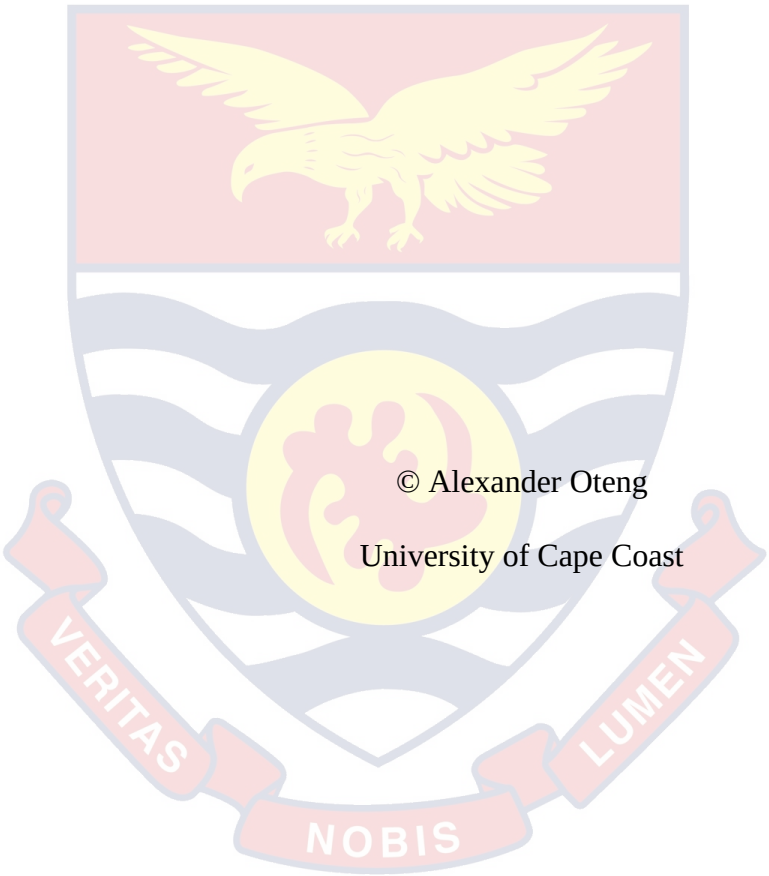
UNIVERSITY OF CAPE COAST

LIVELIHOOD VULNERABILITY AND ADAPTIVE CAPACITY OF SMALLHOLDER OIL PALM FARMERS IN KWAEBIBIREM MUNICIPALITY OF GHANA

ALEXANDER OTENG

2020



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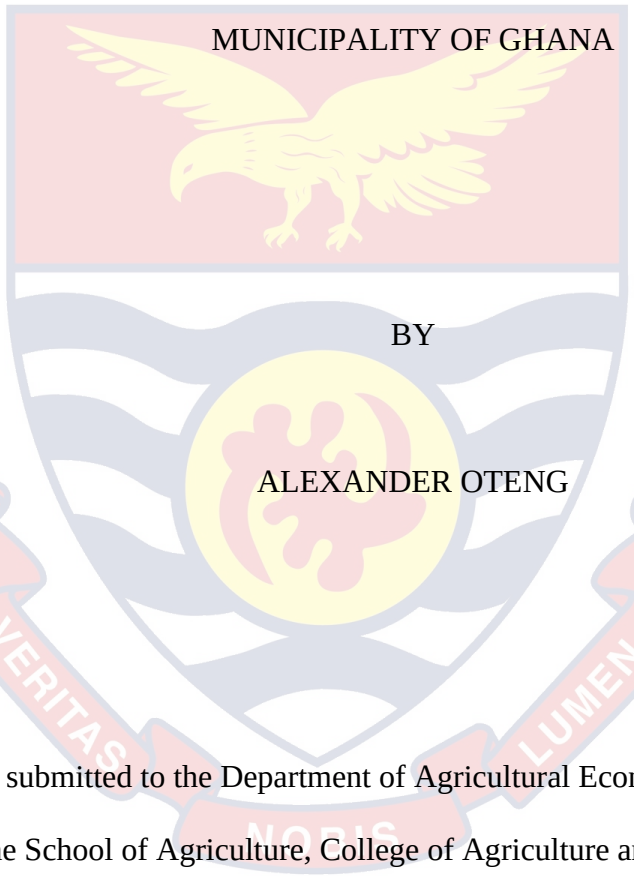

BY

ALEXANDER OTENG

Thesis submitted to the Department of Agricultural Economics and Extension of the School of Agriculture, College of Agriculture and Natural Science, University of Cape Coast, in partial fulfilment of the requirement for the award of Master of Philosophy degree in Agriculture Extension

