53W of the equator with a total of 1,051.2 square km land size (Lawra district first quarter report, 2016). It is about 5.7% of the Region's total land size at 18,476 square km, it has 55 farming communities and share boundaries with Nandom District to the North, to the East by Lambussie-Karni District, to the South by Jirapa and West by the Republic of Burkina Faso (ibid)

The Nandom district on the other hand is located on Longitude 2°25 W and 2°45W and Latitude 10°20W and longitude 11°00W and to the East and South are Lambussie and Jirapa Districts respectively and to the North and West by the Republic of Burkina Faso (Nandom

district composite budget, 2014). It has an area of 567.6 square km which constitutes about 3.1% of the Region's total land area with about 84 communities (ibid).

3.2.2 Geology and Soils

The rocks in the two districts are basically Birimian with dotted outcrops of granite with larger mineral potential that are not yet explored. Recent exploration shows that there is gold deposit of appreciable quantity and there is higher potential of underground water leading to the drilling of many boreholes in the area (Lawra District Composite Budget, 2013 & Nandom District Composite Budget, 2013). The soils consist of laterite soils which are developed from the Birimian and granite rocks found intrusively and extrusive in the area. There are traces of alluvial soil along the flood plains of the Black Volta and sandy loams along the tributaries and most of the people are smallholder crop farmers (Lawra District Composite Budget, 2013 & Nandom District Composite Budget, 2013).

3.2.3 Topography and Drainage

The landscape of the district (Lawra and Nandom) is generally flat and low-lying, meanwhile the land rises to between 30 and 180 meters above sea level with isolated round hills (inselbergs) dotted the landscape. They are under laid by Birimian rocks high in mineral deposits. Black Volta is the main river in the district and drains the district with Kambah, Dangbal and Nawer as its tributaries. The communities have few hills and it is drained by one main river, the Black Volta, to the West making a boundary between Nandom and Burkina Faso. This main river has tributaries in Nandom district such as *Puffien-Baa, Bu-Baa, Kokoligu-Baa and Nandomle-Baa* (Lawra District Assembly Medium Term Development Plan, 2000-2004).

3.2.4 Vegetation and Climate

The two districts are having relatively the same vegetation which is the Guinea Savannah type with short grasses and scattered wooden plants. Common trees include fire and drought resistant species like; baobab, dawadawa, Shea trees and acacia, it has a long dry season coupled with bush fires which reduces the vegetation cover and subsequently reduces rainfall in the area (Lawra District Composite Budget, 2013 and Nandom District Composite Budget, 2013). The climate of the Lawra and Nandom Districts is the tropical; continental type that is having a mean temperature of between 27ºC to 36ºC. The hottest months are February and April and the Maritime air mass blows over the area between April and October making the surrounding to experience a single rainfall regime (Lawra District Composite Budget, 2013 and Nandom District Composite Budget, 2013).

3.2.5 Agriculture Production

There is a forest reserve located in the north-eastern part of Lawra in between Lawra and Nandom, which is about 127 hectares out of which about 39.5 hectares have been converted into a protected area. Environmental degradation in the area is due to anthropogenic activities such as felling of trees for fuel wood and charcoal production, bush burning, inappropriate farming practices, soil erosion, overgrazing by livestock which leads to reduction in the vegetative cover and poor soil fertility. This made the government of Ghana through the Forestry Commission to set up a plantation in Dikpe, Tanchara, Naburyinye, Eremon-Dazuri, Zambo, Bazing, Lyssah, Eremon-Bure Eremon-Yara and Bonpare-toto communities (GSS Analytical Report, lawra & Nandom Districts, 2014).

3.2.6 Population Size

In the 2010 PHC, the total population of the Lawra District is about 89, 734 and is projrcted to be about 106,076 in 2013 consisting of 42,979 males and 63,097 females with a growth rate of 1.7 % (Lawra district composite budget, 2013). The population projection of Nandom district as at 2013 stands at 48, 609, which is made of 23,812 males and 24,797 females (Nandom District composite budget, 2013).

3.2.7 The Study Communities

This study was conducted in two districts of the Upper West region of Ghana, namely; the Nandom and Lawra Districts located in the extreme North western corner of the country. In each district, the study was conducted in one community. In Lawra, Tanchara community was studied and in Nandom, Ko community was studied (See Figure 3.1)

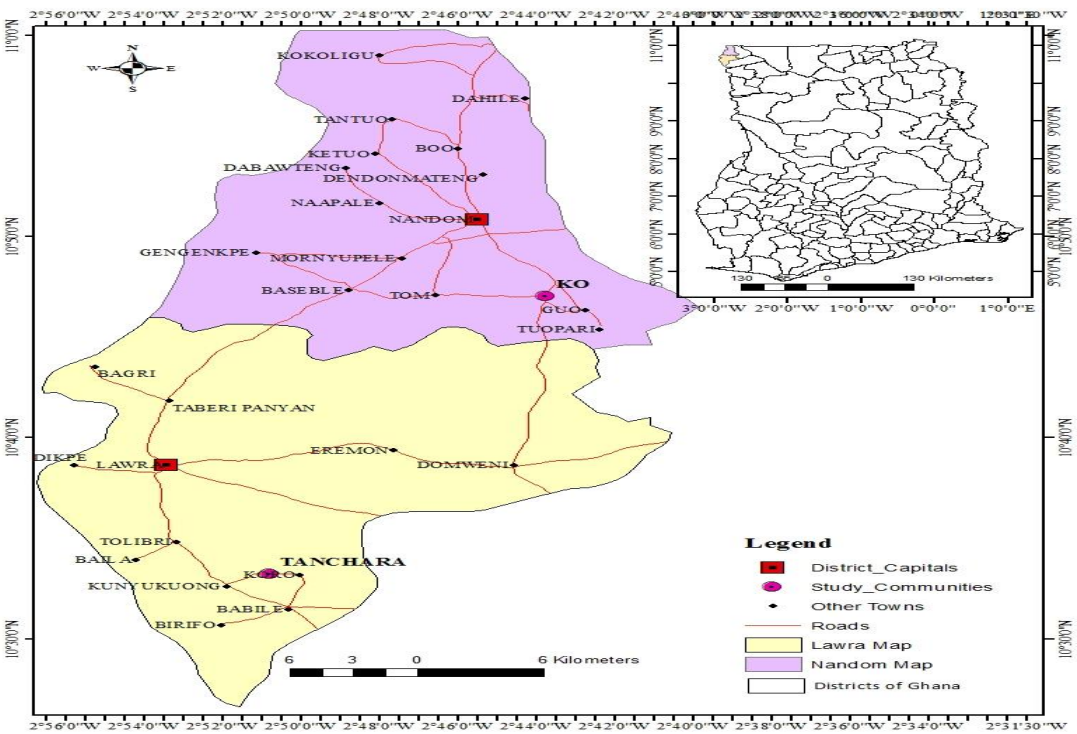

Figure 3.1: Map of the Study Area

Source: author's construct, August, 2017

3.3 Research Approach and Strategy

The study employed the mixed research approach. Thus, both quantitative and qualitative data were collected and analysed. "Mixing means either that the quantitative and qualitative data are actually merged on one end of the continuum, kept separate on the other end of the continuum, or combined in the same way between these two extremes and must be connected. Meaning mixing the qualitative and quantitative research are connected between the data analysis of the first phase of research and the data collection of the second phase of research …" (Creswell, 2009 pg. 208-209). The study used the concurrent mixed method for purpose of ensuring triangulation. This was used instead of sequential explanatory or sequential exploratory designs because it helps foster efficiency in the data collection process, complete understanding of the phenomenon under study and useful for cross-validation of findings. Notwithstanding that, several weaknesses have been observed with this approach, they include, more efforts and experts needed to carry out the two methods concurrently, and the difficulty involved in comparing the results of the two different methods and dealing with discrepancies as well. The study minimised the weaknesses of this approach through triangulation and this increased the study credibility due to the weaknesses in one of the approaches neutralized the other (Hussein, 2015).

The study seeks to understand the dynamics and trends in the types and sizes of farms for Sustainable Intensification Agriculture (SIA) Practices towards Climate Change Adaptation (CCA), Soil and water conservation management (SWCM) practices in Sustainable Intensification Agriculture (SIA) for adapting to Climate Change Adaptation, as well as the dynamics and trends in the types of crops and yields of smallholder farmers. Therefore, this

study adopted a cross-sectional and a historic research strategy. The combination of these strategies was found suitable for drawing past farming practices and analysing changes overtime.

3.3.1 Study Area Selection and Target Population

Purposive Sampling

The study districts and communities were chosen on purpose. These are the study districts and communities of the Sustainable Intensification Trade-Offs in Agriculture Management (SITAM) Project and the study benefited from this project. The study therefore adopted these communities on purpose. Each of these two communities has sub-sections and all sections were studied.

Target Population

The study targeted farming households at the community levels of the two districts. The targeted communities and respondents include Tanchara (Lawra) District farming households and Ko (Nandom) District farming households, opinion leaders and members of social groups (Youth and women groups). The sample population for this study were all farming households in Tanchara with ten (10) sections and all farming households in Ko with six (6) sections. Based on a listing process for the purpose of this study, a total 246 households were counted; Tanchara has one hundred and thirty-three (133) and Ko has one hundred and thirteen (113) (See Table 3.1)

Sources of Data

The study made use of both primary data and secondary data for the purposes of understanding previous studies in the subject area and for situating the study within existing theories, in gathering the quantitative data, a survey method was used involving non-probability and probability sampling techniques as indicated below. Data obtained from this source is basically primary. A case study approach was used in the form of non-probability sampling. Questionnaire was made in English language but administered in Dagaare and English when necessary.

Unit of Analysis

The unit of analysis is basically smallholder farmers' households. This comprises all the households who are into subsistence agriculture in the communities. The primary respondents were the household heads. In the absent of the head of household, the spouse is eligible for the quantitative section.

3.3.2 Three Generational Framework

The study adopted a three generational research approach to data collection and analysis. This framework identifies the following three generation of households; the grandfather's generation, the father's generation and the son's generation. The current generation being the son's generation which comprise the current heads of households and their households involved in farming. These are agriculture household heads who are between the ages of eighteen (18) years and thirty-five (35). Then the father's generation is the generation of the fathers of the current generation of household heads and their households. These are also farming households' heads who are between the ages of thirty-six (36) and fifty-nine (59).

The grandfather's generation is the grandfathers of the current generation/son's generation or the fathers of the fathers' generation. These are household heads who are sixty (60) years plus. The household heads of the fathers and the grandfathers' generations can either be dead or alive or retired.

The application of the intergenerational framework was appropriate because it enabled the study to give account of the historical and evolutionary perspectives of farming systems across the different generations of households. This helped to analyse the trend and dynamics in farming systems across generations. Issues on trend and dynamics included; type and sizes of farms and types of crops and yields level.

3.3.3 Methods of Data Collection and Analysis

Household Survey

Household survey was used to gather quantitative data from agricultural households. One interview as conducted in each of the household for statistical analysis of the results. This method was used because of cost effectiveness and the number of respondents involved. Even though respondents might be uncomfortable in answering questions and could therefore provide inaccurate answers, the researcher was able to obtain inform consent and was clear in asking questions

Sample Population

The study classified the sample population into two categories (Lawra and Nandom Districts). Considering the overall farming households' population in the area, there are about 1500 households in number. However, the total number of farming households in the

two selected communities were taken as the sample frame. This was done to reduce the sample population to fit logistics and resource constraints. There were 246 farming households identified in the two selected communities, thus Lawra (Tanchara) and Nandom (Ko) (See Table 3.1). The principal respondents were the household heads who satisfied the questions in the quantitative questionnaire because they are believed to have more knowledge about the household. A household head is a person who is in charge of the social, economic and spiritual needs of its members to some extend provides all the basic needs of the family. In the absent of the household head, any household member capable of given concrete details about their farming activities were considered to stand in for the principal household head but priority was laid on the spouses.

Sample Size determination

The sample is a fraction of the population to be used in a study. The term sample size is termed differently by many researchers but they all mean the same thing. It is seen as defining the number of subjects included in a sample. “Sample size is an important concept in statistics, and refers to the number of individual pieces of data collected in a survey and is important in determining the accuracy and reliability of a survey's findings” (Fergusson, et al., 2017).

In determining the Sample size, the sample size determination formula of Yamane (1967) was been used;

$$\boldsymbol{n} = \frac{\boldsymbol{N}}{\boldsymbol{1+N(e)^2}}$$ ……..……. Equation 1

Where n = Sample Size, N= Sample Frame, e^2 = error margin/confident level and 1=constant.

But given that; n=? N=246, 1=constant and the of confidence level of $\pm 5\%(0.05)\ thus\ 95\%$ precision

$$\boldsymbol{n} = \frac{\mathbf{246}}{\mathbf{1+246(0.05)^2}} \text{.....Equation 2}$$

$$\boldsymbol{n}\frac{\mathbf{246}}{\mathbf{1+246(0.0025)}} = \frac{\mathbf{246}}{\mathbf{1.63}} \text{..... Equation 3}$$

This implies that $\frac{\mathbf{246}}{\mathbf{1.63}}$ **= 150 Households**

Sampling Design

Ratio and proportion strategy (sampling fraction) were used to distribute the sample size among the two communities as well as the various sections within each community.

Table 3.1 Sampling Procedure

Districts/Communities	Sections	Number of Farming Households	Percentage Selected	Number of Households Selected
Lawra/Babile Tanchara	Tangpour/ Koro 3	13	10	8
	Dangne	18	13	11
	Deboziir	8	6	5
	Gbelinkaa	15	11	9
	Ko	11	8	6
	Koro 1	13	10	8
	Koro 2	13	10	8
	Susu	8	6	5
	Tanchara	21	16	13
	Tanchara Central	13	10	8
	Total	133	100	81
Nandom (Ko)	Naayir	20	18	13
	Baapere	15	13	9
	Bukong	13	12	8
	Zusog	10	9	6
	Peri	8	7	5
	Mhboroto	47	41	28
	TOTAL	113	100	69
Overall Total		246		

Source: Field Survey, January 2017.

The sample size was shared proportionally according to the number of households in each section of the communities. Final lists of respondents were obtained for the survey identifiable by compounds and household heads names. In all, Tanchara and Ko had 81 and 69 households respectively. Using the below ratio and proportion formula, $\frac{\mathbf{n}}{\mathbf{N}} \times 100$, Where n=Sample Population Size of each item and N=Overall Total Population. The sample size was distributed among the communities and sections (See Table 3.1).

Simple random sampling strategy was used to select the farming households for the study to avoid being bias. In random sampling, members of the sample population are in a manner whereby all are having equal chances of being selected, haphazard sampling is avoided due to the proper planning involved (Simon & Goes, 2012). In this, all the two (Tanchara and Ko) communities were mapped serially according to popular compound names and household heads names. Random sampling generator software from google play store was used to generate the sample. This selection was made purely by chance as stated in **(**Fox, et al., 2007**).**

Tools for Data Collection

The first phase was the collection of the quantitative data using structured questionnaire. Computer Assisted Personal Interviews were used (CAPI). The questionnaire was designed and built on an Open Data Kit (ODK) platform using SurveyCTO software and uploaded on smart mobile phones to for the survey. This was used because it is fast and convenient to use than any other tool in this study and avoided spending time in data writing and entering such as the use of Paper Assisted Personal Interviews (PAPI). The type of data was in quantity form. These were collected from the various farming households.

Data Analysis and Presentation

In the quantitative analysis, the responses were screened, coded and inputted into Statistical Package for the Social Scientists (SPSS) software and Microsoft excel. The analysis process made use of decretive statistics; chi-square test was done in non-parametric testing. The quantitative data in the study are presented in the form of tables and charts.

Multiple Household Case Study

Household in-depth study was used to gather basic information about Sustainable Agriculture Intensification from the individual households' level. On this note, "Case study is an empirical inquiry that focus on a contemporary phenomenon in its real-life context, it is used for investigating complex social phenomenon, use multiple sources of evidence, is descriptive and make use of qualitative" (Yin, 2013 pg. 1). Six (6) agriculture households were selected, three (3) each in Tanchara and Ko. However, the best three (3) households were considered afterwards for analysis. Two interviews were conducted in each household at a time. The reason for two interviews, thus; a household head and spouse to build one case was to fish out differences and similarities in responses in terms of males and female's context. Case study is deemed necessary in the intergenerational framework analysis and to get detailed understanding of SIA practices by smallholder farmers. This is because more than one case was used. Data collected were on the types and sizes of farms, types of crops and the yield level as well as soil and water management practices. All names used are not the real names of respondents.

Purposive sampling strategy was used to select households. This was appropriate because it was based two criteria; the age of the household heads, ages above forty-five (45) and on the

analysis of the Sustainable Agricultural Intensification (SAI) practices by the individual households' interviews on the survey conducted. This was determined by scatter plotting of the various households' practices in terms of economic, social and environmental sustainability. Individual personal interviews were conducted using interview guide. Here, qualitative data were collected and analysed. The data were presented in the form of narratives where quotations and paraphrasing were made on interested responses for emphasis purposes. Analysis was done based on thematic areas and contentment. The two responses from each respondent (household head and spouse) were synthesized to make one (1) case from a household.

Observation

Non-participant observation was used to collect data on the types of farms, types of crop grown and methods of soil and water conservation. This method was done in conjunction with the in-depth households' interviews where households' farms were visited. This method was deemed necessary to observe situations study participation described during interviews. This was to enable the researcher to give good description of the situation on the ground using the five senses (Erlandson et al., 1993).

Focus Group Discussions

Focus Group Discussions (FGDs) were conducted in Tanchara and Ko communities to get the general perspective of Sustainable Agriculture Intensification practices in the community level and to clarify ambiguous findings at the households' level. A focus group by definition is a kind of in-depth, open-ended group discussion which last between 1-2 hours that explore specific issues on a pre-determined and limited topic between the discussants and a facilitator

(Robinson, 1999). For that matter four (4) different exercises were carried out in the entire studies, two (2) each in Tanchara (Lawra) and Ko (Nandom). The participants were women (7 – 12 people) and men (7 - 12 people). This was done to establish differences and commonness in opinions from males and females on general perspective of sustainable intensification agriculture practices.

Discussants were purposively selected from each of the sections in each community. These were people who are noted as natural sectional leaders or sectional representatives in terms of community meetings. Two each were selected (a male and a female) from Tanchara community with ten (10) sections. The interest here was to gather qualitative data using this method. However, based on the listing process, Ko community with only six (6) sections, four (4) representatives were selected (2 males and two females) from each of the sections. The data collection was in a form discussion where the researcher was the facilitator. Open discussions were made using interview guide, responses were recorded and notes were taken. The recordings were transcribed, grouped according to themes to reflect the various research objectives. The males and females' responses were synthesized and presented in the form of statements where interesting responses were quoted and/or paraphrased. Data collected were types and sizes of farms, types and yields of crops and soil and water management practices.

Key Informant Interviews

Key informant interview method was used to gather concrete information from the individuals' level to support issues of interest from the previous exercises. "Key informant interviews involve interviewing a selected group of individuals who are likely to provide the needed information, ideas, and insights on a particular subject", they are selected because

they have information or ideas that the researcher needs and are applicable in qualitative study **(**Bernard & Bernard, 2012). Qualitative data were gathered using this method.

In the context of this study, twelve (12) respondents were purposively selected. Six (6) each in Tanchara (Lawra) and Ko (Nandom) communities. The participants took part in one interview each. They included the chief, traditional women leader (Maakazie), Tindaana (Earth Priest), Assembly member and youth leaders (male and female). This makes it flexibility to discover new unintended ideas that were not part of the initial planning stage. Clear information on issues in the past and present was given by these people because they have adequate knowledge about the subject matter. Individual interviews were conducted using interview guide. Voice recorder was used to record the interview proceedings upon the consent of the respondents to help the transcription process. These recordings were transcribed, synthesized and presented on thematic areas of the research alongside the data from the focus group exercises. Data were presented in the form of statements with quotations and paraphrasing. Differences and similarities were teased out from the focus group responses and the key informant interview responses. It was therefore analysed in supportive to the quantitative data. Embedded designs were used, that looks at consistency of patterns of evidence in all the units but within a case (Yin, 2013).

Data Validity and Reliability

Triangulation

The responses from the focus group discussion and the key informant interview sections were triangulated to ensure validity. Triangulation is a way of widening and deepening the understanding of the phenomenon under study and also to increase accuracy and measure

validity in which multiple methods in the qualitative way are employed to increase study credibility (Hussein, 2015). This study used triangulation because, it combines multiple and/or data sources to get a comprehensive understanding in the research for example using focus groups (FGs) and in-depth individual interviews (Carter et al., 2014).

Limitations of the study

The study was limited by the fact that; respondents were in difficulties to reflect and give responses to questions in the past. Estimation of farm sizes and crop yields were also difficult. Most of these cases were in the quantitative phase of the research. This was solved by means of triangulations, especially experience research assistants with good probing ability were engaged in the qualitative phase of the research.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents the results and analysis of data on sustainable Intensification Agriculture towards climate change adaptation among smallholder farmers in North-western Ghana. The chapter is structured in two major parts. The first part is a presentation of the data on the three major themes of the study; thus, the dynamics and trends in the types and sizes of smallholder farmers for adapting to climate change, soil and water conservation management practices among smallholder farmers for climate change adaptation and the dynamics and trends in the types of crops and yields. The second part of the chapter, presents discussions of the findings along same thematic areas.

4.2 Dynamics and Trends in Types and Sizes of Farms by Generation

The analysis on the dynamics and trends in the types and sizes of farmlands are presented based on three-generational historical accounts. Thus, the era of grandparents, the era of parents and that of the current generation of smallholder farming households. Specific cases are presented showing farmer-household findings of the dynamics and trends in types and sizes of farms across the three generations.

4.2.1 The Grandfather's Generation: Types and Sizes of Smallholder Farms

To analyse the types and sizes of farms in the grandfather's era, the data from Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) are presented and analysed first.

Thereafter, three household case studies are presented to highlight the types and sizes of smallholder farms associated with the generation.

In the grandfathers' generation, bush and valley farms were the commonest types of farms. The larger farms were the bush farms. They were estimated between two (2) to six (6) acres or more per household in the case of Tanchara and three (3) to eight (8) acres per household in the case of Ko. In Tanchara, valley field sizes were observed to range between one (1) to two (2) acres per a household. In Ko (Nandom), cultivated valley fields ranged between half (0.5) to two and half ($2^{1}/_{2}$) acres. Contrarily, eight (8) out of twelve (12) people asserted that bush fields were the larger cultivated farm types and sizes in the era of their grandfathers. They justified this during a Key Informant interview;

> *The bush fields were large by then because many of the farmers' crops were cultivated on it. The entire extended family members were cultivating together. Farm produce were shared equally to the various women periodically, say every month. The sharing was done according to the number of mouths each household feeds, so there was nothing like cheating (A Male KII, Ko-10th December, 2017).*

Another discussant aged 50 indicated this as follows;

> *In the past, valley farms were also common just that the sizes were not large as compared to the bush fields. This was limited by the area coverage of the valley stretch to about two (2) to four (4) acres on average to a household (A Male Discussant, FGD, Ko-12th December, 2017).*

In addition, in the grandfathers' era, smallholder farmers cultivated more than one type of farm. The reasons included the increased roles of the extended family system in agriculture production at the time, larger household sizes served as labour force in support of their farming activities, the desire for varieties of crops that cannot be cultivated on one type of farm. In a Focus Group discussion session, a discussant had this to say;

> *Many types of farms were cultivated at a time to get more crops to feed the large household sizes. Households' members were also having taste for many crop types of which all cannot be cultivated on one type of farm to give high yield. Some crops*

are having traditional importance to every household. For example, millet, (Pennisetum glaucum), yam (dioscorea spp), beans (glycine max), bambara nuts (Vigna subterranean) and groundnuts (Arachis hypogaea) are used for social purposes such as funerals, festivals and one cannot do without it. (A Male Discussant, FGD, Ko-13th December, 2017).

Farmers in the past were able to get early matured crops from the valley fields thus, they cultivate there first and also this reduce risk in terms of crops failure in seasons of less rain. The yields of crops from the valley were used to supplement yields from other types of farms to meet their food needs. Lastly, they were encouraged by the fertile nature of the soil which increases crops yields (A Female Discussant, FGD, Tanchara-5th December, 2017).

Generally, the responses show that, the aim of multiple farms was to increase the availability of foodstuffs throughout the year to be able to feed the many people that were found in various families under the extended family system in the past. In the case of Tanchara valley fields were cultivated in smaller sizes and limits of three (3) acres or less per household. Valley fields were tilled and early maturing food crops sown and harvested early to address food shortages. According to the discussants, the earlier cultivation of food crops in valley farms was to promote early development of crops in the cultivated valleys and prevent the food crops from being submerge in flood waters in heavy rainy season. The sizes of compound farms cultivated in this era ranged from two (2) to four (4) acres or less per a household. These sizes varied greatly with respect to the closeness of neighbouring houses. In many cases, there were communal extended family farming system but with separate households within. In this case the farm produce was shared to their women every month depending upon the rate at which they consume

To further deepen the analysis, three household case studies are presented. The case studies reveal the types and sizes of farms that were cultivated in the grandfather's generations of

smallholder farmers in the households' level. These cases include, the case of Zuuro household, the case of Chaara household and the case of Challa household.

Case 1: The case of Zuuro's household: Types and sizes of farms in grandfather's generation

Mr. Zuuro is a resident of Naayir, a section of Ko community in the Nandom District of the Upper West Region of Ghana. He has been into farming for the past sixty-five (65) years. He witnessed how farming activities that were carried out during his grandparents and parents' era which has equipped him well in his farming activities till date. His highest educational level is junior high school. His wife Yaale is fifty-seven (57) years old and also had a basic level education. The training he went through at his grandfather's time was extended family farming arrangements where his grandfather, father and his entire siblings were farming together. He has a household size of ten (10) after the collapse of the extended family system of agriculture when his grandparents and parents died. Out of the ten (10) households, four (4) are males and six (6) females. Two (2) of his children are currently in school and four (4) are not schooling. There are six (6) active members of his household who are capable of working on his farm, comprising; himself, his wife, two (2) of his children and two (2) of his daughter in-laws.

According to Mr. Zuuro's, bush fields were commonly cultivated during the time of his grandparents. All farmers cultivated larger sizes of farms in the bush farms than the valley farms by then. According Mr. Zuuro's, land preparation initially started earlier and planted late due to the raising of mounds for planting of food crops such as millet (*pennisetum glaucum*) and beans. In the case of old farms, stalks of millet (*pennisetum glaucum*) were removed from the mounds and crops residues gathered and burnt before making old mounds

loose. Farmers who needed to cultivate new field had to start land clearance in January, involving the cutting of trees, digging out grasses stocks and burning the materials. This is termed *"Pere"* in the local language. This was done to ease mounds making with hoes. He had this to say;

> *The farming that was done during my grandfather's time is very different from recent times. They used not to cultivate compound farms by then. These were places where domestic animals were grazing on and any attempt to cultivate there will expose the crops to animals' destruction. The concentration of farmers was much on the bush fields and the valley areas than the compound field* (*A Male Respondent, HHCS, Ko-16th December, 2017).*

That apart, valley fields were also cultivated in larger sizes. Smallholder farmers were able to expand the sizes of their farmlands through the efforts of the communal extended family system. According to Mr Zuuro multiple types of farmlands were cultivated by their grandparents due to the following reasons; one type of farm was not suitable for the cultivation of all crops varieties to meet household consumption needs, multiples farmlands was useful for creating crop diversification. The cultivation of multiple farmlands was meant to lessen hunger at the household's levels. In hunger periods, early maturing crops like maize (*Zea mays*) commonly cultivated in valleys farms were harvested and consumed as coping mechanism to periodic hunger. The study equally observed that the division of farmlands into plots were common in the generation of their grandfathers. However, the method of farming was predominantly mixed cropping.

Case 2: The case of Chaara's household: Types and sizes of farms in grandfather's generation

Mr. Chaara is fifty-five (55) years old farmer who resides in Dangne, a suburb of Tanchara community in the Lawra District of the Upper West Region of Ghana. He has attained a senior secondary school certificate. His wife, Zulo is a forty-five (45) years old woman, who

is a farmer but also engages herself in fashion designing as her main economic activity. He has a household size eight (8); three (3) males and five (5) females and six (6) of them are in school. Only two out of the six (6) are workers of his farm, thus his wife and himself. The trend and dynamics in the types and sizes of farms were traced from his grandfathers and fathers time to the current practices that he employs.

Mr. Chaara indicated that his grandfathers used to cultivate bush farms, compound farms and valley farms in the past. The bush field, the largest was about three and half (3.5) acres or more by then. The compound fields' sizes were about two (2) acres or more per a household. The valley field by then was like an acre. There was no crop failure on those fields especially the valley fields. He had this to say;

> *... I belief that the valley fields were more fertile than the other types of fields because the top soils that are washed down from the uplands are deposited at this area which increases it fertility all the time ... (A male Respondent, HHCS, Tanchara-10th December, 2017).*

Mrs. Zulo Chaara also affirms that, the place was fertile and early matured crops were cultivated annually in the valley fields. Given the fertile nature of the valley fields, Mr. Chaara recounted that good harvest was most obtained from the valley fields. However, smallholder farmers still cultivated multiple farms in the era of his grandfather. This Mr Chaara disclosed necessitated their desire to cultivate different varieties of food crops. At the same time, not all the crops could do well at one place. The fertility level of the lands varies from one farmland to the other, and suitable to the different crop's varieties cultivated at the time.

Case 3: The case of Challa's household - Types and sizes of farms in grandfather's generation

Challa is a seventy-four (74) years old farmer. He has two (2) wives; Menuo who is sixty-one (61) years old and Faala, a forty-four (44) year old woman. They all live together in Koro 3, a section of Tanchara in the Lawra District of the Upper West Region of Ghana. He had no formal education. His family size is fifteen (15); five (5) males and ten (10) females. Ten (10) of his children are in school. Out of the entire membership, only four (4) are active farmers. He has been a farmer in the community for more than sixty (60) years. He is conversant with the farming practices having been nurtured since his grandparents and parents time. He has both experiences of the past and the presence farming practices. Pertinent issues were gathered from his household on the dynamics and trends of the types and sizes of farms in sustainable agriculture intensification practices. Mr Challa gave narrative from the era of the grandparents to the current generation, highlighted issues on the transitional generation. Every indication shows that there are variations between the previous ways of farming and the present time which are presented below. Information taken from Mr. Challa household shows that, during his grandfather's time, they were cultivating two types of farms; bush farms and compound farms. Among these types, the compound field was not cultivated much as compared to the bush farm. It was the bush fields that were cultivated much to meet their crops needs. He had this to say;

> *... They were cultivating bush field and the size was about ten (10) acres or more. This farm was larger in the sense that, there was no competition for land and they can farm up to where their energy can support them up to ... (A Male Respondent, Tanchara-8th December, 2017).*

From the household's farming activities by then, it was deduced that, the reasons for cultivating more than one type of farm were; when food crops cultivated in the bush field failed crops from the compound farms are used to compensate as reported by the household

head. There were also more hands to support food crops cultivation under the extended family farming system. The farming practice then was primarily through the raising of mounds and all the crops were grown in the mixed form.

4.2.2 The Father's Generation: Types and Sizes of Smallholder Farms

The fathers' generation witnessed a shifting orientation from cultivating bush farms towards introducing compound fields. Thus, the commonest types of farms included bush farms, valley farms and compound farms. The sizes of bush fields started reducing in this generation. There were also valley fields in the era. The sizes of valley fields remained the same and crops cultivated in the grandfathers' era were still grown in this era. However, farms were not characterized by much sub-division into smaller farm plots. The division was done by few farmers who were practicing mono-cropping and cultivated crops such as groundnut/peanut (*Arachis hypogaea*), beans (*Glycine max*) and bambara nuts (*Vigna subterranean*) on the bush fields. This was influenced by the fertility level of the soil in those areas. Crops such as beans (*glycine max*) and millet (*Pennisetum glaucum*), as well as groundnuts (*Arachis hypogaea*) and bambara nuts (*Vigna subterranean*) were grown on mixed cropping bases because these crops do not need much nutrients to grow healthy to give high yields. This type of crops is also necessary.

For the purpose of deepening the analysis, the three household cases that were presented in the previous section will be continued. The focus here will be on the types and sizes of farms in the father's generation.

Case 1: Mr. Zuuro recounts on the types and sizes of farms in father's generation

In the era of his father, the pattern began changing from the previous farming practices. His father and siblings were cultivating together anyway but there were few cases where individual owned farms and still be part of the extended family communal farming. Meanwhile the same bush and valley farms were still cultivated. At the latter part of this stage of his experience in farming, the family started cultivating compounds farms but this was done by making gardens to prevent the crops from animal destruction. This was not new to them because they already knew that the compounds areas were meant for animals to graze on and nobody could be held responsible for any destruction in one's farm by animals. The sizes of these farms were not quite different from the era of the grandfathers as individuals started owning fields on their own and still being part of the extended family too.

According to the narratives of Mr. Zuuro during an interview session, farms types in his father's era were predominantly bush, valley and compounds fields. Smallholder farmers cultivated fewer compound farms in the case of Nandom (Ko). Though there were vast arable lands within the community, smallholder farmers cultivated portions lesser than the available lands. Farm sizes never exceeded four (4) acres. Smallholder farmers who desired to cultivate compound farms started making gardens around their settlements. Every household cultivate a compound field as revealed that;

> *"...This was also the time in which many households started abandoning bush fields, but a few were into it until recent times where smallholder farmers have abandoned cultivating on bush farms" (A Male KII, Ko- 13th December, 2017).*

The fathers' generation also witnessed a shift from cultivating bush farms to compound fields in the study area. The sizes of bush fields started reducing accordingly. There were also valley fields at that era. The sizes of valley fields were the same and crops cultivated in

the grandfathers' era were still grown in his father's era. However, multiple farms were not characterized by much division of plots. The division was done by few farmers who were practicing mono-cropping and cultivated crops such as groundnut/peanut (*Arachis hypogaea*), beans (*Glycine max*) and bambara nuts (*Vigna subterranean*) on the bush fields. Mono-cropping was influenced by the fertility level of the soil in those areas. Crops such as beans (*glycine max*) and millet (*Pennisetum glaucum*), as well as groundnuts (*Arachis hypogaea*) and bambara nuts (*Vigna subterranean*) were grown on mixed cropping bases because these crops do not need much nutrients to grow healthy to give high yields.

Case 2. Mr. Chaara recounts of the types and sizes of farms in father's Generation

According to Mr. Chaara, compounds farms; bush farms as well as valley farms were cultivated at the time of his father. The bush fields were more cultivated at the time also. Compound farms covered barely the entire lands belonging to various households and the average size of a field per household was about three (3) acres or more. To him, the decision to move away from tilling of bush farms started at this era. He added that, people were still cultivating larger bush farms but generally the interest was limited due to low soil fertility and the reduction in crops yield

They were also cultivating valley fields of similar sizes as that of their parents' time. At this time, gardens were cultivated by few households. These gardens were made at the compound field only during the wet season farming. Food crops such as yam and vegetables were cultivated. Some gardens were also made on valley fields that are closed to streams or stagnant waters that could last for long after the end of the raining season for dry season farming. However, such farm sizes were not up to quarter an acre. The main purpose of the

multiple farms is to protect and control lands they inherited from their fathers, to provide their households with green vegetables for sometimes, trade for income and to be able to feed the large family size members.

Case 3: Challa recounts on the Types and Sizes of Farms in Father's Generation

At the time of his fathers, interest on bush farms began reducing and attention was drawn on the cultivation of compound farms. However, bush farms according to him were still the main type of farm until the current era, where there was a complete disinterest for bush fields. The period was also characterized by reduced interest on the extended family farming system. It resulted to labour limitation for the cultivation of larger farm sizes. At the same, migration and relocation to the southern part of Ghana was paramount. Some of the extended family members migrated to the southern part of the country to engage in farming activities. This further compounded the issue of access to labour for agriculture production, as most of the family labour force have migrated. The effect was the cultivation of small farm sizes and finally the total neglect and disinterest of bush fields' cultivation. Compound fields were now becoming the main type of farm at the later part of his father's era.

4.2.3 The Son's Generation: Types and Sizes of Smallholder Farms

In the son's generation (current generation), the patterns of farmlands are predominantly compound farms, valley fields and gardens. For instance, whilst compound farmlands were previously regarded as grazing land in Ko, compound farms are now main. The cultivation of compound farms is not new in Tanchara of the Lawra district as these farms were cultivated during the grandfather and father eras. A Discussant revealed this during the Focus Group Discussion (FGD) sessions as follows;

> *In the past, bush and valley fields were dominating as in the era of our grandfather. The Compound fields were used as grazing grounds, one out of ten (10) farmers were cultivating home fields by then where gardens were made to prevent animals from destroying the crops but now compound farms are common and large (A Discussant, FGD, Ko-12th December, 2017).*

Bush fields are less cultivated in recent times. Almost all farmers in Ko and Tanchara indicated that, they have abandoned bush farms cultivation. Accordingly, few smallholder farmers cultivate it in a smaller scale compared to that of their fathers and grandfathers time. The change was observed to have been influenced by low soil fertility which manifest in low yields in annual productions and serving as a disincentive to bush farms. Smallholder farmers indicated that the average size of bush field is not more than two (2) acres per a household in a season. Just a few people are into bush fields' cultivation; mostly by those with inadequate home fields or without a valley field. Farmers can cultivate about two (2) to three (3) acres on their abilities to work on. Smallholder farmers further indicated that the modernisation of the family system and lifestyle has influenced the sizes of their farms. A discussant said this;

> *…in the past, there were many hands from the extended family line in supporting farming activities. Children were also helpful in farming but now almost every child is in school and return home late, making them unable to help their parents in farming. There is nothing to do about it; therefore, farmers cultivate the sizes that they can easily manage well (Male Discussant, FGD, Ko-14th December, 2017).*

Though most smallholder farmers have abandoned bush fields; the few into bush fields depend on tractor services to cultivate larger farms sizes especially in the case of Ko community. Currently, the minimum farm size per a household is about 0.2 acre and maximum of 22.5 acres of land among all the two areas with a standard variation of 3.7 acres. On district grounds, a standard deviation of 2.6 acres is for Tanchara and 4.6 acres for Ko. There is variation among the districts; while Tanchara is having minimum (about 0.8

acres) and maximum (about 10.5 acres), Ko, is having minimum (about 0.19) and maximum (about 22.5 acres). Currently, the average plot size in Tanchara and Ko are about 4.2 and 5.5 acres respectively while the average of the two districts is about 3.7 acres (See Table 4.1).

Smallholder farmers expressed interest to expand their valley fields in order to increase their production. However, this has been limited by the geographic extent of the valley. At least more than half ($^{1}/_{2}$) of the farmers are into gardening which are located far away from their homes, specifically along the valley. Garden sizes are small, less than half (½) an acre and not more than an acre. Most of those who cultivate gardens are the lucky ones who have shear of plots from the dugout irrigation facility, typically in Tanchara community and those who have valley plots closer to stream or stagnant waters. Farming in this area is of two types; cultivating in the wet seasons and in the dry seasons. The dry season is usually shorter, lasting between November to January for those non-dugout users and to February/March in the case the dugout users. Farmers have drastically reduced the cultivation of bush fields in this era. The decline in the cultivation of bush fields has been partly influenced by pest (monkey) destruction and the distance from their households' to their farms.

Table 4.1 Average farm size cultivated by households

	Lawra (acres)	Nandom (acres)	Total (acres)
Average	4.2	5.5	4.8
Std. Deviation	2.6	4.6	3.7
Minimum	0.8	0.19	0.2
Maximum	10.5	22.5	22.5

Source: Field Survey, June, 2017.

Among the current generation, farmers engage in multiple types of farms in the study area. This is due to many reasons including; the desire to cultivate many crops at a time but it is

not possible to grow all these crops at the same time. These multiple farms also come as result of fragmentation of lands which makes it difficult to get large farms at one place. It is also a way to secure them against crop failure in terms of bad weather and they also do that to maintain lands inherited from their forefathers.

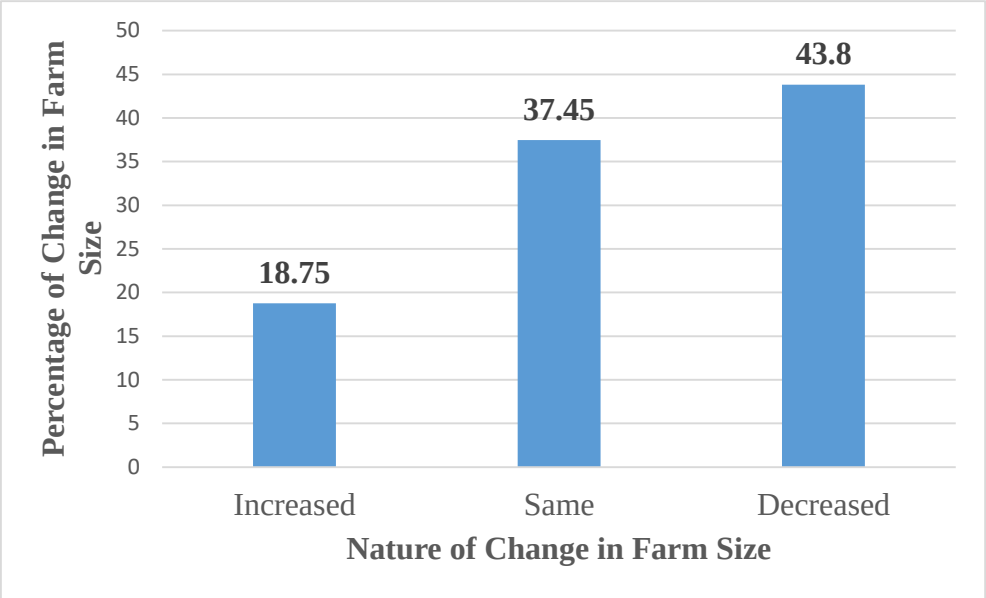

Figure 4.1: Change in Farm Size over the past Five (5) Years

Source**:** field survey, June, 2017

The survey results show that farmers (about 43.8%) reported a decline in their farm sizes over the past five years. On the other hand, farmers (about 37.45 %) said their farm sizes remain the same over the past five years (See Figure 4.1). This reduction is due to farmers abandoning the cultivation of bush fields with less competition to the cultivation of small and limited compound and valley farms with high pressure.

At this point, three household case studies are presented. For the purpose of deepening the analysis, the three household cases that were presented in the previous sections will be continued. The focus here will be the types and sizes of farms in the son's generation (the current generation of households). The cases include, Mr. Zuuro narrative in the

contemporary smallholder agriculture production in Tanchara. Mr. Chaara's observation of the smallholder farming practices in recent times as well as the experiences of Mr. Challa.

Case 1: The case of Zuuro's household on the Types and Sizes of Farms in Son's Generation

Mr. Zuuro in his effort to intensify agriculture production to adapt to climate change; unpredictable rainfall pattern coupled with reduction in soil fertility in the current era, has taken different paradigm but similar to the past eras of his grandparents and parents. Many other types of farms are added and managed by him and his household. These are; compound farm, valley farm and garden. This is what he said;

> *… Farming practices currently are very different from that of the previous practices by the past generations, now I manage a compound farm, valley farm and gardens but in the past, only bush and valley fields were managed by my parents and grandparents (A male Respondent, HHCS, Ko-14th December, 2017).*

Much concentration is now on the compound farms more than the other types of farms, particularly the bush field. Compound farm is the largest cultivated among all the types of farms that his household cultivates. The size initially was larger than now though they were not cultivated. It has been reduced due to division of the extended family system leading to shearing of farmlands. This new trend initially started during his parent time where the sizes declined after the demise of his father which led to the separation among them.

He cultivates on valley farm too which used to be larger but now small because of sharing of the arable lands among the family members. The reduction in the size of his valley field is also attributed to the conversion parts of his land for gardening for both wet seasons and dry seasons farming. This is done at portion of the valley field that is closer to stream or stagnant water. He draws water to irrigate the crops manually. Mr. Zuuro and his household does not cultivate any bush field; this farm was much cultivated at the time of his

grandfathers and fathers but gained less attention in the current era due to low fertility. This what he said;

> *… I do not cultivate bush farm because the land fertility does not support yield anymore. The land is not fertile and it is very far to carry compost and manure to fertilize it. Compost can be made on the farm but there is no water to water it in the dry season. I want to increase production but I do not have a bigger land at one place, so I have to farm piece-piece at available places … (A male Respondent, HHCS, Ko-15th December, 2017).*

He indicated the multiple crops do not do well on one type of farm, hence the need for multiple types of farms to be able to cultivate many different crop varities that are needed in his household. For example, groundnuts (*Arachis hypogaea*) cannot do well in valley areas but rice (*Oryza sativa*) can, so if he wants to farm both he has to get both water-log and upland areas to be able to attain better harvest. He said that, it is not possible that crops from all the types of farms can fail him in terms of bad weather such as low rainfall or too much rain. If the rainy pattern is poor but crops at the valley side can support his food needs to some extent.

Case 2: The case of *Chaara's household: Types and Sizes of Farms in Son's Generation*

In this current era, Mr. Chaara revealed that, the types of farms that he is cultivating are not too different from the time of his grandparents and fathers, except that, gardening is now the main farms unlike the past. The types of farms in his household recently are compound farms, valley farms and gardens. According to him, the dry season gardening is helpful with the current climatic situation. It gives his household extra income and helps improves his household's vegetable needs. The difference between the past and present types of farms, are the sizes of these farms and the dry season cultivation. The compound farm was about six (6) acres but this has reduced in recent times because of the desire for nuclear family

system. Mr. Chaara now cultivates only 1.5 acres of compound farm. He again owns a valley field which is about one and half (1.5) acres and two gardens; one was acquired after the construction of the community's dugout for dry season gardening and the other converted portion of his valley farm (See plate 4.1). He engages in gardening twice every year, in the wet and dry seasons.

Plate 4.1: A converted valley farm to garden

Source**:** Field Observation, Tanchara-5th December, 2017

According to Mr. Chaara, multiple farm types is useful for the cultivation of different crops varieties needed in his household. Mr. Chaara indicated that yield level reduces when multiple crops are cultivated on the same plot at the same time. The reason for multiple farms is that, some places have rich soil, others do not, and some places will yield better with little rain while others do not, so he wants them to avoid risk. Another reason is to increase the number of crops that he cultivates. In the current era, farmers further divide their farms for cropping purposes. This is due to the low level of soil fertility. The food is enough for him

and his family for the year and sometimes it is not, in such case, they resort to buying from the market through the sale of their farm animals and income from his wife's fashion works.

Case 3: The case of Challa's household: Types and sizes of farms in sons' generation

Mr. Challa's household only cultivates around his surroundings. According to him, the division of land among extended family members after the death of his father and his age limited farmlands size for food crops production. Mr. Challa siblings have started travelling to the southern part of the country to equally engage in farming activities in Techiman in the Brong-Ahafo Region for food crops cultivation, and the Sefwi area in the Western Region for cash crop cultivation particularly cocoa (*Theobroma cacao*) farming. Though there is vast arable land for food crops cultivation, Mr. Challa is unable to cultivate bush fields due to his age because he is not having strength anymore. Farm type is basically a compound farm. The size of the compound farm size ranges between four (4) to six (6) acres. His spouse said that;

> *… The reason why my husband stopped cultivating bush field is that, all the people who were cultivating there have stopped, so any time we farm our crop are predisposed to pest destruction, especially monkey will finish it all…. The reason why our household stopped cultivating there is that, all the youth in the various households have migrated to southern Ghana leaving my husband only who is old and can no more cover long distances to farm … (A Female Respondent, Tanchara 9th December, 2017).*

In his case, he has no multiple farms, however he has divided the farmland into plots to plant different crops. Mr. Challa indicated that his compound field is still larger because most of his siblings, brothers and sons are away from home and he possesses it alone.

The analysis on trends in types and sizes of farms reveals both similarities and variations between the three generations. In the grandfathers' era, the primary types of farms were bush farms and valley farms. The bush farms were the largest and the size of the valley farms too

were large. The bush farms were larger because; many of their food crops such as millet (*Pennisetum glaucum*), beans (*Glycine max*), peanuts/groundnuts (*Arachis hypogaea*), bambara nuts (*Vigna subterranea*) and sorghum (*Sorghum bicolor*) were grown there (Table 4.2). Labour was available and enough because households were larger in sizes and there was no competition for land. Valley farms were cultivated for harvesting early crop such as maize (*zea mays*). Compound fields were served as grazing grounds for livestock because farmers wanted their animals closer to them for proper care.