OCTOBER 2020

DECLARATION

Candidate's Declaration

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

Candidate's Signature…… Date……

Name: Alexander Oteng

Supervisor's Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature…… Date……

Name: Professor Ernest L. Okorley,

Co-Supervisor's Signature……. Date……

Name: Dr. Moses Kwadzo

ABSTRACT

Several studies reveal that smallholder farmers in Sub-Saharan Africa are the most likely to experience livelihood vulnerability. This study therefore, investigate livelihood vulnerability and adaptive capacity of smallholder oil palm farmers in Kwaebibirem Municipality of the Eastern Region of Ghana. A cross-sectional survey design was employed and a simple random sampling technique was used to select 204 smallholder oil palm farmers. A structured interview schedule was used to correct primary data. Principal Component Analysis was conducted to determine factors that best explain the exposure, sensitivity and adaptive capacity of the farmers. Composite livelihood vulnerability Index was used to calculate respondents' levels of exposure, sensitivity, adaptive capacity and livelihood vulnerability. It was found that farmers' exposure to vulnerability is moderate to high especially to institutional constraint. The sensitivity indices were 0.54 and 0.81 respectively indicating that farmers' sensitivity was moderate to high. The adaptive capacity of the farmers was found to be moderate and they can use several strategies including, farm practices strategy, institutional strategy, on and off-farm strategy, information strategy, intervening strategy, selling strategy, transacting strategy, marketing strategy, chemical control strategy, organizational strategy and certified material use strategy. In Kwaebibirem Municipality, smallholder oil palm farmers are vulnerable. It is recommended that, Department of Agriculture educate the farmers on good agronomic practices and livelihood strategy diversification to increase their options at reducing livelihood vulnerability.

KEY WORDS

Adaptive Capacity

Exposure

Farm-based livelihood system

Sensitivity

Smallholder oil palm farmers

Vulnerability

ACKNOWLEDGMENTS

I wish to express my profound appreciation to my principal supervisor Professor Ernest L. Okorley, for his exceptional suggestions, constructive criticisms, patience and encouragement in the course of this work. I am also grateful to the co-supervisor, Dr. Moses Kwadzo for his enormous dedication and guidance for successful completion of this study. I am grateful to Dr. George Yawson, Head of Crop Protection Division, Oil Palm Research Institute (CSIR-OPRI) for his words of encouragement. My special thanks to Dr. J. Adu Kumi, Head of Agribusiness Department, Presbyterian University, Ghana, Okwahu campus for his motivational words and guidance. I am thankful to Dr. Isaac Danso Head of Agronomy Division Oil Palm Research Institute (CSIR-OPRI) for not hesitating in time of consultation for Agronomic information on oil palm. I am also indebted to Mr. Felix Swanzy, Acting Head of Commercialization and Information Division for his exceptional advice and guidance. I am most grateful to Mr. Emmanuel W. Nkoom for his tremendous advice. My profound gratitude goes to all my course-mates for their maximum support. Finally, my heartfelt gratitude goes to my wife Mrs. Susana Oteng and my two sons, Caleb Amoabeng, and Lemuel G. K Yawson and all those who by their prayers and support, this work has been accomplished successfully. God richly bless you and replenish all that you have given.

DEDICATION

This work is dedicated to my wife, Susana Oteng and my two sons Caleb Amoabeng and Lemuel, G. K Yawson for their tremendous support.

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LIST OF ACRONYMS

BOP	Benso Oil Palm Plantation
CPO	Crude Palm Oil
CSIR	Council for Scientific and Industrial Research
DFID	Department for International Development
EAS	Extension Advisory Service
FAO	Food and Agriculture Organization
FFA	Free Fatty Acid
FFB	Fresh Fruit Bunches
FOHCRI	Forest and Horticultural Crop Research Centre
GDP	Gross Domestic Product
GOPDC	Ghana Oil Palm Development Corporation
IFAD	International Fund for Agriculture Development
IPCC	Intergovernmental Panel on Climate Change
MOFA	Ministry of Food and Agriculture
MPOC	Malaysia Palm Oil Council
OPRI	Oil Palm Research Institute
PCA	Principal Component Analysis
PSI	President's Special Initiative
SEWA	Self-Employed Women's Association
TOP	Twifo Oil Palm Plantation
USDA	United States Department of Agriculture
WIA	Women in Agriculture

CHAPTER ONE

INTRODUCTION

Chapter One deals with the background to the study, statement of the problem, the general objective, specific objectives, research questions, significance of the study, delimitations, limitations, definition of terms and organization of the study.

Background to the Study

In developing countries, individuals who dwell in rural areas survive on low incomes with a high level of uncertainty. This occurs as a result of low returns from farming activities which serves as a chief source of rural livelihood. World Bank (2004) revealed that about 70% of the workforce in low-income countries are employed in the agricultural sector who exhibit higher vulnerability to risk and uncertainty. These factors range from climatic variability, crop yield failure, input price variability, incidences of pest and diseases, environmental degradation, pollution from industrial sites, oil spillage, insecurity, and others.

Small-scale farmers are unable to equip themselves against risk and uncertainty due to the aforementioned factors and consequently, there is a decline in their consumption expenditures (Ayinde, 2008). Besides, strategies are also adopted by the household in order to mitigate the impact of the risks and uncertainties. Furthermore, the behaviour of the household would vary depending on whether or not they have access to measures to cope with emergencies. However, the extent of losses occurred during farmers' exposure to certain risks is also dependent on the nature of the enterprise.