Table 4.2 types and sizes of farms by generation

Generation	Types of farms	Sizes of farms
Grandfather's Generation	Bush farms and valley farms	Large
Father's Generation	Bush farms, valley farms and compound farms	Medium
Son's Generation	Compound farms, valley farms and gardens	Small

Source: Field Survey, December, 2017

In the era of fathers, the primary types of farms were bush farms, valley farms and compound farms. The sizes of these farms were generally smaller than those of the grandfathers' generation. In the fathers' era, households reduced the sizes of bush farms and started the cultivation of crops on compound farms in addition to the rearing of livestock. Farmers reduced sizes of bush farms because of poor crop yields arising from poor soil fertility, inadequate rainfall and less availability of labour (See Table 4.2). By shifting their attention to smaller compound farms, farmers are able to improve soil fertility through the application of manure and compost which improves the moisture retention capacities of soil for supporting crop growth during dry spells and drought. In addition to compound farms,

farmers in this era maintained the cultivation of valley farms because they have better soil fertility and moisture retention capacities for supporting crop growth during droughts.

In the son's era, households have abandoned the cultivation of bush farms. In place of this, they are concentrating much on the cultivation of compound farms, valley farms and gardens. In general, farm sizes are smaller than the sizes of farms in the earlier generations (See Table 4.2).

The shift from larger bush farms to smaller compound farms is driven by the preference of farmers to practice some form of SIA such as the application of manure and compost, ridging and boundary bounds. Bush farms have over the years become unproductive and crop yields have been low mainly because of poor soil fertility. Poor soil fertility is also meant that water or moisture retention capacities of soils are low which fail to support plant growth during dry spells and droughts. The overall impact is that, a poor yield from bush farms is undermining food security among households. To address this problem, the current generation of farmers are concentrating on compound farms, valley farms and gardens, using SIA that enables them adapt food crop farming to climate change.

On the Compound farms, there is high fertility on the fields due to the availability and application of household waste and manure. The compound farms are small in size so that farmers are able to practice good agronomic management practices to increase production of food crops. The farms are around the houses; this reduces the distance between farms and homes. Composts made at homes are easily applied on these fields to increase soil fertility and yields.

Smallholder farmers also preferred valley farms in all the generations due to the availability of alluvial/flood plains. Eroded materials from the upland regions are deposited in these areas and thereby increase the soil fertility. Crop failure is not common on these farms because there is high soil moisture retention. Households harvest early matured crops from flood plans to support their food needs because these areas are cultivated first.

Preference for gardening is high in recent times because it is a way of promoting continuous cultivation. Farmers practice two (2) seasons of cultivation (wet and dry) to increase production and decrease vulnerability among farmers. Different types of crops are grown. In the wet season, cereals are grown while in the dry season; vegetables are cultivated to diversify their food and nutritional needs. Farmers are able to adequately apply organic fertilizers as a result of the small garden sizes. Farmers make use of dugouts, streams and wells to irrigate crops in the dry seasons. Farmers get supplementary income from the dry season gardening through the sale of the vegetables.

By focusing on smaller compound farms, farmers are better able to improve soil fertility through the application of compost and organic manure. This also improves the moisture and water retention capacities of the soil and thus improves the soil ability to support plant growth during droughts. The result is that farmers have improved yields from compound farms and this helps households meet their food needs; although deficits are common. By focusing on the cultivation of valley farms, farmers are also able to adapt food crop to climate variability. Valley farms are generally known to have more fertile soil and higher moisture and water retention capacities due to the presents of alluvial soil and the fact that the area is waterlog. This helps the crops survive during drought. As a result of better soil fertilities and

water retention of soils, yields from the valley farms are good and this helps to meet food needs of households.

Another strategy for SIA is the choice of gardens, particularly, in the valley fields. Famers are resorting to setting up gardens, both raining season and dry season gardens as part of the valley fields. This means that farmers are reducing the sizes of valley farms by converting portions into gardens. This support SIA in the following ways; firstly, by reducing the sizes of valley farms further, farmers are better able to practice sustainable water and soil conservation methods such as bunding, ridges, application of organic manure and compost and other improved farm management practices. Manure and compost are readily available at farmers' places of residents which are normally used to improve soil and water management on compound farms. Secondly, by setting up gardens as part of valley fields; farmers are better able to intensify the application of organic manure and compost for the production of vegetables and other crops. Furthermore, gardens enable all year round production, raining season and dry season production, another form of intensification. To support dry season gardening, farmers dig shallow groundwater wells from which they draw water to irrigate their crops during the dry season. Such all year round production has improved crop yields and incomes for supporting households' consumption. Thus, this is helping households better adapt agriculture to climate variability. Thirdly, there are other factors that support or reinforce farmers' choices for SIA in household production system. These include; the lack of labour, increased population demand for land for residential purposes and urbanization.

4. 3 Dynamics and Trends in Types of Crop and Yields by Generation

The data analysis and presentation reveal changes in types of crops and yields between different generations of smallholder farming households. First, data from in-depth interviews and focus group discussions are analysed and presented in a three generational perspective (grandfathers' generation, fathers' generation and current generation). However, data on the current generation are supplemented with results from the survey. This is then followed by a presentation and analysis on three household case studies.

4.3.1 The Grandfathers Generation: Types of Crops and Yields

Generally, leguminous crops, cereals, stem and root tubers and vegetables were grown during the grandparents' generation. The era was characterized by the cultivation of wide diversity of crops. These include millet (*pennisetum glaucum*), groundnuts/peanut (*Arachis hypogaea*), bambara nuts (*vigna subterranea*), beans (*vigna unguiculata*), guinea corn, maize (*zea mays*), rice (*Oryza Sativa*), beans (*Glycine max*), sorghum (*sorghum bicolor*), yam (*dioscorea spp*), aerial yam (*Dioscorea Bulbifera*), potatoes (*solanum tuberosum*) and vegetables such as pepper (*Capsicum*), okra (*abelmoschus esculentus*) and pumpkin leaves (*cucurbita spp*). All the above were local or indigenous crop varieties. Aside these crops, there were some typical traditional crops that were grown in this era. This is what a fifty-six (56) year old farmer said during a key informant interview session;

> *… The types of crops in the grandfathers' era include but not limited to Dawuli and Be-luri; kinds of legume crops that were harvested after Chris mass is celebrated and some type of legumes called "kubara", harvested before Christmas, yam (dioscorea spp), millet (pennisetum glaucum), and maize (zea mays) called "zeze", these crops take longer time to mature … (A Male Respondent, KII, Ko-14th December, 2017).*

The crops outline above were grown on different types of farms according to the soil fertility level, nature of the landscape and the soil type. They include but not limited to millet (*pennisetum glaucum*), groundnuts (*Arachis hypogaea*), bambara nuts (*vigna subterranea*), guinea corn (*sorghum bicolor*), beans (*glycine max*), sorghum (*sorghum bicolor*), yam (*dioscorea spp*), aerial yam (*Dioscorea Bulbifera),* potatoes (*solanum tuberosum*) and vegetables such as pepper (*Capsicum*). The yield situation was good by then. The yield was enough for their consumption and even with surpluses which were not sold. A key informant had this to say;

> *… On the bush fields', traditional crops such as groundnuts (Arachis hypogaea), millet (pennisetum glaucum), beans (glycine max) and Bambara nuts (vigna subterranea), "Dawuli", "Be-luri", "zeze", "kubara", aerial yam (Dioscorea Bulbifera), potatoes (solanum tuberosum) and yam (Dioscoera Spp) were grown there … (A Male Respondent, KII, Ko-14th December, 2017)*

Generally, in both communities, Tanchara and Ko, the sizes of bush fields were large by then. In this type of field, groundnuts (*Arachis hypogaea*) are normally mixed with other crops like; millet (*pennisetum glaucum*) and groundnuts (*Arachis hypogaea*) or beans (*glycine max*), groundnut (*Arachis hypogaea*) and bambara nuts (*Vigna subterranea)* together. Farmers reported that maize (*zea mays*) was not planted on the bush farms because pest like monkeys will destroy them. The yield situation on this farm was good.

There were valley fields too where farmers were growing crops such as yam (*dioscorea spp*), maize (*zea mays*), rice (*Oryza Sativa*), potatoes (*solanum tuberosum*) and vegetables in the form of okra (*Abelmoschus esculentus*), pepper (Capsicum), pumpkin leaves (*cucurbita spp*) and tomatoes (*lycopersicon lycopersicum*). All these crops were indigenous varieties but the

yield was good meanwhile farmers were not applying fertilizer because the soil fertility was high.

On the Compound farms, it was reported in Tanchara in a focus group session that; ground nuts (*Arachis hypogaea*), bambara nuts (*vigna subterranea*), millet (*pennisetum glaucum*), beans (*Glycine max*) and sorghum (*sorghum bicolor*) were cultivated. About 10/12 of the respondents in the key informant session asserted that;

> *Even some people can provide a three-year-old cereal when needed and this shows how great a farmer is (A Male Respondent, KII, Tanchara-December, 2017*).

In Ko, there were no compound farms by then. Those who used to cultivate on these types of farms were getting high yields. The crop varieties grown were basically indigenous type. On the reason why, farmers were growing indigenous crops varieties, a farmer made this remarks in a focus group discussion;

> *There was nothing like improved crop varieties in the past, only the local varieties were available because they were not having any problem with the yields. They used to get enough from whatever they cultivate. There was adequate rainfall and nutrients level in the soil by then (A Male Respondent, FGD, Tanchara- 9th December, 2017).*

In many cases they even get surpluses which were normally not for sale. The surpluses were stored for household consumption with minor sales till it gets finished. Until the old ones get finished farmers do not start to consume the new harvest. Sometimes the surplus is exchanged for other products that the household is not having under the barter system. It was not common to see someone selling his/her surpluses. In a focus group session, a discussant said that;

> *… The surpluses were not sold but crop like groundnuts were sold at funeral grounds by women because traditionally groundnut is served as food to mourners on funeral grounds. If the bereaved families do not have, mourners can buy from them to sustain themselves. They used to feed on the old food until sacrifices are made to usher them into the*

> *consumption of new farm produce ... (A Female Discussant, FGD, and Tanchara-10th December, 2017).*

Other uses of these surpluses were; giving produce to people who are in need of it to farm in returns, for sale in the market to buy farm implements like hoes and cutlasses and keeping surpluses for over years to show how great a farmer is (prestige). This is what a sixty-five (65) years old experienced farmers had to say in a focus group discussion;

> *The yield was better and we were able to feed on our own produce up to the next harvesting season. Most farmers do not usually sell the surplus but some crops like beans (Glycine max) and groundnuts (Arachis hypogaea) were sold to buy hoes and cutlasses. At times some produce is given as loan to others and the owner to get a reciprocal benefit through farming in returns (A Male Discussant, FGD, Ko-December, 2017).*

The high yield was attributed to the availability of many cattle of which the droppings were used to fertile the land. The rainy season too was longer than now. In many cases, the surpluses were kept as a prestige among farmers; a farmer who can produce more than two-year-old grains when needed is a great farmer and powerful man.

At this point the story of Mr. Zuuro's households, Mr. Chaara;s household and Mr Challa's household are narrated on what the situation on the types crop and yields of crops in their grandfather's time looked like. This is a continuation of the household case studies from the previous presentations.

Case 1: The case of Mr Zuuro's household: Types of Crops and Yields in the Grandfathers Generation

It was clearly indicated that; in his grandfathers' era farmers were growing cereals, legumes, root and tuber. For example, guinea corn, groundnuts/peanut (*Arachis Hypogaea*), bambara nuts (*Vigna Subterranean*), sorghum (*Sorghum Bicalor*), yam (*Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*) and beans (*Glycine Max*) were commonly grown during the time of the grandfathers. Mr. Zuuro indicated that the types of

farms during his grandfather's time is quite different from recent times. They used not to cultivate around the houses, these were places that their animals were grazing on and any attempt will expose the crops to animals' destruction. Bush farms and valley farms were the common type of farms these crops were grown on.

On the bush farms where many farmers were cultivating used to be good for majority of their crops like; millet (*Pennisetum Glaucum*), groundnuts/peanut (*Arachis Hypogaea*), beans (*Glycine Max*), bambara nuts (*Vigna Subterranean*), yam (*Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*) and potatoes (*Solanum tuberosum*) were grown here. Mixed cropping was done mostly in the pattern as; millet (*Pennisetum Glaucum*) and beans (*Glycine Max*); the millet (*Pennisetum Glaucum*) which mature late are planted on top of the mounds and the beans (*Glycine Max*) that mature early are planted on sideways of the mounds. After harvesting the beans (*Glycine Max*), mulching is done on the base of the millet (*Pennisetum Glaucum*) for healthy growth and production. Bambara nuts (*Vigna Suterranean*) and groundnuts/peanut (*Arachis Hypogaea*) were planted together on flat grounds, while mounds were raise to plant yam (*Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*) and sometimes with maize. The yield was good meanwhile they were not applying fertilizer to their crops, their time cannot be compared with this time around at all.

On the valley farms; yam (*Dioscorea Spp*), aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*), rice (*oryza Sativa*), maize (*Zea Mays*) and sometimes vegetables (just for household's consumption) were cultivated. Vegetable crops in the form of okra

(*Abelmoschus Esculentus*), pepper (*Capsicum*), tomatoes (*Lycopersicon Lycopersicum*) were cultivated. This is what the households spouse had this to say;

> *The planting pattern was; rice (Oryza Sativa) and maize, yam (Dioscorea SPP), aerial yam (Dioscorea Bulbifera) and Potatoes (Solanum tuberosum) all together on one farm. In the dry season when yam (Dioscorea Spp) is no more available, the potatoes (Solanum tuberosum) and aerial yam (Dioscorea Bulbifera) are substituted to satisfy their food needs. The land preparation here is done when the raining season is about to set in. Mostly, people undertake activities on this type of farm late but first to cultivate in the sense that, the place is valley which gets moist with any little rain as compared to the upland. People get early harvest from this type of farms (Household Head's Spouse, HHCS, Ko-14th December, 2017).*

All these crops were purely the indigenous varieties. They were not familiar with the growth of improved varieties of crops because the yield was enough for them. The general yields situations for these types of crops were good and sufficient for the various households' consumption and even with some surpluses. The surpluses were kept and fed on, until it gets finished, they do not start consuming the new produce even after sacrifices are done to give way for taking new crops. On the issue of yields this is the words of the household head;

> *…. The yield was very good; they can even cultivate a small farm anywhere but get more yields. Their days were not like our time in which farmers cultivate large farms but might not get enough. For now, it is a probability in getting profit from one's farm activities. They consumed their own food produced throughout the year and some were even left which were kept to feed on till it gets finished. Agricultural produce was for major consumption with minor sales … (A Male household head, HHCS, Ko-14th December, 2017).*

Case 2: The case of Mr. Chaara's household: Types of Crops and Yields in the Grandfathers Generation

Generally, Mr. Chaara indicated that during his grandfather's time cereals, legumes, roots and tubers and vegetables were cultivated. These crops notably were; groundnuts/peanut (*Arachis Hypogaea*), bambara nuts (*Vigna Subterranean*), maize (*Zea Mays*), millet (*Pennisetum Glaucum*), sorghum (*Sorghum Bicolor*), rice (*Oryza Sativa*), cowpea (*Vigna Unguiculata*), yam *(Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum*

tuberosum), okra (*Abelmoschus Esculentus*), pepper (*Capsicum*), garden eggs (*Solanum Melongena*), pumpkin (*Cucurbita SPP*) and tomatoes (*Lycopersicon Lycopersicum*). In the grandfathers' era, farmers used to grow majority of these crops on the bush farms because that was the most cultivated type of farm than any other. Millet (*Pennisetum Glaucum*), bambara nuts (*Vigna Subterranean*), cowpea (*Vigna Unguiculata*), yam (*Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*) and groundnuts/peanut (*Arachis Hypogaea*) were crops grown on the bush farms. The bush fields were having high fertility level leading to high yields.

Another basic type of farms cultivated in this era were valley fields. These fields were having enough nutrients which supported crops growth and production. On the valley fields, rice (*Oryza Sativa*), maize (*Zea Mays*), yam (*Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*) and potatoes (*Solanum tuberosum*) were usually cultivated. The cultivation of compound fields was not common in this era but just a few do engage in it, especially in the Tanchara community. For example, millet (*Pennisetum Glaucum*), guinea corn and groundnuts/peanut (*Arachis Hypogaea*) were grown here. There were high yields because the fertility was high. In this era, his grandfathers could feed on their own produce throughout the year with surpluses. These surpluses were kept to feed on with minor sales in extreme cases. All cultivated crops were basically the local/indigenous varieties. Thus, farmers were cultivating more of the indigenous crops' varieties. Farmers' awareness on the cultivation of improved varieties was very limited and farmers were having no problem because they were not experiencing low yield.

Case 3: The case of Mr. Challa's household: Types of Crops and Yields in the Grandfathers Generation

The story from Mr. Challa's household show that, during his grandfather's time, the basic crops were, millet (*Pennisetum Glaucum*), sorghum (*Durra sorghum bicolor*), bambara nuts (*Vigna Suterranean*), yam (*Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*), groundnuts/peanut (*Arachis Hypogaea*), white beans (*Glycine Max*) and potatoes (*Solanum tuberosum*) as well as vegetables in the form of okra (*Abelmoschus Esculentus*), pepper (*Capsicum*), pumpkin leaves (*Cucurbita spp*), garden eggs (*Solanum Melongena*) and tomatoes (*Lycopersicon Lycopersicum*). These were planted on bush farms and compound farms only.

The bush farm was the major type of farm by then and most of their crops were grown there. The common crop types on this type of farm included; millet (*Pennisetum Glaucum*), sorghum (*Durra sorghum bicolor*), cowpea (*Vigna Unguiculata*), groundnuts/peanut (*Arachis Hypogaea*), bambara nuts (*Vigna Suterranean*), yam (*Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*) and maize (*Zea Mays*). According to him, his grandfather could depend on his own food crops until the next harvesting season, if some remain, they sell it and use the money to buy new ones to keep, thus if the current harvest is not much. In some cases, crops are sold to buy other crops that the household do not have. All these crops were virtually the local/indigenous varieties they used to grow.

The compound field was less cultivated because many of their crops were cultivated on the bush farms. On the compound field, millet (*Pennisetum Glaucum*), yam (*Dioscorea spp*), groundnuts/peanut (*Arachis Hypogaea*), bambara nuts (*Vigna Suterranean*) and white beans

(Glycine Max) were grown. This is what he had to say about the types of crops grown on the compound field during his grandfather's time;

> *... Groundnuts/peanut (Arachis Hypogaea), millet (Pennisetum Glaucum), sorghum (Durra Sorghum bicolor), beans (Glycine Max) intercropping with millet (pennisetum glaucum), yam (Dioscorea SPP) and potatoes (Solanum tuberosum) were planted together on the same plot ... (Household Head, HHCS, Tanchara-10th December, 2017).*

4.3.2 Types of Crops and Yields in the Father's Generation

This era also experienced the same types of crops just as in the grandfathers' era. Leguminous crops, cereals, roots and tubers and vegetables that were grown in the grandfathers' era were also grown by the fathers' generation. The general crops in this era were; groundnut/peanuts (*Arachis hypogaea*), millet (*pennisetum glaucum*), maize (*zea mays*), sorghum (*sorghum bicolor*), rice (*Oryza Sativa*), cowpea (*vigna unguiculata*), yam (*dioscorea spp*), aerial yam (*Dioscorea Bulbifera*), potatoes (*solanum tuberosum*), bambara nuts (*vigna subterranea*) and vegetables such as tomatoes (*Lycopersicon lycopersicum*), pepper (Capsicum), onion (*allium cepa*), okra (*abelmoschus esculentus*), beans leaves (*glycine max*) and pumpkin (*cucurbita spp*). These crops were grown on specific types of farms, like in the compound farms, bush farms, and valley farms.

Crops of different varieties were grown on bush farms which were the largest type of farm among all the other types of farms. Some of these crops were; millet (*pennisetum glaucum*) ground nuts/peanut (*Arachis hypogaea*), bambara nuts (*vigna subterranea*) and beans (*glycine max*). All these crops were local/indigenous crops varieties with high yield. The yields were enough for the consumption needs of many farming households and even with surpluses at the end. In Ko, it was clear that. guinea corn (*bicolor*) and Sorghum (*sorghum bicolor*) known in the local dialect as *"dawole"*, the late millet (*Pennisetum glaucum*) called

"zea", maize (*zea mays)*, beans (*glycine max*) called *"susuli";* very black in nature, bambara nuts (*Vigna subterranea*), sorghum (*sorghum bicolor*), yam (*dioscorea spp*), aerial yam (*Dioscorea Bulbifera*), cowpea (*Vigna unguiculata*), millet (*Pennisetum glaucum*) and groundnuts/peanut (*Arachis hypogaea*) were grown. In a focus group discussion session, a fifty-five (55) year old man had this to say;

> *... The era of our fathers was dominated by the cultivation of certain types of traditional crops like yam (dioscorea spp), aerial yam (Dioscorea Bulbifera) called "wonkanpore", sweet potatoes (solanum tuberosum), maize (zea mays), rice (Oryza Sativa), potatoes (solanum tuberosum) called "peare" were grown ... (A Male Discussants, FGD, Ko-10th December, 2017).*

Another type of farm at this era was the cultivation of valley farms where yam (*dioscorea spp*), aerial yam (*dioscorea bulbifera*), potatoes (*solanum tuberosum*), rice (*Oryza Sativa*), maize (*zea mays*), garden eggs (*solanum melongena*) and okra (*abelmoschus esculentus*) were planted. A male discussant had this to say in a focus group session;

> *... Early maize (zea mays), millet (pennisetum glaucum) and okra (Abelmoschus esculentus) were mainly grown here. These crops were chosen because other crops such as ground nuts/peanut (Arachis hypogaea), bambara nuts (Vigna subterranea) and beans (glycine max) are not suitable for water-logged areas. Maize (zea mays) yield was about three (3) bags or more, millet (pennisetum glaucum) about two (2) bags. There were crops traditionally grown by men and women in the past. Millet (pennisetum glaucum), maize (zea mays) and beans (glycine max) were grown by men and women Pumpkin (cucurbita spp) and okra (Abelmoschus esculentus) … (A Male Discussant, FGD, Tanchara-10th December, 2017).*

The yield was good as compared to now. About 10/12 of the key informants in interview sessions shared the same idea that, Valley fields are suitable for the growth of maize (*zea mays*), rice (*Oryza Sativa*), yam (*dioscorea spp*), aerial yam (*Dioscorea Bulbifera*), guinea corn (*sorghum bicolor*), potatoes (*solanum tuberosum*) and tomatoes (*lycopersicon lycopersicum*) and the yields were better by then.

Compound farms cultivation was also introduced by this generation. Some crops that were grown on the compound farms included; millet (*pennisetum glaucum*), maize (*zea mays*) and some vegetables, this is what a respondent said this in a focus group discussion session;

> *… In our fathers' time, millet (pennisetum glaucum), maize (zea mays) and vegetables such as okra (abelmoschus esculentus), pumpkin leaves (cucurbita spp) and pepper (Capsicum) were grown on the compound fields. The vegetables could be sold but the main purpose was for home consumption only … (A Female Discussant, FGD, Tanchara-11th December, 2017).*

Pepper (*Capsicum*) was cultivated on a separate plot on the compound fields. The reason for this was that, pepper (*Capsicum*) needs a lot of air and enough moisture to grow well putting it together with other crops will reduce the yields. The general yield was good. In specific terms; an average farmer can get maize (*zea mays*) about two (2) bags and yam (*dioscorea spp*) about four hundred (400) to two thousand (2000) tubers.

The general yield during this era was enough for farmers' households' consumption with surpluses which were sold and the proceeds re-invested into the farming activities in the following season. Some people do not sell their left-overs at all. A respondent said;

> *The yield was sufficient enough for many farmers such that, there were surpluses which were kept mainly for specific traditional performances like funeral, sacrifices and serving visitors who visit a household (A Male KII, Tanchara-9th December, 2017).*

In a similar way, a discussant had this to say on the yield situation during this era in a focus group discussion in Ko;

> *… The yields during the time of our fathers were good as compared to now because the land was fertile to extend that any small plot cultivated gives high yield. They can depend on their own food for the whole year with surpluses. These surpluses were bartered with food items that the households do not have… (A Male Discussant, FGD, KO-12th December, 2017)*

At this point, I shall present the three case studies highlighting the type of crops and the nature of the yield in their fathers' era. These households are; Mr, Zuuro, Mr. Chaara and Mr. Challa's households.

Case 1: The Case of Mr. Zuuro's households; Types of Crops and Yields in the Father's Generation

Generally, the story of Mr. Zuuro household revealed that cereals, legumes, tubers and vegetables related crops were grown in his father's era. The typical crops include; guinea corn, groundnuts/peanut (*Arachis Hypogaea*), millet (*Pennisetum Glaucum*), bambara nuts (*Vigna Unguiculata*), sorghum (*Sorghum Bicolor*), yam (*Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*) and soya beans (*Glycine Max*) and some vegetables like okra (*Abelmoschus Esculentus*), pumpkin leaves (Cucurbita SPP), tomatoes (*Lycopersicon Lycopersicum*) and Pepper (*Capsicum*). These crops were grown across the various types of farms depending on the ability of the soil to support crops growth. Bush farms were still dominant at this time and still contained many of their major crops. Crops such as groundnuts/peanut (*Arachis Hypogaea*), bambara nuts (*Vigna Suterranean*), millet (*Pennisetum Glaucum*) cowpea (*Vigna Unguiculata*), yam (*Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*) and potatoes (*Solanum tuberosum*) are commonly plant here.

On the compound farms which cultivation started gradually during the grandfathers and fathers' eras, basically, groundnuts/peanut (*Arachis Hypogaea*), bambara nuts (*Vigna Suterranean*) were cultivate on a small scale. Yam (*Dioscorea spp*), aerial yam (*Dioscorea Bulbifera*) and potatoes (*Solanum tuberosum*) were cultivated by making compound gardens to prevent animal destruction because these crops are grown very early in the planting season. Crop yields at this type of farm were very good. Valley fields that were cultivated

during the grandfathers' time are still being cultivated in his fathers' time. Crops in the form of yam (*Dioscorea spp*), aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*), rice (*Oryza Sativa*) and maize (*Zea mays*) were grown. They mixed either maize (*Zea mays*) or rice (*Oryza Sativa*) with yams (*Dioscorea spp*) and aerial yam (*Dioscorea Bulbifera*). The rice (*Oryza Sativa*) or maize (*Zea Mays*) were planted in between the mounds spaces. There was very good yield at this field. These primary crops were all the local varieties. This is what Mr. Zuuro said on yields and food sufficiency at the time;

> *In this era, the lands were very good in terms of fertility to plant crops. The yields were very good and households were able to meet their consumption needs with surpluses. These surpluses were sold to pay children school fees, to support farming in the next season and for traditional activities such as funerals and sacrifices (Head of Household, HHCS, Ko-14th December, 2017).*

Case 2: The Case of Mr. Chaara's Household; Types of Crops and Yields in the Father's Generation

During the fathers' time, the type of crops cultivated were not much different from that of the grandfather generation. The dominant type of crops grown on these types of farms were; millet (*Pennisetum Glaucum*), maize (*Zea Mays*), groundnuts/peanut (*Arachis Hypogaea*), bambara nuts (*Vigna Subterranean*), yam (*Dioscorea SPP*), sorghum (*Durra Sorghum bicolor*), okra (*Abelmoschus ESculentus*) and pepper (*Capsicum*). The yields were good by then. The type of farm common in this era was bush farms. Crops such as cowpea (*Vigna Unguiculata*), groundnuts/peanut (*Arachis Hypogaea*), bambara nuts (*Vigna Subterranean*), maize (*Zea mays*) and millet (*Pennisetum Glaucum*) were grown on the bush fields. At this time the number of crops on this field reduced because their attention on bush farms decreased. This era also continued the cultivation of valley fields where crops such as millet (*Pennisetum Glaucum*), sorghum (*Durra sorghum bicolor*) and cowpea (*Vigna Unguiculata*)

were planted on raised mounds. Yam (*Dioscorea spp*) were cultivated with aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*), sometimes rice (*Oryza Sativa*) or maize (*Zea Mays*) in between the yam (*Dioscorea spp*) mounds. If the area is too water-logged, rice (*Oryza Sativa*) is preferable and if it is less water-logged, maize (*Zea Mays*) is opted for, sometimes millet (*Pennisetum glaucum*) were grown but groundnuts/peanut (*Arachis hypogaea*) and bambara nuts (*Vigna Suterranean*) were not grown on valley fields because the place is muddy.

Case 3: The Case of Mr. Challa's Household; Types of Crops and Yields in the Father's Generation

In the fathers' era, farming activities carried out were not quite different from that of his grandfathers' time. On the compound farm, sorghum (*Durra sorghum bicolor*), bambara nuts (*Vigna Suterranean*), yam (*Dioscorea spp*), groundnuts/peanut (*Arachis Hypogaea*), millet (*Pennisetum Glaucum*), white beans (*Glycine Max*) and potatoes (*Solanum tuberosum*) and aerial yam (*Dioscorea Bulbifera*) were grown. There were good yields during this time. The concentration on bush fields started fading out for compound farms. On the bush farm, millet (*Pennisetum Glaucum*), sorghum (*Durra sorghum bicolor*) and beans (*Glycine Max*) only were grown. The yields at the bush field was good but it was not up to the grandfathers' time. He said they were able to feed the household with their own food for the whole year. There were surpluses which were sold for income and also for performing traditional rites such as funerals and sacrifices.

4.3.3 Types of Crops and Yields in Grandson's Generation

Many farmers in the current generation according to Key Informants and Focus groups discussants usually cultivate cereals, legumes, roots and tubers as well as vegetables. These

crops include; millet (*pennisetum glaucum*), rice (*Oryza Sativa*), maize (*zea mays*), soya beans (*Glycine max*), groundnuts/peanuts (*Arachis hypogaea*), bambara nuts (*vigna subterranea*), cowpea (*vigna unguiculata*), yam (*dioscorea spp*), aerial yam (*Dioscorea Bulbifera*), sweet potatoes (*solanum tuberosum*) and potatoes (*solanum tuberosum*). Farmers also cultivate vegetables in the form of pumpkin (*cucurbita spp*), carrot (*Daucus carota*), onion (*allium cepa*), cabbage (*brassica oleracea*), tomatoes (*lycopersicon lycopersicum*), pepper (*Capsicum*) and okra (*abelmoschus esculentus*). The survey had it that averagely, about 94.3% of smallholder farmers cultivate maize (*zea mays*), about 91.3% cultivate groundnuts (*Arachis hupogaea*), about 61.9% cultivate millet (*Penninsetum glaucum*) and about 13.7 % cultivate vegetables. There are variations in percentages among the two districts. In Tanchara about 98.8%, 91.4%, 71.6% and 2.5% of smallholder farmer's households cultivate maize (*zea mays*), groundnuts/peanuts (*Arachis hupogaea*), millet (*Penninsetum glaucum*) and the least crop cultivate is rice (*oryza stiva*) respectively. On the other hand, in Ko (Nandom) community, about 89.9% of smallholder farmers cultivate (*zea mays*), groundnuts/peanuts (*Arachis hupogaea*) 91.3% and millet (*Penninsetum glaucum*) 52.2% and the least crop cultivate is vegetable representing about 10.1% (See Table 4.3). Reference to the above, these crops are grown by farmers on different fields' altogether, depending on the type of crop and the nature of soil that is good for it. Thus, some crops are good on one type of farm but are not good for others.

Table 4.3 Crops grown in the households of current generation

Crops grown	Lawra (%)	Nandom (%)	Average (%)
Maize (*zea mays*)	98.8	89.9	94.3
Groundnut/peanuts (*Arachis hypogaea*),	91.4	91.3	91.3
Millet (*pennisetum glaucum*)	71.6	52.2	61.9
Vegetables (okra, pepper, tomatoes)	17.3	10.1	13.7
Bambara nuts (*vigna subterranea*)	6.2	60.9	33.5
Sorghum (*sorghum bicolor*)/guinea corn	14.8	63.8	39.3
Tubers (Yam, sweet potatoes, aerial yams)	37	27.5	32.2
Rice (*Oryza Sativa*)	2.5	24.6	13.5
Soya beans (*Glycine max*)	26	36.2	31.1
Total Number of Households	81	69	150

Source: field survey, June, 2017

Compound farms are the dominant types of farms cultivated by farmers in the son's era. Crops that are cultivated on the compound farms are guinea corn (*Durra bicolor*), sorghum (*sorghum bicolor*), millet (*pennisetum glaucum*), groundnut (*Arachis hypogaea*), bambara nuts (*vigna subterranean*), cowpea (*vigna unguiculata*) and even yam (*dioscorea spp*) in extreme cases where compound gardens are made. Apart from these, sorghum (*sorghum bicolor*) and some few vegetables like, okra (*Abelmoschus esculentus*), pepper (*Capsicum*) and pumpkin leaves (*cucurbita spp*) are usually planted around the edges of the farms for household consumption with minor sales. The yield is good when fertilizer is applied and rainfall is good. This is what a forty-two (42) year old man had to say in a focus group discussion;

> *On the compound farms, maize (zea mays) and groundnut, at times millet (pennisetum glaucum) and yam* (dioscorea spp) *are cultivated in small quantity due to the many crops with limited land. Farmers cultivate both local and improved varieties of crops. The improved varieties are cultivated more than the indigenous varieties. The local varieties of crops such as yam (dioscorea spp), millets, groundnuts (arachis hypogaea) and sorghum (sorghum bicolor) are plant in small quantity in order to use it for traditional purposes. Yam cultivation has reduced in recent times because of low rain pattern (A Male Discussant, FGD, and Tanchara-10th December, 2017).*

In the Ko community, similar crops are grown as indicated by many of the respondents, about 9/12 of respondents in the key informant interview reported that, many of their crops are grown on home fields in the current generation. These are; millet (*Pennisetum glaucum*), maize (*Zea mays*), white beans (*glycine max*), bambara nuts (*Vigna subterranean*) and groundnuts/peanut (*Arachis hypogaea*). The yield situation on this field is not stable; it varies greatly with the ability of a farmer to put up good agronomic practices and availability of rainfall. A sixty-one (61) year old farmer had this to say;

> *There was bumper harvest during the era of my grandparents as compared to today. They could cultivate small plot and harvest plenty but now the situation has changed. There used to be surpluses from harvest after feeding on it throughout the year, at times the left-overs are sold. Now the situation has changed, not all the times that our food is enough for consumption let alone talking about Surpluses (A Male Respondent, KII, Ko-14th December, 2017).*

The current generation still cultivate valley fields just like the time of the older generations. On this field, crops grown are; millet (*pennisetum glaucum*), maize (*zea mays*), yam (*dioscorea spp*), okra (*Abelmoschus esculentus*) and rice (*Oryza sativa*). The yield here is still good because farmers' belief that eroded soil particles are deposited there. An average farmer can get about two (2) bags of maize (*Zea mays*) and millet (*pennisetum glaucum*) a bag. On general perspective, discussion in Tanchara further shown that crops like; rice (*Oryza sativa*), yam (*dioscorea spp*), aerial yam (*Dioscorea Bulbifera*) and potatoes (*solanum tuberosum*) are cultivate interchangeably and the yield is good upon the unpredictable rainfall pattern, because the place is always moist and have nutrients eroded from upland areas. A thirty-five (35) years old male key informant said that;

> *I grow maize (zea mays) and late millet (pennisetum glaucum) thus "Dorado" on the valley field, guinea corn, yam, potatoes (solanum tuberosum), and few vegetables because the place is still fertile and moist than any other types of farm. These crops are suitable for the valley area because the maturity period is long and is good for this type of farm where the field*

gets moist early and takes a long time to dry up. A Male Key Informant, Ko 13th December, 2017)

In the current generation, many farmers have embarked on the cultivation of gardening where crops of many types are grown to support produce from the valleys farms and compound farms. They plant crops like maize (*Zea mays*) and rice (*Oryza Sativa*) in the wet seasons and in the dry seasons; vegetables such as tomatoes (*lycopersicon lycopersicum*), pepper (*Capsicum*), cabbage (*Brassica oleracea var*), garden eggs (*Solanum melongena*), pumpkin leaves (*cucurbita spp*), beans leaves (*glycine max*), onion (*allium cepa*) and okra (*abelmoschus esculentus*) are grown. The yields are okay when the farmer applies manure. A key informant interview granted in Tanchara shows that, crops at this type of farms yield was good especially when ACDEP RESULTS project was in session using the Ko dugout. Many forms of technical assistance were given to farmers by personnel but after the project is over the yield is not good again. The crops start dyeing at some point meanwhile, it is the same seeds provided by the NGO that farmers are still growing. A forty-one-year-old farmer had this to say in a key informant session;

> *... The crops yields were high when I started gardening through the help of ACDEP RESULTS project but after sometimes the yield has reduced because the seeds germination and growth is not good as compared to the initial seeds given to me by the NGO ... (A male key informant, Tanchara-12th December, 2017).*

Focus group discussion indicated that, apart from the gardens from the dugout, other farmers use part of their valleys fields to make gardens at where there is available water source in the dry season. Other farmers, just a few also make use of the irrigation facility along the Black-Volta which is very far away from their residence. The gardens serve as an alternative source of income to a larger proportion of the farmers even in the dry season. Crops from these fields are mainly for sale with minor consumption depending on the time of the season

in which it has been cultivated. In the dry season, they are for sale with minor consumption while in the wet season; they are for consumption with minor sales. Garden varies in sizes and farmers cultivate maize (*zea mays*) and rice (*Oryza Sativa*) only during the rainy/wet seasons and tomatoes (*lycopersicon lycopersicum*), onion (*allium cepa*), cabbage (*Brassica oleracea var*), pumpkin leaves (*cucurbita spp*), beans leaves (*glycine max*), garden eggs (*Solanum melongena*) and okra (*Abelmoschus esculentus*) are planted on separate beds in the dry season. Some could be mixed but a crop like okra (*abelmoschus esculentus*), beans leave (*glycine max*) and pumpkin leaves (*cucurbita spp*) cannot be mixed with other vegetables. The dry season period is usually short, mostly from November to January in the area except the Black-Volta irrigation system which can last beyond January.

Bush fields are given less attention in the son's era, just a few farmers still cultivate it to plant millet (*pennisetum glaucum*), beans (*Glycine max*), groundnut (*Arachis hypogaea*) and sometimes bambara nuts (*vigna subterranea*). People stopped farming on this field due to reasons like; the soil shows low fertility which leads to low yield, the crops at this place are exposed to pest such as monkeys because many people are no more cultivating there. From specific view point, the yield from the bush fields is bad in the absent of fertilizer application. The yield is not just good all, but sometime it is good when the rain fall is good. This is the remarks of a female key informant;

"… Bush fields are not common in recent times but the few who cultivate it plant few crops basically; millet (pennisetum glaucum), maize (zea mays) and beans…" (A Female KII, Ko- 13th December, 2017).

Farmers consider the nutrient level before mixing crops with each other in all the types of crops they grow. Those with many livestock applies manure more than inorganic fertilizers

and those with few animals apply more of inorganic than organic. A key informant had this to say on his yield;

> *The yield is sufficient to feed on it for the whole year, in few cases, there are some surpluses which we sell to pay our children school fees, many people who food is not sufficient for consumption means that they have sold all out immediately after harvest (A Male Key Informant, KO-14th December, 2017).*

In similar way, responses from a focus group session show that the yields of crops are not the same across all seasons, there are variations from season to season. A discussant revealed that;

> *The yield situation is not the same in all seasons, whenever the rainfall is high, the yield is good and people can feed on their own food for the whole year, scarcely can you see surpluses. Less rainfall is always a disaster because people cannot recoup what they have invested into the farming process for the season let alone satisfying their consumption needs (A Male Discussant, Tanchara-10th December, 2017).*

Those people who can put good agriculture practices on their farms get enough food to meet their consumption needs and the majority who refused do not get enough to feed on for the whole year; they tend to buy from the market. Majority of the farmers sell their crops to pay their children school fees leaving very small quantity to feed on, increasing food shortages in their households. Those who cultivate gardens get extra income during the dry seasons to carter for their households' expenses and they are able to feed on their own produce throughout the year. The produce from the gardens are sold to re-buy food from the market. Many people do sell some of their produce to attend to emergencies like health expenses. A Discussant said;

> *… Generally, the yield is not sufficient to consume, it gets finished by April, and we then buy from the market. In actual fact it supposed to be enough for our consumption but some are sold to attend to other household's needs. Many get something to eat but by July there is always shortages, the reason is that we rather sell to pay our children school fees instead of keeping it to eat. Few people are capable of feeding on their own farm produce throughout the year. They are the people who can put good practices on their farms to get high yield*

and the majority who refused does not get enough to feed on for the whole year, they tend to buy from the market (A Male Discussant, FGD, and Ko-13th December, 2017)

Farmers cultivate both traditional varieties and improved varieties of crops in the current generations. The improved varieties of crops give high yields than the local varieties but they still grow the local ones as well for many reasons. The local varieties are used for social and religious purposes. The yields are not constant; it depends on farmers' ability to apply good agronomic practices such as making ridges, bunds and the application of fertilizers coupling with the nature of rainfall pattern within the season. The yields are good when rainfall is high and bad when rainfall is low. Those who get higher yields are able to feed their households and get surpluses for sale. On issues of crops varieties and yields, this is the remarks of a forty (40) year old man in a key informant interview session;

... The traditional varieties are; white beans (Glycine max), millet (pennisetum glaucum) bambara nuts (vigna subterranea), groundnut/peanuts (*Arachis hypogaea*), *yam (dioscorea spp), and aerial yam (Dioscorea Bulbifera). The improve varieties they cultivate are; maize (zea mays), sorghum (sorghum bicolor), groundnuts (china), maize and beans (Glycine max).We grow both varieties in order to safeguard ourselves against crops failure as a result of the bad weather. The yield of the local verities of crops is not good as compared to the previous times, an average farmer can get millet (pennisetum glaucum) about two (2) bags and beans (glycine max) a basin on one and half (1.5) acres of a bush farm. There are low yields sometimes because of less rainfall and less soil fertility of the farms ... (A Male Discussant, Ko- 14yh December, 2017).*

In a similar way, a key informant in an interview session had this to say;

... Farmers still cultivate some traditional crop varieties because they are drought resistant, for example groundnut. The traditional varieties maturity date is long giving less chance to yield high under this era of short raining season but we still grow it because it is customarily significant as we use them for our festivities such as funerals and rituals. It will be a very big disgrace if a great farmer cannot provide such items when the needs arise such as welcoming of visitors or when someone dies in the family... (A Key Informant, Tanchara-10th December, 2017).

The food is not enough at times, by four (4) months times, it gets finished, even after Christ mass, some households start buying from the market. In the lean season, farm animals are

sold to buy food from the market in some cases, but if the gardens give good yield, vegetables are sold to buy food items. This is what a sixty (60) year old woman in key informant interview reported that;

> *… My yield has reduced drastically and I am not able to feed my household throughout the year because as a woman I do not have enough fields to cultivate. My husband is also late but through the sale of livestock and casual labour I am able to get food to feed on … (A Female Key Informant, Tanchara-10th December, 2017).*

She added that;

> *… The yield situation is somehow good but it is not consistent, when the rainfall pattern is good throughout the farming season, the yield is enough and can be sufficient for our consumption. If some remains, it is sold but sometimes too it does not meet our consumption needs, particularly when the rainfall is not good. … (A Female Key Informant, Ko, 13th December, 2017*).

At this point, results from the three household case studies are presented as continuation from the previous generations. The case studies this time give narratives of the trends in types of crops and yields of households in the current generation. These include the case of Mr. Zuuro's household, the case of Mr. Chaara's household and the case of Mr. Challa household.

Case 1: The Case of. Zuuro's Households; Types of Crops and Yields in Grandson's Generation

Generally, the household cultivate cereals, roots and stem tubers, legumes and vegetables. These crops are characterized with the cultivation of both the local and improved varieties. Traditional/indigenous varieties include; yam (*Dioscorea SPP*), millet (*Pennisetum Glaucum*), groundnuts/peanut (*Arachis Hypogaea*), bambara nuts (*Vigna Unguiculata*), guinea corn, aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*), rice (*Oryza Sativa*), vegetables and beans (*Glycine Max*). The improved varieties are; millet (*Pennisetum Glaucum*), groundnuts/peanut (*Arachis Hypogaea*), sorghum (*Sorghum Bicolor*), guinea

corn, rice (*Oryza Sativa*), vegetables and beans (*Glycine Max*). This is what he said on the rationale for growing both improved and local breeds of crops;

> *My household decided to grow both varieties in a season because; the local ones are needed for social purposes such as welcoming visitors and funerals, even though the yield is not good but we are forced to grow it small. High rain brings about high yields among both the improved varieties and indigenous varieties while low rain brings about an appreciable level yield for the improved varieties than the indigenous. We do not cook for our mourners on funeral days, what we offer them is water and groundnuts/peanut (Arachis Hypogaea). Crops such as millet (Pennisetum Glaucum) and beans (Glycine Max) are used in performing rituals on funerals days when the body is laid on stage. As an Uncle when your sisters' children pay you a visit, you need to give them either Groundnuts/Peanut (Arachis Hypogaea) or Bambara nuts (Vigna Suterranean) or both to represent your care for them (Household's Head and Spouse, HHCS, Ko-14th December, 2017).*

The above mentioned crops are grown on separate types of farms based on how compactible the soil and crop are to each other. Compound farm is the biggest among all the types of farms that his household cultivates. Most of his major crops including groundnuts/peanut (*Arachis Hypogaea*), maize (*Zea Mays*), beans (*Glycine Max*), bambara nuts (*Vigna Suterranean*), millet (*Pennisetum Glaucum*), yam (*Dioscorea spp*) and sorghum (s*orghum bicolor*) are planted here. The yields used to be poor but due to the intervention in the form of training and education from the Lawra and Nandom Districts crop departments and Centre for Indigenous Knowledge and Organizational Development (CIKOD) Ghana operational in the community, he is able to get much. He makes use of the household waste to fertilize the land which increases the yield. He said that;

> *… In the compound field, maize, millet (Pennisetum Glaucum), groundnuts/peanut (Arachis Hypogaea), bambara nuts (Vigna Suterranean), soya beans (Glycine Max), yam (Dioscorea spp), aerial yam (Dioscorea Bulbifera), sweet potatoes (Solanum tuberosum) and Potatoes (Solanum tuberosum) are grown. The yield sometimes back was not good but due to the application of manure and compost, the yield has increased enough for his household consumption with surpluses. He used to buy from the Wala marketing women but now they rather buy from him … (Household Head, HHCS, Ko-14th December, 2017).*

The valleys farm used to be bigger but now it is very small because of the shearing among family members and the notable crops he grows are; yam (*Dioscorea spp*), aerial yam (*Dioscorea Bulbifera*), maize (*Zea Mays*), rice (*Oryza Sativa*), okra (*Abelmoschus Esculentus*), pepper (*Capsicum*) and tomatoes (*Lycopersicon Lycopersicum*). The yield is good just that the land is not big enough. The vegetables grown here are basically for his household's consumption with minor sales.

He also cultivates garden fields. These fields are two; one around a dugout irrigation facility and the other being a conversion of part of his valley field. He cultivates these fields two times in a year. Thus during both dry and wet seasons. In the wet season, he plants rice (*Oryza Sativa*) and maize (*Zea Mays*) in these gardens while in the dry season only vegetables such as tomatoes (*Lycopersicon Lycopersicum*), pumpkin leaves (*Cucurbita spp*), pepper (*Capsicum*), onions (*Allium Cepa*), cabbage (*Brassica oleracea var. capitata*), garden eggs (*Solanum Melongema*) and beans (*Glycine Max*) leaves which are grown. The yields are good when he is able to apply enough manure, otherwise it does not do well. He suspects it is the continue cultivation of the fields that makes the nutrients depleted because he cultivates there twice every year. All produce from these fields is meant for sale with minor consumption. He had this to say;

> *In the wet season, all the vegetables that I cultivate are the local varieties, especially okra, pepper (Capsicum), pumpkin leaves (Cucurbita SPP) and tomatoes (Lycopersicon Lycopersicum), this is because they are planted for household's consumption. In the dry season gardening, the improved varieties are used because; the season is shorter in water availability and those ones mature faster (Household head, HHCS, Ko-14th December, 2017).*

The overall returns from Zuuro farms are enough for the consumption by his household even with some surpluses. These surpluses are for sale to support his farming activities in the next season, payment of his children school fees and other household maintenance activities.

Case 2: The Case of Mr. Chaara's Household; Types of Crops and Yields in Grandson's Generation

According to him, the son's generation has fewer changes on the types of crops but they rather introduced more new varieties of crops. Similarly, cereals, legumes, roots and tubers and more vegetables are grown. The vegetables are for sale with less consumption in the wet seasons. The dominant type of farm is the compound farm where majority of his crops are cultivated. Crops such as maize (*Zea Mays*), millet (*Pennisetum glaucum*), groundnuts/peanut (*Arachis Hypogaea*), sorghum (*Durra Sorghum bicolor*), bambara nuts (*Vigna Suterranean*) and few yams are grown here. The yields on this field are good due to the application of inorganic fertilizer generated through household waste and animals' droppings. His household still cultivate a valley farm. On the valley farm, rice (*Oryza Sativa*), yam (*Dioscorea SPP*), aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*) and maize (*Zea Mays*) are basically grown. Upon the continue cultivation of the valley field from the grandfather's era to the fathers' era, he and his household still cultivate it because the yields are good. He perceived the fertility on this field to be high due to deposit of eroded particles from other elevated areas.

His household has also introduced the cultivation of gardens. He cultivates these fields twice every year, wet and dry seasons. In the rainy seasons he plants rice (*Oryza Sativa*) and vegetables such as tomatoes (*Lycopersicon Lycopersicum*), pepper (*Capsicum*), onions (*Allium Cepa*), beans (*Glycine Max*) leaves and pumpkin leaves (*Cucurbita SPP*) in the dry

season gardening. The yields are good, especially when he is able to apply manure. He travels all the way to a town closed to the Black-Volta with an irrigation facility to do his dry season gardening apart from the plot he owns at the dugout irrigation in Tanchara-Ko.

He cultivates both indigenous and exotic varieties of crops. The traditional verities are, millet (*Pennisetum Glaucum*), maize (*Zea Mays*), yam (*Dioscorea SPP*), bambara nuts (*Vigna Suterranean*) aerial yam (*Dioscorea Bulbifera*), potatoes (*Solanum tuberosum*) and vegetables such as; pepper (*Capsicum*), tomatoes (*Lycopersicon Lycopersicum*), pumpkin leave (*Cucurbita spp*) and garden eggs (*Brassica oleracea var. capitata*). The improved varieties too are cowpea/groundnut (china beans), sorghum (*Durra Sorghum bicolor*), maize (*zea mays*), tomatoes (*Lycopersicon Lycopersicum*), onions (*Allium Cepa*) and pepper (Capsicum). On the issues of crops varieties and yields, Mr. Chaara had this to say;

> *... I cultivate the improved varieties more than the traditional ones because, the improved varieties are early maturing and the indigenous varieties drought resistant. The yield alternates; sometimes it is enough to feed on for the whole year, sometimes it does not. When we lack food, we resort to buying from the market through the sale of our animals and money from the dry season gardening ... (Household Head, HHCS, Tanchara 10th December, 2017).*

He added that the yield by way of description is good when he left the land to fallow for more than two years before cultivating with the application of manure and compost. He has been practicing land fallow but this is within a very small time period like two or three years.

Case 3: The Case of Mr. Challa's Household; Types of Crops and Yields in Grandson's Generation

Interestingly, in the grandsons' era, Mr. Challa's household cultivates and manages only a compound farm. He plants crops such as millet (*Pennisetum Glaucum*), beans (*Glycine Max*), sorghum (*Durra sorghum bicolor*), maize (*Zea Mays*), groundnuts/peanut (*Arachis Hypogaea*), yam (*Dioscorea spp*), aerial yam (*Dioscorea Bulbifera*) and some vegetables

like pepper (*Capsicum*), okra (*Abelmoschus ESculentus*) and pumpkin leaves (*Cucurbita spp*). In terms of yield, his yields have reduced but he and his household is able to feed from their own farm produce up to the next season, just that there is no surplus to sell. The field is not fertile but due to the application of manure, compost and sometimes chemical fertilizer, he is able to get enough yields. He had this to say with regards to his farming practices;

> *... The place is not fertile right now, so our food sufficiency fluctuates, there are some years that it will be enough for our consumption, sometimes, it is not. It is enough when he is able to apply compost, manure or chemical fertilizer. He plants both the improved and the local varieties, even though the local varieties yield is low but they are needed them for traditional performances such as sacrifices and funerals ... (Household Head, HHCS, Tanchara-10th December, 2017*).

From the results, the trend in the types of crops shows that, crops in the grandfathers' era included; millet known locally as "Be-luri" and "Kubara" and maize called "Zeze", groundnuts, guinea corn, Bambara nuts, rice, beans called "Dawuli", sorghum, yam, aerial yam, potatoes and vegetables like pepper, tomatoes, okra and pumpkin leaves. All these crops were indigenous varieties which were grown on bush farms and valley farms (See Table 4.4). However, indigenous varieties like beans called "Dawuli", millet called Be-luri" and "Kubara" and maize called "Zeze", are no more cultivated in the current era. The general yield situation was good without the application of fertilizer and farmers were able to feed from their own produce throughout the year and still had surpluses. These surpluses were for consumption. However, there were produce such as beans (*Glycine max*) and groundnuts (*Arachis hypogaea*) can be sold to buy farm implements like hoes and cutlasses. Other uses of surpluses included; storage for prestige, for traditional rites like funerals and sacrifices, in trading for other food stuffs that the household is not having under the barter system and given it out to others as loan payable through farming for the giver. The reason given for the

cultivation of only the local varieties were that, there were no improved crop varieties in the system and the fact that the local varieties were giving the maximum yields to farmers. During this era, farmers basically consumed crop produce; animals are sold to buy households food ingredients to support their nutritional needs. Surpluses were stored for consumption.

Table 4.4 Smallholder farmers' perception on types of crops and yield situation by generation

Generation	Types of Fields	Types of crops grown	Crops varieties	Yields situation
Grandfather's Era	Bush Farms	Beans called "Dawuli", millets called Be-luri" and "Kubara" and kind of maize called "Zeze", Bambara nuts, groundnuts, yam, and aerial yam	Indigenous	High
	Valley Farms	yam, and aerial yam, maize, rice pepper, tomatoes, okra and pumpkin leaves	Indigenous	High
Father's Era	Bush Farms	Bambara nuts, beans and millet	Indigenous	Moderate
	Valley Farms	yam, and aerial yam, rice, maize, pepper, tomatoes and okra	Indigenous and Improved	High
	Compound Farms	Millet, beans groundnuts, Bambara nuts, yam, aerial yam, pepper and pumpkin leaves	Indigenous and Improved	High
Grandson's Era	Compound Farms	Millet, maize, beans groundnuts, Bambara nuts, yam, aerial yam, pepper and pumpkin leaves	Indigenous and Improved	Moderate
	Valley Farms	yam, and aerial yam, rice, maize,	Indigenous and Improved	Moderate
	Gardens	pepper, onions, garden eggs, tomatoes and okra	Improved	High

Source: Field Survey, December, 2017

Similarly, the fathers' generation cultivated bush farms, valley farms and introduced compound farms where cereals, legumes, tubers and vegetables are grown. Crops such as millet, groundnuts, maize, guinea corn, Bambara nuts, rice, beans, sorghum, yam, aerial

yam, potatoes and vegetables like pepper, tomatoes, okra and pumpkin leaves were grown. The yields were good comparing to the current era (See Table 4.4). This era experienced the introduction of fertilizer application and improved varieties of crops on the bush farms; the compound and valley farms were fertile enough to support crop growth and production. The yields in general were enough for consumption. There were surpluses which were for minor sales and consumption. There were other uses that included; religious sacrifice, funeral rites and gift.

In the current era, thus the grandson's generation, farmers cultivate similar crops just like in the grandfathers and fathers' eras. These crops included millet, groundnuts, maize, guinea corn, Bambara nuts, rice, beans, sorghum, yam, aerial yam and potatoes. Others include vegetables like pepper, tomatoes, okra and pumpkin leaves. (See Table 4.4). Farmers grow both the improved and the local varieties of crops. The very local types such as "Dawuli", Be-luri", "Kubara" and "Zeze" are no more cultivated in this era because the yield is low due to the long gestation period (See Table 4.4). In this era stallholder farmers are cultivating compound farms, valley farms and gardens. In the current generation, majority of their crops are grown on the compound farms followed by valley farms and gardens. Even though the yield level fluctuates from season to season depending on the state of rainfall and farming practices, some farmers are able to feed on their own crops for barely seven (7) months after harvest. Proceeds from the dry season farming are used to buy food items from the market in the lean season.

4.4 Soil and Water Conservation for Sustainable Intensification Agriculture

This section looked at Sustainable Intensification Agriculture (SIA) practices among the current generation only. It focuses on the contemporary soil and moisture management methods used by smallholder farmers for intensification agriculture. Data for this analysis were drawn largely from in-depth interviews and focus group discussions coupled with quantitative data from the survey. Specific cases are presented based on the in-depths studies and the focus group discussions. The results show that the current generation of smallholding farmer households employ multiple soil and water conservation methods for improving soil fertility. These include the application of manure, compost and crop residue, boundary bunding and ridging.

Manure Application

Organic manure from household waste and animals' droppings was observed to have been used to improve soil fertility both in the compound farmlands and gardens. The challenge with manure application is the availability of animals. Smallholder farmers without animals are unable to access animals manure. The current increase in the theft of livestock in the area hinder manure availability and collection. In the absence of manure, smallholder farmers apply chemical fertilizers to increase crops yields. This is what a fifty (50) year old key informant had it that;

> *... I am applying manure on my farm but I am not able to get enough from my farm because I do not have many animals. The cost of chemical fertilizer is also expensive to come by. I would have wished to apply organic fertilizer like manure only but I do not have many farm animals to produce it ... (A Male Respondent, KII, Ko-13thDecember, 2017).*

The survey also reveals that smallholder farmer households apply manure on their plots which is made from animal droppings to increase the soil fertility. About 34% of households interviewed confirmed this assertion (See Figure 4.2).

Compost and Crop Residues Application

Farmers apply compost to compound farms before they plough or make ridges. The compost is produced from crops residue and remains of grasses. Crops stalks are also not burnt but left on the field to decompose, especially in the case of Nandom-Ko. The process of making the compost depends on the readily availability of materials in the form of crops residues. This makes it costly and labour intensive. Smallholder farmers sometimes hire labour to gather the materials and carry compost back to the fields due to the distance of the materials from their farmlands. A key informant had this to say;

> *… On the compound fields, I usually use compost which I make on my own from crops residues and waste materials to fertilize the soil. This is a very good way of improving soil fertility because the compost can remain in the soil for more than one year. I usually get high yield the following year than the first year of application. The problems associated with this method is that; making compost from crop residues is tiresome due to the continuous watering to facilitate rapid decomposition of the materials… (A Male Informant, KII, Tanchara-12th December, 2017).*

In some cases, smallholder farmers practice ridging in land preparation process, where they burry the stalks of crops under the ridges to improve the fertility of the soils. In situation where a tractor service is needed in land preparation, compost is first of all applied before the field is ploughed. Manure is mostly used in addition to no burning of farms during the dry season but sometimes if the farmer intention is to grow yam, the compost might be used before mounds are raised. On compost application, a key informant said that;

> *I organize women to carry the compost to the field before I plough and plant crops like maize (zea mays) to increase the yields. The home fields' nutrients are improved through the use of manure and compost in recent times but in previous time these fields were not cultivated,*

the few who used to cultivate on it do not apply anything to improve the soil nutrients (A Key informant, KII, Ko-14th December, 2017).

Composting is done on valley farms as well, especially when yam is to be planted; this was confirmed by 10/12 of the key informants interviewed. The compost preparations are aided by Agriculture Extension Officers from the District Assemblies (department of crops) and also from the Centre for Indigenous Knowledge and Organizational Development (CIKOD) field workers through training. This is what a key informant had to say;

… I get more knowledge in compost making and my yields increase. I had this skill through the training sessions from Agricultural Extension Officers on how to prepare and apply compost and manure. My only problem is that I am not able to make enough compost for all the farms. The reason is that, it is very tiresome in gathering crops remains for making the compost and carrying the compost back to the farms… (A Male Informant, KII, Ko-13th December, 2017).

Evidence from the survey shows that many agricultural households apply compost on their farms basically on compound farms. These are produced by farmers themselves through the training given to them by Agriculture Extension Officers. The materials used in producing the compost are basically crops residues and domestic waste from households including ashes and rubbish. The proportion of households who use this method on their plots is about 38% (See Figure 4.2). Evidence gathered shows that farmers wish to apply other alternative ways such as organic fertilizers but are constraint in knowledge and skills.

Inorganic Fertilizer Application

One of the soil moisture conservation methods used by farmers on valley farms is the application of chemical fertilizer. This is used by farmers who do not have farm animals to produce manure and/or do not also know how to prepare compost on their own. These are the category of farmers who have had no training on compost making. Sometimes

smallholder farmers do apply inorganic fertilizer in addition to the manure and compost. Of all the key informant interviewees 11/12 of them shared the same view. On the compound farms some farmers at times do apply chemical fertilizer but this is of small quantity. The dose method is used in applying chemical fertilizers and is done on two phases before the maturity of the crops; first, Nitrogen, Phosphorus Potassium (N.P.K.) is applied to fasten crops growth and in the second phase, ammonia sulphate is applied to increase crop yields. The chemical fertilizer is not applicable on any other crop apart from cereals such as maize, rice and sorghum. During a focus group discussion session, a forty-eight (48) year farmer had this to say;

> *... Chemical fertilizers are used by larger section of farmers, because they are readily available in the market. I personally can confirm that the yield is not the same when I apply inorganic fertilizer comparing to the organic fertilizers, the organic last longer and gives higher yields than the inorganic. Many of us refused to attend the training session on organic manure and compost production organized by the Agriculture Extension Officers from the District Department of crops and sometimes by CIKOD Ghana ... (A Male Respondent, FGD, Tanchara- 11th December, 2017).*

It was also observed that about 23% of all agriculture households utilised chemical fertilizers to improve soil fertility (See Figure 4.2). Even though farmers are aware of the negative effects of the use of inorganic fertilizers on their farms yet continue using it together with the organic fertilizer. Resultantly, smallholder farmers apply both inorganic and organic fertilizers to minimise the adverse effects of the chemical fertilisers.

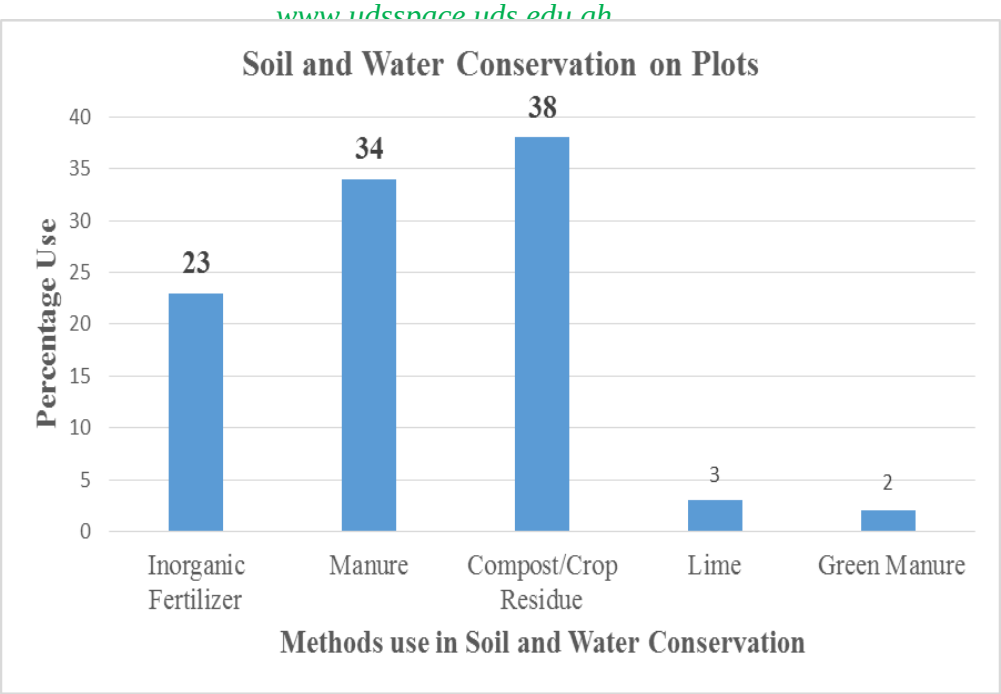

Figure 4.2: Soil and water conservation method on plots of current generation
Source: Field Survey, June 2017

Boundary Bunds and Ridging

On the compound farms, farmers make tired, ridges, raise beds and use organic fertilizer to improve soil fertility. The crops are planted in straight lines form. Farmers use different strategies to conserve and retain water on the field. In situations whereby, a tractor service is used in land preparation instead of ridges and beds, boundary bunds are made around the edges of the farms to check soil erosion. Water ways are equally created on the fields for easy flow of run-off water. The use of ridges especially tired-ridges helps to improve soil fertility and retain water on the field for a long time while soil erosion is less. On the other hand, when tractor is not used, tired-ridges and boundary bunds are used together. In a key informant interview session, a farmer had this to say;

> *… I use boundary bunds and tired-ridging to improve water retention on my farms and in situation where tractor service is used, I make "small-small gutters" on the field to prevent all the water from running out of the field or to cause erosion… (A Male Respondent, KII, Ko-13th December, 2018).*

There are many ways in improving soil fertility level on valley farms. These are; farmers raise mounds when the place is water-log and make bunds around it to prevent erosion. Instances where groundnut is to be grown, higher beds are made because groundnut does not require too much saturated soil. Valley farms are prone to flooding and farmers use various methods to prevent run-off water from destroying their farms. It was disclosed in a key informant session that making ridges and bunds around a valley farm prevents water from running into or out of the farm. This prevents over saturation of the soil and erosion on the field. It does not affect crops growth thereby increase the yield than planting on the flat ground. In a focus group discussion, a forty-eight-year-old woman had this to say;

> *On the valley farms, ridges and boundary bunds are used to check soil moisture conservation. In areas where the land is slopes and a tractor service is used, bunds and trenches are used to check erosion. Making ridges is necessary when the farmer is to grow crops that do not like much water such as groundnuts and bambara nuts but are to be grown in a water-loge area (A Female Respondent, FGD, Tanchara-10th December, 2017).*

The survey results indicated that farmers employ many methods in managing soil and water on their fields. Many farmers use boundary bunds and ridging in their attempts to conserve soil and water, about 21.3% agricultural households apply this to their cultivated plots. Meanwhile, boundary bunds happened to be the main method that farmers use to control soil erosion especially in checking run-off water. This is practiced on about 48% of households' plots cultivated (See Table 4.5). These methods are also used on valley fields for checking soil erosion. The advantage of this practice is that, boundary bunds ones made are easy to re-make in the subsequent years. The challenges involved in the use of these methods are that, it is difficult to make ridges especially along sloppy grounds of fields, boundary bunds are difficult to make in the first time and these methods cannot be effectively used on larger farms.

Table 4.5: Soil and water Conservation practice in the current generation

Soil and water conservation practice	Frequency	Percentage of plots applied
Boundary bounds and tied -ridging	139	21.3
Farmer-managed, Natural Re-generation (FMNR) and Boundary bounds	13	2
Cover cropping and mixed cropping	147	22.5
Boundary bounds and Soil mulch	1	0.2
Boundary bound and Mixed cropping	19	2.9
Boundary bound, crop rotation and mixed cropping	2	0.3
Crop rotation and Mixed cropping	4	0.6
Boundary bounds, crop rotation and tied ridding	21	3.2
Boundary bounds and crop rotation	30	4.6
Crop rotation and tired-ridging	52	9.5
Minimum tillage and mixed cropping	14	2.1
Minimum tillage only	43	6.6
More than 3 practices	50	7.7
None	108	16.5
Total responses to this question:	653	100

Source: field survey, June 2017

Cover Cropping and Mixed Cropping

On the valley fields, cover cropping is done sometimes to serve as both moisture conservation and erosion prevention reclamation. Mixed cropping is done on farms where mounds are made to plant yam *(dioscorea spp),* potatoes *(solanum tuberosum),* aerial yam *(Dioscorea Bulbifera),* maize *(zea mays)* and sometimes okra *(abelmoschus esculentus).* The reason why these crops are grown together is that, compost is normally applied before laying mounds which makes the soil very rich to support more than one type of crop. On the other hand, the aerial yam and yams serve as canopies to prevent evaporation and gives crops the needed atmospheric conditions to grow well. Results from the survey indicated that smallholder farmers apply cover cropping and mixed cropping methods on about 22.5% of all their cultivated plots (See Table 4.5).

Crop Rotation

Practicing of crops rotation is common on types of farms such as compound and valley. Farmers rotate non-nitrogen fixing crops with nitrogen fixing crops; legumes are rotated with cereals. It was evidential that crop rotation happened to be one of the ways farmers use in conserving soil and moisture on their fields. Just a few smallholder farmers are into crop rotation; this represents about 13% of all cultivated plots by smallholder farming households. Some households do not apply any kind of method on their cultivated plots in terms of soil and water conservation (See Table 4.5).

Other methods in soil and water conservation

Earthen out

This is one of the common methods farmers use in conserving soil and water on their farms, especially on compound farms. This method involves heaping soil under crops to improve the nutrients absorption ability and also increases moisture retention on the field. This method is commonly practiced among cereal crop farmers. Usually when ridges are used or even on ploughed fields, this method is usually used. The types of farms that this method is applied are compound farms and valley farms as indicated by a fifty-one (51) year old farmer;

> *The earthen out method is very important, especially to the cereal crops' farmers, anyone who grows millet and sorghum supposed to heap the crops base with soil if not, the yield will be low (A Male Discussant, FGD, Ko-14th December, 2018).*

Mulching

Mulching is done primarily on gardens of smallholder farmers. Soil moisture is maintained by mulching the beds with dry grasses and sometimes farmers make sunken beds/lower beds

to improve water retention. Sometimes farmers apply this method on yam mounds to increase the germination ability. This method is good because the soil is kept moist for sometimes even when rain stops for long time, thus, it improves crops growth and production. While many gardeners across the area are familiar with raised-*bed* gardening, some farmers are making *sunken* beds in gardening to check soil moisture improvement.

Famer-Managed Natural Regeneration (FMNR)

With this method, trees on the farms are left to grow but to a level that will give sufficient sunlight for crop growth and production. The branches are pruned to reduce the rate of sunlight obstructions. This method improves soil fertility in terms of soil moisture conservation and reduces erosion on the fields. The leaves of these trees when shed serves as nutrients in the long term but in the short term serves as mulched on the land. Farmers who use this method apply it on their valley and compound farms only.

Benefits of the use of Soil Moisture Conservation

The methods smallholder farmers use is able to make the soil rich as moisture retention and soil fertility is increased due to the reduction in soil erosion. The use of organic manure in soil and water conservation bring about long-term benefits because a method like composting can remains in the soil for longer time, say about three (3) years or more. There are higher yields when the farmer is able to put up good farming practices.

Challenges in the use of Soil and Moisture Conservation Methods

The use of inorganic fertilizer makes the soil dry resulting in the wittering of the crops. The growth and development of food crops are often affected in the midst of less rainfall

especially in farmlands where intensive inorganic fertilisers are applied. Over or improper chemical fertilizer application has effects on crops roots development. Smallholder farmers' belief that less rain makes the soil dry up rapidly due to the application of chemical fertilizers. Another challenge is that; it is expensive to buy inorganic fertilizer. It is also uneasy for people without animals to prepare manure because they lack animals' droppings. It is difficult to apply compost especially when one cannot correctly prepare. The situation on the use of manure is compounded by distances between the farmers' home and location crop residues due to transportation problems. In a focus group session, a discussant said;

> *It is always our wish to apply compost on all the farms but it is difficult in making it and stressful in carrying it to distant places, notably the bush farms, valley farms and gardens. Compost can be made on the farm premises but it is not easy because households waste has to be added to the it and watering has to be done regularly to speed up the rate of decomposition (A Male Respondent, FGD, Tanchara-10th December, 2017).*

At this point, three household case studies are presented. The case studies describe the soil and water conservation methods that are employed by these households in their SIA practices. These include the cases of Mr. Zuuro's household, the case of Mr. Chaara's household and the case of Mr. Challa household.

Case 1: The Case of Mr. Zuuo's Households on Soil and Water Management methods: Compost and Manure

On the compound farm, Mr. Zuuro applies compost and manure. He does not burn his farm after harvesting the crops as well. The compost is made from crops residues such as legume and the manure is gotten from animal's droppings. He makes the compost himself and indicated that the compost making is quite technical and many farmers could not do it, especially those who have undergone no training; he emphasised on this by saying that;

I personally hate burning bushes because of that, people afraid to set fire on my farm land. I do not cut trees on the farm lands as well, they are left to grow naturally. I apply compost on my farm which I make on my own (HHCS, Ko-16th December, 2017).

In making the compost, a deep pit is constructed deep and crops residues are collected in it, household's wastes after sweeping including ashes are dump in the pit (See Plate 4.2). The materials are watered to facilitate rapid decomposition. The compost is scooped and carried to the fields and is spread before the land tilling starts. He uses manure as well, which are generated from animals' droppings. After sweeping the animals pens, the wastes are dumped at various points on the farm before rain sets in. As it rains, the nutrients from the droppings gradually spread across the field. Composting is similarly practice on the valley fields where he applies compost before laying mounds when he is to plant yam during the season. Compost is used only when he wants to grow yam and other tuber crops. The soil fertility in his garden reduces rapidly because of two-times cultivation per season; this makes him to apply manure from animals' droppings on it. In the wet season, nothing is applied to improve the soil fertility but he does apply the manure in the dry season vegetable cultivation.

Plate 4.2: A constructed compost making platform

Source: Field Observation, Nandom-Ko, 12th December, 2017

Farmer-Managed Natural Regeneration (FMNR)

He also practices Farmer-Managed Natural Regeneration (FMNR) which is one of the projects by the Centre for Indigenous Knowledge and Organizational Development (CIKOD) Ghana, an NGO operating in the community. He said on his farm, the dominant species of tree he left include; Ebony, Shea and Dawadawa. On the practice of Farmer-Managed Natural Regeneration (FMNR), this is what he said;

> *In the Farmer-Managed Natural Regeneration (FMNR), plants are left to grow naturally on the fields without cutting while the crops are planted under the tress. I however routinely prune the trees branches to give way for sunlight to reach the crops. The leaves that are dropped serves as nutrients. There are many other unintended benefits I get apart from improving fertility and conserving soil and water on the farm. These include; getting fuel woods and sticks for building purposes (Household head, HHCS, Ko-13th December, 2017).*

Crop Rotation and Mixed Cropping

He practices crop rotation on this farm where the field is divided into plots. In the first year, he applies compost before laying mounds to plant his yam *(dioscorea spp),* aerial yam *(Dioscorea Bulbifera),* and potatoes (*solanum tuberosum*) are planted together. In the following season, he spreads the mounds and plants millet *(pennisetum glaucum).* In the third year, he makes beds to plant groundnuts and/or beans *(Glycine max).* In the fourth year, he makes ridges to cultivate maize *(zea mays)* or sorghum *(sorghum bicolor).* Mixed cropping is more practiced on the valley farms. Many types of crops are grown together on this field by making mounds. These crops are; yam *(dioscorea spp),* potatoes *(solanum tuberosum),* aerial yam *(dioscorea bulbifera)* including okra *(abelmoschus esculentus)* and rice *(oryza sativa)* and/or maize *(zea mays).* He can also plant rice in between the mounds at the same time. In the following year, the mounds are spread to plant rice (*oryza sativa*) and

maize (*zea mays*) together. He said that the potatoes and yam leaves spreads to cover the mounds to increase moisture conservation and prevents erosion.

Boundary Bunds and Ridging

Mr. Zuuro indicated that, he makes boundary bunds to check soil erosion on his compound farm. He also makes ridges which serves as both moisture and nutrients' management strategy because the nutrient beneath are turn up and water retention increases during the process because when it rains, run-off water does not easily get out of the field. In cases where tractor services are patronized, channels are created on the field for run-off water to move freely without causing erosion and sometimes the boundary bunds are made around the field. On valley farms, making boundary bunds is a very important component because the field is runway of water and erosion is very common. He is likely not to get anything from this field when he fails to make bunds because water will wash everything away.

Making of Sunken Birds and Mulching

The sunken birds are kind of birds that are made lower than the surface of the land to facilitate moisture retention. Mulching is also done using dry grasses to reduce evaporation on the field. These two practices are very important in dry season farming because the period is constraint with water. The source of water is through hand-watering from ponds, streams and wells.

Chemical Fertilizer

He also cultivates small bush farm which is less fertile but he applies neither compost nor any other manure because of the distance involved. He has started growing trees naturally to

improve the soil fertility. He also makes sure that the field is not burnt after harvesting; this helps to improve the content of organic matter. He uses inorganic fertilizer in extreme cases when maize is planted, meanwhile he indicated that he dislikes using chemical fertilizers because it does not last on the field like the compost does and also dries up the fields easily. He mostly grows crops that do not need so many nutrients such as beans, Bambara nuts and groundnuts.

Benefits of the use of Soil and Moisture Management Practices

The following benefits are associated with the farming practices Mr. Zuuro uses; in the Farmer-Managed Natural Regeneration (FMNR) process, the leaves dropping from the trees decay and improve the soil fertility. The pruned materials from the trees serve as fire wood to his households. Most of the trees that are left have enormous economic benefits such as selling and taken as fruits. His household as well as other people from the community also benefit, for example trees such as Ebony, Shea and Dawadawa are so important, and are edible. They also serve as cover on the land which reduces the rate at which the soil gets dry up. He also gets some sticks to roof his house and also in staking his yam. Farmer-Managed Natural Regeneration (FMNR) has many more benefits such as erosion prevention, nutrients and moisture management and it is not difficult to do. He had this to say;

> *I am motivated by the fact that; my production keeps on increasing in any practice that I do. Aside that, there are other unintended benefits such as fire woods, fruits I get. My farm management style has influenced many farmers to stop bush burning to a point that my fields are used as a study Centre of many organizations (Household head, HHCS, Ko-13th December, 2017).*

The old boundary bunds are easily re-constructed in the next season. The crops are able to withstand long days of no rain to bring about good yields when mulching, boundary bunds and ridges are used.

Challenges associated with the use of Soil and Moisture Management Practices

Mrs. Zuuro indicated that, making the compost is very difficult, especially in the absence of the women; the men only dig the pit and it is left unto the women to fill it with crops residues. At the same time their role is to carry water to water the waste materials in the compost pit which is also very tiresome. He justified this follow;

> *"Another challenge is that in areas where the trees are many, the roots of the trees make using hoe on the soil very difficult, especially in raising mounds for yam. It is also not easy to use tractor services in land preparation" (Household head, HHCS, Ko-13th December, 2017).*

After the compost is ready, the men only scoop it from the pit and the women are to carry them to the field by head portage which is difficult to do. In the Farmer-Managed Natural Regeneration (FMNR) practices people see him as a wicked person because he does not allow them to cut trees from or burn his field.

Case 2: The Case of Mr. Chaara's Households on Soil and Water Management Methods.
Compost and Manure

On the compound farm, Mr. Chaara add compost and manure to increase the soil fertility on his field. Anytime he applies compost on a plot, he does not apply any form of fertilizer in the following year; he only turns over the ridges to plant the crops. In the compost preparation process, households' wastes including rubbish and ashes are dumped in the pit containing some crops residues like groundnuts, bambara nuts and beans. On Mr. Chaara valley farm, composting is also done. He ensures that the farm is not burnt during the dry season. The application of compost is less on his farm because he makes it at home and carry

it to the field. The distance is far from the house particularly, the valley farm. He makes mounds to plant yam but also construct bunds around the farm to prevent erosion on it. Sometimes he applies the compost at some parts before ploughing with a tractor.

Crop Rotation

He also practices crop rotation on his compound field. He divides the farm into plots for cropping purposes and applies compost before making mounds to plant his yam *(dioscorea spp)*. In the following planting season, he spreads the mounds and grows groundnuts. In the third year, he makes ridges and grows either millet *(pennisetum glaucum)* or maize *(zea mays)* and in the final year, he plants beans.

Inorganic fertilizer

On his compound field, he sometimes applies chemical fertilizer to cereal crops such as maize *(zea mays)* and millet *(pennisetum glaucum)* apart from the use of compost. The chemical fertilizer also gives high yields when rainfall is good in the season. Mr. Zuuro does not prefer chemical fertilizer, even though he applies chemical fertilizer. He applies fertilizers because his farm is large and he cannot get enough compost and manure to apply all. On the gardens, he basically applies inorganic fertilizer to increase the soil fertility. The inorganic fertilizer is applied to cereal crops that are planted during the wet seasons while manure is applied on vegetables grown in the dry seasons.

Boundary Bunds and Ridging

Bunds are made around the farm to prevent run-off water from entry the field to cause erosion. The ridges are made in the land preparation process to plant crops. He makes ridges to cover crop residues, which are decomposed to increase the soil fertility. The ridges and

boundary bunds help to retain water on the field by preventing water from running out (See Plate 4.3). In situations where, he ploughs the field; small channels are created on the farm to serve as water run-ways. In improving water retention, the best of ridging is tire-ridges made and after making it, he again makes the floor soil loose to prevent moisture evaporation, especially when millet and sorghum are grown

Plate 4.3: Soil and water conservation strategy using ridges
Source: Field Observation, 13th December, 2017

The use of Sunken Beds and Mulching

Sunken beds are made to conserve soil moisture on gardens. Dry grasses are applied on the base of the crops to obstruct evaporation. Erosion is also controlled by creating trenches into pond for run-off water to empty there. The garden walls also serve as a kind of preventive measure to erosion on the gardens.

Benefits of the use of Soil and Moisture Management Practices

The ultimate advantages in the adoption of these methods are that, the yields increase and one-time application allows soil fertility to remains on the field for more than a year as in the case of compost application. These methods are advantageous because there is high water retention on the farm lands. It also gives enough working spaces in the farm especially when

ridges are made. It facilitates aeration and lastly it prevents erosion even on heavy raining period. The crops can withstand moments of no rain without wittering. On the aspect of benefits, this is what he said;

> *The soil nutrients are improved especially when manure is applied and making of ridges (Garo) turns the nutrients that are deep in the soil up for crops growth and development (Household Head, HHCS, Tanchara-10th December, 2017)*

Mr. Chaara clearly stated that he will continue to apply manure and compost, making ridges, tired-ridges as means to manage erosional activities and moisture management. He would also be happy if there could be any aid from any organization to improve irrigation during dry season farming just as the Association of Church Development Projects (ACDEP), Results project. The yield was good initially but with time even seeds germination is a problem let alone growth, the crops get dry after growing for sometimes meanwhile there is enough watering.

Challenges Associated with the use of Soil and Moisture Management Practices

It is difficult to prepare compost, it is labour intensive; hiring women to carry crops residues into the pit and compost back to field is demanding. On challenges related to preventive burning on the field and the use of inorganic fertilizers, Mr. Chaara has this to say;

"The fertilizer is very expensive to buy and there are also difficulties in controlling people from burning farm lands" (Household Head, HHCS, Tanchara-10th December, 2017).

It is difficult to make ridges and boundary bunds; this cannot be supportive if one is into large farms. The methods for improving the soil moisture content are challenged by the difficulties in making tired-ridges, farmers are less likely to manage large field.

Case 3: The Case of Mr. Challa's Households on Soil and Water Management methods.

Manure and Chemical Fertilizer Application

On the compound farm, Mr. Challa improves soil fertility on this field by using manure and chemical fertilizer. The organic fertilizer (manure) is largely used by him in addition to the use of inorganic fertilizer which is less used. He does not use compost but he rather applies more manure because he is having a lot of animals with the exception of cattle. He indicates that all his cattle were stolen years back. The manure is dumped at a strategic place for subsequent spreading into the entire farmland (See Plate 4.4). He also manages soil nutrients by preventing people for burning his compound after harvesting the crops. He is not applying compost on his farm because he does not have any knowledge to make it.

Plate 4.4: Manure generated from animals' droppings kept for subsequent use on a household farmland

Source: Field Observation, Tanchara-6th December, 2017

Boundary Bunds and Ridges

The compound farm land preparation involves the making of ridges (tired-ridges) and boundary bunds around to prevent water from running out or into the farm. The boundary bunds are done around the edges of the farm to prevent water from running through the field.

He lines up the crop's stalks in between the old ridges before making the new ones on top. The nutrient therefore increases when the residues decompose.

Cover Cropping and Mixed Cropping

On the compound, another method is the practice of cover cropping. Crops such as beans *(Glycine max)* are planted together with millet *(pennisetum glaucum)* to fix nitrogen. Moisture is conserved by means of mulching the crops such as millet *(pennisetum glaucum)* and sorghum *(sorghum bicolor).* The beans *(Glycine max)* needs enough rain to give good yields and are planted together with millet *(pennisetum glaucum)* of which the beans *(Glycine max)* do mature and harvest early given way for the millet *(pennisetum glaucum)* to also grow to maturity. Sometimes groundnuts/peanut (*Arachis hypogaea*), bambara nuts *(vigna subterranea)* are grown together.

Benefits of the use of Soil and Moisture Management Practices

The yield is better any time he uses the above methods. The manure can last longer on the field than any kind of inorganic fertilizer. The run-off water cannot enter and destroy his farm because the boundary bunds block it. There is less erosion effect on the farm as a result.

Challenges Associated with the use of Soil and Moisture Management Practices

The chemical fertilizer is costly and it makes the soil dries faster in season of no rain which makes smallholder farmers to register low crop yields. It is difficult to make the bunds and ridges. He has the interest in applying inorganic fertilizers but he scarcely gets it due to the cost involved. He also wishes to apply compost on his field but he has no knowledge to make it.

The results show that the main forms of soil and water conservation methods practiced by most farmers on compound farms are the application of compost and manure, boundary bunds and ridging. A few people apply chemical fertilizers on the compound farms and practice Farmer-Managed Natural Regeneration (FMNR) (See Table 4.6). The application of compost and manure are nutrient improvement measures while boundary bunds and ridging are erosion prevention and moisture conservation measures.

Similarly, the application of compost, boundary bunds, mixed cropping; crop rotation and the use of chemical fertilizer are the main means of improving soil and water conservation on valley farms (See Table 4.6). Few farmers are practice Framer-Managed Natural Regeneration (FMNR). Whereas compost and chemical fertilizer are nutrients improvement techniques, boundary bunds is an erosion prevention measure and the Framer-Managed Natural Regeneration (FMNR) is used to manage the soil nutrients, moisture and erosion.

Table 4.6 Methods of soil fertility, moisture and erosion prevention by current generation

Types of farms	Soil fertility management	Soil erosion management	Soil moisture conservation
Compound	Compost, manure, crop rotation and inorganic fertilizer.	Ridging and boundary bunds.	Ridging, mulching and cover cropping
Valley	Compost, boundary bunds and chemical fertilizers	Boundary bunds and Ridging.	Boundary bunds, mixed cropping and Ridging
Garden	Manure and inorganic fertilizer.	Drain channels	Mulching and sunken beds

Source: Field Survey, December, 2017

On the gardens, application of manure is the main means of soil conservation and this may be combined with the application of little quantity of chemical fertilizer. Other methods include, mulching and sunken beds for moisture retention.

4.5 Discussion of the Results

4.5.1 Types and Sizes of Farms for Sustainable Intensification Agriculture (SIA)

The results show a shift in types and sizes of farms for the purpose of supporting SIA for climate change adaptation. The analyses reveal a shift from large bush farms to smaller compound and valley farms, including gardens. The rationale is mainly to support Sustainable Intensification Agriculture (SIA) as a means to adapting farming to climate change. This conforms to the findings that bush fields were largely cultivated by smallholder farmers in the past which included both uplands and lowlands fields that are located far away from the farmers' home of residence (Naab, et al., 2005). This study only looked at bush farms to comprise both highlands and lowlands without considering valley farms as a separate type of farm with its unique characteristics that support crops production. Bush farms are far away from farmers' homes of residence. This is in relation to the assertion that, bush fields are those fields that are furthest away from the homestead and it takes farmers several kilometres to get to the premises (Vanlauwe, et al., 2010). Farmers have abandoned their bush farms and engaged in the cultivation of compound farms. This is also similar to his work that, cultivation of bush farms which were dominant among many farmers in the past is not common in the current generation due to less nutrients availability in the soil as compared to the compound fields (Vanlauwe, et al., 2010). Meanwhile farmers still maintained valley fields which were cultivated in the past generation as well.

Compound farms show higher level fertility among almost every smallholder farmer that makes its cultivation intensive. Much attention is on the cultivation of compound farms to get higher yields for both household consumption and for income. This is similar to the evidence that, in northern Ghana, farmers have shifted from traditionally cultivating of bush farms to compound farming to feed their families only to farming to sell in recent times; this is as a result of changing the social custom pattern from extended system to individualism (AFFRITC, 2018). Similarly, it is reported that nutrients level in compound/home fields is higher in the savannah regions of Africa and is relatively higher among many sections of the countries, especially among smallholder farmers (Vanlauwe, et al., 2010). Farmers' belief that household and animals' wastes such as ashes, left – overs and droppings are dumped on compound farms to improve soil fertility because these serve as manure. It is in line with the fact that, in sub- Saharan Africa, farmers who use crop residues help to increase crop yield per plot and in situations whereby there is no crop residues, there is a significant reduction of yield (Andersson & D'Souza, 2014; Thierfelder et al., 2013). The results also support the assertion that framers use crops residues to improve the soil structure and fertility which reduces the rate of soil degradation (Panagos, et al., 2015).

The results reveal some inter-generational differences. For instance, preference for small compound farms is high in the current generation as opposed to larger bush farms in the grandfathers' era. These results also reveal some similarities as in the common choice of valley farm occur in all the three generations of farmers. This conform to findings that land acquisition, ownership and utilization features of Smallholder farmers' also known as "family farms" are having a kind of inter-generational links with varying degree of

similarities and differences (Ahearn & Newton, 2009). The cultivation of gardens is inclusive in the practices of smallholder farmers in their bit to reduce the adverse impacts of climate change by increasing productivities. This is in line with a study which showed that, in the past farmers' adaptation measures were mostly on diversification of production and migration to other localities but in recent times, they are adopting the usage of shallow underground water for irrigation of vegetables in gardening, referred to as Farmer-driven Small-scale irrigation (Laube, & Awo, 2012). In the same vein, farmers use adaptation measures such as dry lands irrigation in their bit to increase yield to avert climate change challenges (Apata et al., 2009). According to Vanlauwe et al., (2010), home gardens are also called compound farms, farms that are near the homestead or within the settlements, and that this is dominant among the many rural savannah farming communities. However, the study findings do not support Vanlaue et al., (2010) findings that farmers make gardens on their compound farms. Results from this study reveals that gardens are established in valley areas and one largely part of the valley fields for easy access to water for irrigation.

The findings reveal that farmers reduced the sizes of their farmers as a strategy to be able to intensify agriculture in this era of climate change coupled with low soil fertility. They do this to make it easier to apply good agronomic practices such as manure and composting. This supports the assertion that the world trend and pattern of average farmland distribution shows a decrease in sizes of farms in lowest and lower middle-income countries like Sub-Saharan Africa than the developed countries such as America and Europe (Lowder, et al., 2016). The sizes of farms of smallholder farmers are generally smaller today as compared to the past. This is farmers' strategy to intensify agriculture through cultivating and better

maintaining smaller farms than bigger once. This is in line with the fact that, in many cases the average plots sizes of smallholder farmers are small and is about 4.25 acres or less (Amanor-Boadu, et al., 2015; Wood, 2013). This evidence backs the findings of Dewbre & Borot de Battisti (2008) that, in the past Africa agriculture increase was mainly through an expansion of cultivated land not from increase in yield from a fixed field. Aside the need for SIA, the reduction in the farm sizes of farmers is triggered by factors such as change in households' composition, social tides, migration, modern education and reduced soil fertility. This evidence is not far from the findings underscoring that, in the northern parts of Ghana, farmers' plots sizes reduce as result of reduction in family/households' composition by means of migrating leaving the elderly household heads is having negative impact on food production and households' food security (Nakasone, & Suvedi, 2017).

4.5.2 Types of Crops and Yields for Sustainable Intensification Agriculture (SIA)

The analyses of the results reveal that generally (See Table 4.4), farmers have maintained the same types of crops across all the three generations of households. Thus, all generations maintained the cultivation of cereals, roots and tubers, legumes and vegetables. However, the varieties of crops have changed between generations. The era of the grandfather witnessed the cultivation of indigenous varieties only. The fathers' era witnessed the cultivation of predominantly indigenous varieties together with the introduction of new crops varieties. The grandsons' era/current generation is witnessing the cultivation of both new varieties of crops and indigenous crop varieties except that the former is predominant. These new varieties include maize, sorghum, groundnuts and beans. Farmers cultivate both new and indigenous varieties because the new varieties give high yields due to its short maturity

period under low/shorter rainfall. On the other hand, farmers are still cultivating indigenous varieties such as groundnuts, bambara nuts, beans, millet, and yam because they are used for social performances such as funerals, festivals and giving as gift to visitors. Farmers do this to adapt to climate change in the sense that in terms of low rainfall, the new varieties do not experience complete failure because they mature early and the indigenous varieties are drought resilience. In seasons of better rainfall, all the two crops verities give high yields increasing the level of food security among households.

In the current generation, farmers are cultivating more new crop varieties mainly to support their SIA practices for climate change adaptation. These include; firstly, cultivating early maturing crops varieties on smaller size compound farms and smaller size valley farms for adapting to climate change. By better managing soils on smaller farms, farmers are able to adapt crops to climate risk factors such as shorting rainfall, dry spells and droughts. Secondly, by planting early maturing new crop varieties, farmers are able to produce in both the raining season and dry season in gardens along valley fields. Lastly, by maintaining the production of some indigenous crop varieties; farmers diversify their crops for minimizing total crop failure under harsh climatic conditions. Whereas new crop varieties are cultivated for their shorter maturity duration, indigenous crops are cultivated for their resilience to drought. In both cases, better and improved management of the soils enabled by small farm sizes improves soil fertility and moisture retention for supporting adaptation to shorter duration rainfall and drought.

The types of crops that farmers grow are mainly cereals, legumes, roots and tubers and some vegetables; notably, Millet, maize, beans groundnuts, bambara nuts, yam, aerial yam, pepper

and pumpkin. These findings support the results that in Africa, especially West Africa, smallholder farmers cultivate cereals, legumes, and tubers such as sorghum, millet finger, rice, cowpea, bambara groundnut and Africa yam beans (Emmambux &Taylor, 2013). In a similar way, it is also in line with the report of Ghana statistical service which shows that these crops mentioned above are suitable for the prevailing climatic conditions in the upper west region of Ghana (GSS, 2014). Crops diversification is done among farmers to sustain and intensify agriculture. This is in line with the results that farmers use crop diversification as a means to intensify agriculture and to adapting to climate change impacts (Zimmerer, 2011). Crops diversification is a way of protecting the natural ecosystem which intends to reduce the rate of climate change. This supports the findings that crop diversification promote ecosystem functioning and resilience (Lin, 2011).

Farmers of the current generation are engaged in the cultivation of gardens especially in the dry season using irrigation. This corroborate the work of Dile, et al., (2013) that one way farmers achieve sustainable intensification in Sub-Saharan Africa is harvesting water for small-scale irrigation in the dry season. This also supports the assertion that in the past farmers' adaptation measures to climate change based on production diversification and migration but in recent times, they are adopting the usage of shallow underground water for irrigating vegetables in gardens, this act called Farmer-driven Small-scale irrigation (Laube & Awo, 2012). Farmers are not expanding their farm sizes but still are able to feed their households. This supports the findings of Bekunda, et al., (2010) that supporting food demands of African population can be achieved through intensification of the current lands not by converting new ones. The valley fields upon the long-time of cultivation since the

grandfathers' era is still fertile and supports many of the major crops cultivated by farmers in the current era, especially the improved varieties and some local varieties. This results supports the assertion that, the rate of nutrients depletion on alluvial soil is low if not zero because of the continuous deposition of eroded organic materials from upland regions and this supports crop yields for a longer time range (Kumar, et al., 2017).

On the issue of crops varieties, farmers cultivate both indigenous and improved varieties of crops that have different maturity periods to be able to reduce crops failure in the age of climate change and its impacts on agriculture. This is in line with the findings that farmers grow crops with different maturity periods to be able to intensify agriculture and safeguard them from climate change impacts (Zimmerer, 2011). The improved varieties are early maturing; this is necessary because climate change has reduced the duration of rainfall. This is similar to the findings that, climate change brings about higher temperature and reduction in rainfall which affects crop yields and farmers are adapting to this through timely planting of diversified crops varieties and mulching (Ezeaku, 2014; Kalanda-Joshua et al. 2011 & Majule et al. 2013). The growing of improved and local varieties of crops give way to different maturity and harvesting time to able to reduce climate change impacts and the ability to use it is determining by farmers' exposure to training and education. This supports the findings that, farmers are trying hard to increase production in this era of climate change through the adoption of improved varieties of crops which is influenced by farmers' farm sizes and attendance to demonstration fields (Danso-Abbeam, et al., 2017; Li, et al., 2013 & Di Falco, et al., 2010). Farmers still cultivate local varieties of crops such as bambara nuts, millets, beans, yams and groundnuts because of its social and religious importance attached

to them apart from the good taste consumers have for them. This is in relation to the findings that some smallholder farmers in recent times still cultivate indigenous crops varieties because of overwhelming importance they attached to them meanwhile many are of the view that these varieties are likely to disappear in the system (Jarvis, et al., 2011).

Meanwhile, some typical local varieties such as "Dawuli", Be-luri", "Kubara" and "Zeze" have extinct because they take longer maturity period leading to low yields. The local varieties are still cultivated in small quantities because they are used for traditional performances and some believed that, the local varieties are tasteful than the improved varieties for example the local beans, Bambara nuts and millet. This is in line with the assertion that farmers plant traditional crop varieties such as the local maize which they belief has good taste, easily cultivated, accessed and stored than the hybrid and synthetic ones (Nyantakyi-Frimpong, 2013). This finding is also in relation to the fact that, farmers from the onset of domestication of crop biodiversity to the current era of the 21st century have moved from the cultivation of indigenous varieties to improved varieties to adapt to climate change, especially in West Africa where rainfall has decreased in the last forty years (Vigouroux, et al., 2011). Famers cultivate more of the new crop varieties than the indigenous varieties. It is in consonance with the finding that, smallholder farmers cultivate improved varieties of crops to increase staple food crops yields than the local varieties. However, farmers who do not make use of organic fertilizer and irrigation are lowering the yields of crops such as maize and other cereals (Abebe, et al., 2013). The findings do not agree with the bit of Abebe, et al., (2013) findings indicating that the practice of irrigation and application of organic fertilizers lower crop yields because farmers in the study area

intensify agriculture by means of manure and compost to increase soil fertility as well as the use of small dry season irrigation gardens to adapting to climate change. The main reason why farmers in the current era have reduced the cultivation of indigenous varieties of crops is that there are low yields but still cultivate it because it is drought resilient. This supports to the findings that in the Sahel Region, farmers who cultivate staple food crops of indigenous varieties like millet and sorghum in the past were resilient than current era, this makes farmers to shift to the cultivation of improved varieties with high yield under less soil fertility conditions (Sultan, et al., 2013).

Farm sizes have been reduced and maintained for a long time throughout the son's generation but are able to produce and feed their households even though the yields are not same comparing it to the past. This corroborates the findings that farmers intensify agriculture by reducing their farm sizes and make efficient utilization of resources to protect the ambient quality of the environment while yields are increased (Cook et al., 2015; Foley et al. 2011 & The Royal Society. 2009 cited in Cook et al., 2015). This is also in line with the findings that, global pattern of crop yields is affected by climate change coupled by managements practices (Licker, et al., 2010). The yields changes with time as a results of reduction in nutrients and low rainfall regime. This is quite similar to the results that, climate change has seriously threatened food security in Africa, leading to a continuous change in yields over time, especially on cereals crops such as; wheat, maize, sorghum, millet and rice (Knox, et al., 2012). Again, it reflected the conclusion that, inter-annual crops yield in savannah and guinea savannah regions of Ghana is affected by low rainfall and high temperature as a result of Climate Change and Variability (Amikuzino & Donkoh, 2012). This does not agree with

the findings of Osborne & Wheeler (2013) that, there is a change in crops yields in the past, but this decrease is not through time, it is as results of non-climatic factors especially among rice, wheat and maize farmers. This was not analysed on inter - generational perspectives.

Smallholder farmers have reduced their farm sizes, yet are able to get enough to feed on depending on whether one is able to put in good agricultural practices or not. It is in line with the findings that, in the world, small holder farmers with small farm sizes have higher marginal output of high value crops compared to the medium and larger holding farmers, they contribute to both diversification and food security (Mahendra, 2014). Farmers increase their yields through the use of more inputs. This supports the finding that, farmers attain agricultural intensification through increasing agricultural inputs to add up to per-hectare yields either than expanding cultivated land and this goes a long way to protecting forest ecosystem (Phelps, et al., 2013). It also supports the idea that, smallholder farmers who adopt the cultivation of improved seeds and the use of organic manure to increase soil fertility increased their yields (Peprah, et al., 2016).

Farmers get enough harvest and are safe from crops failure due to the practicing of crops diversification. This finding supports the ideas that farmers who are into crops diversification stand the chances of reducing pest outbreak, pathogen transmission, buffering crops against adverse climate change effects to reduce hunger while improving environmental change resiliency (Rusinamhodzi, et al., 2012 &Lin, 2011). It is also similar to the finding that, farmers who practice organic farming have high food security with diverse diet, they also produce diverse range of crops and have better health situations than that of conventional farmers (Altieri, et al., 2012). The yield situation varied among generation, at times is high,

moderate or low. This evidence is similar to the fact that global crop yield in recent times has been categorized into four (4) main types; situation where yield never improved from the past, yield still is stagnant, yields has decreased over the year, yield has increased and collapsed and yields still on increasing of which some areas are rapidly increasing compared to the past (Ray et., al, 2012). Farmers sell some of their farm produce to buy other food stuffs that the households are in need of. This supported the work of Kirimi, et al. (2013) that, smallholder farmers diversify their dietary needs through sale of crops and re-buying of other staple food.

4.5.3 Soil and Water Conservation Methods

The findings revealed that smallholder farmers employ integrated crop soil management in practicing SIA. Smallholder farmers use compost, manure, boundary bunds and ridging to conserve soil and water on their farms. This is in line with Vanlauwa et al., (2010) that smallholder farmers in Sub-Saharan Africa use integrated soil fertility management to improve soil fertility on their fields. This practice involves the use of organic manure, grain and legumes rotation. The findings suggest that most farmers actually rely on the application of organic manure under Integrated Crops Soil Management for SIA. Thus, the findings largely support the assertion by Chen, et al (2011) that many smallholder farmers in the World are using environmentally friendly approaches to increase the yield level of grains and cereals twice the current yields without the use of much fertilizer through an integrated crop-soil management.

The application of compost and manure is the main method that farmers use in maintaining soil and water on their farms. The findings support the work of Banerjee et al (2011) that

soil fertility and health can be increased to enhance crops growth and production through the use of bio-fertilizer and compost. This is similar to the findings that many smallholder farmers in the World are using organic means to improve nutrients to gain higher yields from the same plots size because of better health situations than that of conventional farmers in securing food (Altieri, et al., 2012). Farmers use manure to fertilize compound farms in many instances. This supported the work of Bekunda et al (2010, pg. 24) that nutrients application takes the form of livestock manure, crop residues in situ or transferred from other production areas and compost which is a value added product of a collection of a range of organic compounds that have been incubated for a period to allow for their decomposition. The finding does not support the assertion that in Africa, farmers mainly use crop residues under no-tillage system to conserve soil and water on their fields to increase crop yield per plot (Andersson & D'Souza, 2014 & Thierfelder et al., 2013) but rather combines manure with methods such as ridging, composting and bunding. The use of compost and manure is a way to increasing crops yields due to the improvement in soil fertility. This is similar to the work of Kassam, et al. (2011) that smallholder farmers intensify agriculture through the use of irrigation technology in dry season farming, soil water and nutrient management systems. It also supports the assertion that nutrients level in compound/ home fields are high in savannah regions due to the presence of manure, especially among the smallholder farmers (Vanlauwe, et al., 2010). The findings are also in line with Nyantakyi-Frimpong (2013) that, smallholder farmers in Northern Ghana use compost to reclaim barren lands by burying and soaking it with run-offs to make the moisture seeps to enrich the soil and attracts termites that bore holes for higher penetration and soil aeration for crop growth. This does not support the work

of Guto, et al. (2012) that, smallholder farmer' production cannot be increased through crops residues retention on poor fields, rather on the rehabilitation of physical and chemical components of the soil. The use of residues and compost can help increase soil nutrients while maintaining the soil moisture as well. This supports the work of Agriinfo (2015) that soil and water management can be improved using artificial means like the use of plant residues and sawdust. control temperature, prevent surface compaction, reduction of run-off and erosion which helps increase water absorption and reduce evaporation.

The results also showed that farmers use boundary bunds and ridges to maintain soil structure. This has prevented further expansion of farmlands affected by erosion and cultivated lands. This finding also relates to the work of Ligonja & Shrestha (2015) which showed that smallholder farmers use ridges, bunds, cut-off drains, to prevent soil erosion. The findings do not support the work of Ngwira, et al. (2013) that in Africa, smallholder farmers' belief that making ridges and bunds do not improve soil fertility management. It is also not in agreement with the findings of Giller, et al. (2011) that in Sub-Saharan Africa, soil erosion on farms can only be conserved in the form of minimum or zero tillage to increase stability in crops production. The use of compost and manure is also safe because it does not cause underground and surface water pollution. This is in line with Barrow's assertion that methods of improving soil fertility should be geared towards enriching the soil without contaminating streams and underground water (Barrow, 2012). The use of bunds and streams in irrigation help check soil erosion as in the findings of Hiscock (2014) that Soil erosion can be checked through the use of bunds and trenches as well as the creation of ponds to collect excess water for later usage.

Furthermore, smallholder farmers practice mixed cropping as a means of conserving soil moisture. This finding supports the assertion that practicing intercropping of cereals with legumes crops is a way to sustainably introduce biological nitrogen fixation naturally (Cortés-Mora et al., 2010 & Lithourgidis et al., 2011). It is also in line with the findings that, smallholder farmers who intercropped cereals with legumes generate high quality organic matter at a larger amount and this improves production comparatively with regular maize mono-cropping (Rusinamhodzi, et al., 2012). The crop rotation practice by farmers is a way of checking soil erosion and replacing of nutrients as indicated in Hiscock (2014) that, rotation of crops is an important method for checking erosion and maintaining productivity of soil. Crop rotation is also one the common practice farmers are into to intensify agriculture, especially on compound farms. This result supports the assertion of Smith et al. (2010) that, smallholder farmers practice crop rotation to increase yields and is a good act in controlling or suppressing disease on farms. The rotation of legumes and cereal crops by farmers support the findings that, farmers in Ghana practice crops rotation of which legumes crops such as pigeonpea and beans (Glycine max) with cereals crops such as maize and this increases crop yields because of the nitrogen fixation ability of legume crops (Adjei-Nsiah, 2012).

Also, on the compound farms, farmers apply manure and compost as the main means of improving soil and water conservation. Few farmers are practicing Farmer-Managed Natural Regeneration (FMNR) and the application of chemical fertilizer. Whereas compost and chemical fertilizer are nutrients improvement techniques, boundary bunds are an erosion prevention measure and Farmer-Managed Natural Regeneration (FMNR) is to manage the

soil nutrients, moisture and erosion. This is similar to the works of Ligonja & Shrestha (2015) that the use of on-farm tree planting by farmers can control soil erosion. On the other hand, it does not support the idea that farmers should leave trees to grow naturally rather than planting it. This finding supports the claim that all over the world, smallholder farmers use shade trees to maintain water availability in the soil, coffee crops are mainly use to prevent soil erosion and evaporation activities in both dry and wet seasons (Lin, 2010) but those trees are naturally grown.

On gardens, smallholder farmers apply usually organic manure for soil and water conservation. This is usually supported by the application of small quantities of chemical fertilizer. The finding supports the claim that, "smallholder farmers in Africa who use chemical fertilizers, manure and leguminous crops have been keen to agricultural intensification" (Foley et al., 2011 pg.340). The use of chemical fertilizer is not sustainable for smallholder farmers in Northern Ghana because in the long-term there could soil pollution. This supports the assertion that, fertilizer utilization can have the potentials of contributing to lower crop yields in the long run particularly for smallholder farmers (Chapoto, et al, 2015). Farmers use dug out wells to irrigate their crops during the dry season. This is similar to the findings of Apata et al. (2009) that smallholder farmers in Africa use adaptation measures such as dry lands irrigation. It also supports to the claim of Zimmerer (2014) that dry season irrigation intensifies agricultural activities as it extends the growing period and production is increased.

4.5.4 Summary and Conclusions

Firstly, it can be concluded that smallholder farmers have shifted from the cultivation of large bush farms to smaller farms comprising compound farms, valley farms and gardens. This shift is to support SIA practices for adapting agriculture to climate variability. Smallholder farmers therefore reduced the sizes of their farms to be able to employ good agronomic practices such as soil and water conservation methods as well as the use of certified seeds or improved varieties of crops to get maximum yields from the small cultivated land under rainfall variability. Parts of the valley farms are also converted into gardens to facilitate both wet and dry season farming in adapting to climate change and sustainable food production. The reduction in farms sizes is also attributed to sharing of farmlands among family members, population expansion, leading to expansion of settlements in the case of compound farms.

Secondly, it can also be concluded that, the types of crops farmers cultivate are the same across the three generations except that varieties are changing from indigenous to early maturing new crop varieties. The type of staple crops farmers cultivate are mainly legumes, cereals roots and tubers and vegetables; specifically, groundnuts, maize, millet and yam. However, there are differences in the varieties grown. In the grandfathers' era, all were indigenous varieties. In the fathers' era, farmer maintained the cultivation of indigenous crop varieties but started the introduction of new crop varieties. In the sons' era, both varieties are cultivated except that more new crop varieties are cultivated. The yields depict a decreasing trend from high to moderate yields level from the grandfathers to the fathers' generations and low in the sons' generations. These crops are cultivated on compound farms, valley

farms and gardens. Farmers are adapting to climate change by converting parts of valley farms into gardens. Bush farms are abandoned and farmers' concentration is now on small compound farms to be able to put in better agronomic practices.

Farmers also introduce the cultivation of improved varieties with short maturity period. This measure is a way of intensifying agriculture to adapting to climate change effects on their activities such as short duration of rainfall. Smallholder farmers in the current generation are still cultivating traditional/indigenous varieties of crops in small quantities to satisfy their socio-cultural practices such as funerals, religious sacrifices, festivals and gift even though there is low yield. This habit does not support intensification agriculture due to low yields smallholder farmers get at the end. Farmers' ability to identify the type of farm that supports a particular crop type is an opportunity for farmers to better practice Sustainable Intensification Agriculture (SIA).

Finally, it can be concluded that smallholder farmers are pursuing SIA through Integrated Soil Management (ISM) that predominantly rely on the application of organic manure and materials. Other agronomic practices include; ridging, boundary bunds, intercropping, crop rotation, Farmer-Managed Natural Regeneration (FMNR), mulching and the application of little quantities of chemical fertilizer.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 Introduction

The study investigated how Smallholder Farmers are practicing Sustainable Intensification Agriculture for Climate Change Adaptation in Lawra and Nandom Districts of the Upper West Region. The study was conducted using Survey, Key Informant Interviews, Focus Group Discussion, and Smallholder Agricultural Households In-depth interviews. Areas looked at included; the dynamics and trends in the types of farms and sizes of farms, dynamics and trends in types of crops and yield and the soil and water conservation management practices that smallholder farmers are adapting in Sustainable Intensification Agriculture for Climate Change Adaptation. Though the household members think the use of ridges and bunds are the best ways to conserve water and soil nutrients, low income and the high cost of hiring labour to make ridges compelled them to opt for ploughing flat which is cheaper. The conclusions for the study and some recommendations emanating from the findings are presented in this chapter. The recommendations are focused on how Smallholder Farmers Sustainable Agriculture Intensification practices can be improved, implications on policy formulation as well as future research issues.

5.2 Summary of Findings

The analysis on trends in types and sizes of farms reveals both similarities and variations between the three generations. In the grandfathers' era, the primary types of farms were bush farms and valley farms. The bush farms were the largest and the size of the valley farms

were equally large. The bush farms were larger because; many of their food crops were grown in the bush farms and labour was available and adequate because of the larger household's sizes under the extended family system in addition to the limited competition for arable lands at the time. Valley farms were cultivated for harvesting early crop such as maize *(zea mays)*. Compound fields served as grazing grounds for livestock because farmers wanted their animals closer to them for proper care.

In the era of fathers, the primary types of farms were bush farms, valley farms and compound farms. The sizes of these farms were generally smaller than those of the grandfathers' generation. In the fathers' era, households reduced the sizes of bush farms and started the cultivation of crops on compound farms in addition to the rearing of livestock. Farmers reduced sizes of bush farms because of poor crop yields arising from poor soil fertility, inadequate rainfall and less availability of labour. By shifting their attention to smaller compound farms, farmers are able to improve soil fertility through the application of manure and compost which improves the moisture retention capacities of soil for supporting crop growth during dry spells and drought. In addition to compound farms, farmers in this era maintained the cultivation of valley farms because they have better soil fertility and moisture retention capacities for supporting crop growth during droughts.

In the son's era, households have completely abandoned the cultivation of bush farms. In place of this, they are concentrating more on the cultivation of compound farms, valley farms and gardens. In general, farm sizes are smaller than the sizes of farms in the earlier generations. The shift from larger bush farms to smaller compound farms is driven by farmers' preference to practice some form of SIA such as the application of manure and

compost, ridging and boundary bounds. Bush farms have over the years become unproductive and crop yields have been low mainly because of poor soil fertility. Poor soil fertility also meant that water or moisture retention capacities of soils are low and fail to support plant growth during dry spells and droughts. The overall impact is that, poor yield from bush farms is undermining food security among households. To address this problem, the current generation of farmers are concentrating on compound farms, valley farms and gardens for practicing SIA that enables them adapt food crop farming to climate change.

In the Compound farms, fertility level is high due to the availability and application of household waste and manure. The compound farms are small in size so that farmers are able to practice good agronomic management practices to increase production of food crops. The farms are around the houses; this reduces the distance between farms and homes. Composts made at homes are easily applied on these fields to increase soil fertility and yields. Valley farms are also preferred because; there is the availability of alluvial/flood plains. Eroded top soil materials from the upland regions are deposited in these areas and thereby increasing the soil fertility. Crop failure is not common on these farms because there is high soil moisture retention. Households harvest early matured crops from flood plains to support their food needs because these areas are cultivated first.

Preference for gardening is high in recent times because it is a way of promoting continuous cultivation. Farmers practice two (2) seasons cultivation (wet and dry) to increase production and decrease vulnerability among farmers. Different types of crops are grown. In the wet season, cereals are grown while in the dry season; vegetables are cultivated to diversify their food and nutritional needs. Farmers are able to adequately apply organic fertilizers as a result

of the small garden sizes. Farmers make use of dugouts, streams and wells to irrigate crops in the dry seasons. Farmers get supplementary income from the dry season gardening through the sale of the vegetables.

By focusing on smaller compound farms, farmers are better able to improve soil fertility through the application of compost and organic manure. This also improves the moisture and water retention capacities of the soil and thus improves the soil ability to support plant growth during droughts. The result is that farmers have improved yields from compound farms and this helps households to meet their food needs; although deficits are common. By focusing on the cultivation of valley farms, farmers are also able to adapt food crop farming to climate variability. Valley farms are generally known to have more fertile soil and higher moisture and water retention capacities due to the presents of alluvial soil and the fact that the area is waterlog. This helps the crops survive during drought. As a result of better soil fertilities and water retention of soils, yields from the valley farms are good and this helps to meet food needs of households.

Another strategy for SIA is the choice of gardens, particularly, in the valley fields. Famers are resorting to setting up gardens, both raining season and dry season gardens as part of the valley fields. This means that farmers are reducing the sizes of valley farms by converting portions into gardens. This supports SIA in the following ways; firstly, by reducing the sizes of valley farms further, farmers are better able to practice sustainable water and soil conservation using bunding, ridges, application of organic manure and compost and other improved farm management practices. Manure and compost are readily available at farmers' places of residence which are normally used to improve soil and water management on

compound farms. Secondly, by setting up gardens as part of valley fields; farmers are better able to intensify the application of organic manure and compost for the production of vegetables and other crops.

Gardens enable all year-round production; raining season and dry season production, another form of intensification. To support dry season gardening, farmers dig shallow groundwater wells from which they draw water to irrigate their crops during the dry season. Such all year-round production has improved crop yields and incomes to support households' consumption. Thus, this is helping households better adapt agriculture to climate variability. Thirdly, there are other environmental factors that support or reinforce farmers' choices for SIA in household production system. These include; the lack of labour, increased demand for land for residential purposes and urbanization.

The results show a shift in types and sizes of farms for the purpose of supporting SIA for climate change adaptation. The analyses reveal a shift from large bush farms to smaller compound and valley farms and gardens and this is mainly to support Sustainable Intensification Agriculture (SIA) as a means to adapting farming to climate change.

The trend in the types of crops shows that, crops in the grandfathers' era included; millet known locally as "Be-luri" and "Kubara" and maize called "Zeze", groundnuts, guinea corn, Bambara nuts, rice, beans called "Dawuli", sorghum, yam, aerial yam, potatoes and vegetables like pepper, tomatoes, okra and pumpkin. All these crops were indigenous varieties which were grown on bush farms and valley farms. However, indigenous varieties like beans called "Dawuli", millet called Be-luri" and "Kubara" and maize called "Zeze",

are no more cultivated in the current era. The general yield situation was good without the application of fertilizer and farmers were able to feed from their own produce throughout the year and still had surpluses. These surpluses were for consumption. However, produce such as beans *(Glycine max)* and groundnuts (*Arachis hypogaea*) can be sold to buy farm implements like hoes and cutlasses. Other uses of surpluses included; storage for prestige, for traditional rites like funerals and sacrifices, trading for other food stuffs that the household is not having under the barter system and given it out to others as loan payable through farming for the giver. The reason given for the cultivation of only the local varieties were that, there were no improved crop varieties in the system and the fact that the local varieties were giving the maximum yields to farmers. During this era, farmers consumed crop produce; animals are sold to buy households food ingredients to support their nutritional needs. Surpluses were stored for consumption and other purposes.

Similarly, the fathers' generation cultivated bush farms, valley farms and introduced compound farms where cereals, legumes, tubers and vegetables are grown. This era experienced the introduction of fertilizer application and improved varieties of crops on the bush farms; the compound and valley farms were fertile enough to support crop growth and production. The yields in general were enough for consumption. There were surpluses which were for minor sales and consumption. There were other uses that included; religious sacrifice, funeral rites and gift.

In the current era, thus the grandson's generation, farmers cultivate similar crops just like in the grandfathers and fathers' eras. These crops included millet, groundnuts, maize, guinea corn, bambara nuts, rice, beans, sorghum, yam, aerial yam and potatoes. Farmers grow both

the improved and the local varieties of crops. The very local types such as "Dawuli", Beluri", "Kubara" and "Zeze" are no more cultivated in this era because the yield is low due to the long gestation period. In this era stallholder farmers are cultivating compound farms, valley farms and gardens. In the current generation, majority of their crops are grown on the compound farms followed by valley farms and gardens. Even though the yield level fluctuates from season to season depending on the state of rainfall and farming practices, some farmers are able to feed on their own crops for barely seven (7) months after harvest. Proceeds from the dry season farming are used to buy food items from the market in the lean season.

The analyses of the results reveal that generally, farmers have maintained the same types of crops across all the three generations. Thus, all generations maintained the cultivation of cereals, roots and tubers, legumes and vegetables. However, the varieties of crops have changed between generations. The era of the grandfather witnessed the cultivation of indigenous varieties only. The fathers' era witnessed the cultivation of predominantly indigenous varieties together with the introduction of new crops varieties. The grandsons' era/current generation is witnessing the cultivation of both new varieties of crops and indigenous crop varieties except that the former is predominant. These new varieties include maize, sorghum, groundnuts and beans. Farmers cultivate both new and indigenous varieties because the new varieties give high yields due to its short maturity period under low/shorter rainfall. On the other hand, farmers are still cultivating indigenous varieties such as groundnuts, Bambara nuts, beans, millet, and yam because of their traditional and social significance such as funerals, festivals and giving as gift to visitors. Farmers do this to adapt

to climate change in the sense that in terms of low rainfall, the new varieties do not experience complete failure because they mature early and the indigenous varieties are drought resilience. In seasons of better rainfall, all the two crops varieties give high yields increasing the level of food security among households.

In the current generation, farmers are cultivating more new crop varieties mainly to support their SIA practices for climate change adaptation. These include; firstly, cultivating early maturing crops varieties on smaller size compound farms and smaller size valley farms for erosion management. By better manage soils on smaller farms, farmers are able to adapt crops to climate risk factors such as shorting rainfall, dry spells and droughts. Secondly, by planting early maturing new crop varieties, farmers are able to produce in both the raining season and dry season in gardens along valley fields. Lastly, by maintaining the production of some indigenous crop varieties; farmers diversify their crops for minimizing total crop failure under harsh climatic conditions. Whereas new crop varieties are cultivated for their shorter maturity duration, indigenous crops are cultivated for their resilience to drought. In both cases, better and improved management of the soils enabled by small farm sizes improves soil fertility and moisture retention for supporting adaptation to shorter duration rainfall and drought. The types of crops that farmers grow are mainly cereals, legumes, roots and tubers and some vegetables; notably, millet, maize, beans groundnuts, bambara nuts, yam, aerial yam, pepper and pumpkin.

The findings revealed that smallholder farmers employ integrated crop soil management in practicing SIA. The main forms of soil and water conservation methods practiced by most farmers on compound farms are the application of compost and manure, boundary bunds and

ridging. A few people apply chemical fertilizers on the compound farms and practice Farmer-Managed Natural Regeneration. The application of compost and manure are nutrient improvement measures while boundary bunds and ridging are basically erosion and moisture conservation measures.

Similarly, the application of compost, boundary bunds, mixed cropping; crop rotation and the use of chemical fertilizer are the main means of improving soil and water conservation on valley farms. Few farmers are practicing Framer-Managed Natural Regeneration (FMNR). Whereas compost and chemical fertilizer are nutrients improvement techniques, boundary bunds are an erosion prevention measure and the Framer-Managed Natural Regeneration (FMNR) is used to manage the soil nutrients, moisture and erosion.

On the gardens, application of manure is the main means of soil conservation and this may be combined with the application of little quantity of chemical fertilizer. Other methods include, mulching and sunken beds for moisture retention. Smallholder farmers use compost, manure, boundary bunds and ridging to conserve soil and water on their farms.

5.3 Conclusions

The study sought to look at the trend in types and sizes of farms from the grandfathers and fathers' eras to the grandsons' era, the dynamics and trends in the types of crops and yields from the grandfathers, fathers to the grandsons' generations and the methods of soil and moisture conservation the current generation is using. It was observed that farmers are practicing sustainable agriculture through an integrated approach to smallholder agriculture that combines different type of farms, crops, oil and water conservation and crop management practices heavily dependent on affordable and practical organic and agronomic practices. The trend in types of farms smallholder farmers cultivate shows a paradigm shift from the grandfathers, fathers to the grandsons' generation. The sizes of these type of farms also exhibited a declining pattern. The types of crops changes over time; smallholder farmers shifted from the cultivation of indigenous crop varieties to the cultivation of improved varieties with yields moving from high to low. Multiples methods are used by smallholder farmers in conserving soil and water on their fields as presentedbelow.

Firstly, the trend in types of farms smallholder farmers cultivate changed over time, thus from one generation to another. Farmers have moved from the cultivation of bush farms and valley farms in the grandfathers' era to the cultivation of bush farms, valley farms and compound farms in the father's era. In the son's era (current generation), farmers are cultivating compound farms, valley farms and gardens. The complete abandonment of bush farms is due to decline in soil fertility level which has effects on food crops production. This paradigm shift is as a result of farmers putting in efforts to increase yield in the period of climate change and its associated impacts on food crops production.

Secondly, the farm sizes have been reduced from large, medium to small in the grandfathers, fathers and grandsons' generations respectively. Smallholder farmers therefore reduced the sizes of their farms to be able to employ good agronomic practices such as soil and water conservation as well as the use of certified seeds or improved varieties of crops to get maximum yields from the small cultivated lands. The reduction in sizes of farms is as a result of the sharing of farmlands among family members, increase in population leading to expansion of settlements in the case of compound farms. Apart from sharing among family members, part of the valley farms is also converted into gardens to facilitate both wet and dry season farming in adapting to climate change and sustainable food production.

Thirdly, the type of staple food crops farmers cultivate are mainly legumes, cereals, roots and tubers and vegetables; specifically, groundnuts, maize, millets, yam and vegetables. These crops run through all the three generations just that it is only the crop varieties that changes remarkably, especially as in the case of the grandsons' generation. The yields depict a decreasing trend from high, medium to low yields levels from the grandfathers, fathers to the sons' generations respectively. Farmers are adapting to climate change by introducing garden fields, abandoning of bush farms and concentrating on small compound farms as the main type of farm. Some farmers also introduce the cultivation of improved crop varieties with short maturity period and higher yields. This measure is a way of intensifying agriculture to adapting to climate change effects on their activities. Their knowledge base is not wide on intensification practices to increase yields because just a few of farmers are able to get a bit of knowledge from the operation of Non-Governmental Organizations and the District Department Agriculture. Farmers sometimes experience a complete crops failure

due to poor rainfall. Smallholder farmers are still cultivating traditional/indigenous varieties of crops in small quantities to satisfy their socio-cultural practices such as funerals, sacrifices, festivals and gifts even though there is low yield. This habit does not support intensification agriculture due to the low yields' smallholder farmers get at the end. Farmers' ability to identify the type of farm that supports a particular crop type is an opportunity for farmers to better practice Sustainable Intensification Agriculture (SIA).

Finally, in soil and water conservation practices, smallholder farmers apply various methods, some of these methods are applicable on specific types of farms while some are general to all types of farms (compound, valley and gardens). On the compound farms, composting, manure, crop rotation, cover cropping, ridging and boundary bunds are basically used in soil and moisture conservation. Compost and manure are used more on this farm because of its closeness to farmers' place of residence; they are able to concentrate much on this farm type to intensify agriculture. Smallholder farmers apply compost, boundary bunds, ridging, mixed cropping, and the use of chemical fertilizers to improve soil and moisture conservation on valley farms. On the gardens, manure, drain channels, mulching, inorganic fertilizers and sunken beds are used to conserve soil and water on the fields. Chemical fertilizers, compost, crop rotation, boundary bunds and ridging are the dominant forms of conserving soil and water on farmlands. Farmers apply multiple of methods to conserve soil and water on their farms of which just a few are able to use it correctly. Farmers do not have strong Farmer-Based Associations to offer peer to peer learning on good agriculture practices.

5.4 Recommendations

The recommendations are in three folds. Recommendations on policy issues looks at smallholder farmers access to water for dry season irrigation, promotion of marketing and agro-inputs supply chain, expansion of outreach and technical assistance and public-private-partnership-led agricultural development. The second is recommendations' on improve practices are; integration of crops and livestock production, training smallholder farmers on SIA practices, there are weak smallholder farmers' associations for knowledge sharing, the adoption of classical crop breeding and crop diversification. The last recommendations look at further research issues.

5.4.1 Recommendations for Policy Formulation;

Access to water for dry season irrigation

Governmental policies and programmes on irrigation should not only based on modern irrigation facilities but also on local methods. This should be community-led approach to enhance farmers accessible to water for dry season gardening. Less technical assistance should be given to smallholder farmers to improve irrigation systems based on farmers' local knowledge and technology of individual to be able to construct well to conserve water during raining season to be used for dry season gardening. This can include planting of trees around water source to reduce the rate of evaporation.

Promotion of marketing and agro- inputs supply chain

The government should make platforms conducive for private sector stakeholders' involvement in the production, distribution and sale of certified seeds and other related inputs to farmers to increase production. Input retailers should be given training on the use and

application of agriculture inputs who will in turn give guidelines to farmers at market gates. Mini-outlet of inputs should be made available at farming communities to make smallholder farmers access inputs.

Expansion of Outreach and Technical Assistance

Government policies should also target expanding outreach and technical assistance to provide farmers with better information about the use and adoption of good agronomic practices (including organic farming, the use of improved seeds as well as soil and water management practices). Government programmes should not only base on subsidizing certified seeds and chemical fertilizer provision but should also include empowering smallholder farmers to be able to improve their activities in adapting to sustainable agriculture and climate change.

Public-Private-Partnership-Led Agricultural Development

Government should formulate policies aim at promoting link between the public sector (Ministry of Food and Agriculture) and Private Sectors (Seed Growers Associations) to introduce their fellow farmers to Sustainable Intensification Agriculture Practices for Climate Change Adaptation through advocacy programmes. This will help promote the trickling down of best agronomic practices to smallholder farmers from their peers. These practices include; compost making and organic manure application, the use of certified seeds and knowledge about planting date of various crop types and varieties.

5.4.2 Recommendations for Improving Practices;

Integration of Crops and Livestock Production

The Crops and Animals Departments of the Ministry of Food and Agriculture (MoFA) should encourage farmers to blend the cultivation of crops with the production of farm animals to help increase soil fertility through manure produced by animals especially on compound farms. Compound farms happened to be the main type of smallholder farmers' farms and manure is used to increase soil fertility. This will go a long way to help farmers generate enough manure to improve and conserve soil on farmlands. The production of abundant manure will not only improve fertility of compound farms but also farms at distant place such as gardens where manure is mainly used.

Training smallholder farmers on SIA

The Crop Department under the Ministry of Food and Agriculture (MoFA) should enhance the capacities of smallholder farmers in the making and application of compost and organic manure for practicing Sustainable Intensification Agriculture for Climate Change Adaptation. Smallholder farmers are willing to embark on agriculture intensification practices through compost and organic manure application but many do not have adequate knowledge to do so. This has limited their ability and capacity to use good agronomic practice that will help increase crops production with the limited land size they have.

There are weak smallholder farmers' associations for knowledge sharing

The Department of Crops and Non-Governmental Organizations should introduce an integrated approach to extension service delivery that should be based on local knowledge and practices of smallholder farmers with a view to scaling uptake of best practices of

Sustainable Intensification Agriculture for Climate Change Adaptation. Giving limited coverage or access to extension, multiple strategies for enhancing extension services should be promoted through; community education/sensitization, farmer groups and peer farmer education. There is low level of co-experience sharing among smallholder farmer population. This has limited their ability and capacity to use good agronomic practice that will help increase production with the limited land size they have.

The Adoption of Classical Crop Breeding

The Ministry of Food and Agriculture (MoFA), especially the Crop Department and Non-Governmental Organizations (NGOs)/Civil Society Organizations (CSOs) and other development partners should help promote a shift from food crop varieties that are susceptible to climate change to varieties that are more resilient. This can be done through education programmes such as crop breeding to help more farmers to learn better agronomic practices and also to improve on the already existing ones. Crop breeding is the practice whereby crop varieties are improved by selecting the best performing plants. This practice helps crops to be resistant to drought, adapt to changing climatic conditions, increase yields and enhance sustainability and global food security.

Crop Diversification

The Crops Department of the Ministry of Food and Agriculture (MoFA) through extension service provision should encourage smallholder farmers to grow multiple crops at a time. Growing a greater diversity of crops would allow farmers to reap the environmental and

energy advantages at a go under this complex and unpredictable weather. They will be able to secure themselves against complete crops failure.

5.4.3 Recommendation for further Research

The study recommends that further investigation should be on the integration of social capital in promoting Sustainable Intensification Agricultural (SIA) and Climate Change Adaptation among smallholder farmers. Social groups help in co-learning among smallholder farmers but this relationship was not touched in the study.

Further research should also look at how smallholder farmers finance their activities. Hence the contribution of Village Savings and Loan (VSL) to Financing Sustainable Intensification Agriculture to Climate Change Adaptation among Smallholder Farmers is highly recommended. This is relevant but was not investigated in the study.

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Appendixes

Appendix A

Qualitative Questionnaire for Key Informants Interviews and Focus Group Discussions

Focus Group Discussion/In-Depth Interview Checklist/Guide. The information provided here will be used for only academic purposes and shall be treated as confidential. Your anonymity of respondents is also assured.

Demographic characteristics

Community…… Age…….. Sex……..

Title……. Occupation……..

Education……. Marital status…….

Household Size …….

THEME A: THE DYNAMICS AND TRENDS OF THE FORMS AND SIZES OF FARMS IN SUSTAINABLE AGRICULTURE INTENSIFICATION PRACTICES

Grandfathers Era:

What **types of farms** did your grandfather/household were cultivating? Probe for

1. I will like us to discuss the **sizes** of the farms, **crops planted** on each type of farm and the **yield situation**. (Probe for types of farms and description of each.).
2. If they had multiple farms, what were the reasons for having more than one farm? Probe for reasons.
3. Was each farm further divided into smaller plots for cropping purposes? If yes, why were farms subdivided into smaller plots and what crops were planted? Probe reasons and cropping patterns.

Parents Era

4. What **types of farms** did your parents/household were cultivating? Probe for
5. I will like us to discuss the **sizes** of the farms, **crops planted** on each type of farm and the **yield situation**. (Probe for types of farms and description of each).
6. If they had multiple farms, what were the reasons for having more than one farm? Probe for reasons.
7. Was each farm further divided into smaller plots for cropping purposes? If yes, why were farms subdivided into smaller plots and what crops were planted? Probe reasons and cropping patterns.

Grand Sons era/current era:

8. What **types of farms** do you and your households currently cultivate? Probe for
9. I will like us to discuss the **sizes** of the farms, **crops planted** on each type of farm and the **yield situation**. (Probe for types of farms and description of each).

10. If you have multiple farms, what are the reasons for having more than one farm? Probe for reasons.
11. Do you further divide each farm into smaller plots for cropping purposes? If yes, why the farms are subdivided into smaller plots and what crops were planted? Probe reasons and cropping patterns.

THEME B: THE DYNAMIC AND TRENDS IN TYPES OF CROPS AND YIELDS

The focus here is basically on;

Grandfathers Era:

1. What types of crops were mostly grown by your grandparents? Probe for types.
2. What are the types of farms and crops planted during their time? (Probe for types in general, traditional and new crop varieties).
3. How was the yield situation during the time of your grandparents' era? Was yield sufficient for meeting consumption needs? Were there surpluses after consumption? What were surpluses used for?

Parents' era

4. What types of crops were mostly grown by your parents? Probe for types.
5. What are the types of farms and crops planted during their time? (Probe for types in general, traditional and new crop varieties).
6. How was the yield situation during the time of your parents' era? Was yield sufficient for meeting consumption needs? Were there surpluses after consumption? What were surpluses used for?

Grand Sons era/current era:

7. What types of crops are mostly grown by you and your household in recent times? Probe for types.
8. What types of crops do you and your households grow currently on your fields? Probe for types of farms and crops planted (types in general, traditional and new crop varieties).
9. How will you describe your yields currently? Do you produce enough to meet consumption needs? Are there surpluses after consumption? What are surpluses used for?

THEME C: SOIL AND WATER CONSERVATION MANAGEMENT PRACTICES IN SUSTAINABLE AGRICULTURE INTENSIFICATION

The focus here is on;

1. Types of methods for improving soil fertility
    a. Types of farms, specific methods and inputs used (organic and inorganic fertilizers)
    b. Advantages and benefits of these methods
    c. Disadvantages and challenges associated with application of these methods

2. Types of methods for checking soil erosion
    a. Types of farms, specific methods and inputs used
    b. Advantages and benefits of these methods
    c. Disadvantages and challenges associated with application of these methods
3. Types of methods for conserving soil moisture
    a. Types of farms, specific methods and inputs used
    b. Advantages and benefits of these methods
    c. Disadvantages and challenges associated with application of these methods
4. What motivated the use of these particular practices or why have you chosen these particular methods?
5. Which practices do you plan to continue using in the future and why? Probe.

Thanks for your time

Appendix B

UNIVERSITY FOR DEVELOPMENT STUDIES,

DEPARTMENT OF ENVIRONMENT AND RESOURCES STUDIES

WA CAMPUS

SUSTAINABLE INTENSIFICATION AGRICULTURE FOR CLIMATE CHANGE ADAPTATION IN NORTH-WESTERN GHANA STUDY

Household survey questionnaire

INTRODUCTION

Good day, my name is …… a masters' student of UDS, conducting my thesis research on Sustainable Intensification Agriculture (SIA) for Climate Change Adaptation (CCA) in north-western Ghana. I would appreciate so much if you could spare me some few minutes to talk to me on this subject. Your views and opinions will be extremely valuable as they will contribute not only to the successful completion of my studies, but also to the larger society for enhancing environmental sustainability.

I promise that any information that you will give to me will be kept in absolute confidentiality and use solely for the purpose of this study. There will not be other third party access to this data and I can state that there is absolutely no risk if you participate in this survey. However, your participation in the survey is completely voluntary and you have the right to discontinue any time you feel so. Thank you for participation.

1. General information

Interviewer Name |_____| **Date** |___/___/___|

District |_____| 1= Lawra; 2 = Nandom

Community |____| 1=Tanchara; 2 = Ko. Village/Section |_____|

Name of Compound |_____| Name of Head of Household |_____|

Household Number |____|

2. Demographic Data

Name of Respondent |_____|

Gender |____| 1= Male; 2 = female

Age |____| Years

Years lived in the community|____|

Head of Household |___| 1= Yes 2= No
Education level |____| 1 = Primary, 2 = Secondary, 3 = Vocational
4= University/ College 5=None
Household size |____|

Marital status |____| 1 = Single, 2 = Married, 3 = Widowed, 4= Separated

Household Data

Members of household by names (start with respondent)	Sex (F/M)	Age Range	Occupation	Education level

Age range: 1= less than 13years, 2= 14 to 21 years, 3=22 to 40years, 4= 40 to 60 years, 5= above 60

Occupation: 1- Farmer; 2- Trader; 3 =Food Vendor/processing; 4= Public/Civil servant; 5 = Pupil/student; 6= Unemployed

Education level: 1=Primary, 2=Secondary, 3=College/Vocational training, 4=University, 5= none

3. Farm Characteristics

Total number of farms cultivated by the household |_____|

Farm Type	Size (acres)	Ownership Status	Duration cultivated (years)	Soil Type
Compound farm				
Valley farm				
River side farm				
Bush farm				
Irrigated Farm				
Garden				

Total farm size |_____| acres

Total size of farm(s) by household 5 years ago |_____|

Over the past 5 years, how has your farm size changed |_____| 1=Increased; 2=Decreased; 3 = No change

a. Types of crops grown in the Past season on compound farm

Type of crop	Major inputs	Total Yield (Kg)	Quantity sold (Kg)	To whom

Type of crops:

To whom: 1=other village members, 2=local traders, 3=external traders

b. Types of crops grown in the Past season on valley farm

Type of crop	Major inputs	Total Yield (Kg)	Quantity sold (Kg)	To whom

c. Types of crops grown in the Past season on river side/bank farm

Type of crop	Major inputs	Total Yield (Kg)	Quantity sold (Kg)	To whom

d. Types of crops grown in the Past season on bush farm

Type of crop	Major inputs	Total Yield (Kg)	Quantity sold (Kg)	To whom

e. Types of crops grown on irrigated farm in the Past season

Type of crop	Major inputs	Total Yield (Kg)	Quantity sold (Kg)	To whom

f. Types of crops grown in the Past season on gardens

Type of crop	Major inputs	Total Yield (Kg)	Quantity sold (Kg)	To whom

Use of irrigation in the past growing season |____| 1=Yes, 2=No

Source of water for irrigation |_____| 1=Well, 2=Dam/reservoir, 3=River, 4=Groundwater

Type of Irrigation method used |_____| 1= watering cane, 2=Canal, 3=Pump 4=Residue water

Irrigation on which type of farm|_____| 1= Compound farm; 2=Valley bottom farm; 3= River side farm; 4= Bush farm; 5= Garden; 6 = other

a. Inputs used in the past season on compound farm

Input	Type	Quantity	Source

Input Type:

Source: 1=Own, 2=other villagers, 3=local market, 4= NGO, 5= Government/FISP

b. Inputs used in the past season on compound farm

Input	Type	Quantity	Source

Input Type:

Source: 1=Own, 2=other villagers, 3=local market, 4= NGO, 5= Government/FISP

c. Inputs used in the past season on valley farm

Input	Type	Quantity	Source

Input Type:

Source: 1=Own, 2=other villagers, 3=local market, 4= NGO, 5= Government/FISP

d. Inputs used in the past season on river side/bank farm

Input	Type	Quantity	Source

Input Type:

Source: 1=Own, 2=other villagers, 3=local market, 4= NGO, 5= Government/FISP

e. Inputs used in the past season on bush farm

Input	Type	Quantity	Source

Input Type:

Source: 1=Own, 2=other villagers, 3=local market, 4= NGO, 5= Government/FISP

f. Inputs used in the past season on irrigation farm

Input	Type	Quantity	Source

Input Type:

Source: 1=Own, 2=other villagers, 3=local market, 4= NGO, 5= Government/FISP

g. Inputs used in the past season on garden

Input	Type	Quantity	Source

Input Type:

Source: 1=Own, 2=other villagers, 3=local market, 4= NGO, 5= Government/FISP

Type of labor used in the past season |_____|

Farm Type	Type of labor	How many people worked	Hours of work per day	How long worked in season
Compound farm				
Valley farm				
River side farm				
Bush farm				
Irrigated Farm				
Garden				

Type of Labour: 1=HH labor, 2=Hired Labor; 4= Social labour pools; 3= both; 5= others

Approximately how many hours in a day: 1= Full day; 2 = Half day; 3= Quarter day; 4= others

How long during the season was the labor used: 1 = Whole season; 2= Half season; 3 = Quarter season; 4 = others

What main implements/ tools have been used on these farms?

Farm Type	Hoe	Cutlass	Dibber	Sickle	Axe	Tractor	Animal traction	Planters
Compound farm								
Valley farm								
River side farm								
Bush farm								
Irrigated Farm								
Garden								

Responses: 1= Yes; 2 = No

Any conservation agriculture methods used |_____|

Farm Type	Conservation agriculture method (list all pertaining to type of farm)
Compound farm	
Valley farm	
River side farm	
Bush farm	
Garden	

Responses: 1=crop residue, 2=boundary bunds, 3=vegetative barriers, 4=Minimum/zero tillage, 5=Green manure, 6=Crop rotation; 7 = Composting; 8 = FMNR; 9= Tied Ridging; 10 = Mixed cropping; 11= Soil Mulch/cover; 12 = others

4. Food security and nutrition

How many months can you feed the household from the food produced |_____|

Has this changed in the past 5 years |_____| 1=Increased, 2=Decreased, 3=No change

If unable to reach food requirements,

What are the other sources of food |_____| 1=Aid, 2=Bought, 3=Gift from friends, 4=support from extended family; 5= borrowing; 6= begging; 7= External remittance; 8=others

6. Household income

What are the major sources of income for the HH |_____| 1=sale of crops, 2=sale of livestock, 3=casual labor, 4=Petty trade, 5=Charcoal making, 6= Formal sector Employment, 7= remittance; 8= Social Transfer; 9=others

Source of income	Estimated Amount earned over the past production season?
Sale of crops	
sale of livestock	
Casual labor	
Petty trade	
Charcoal making	
Firewood sales	
Stone quarrying	
Remittances	
Social Transfer (e.g. LEAP)	
Formal sector employment(monthly income)	

Has any member of the household accessed any loans? |____| 1=Yes, 2=No

Source of loan |_____| 1= Neighbor, 2=Shop Keeper, 3=Savings Group, 4=Bank, 5=Relative, 6= Money Lender, 7= NGO project, 8 = Government scheme; 9 = others.

Total Amount borrowed |_____| New Ghana Cedis

What has the loan been used for? |_____| 1= food, 2=medicine, 3=school fees, 4=social obligations, 5=agricultural inputs, 6= ploughing/hire of labour; 7= Others (specify)

7. Information and Knowledge

What sources of information does the household have? [You may enter multiple responses] |_____| 1= Farmers, 2=farmer groups; 3= VSLA; 4=Radio, 5=TV, 6=Agriculture extension services, 7=NGOs, 8=Traders; 9= others

Which one is the most important to you? |_____|

Why is it the most important to you? |_____