Oil palm is one of the crops whose cultivation is expanding fast in the tropical hemisphere and edible oil produced from it is widely used across the world (Colchester, 2011). There is the highest yield of oil achieved from oil palm on unit area of land relative to other oil-producing crops and two oils are derived from it, palm and kernel oil widely used and recognised in the World Trade (USDA, 2000). Oil palm is a perennial tree and produces fruit bunches throughout the year. The ripe bunch is known as Fresh Fruit Bunch (FFB), and weighs between 10 and 50 kilograms when attaining full maturity, and maximum of 1000 to 3000 single fruitlets are obtained from a bunch.

The crops start to bear fruits approximately 30 months after they are established in the field and remain reproductive at most 20 to 30 years. The fruitlet consists of a kernel enclosed in a shell and enveloped by a fleshy mesocarp. The mesocarp is processed into oil and generally sold as crude palm oil (CPO). The CPO is a product produced by agro-processing industries and is used for many purposes, both food and non-food industry (FAO 2002; USDA 2010; Green Palm 2013). In the humid tropics, area of land put under use for oil palm cultivation on commercial basis is estimated to be 12 million hectares. In terms of global output, Malaysia and Indonesia generate 85% of oil palm and they are considered as major producers. Other significant oil palm producing countries include Nigeria, Costa Rica, Cote d'Ivoire, Cameroon, and Ghana (World Bank, 2010).

In terms of poverty alleviation and the well-being of individuals, the palm oil sector plays a vital role around the world. In many tropical countries, oil palm industries are developing extensively as a result of the crop's motivation regarding high potential productivity. Oil palm tree which is

lucrative and of high yield is recognized as a main source of livelihood for local dwellers and the economy (Chaichee 2007; Feintrenie, Chong & Levang 2010). In areas where the crop thrives well, oil palm production can provide food and livelihood security for many farmers and communities. In value-chain system at the off-farm level, oil palm cultivation contributes to providing a livelihood for players such as transporters, marketers, processors and agro-input sellers (Ofosu-Budu & Sarpong, 2013).

Although oil palm production provides livelihood to many people, it is essential also to consider how secure or sustainable the livelihood is from the smallholding perspective. DFID (1999) concept of livelihood consists of activities undertaken, assets base of individual and capabilities, essential to sustain or improve a living. A livelihood is sustainable when it can adjust to or recover from stresses and shocks and maintain or enhance its capabilities and assets both in the present and future, without endangering the natural resource base (DFID, 2000). As such, the desire of people for sustainable livelihood, warrants the adoption of livelihood strategies for effective management and adaptation in their state of vulnerability. Livelihood strategy involves activities undertaken and choices made by people in order to achieve their livelihood results. It is a changing process in which individuals bring together several activities to satisfy their diverse needs at different times, different places temporarily or permanently (DFID, 2000).

According to Fold and Whitfield (2012), the oil palm sector in Ghana is controlled by the existing two markets: domestic consumption and industrial use to manufacture other products. The oil palm industry in Ghana is categorized into three, the small, medium and large scale sector. In Ghana,

the area of land used for cultivating oil palm, currently estimated at 330,000Ha indicating extensive expansion of oil palm sector (International Plant Nutrition Institute, 2015). The expansion of plantations is due to the processing of palm fruits into edible oil, which normally takes place in rural areas in the country where plantations are mostly established. Ayodele (2010) revealed that, since independence, the oil palm industry in Ghana focus on satisfying domestic demand with the aim to reduce import bills, and largely acting as import substitution industry. This implies that little has been or no effort on the part of Ghana to compete with neighbouring countries for export earnings.

According to FAO (2011), smallholders supply about 70 percent of total food required by Africa and also provide approximately 80 percent of the food needed to be consumed in both Asia and sub-Saharan Africa. In Ghana, the area of land under oil palm production is covered by the majority of private smallholders estimated at 266,100Ha representing 80% of the total area under cultivation (Anaglo, Dankyi-Boateng & Swanzy, 2014). The small-scale sub-sector is typical of growing oil palm variety of low yield, with farms and mills of low productivity and crude palm oil produced is of low quality marketed in the rural selling centre or at small-village markets (Fold & Whitfield, 2012).

Adjei-Nsiah, Zu, and Nimoh (2012) reported that farming is the most economic activity in the Kwaebibirem Municipality and provides a livelihood for over 72% of the working population. The farming system which received much attention in the Municipality is oil palm cultivation which further provides off-farm activities for the well-being of the dwellers, however, small-

holding oil palm farmers in the Municipality are insecure due to production constraints (Anaglo et al., 2014). Meanwhile, many folks both male and female, engage in the cultivation of the crop as the main source of livelihood and income.

Statement of the Problem

In the nineteenth century, oil palm was considered as a major crop in Gold Coast since it featured well in the European market (Amanor, 1994). The price of palm oil in the world declined between the 1860s and 1870s therefore, Gold Coast oil palm industry was unable to compete with its competitors in the world market. Basiron (2007) indicated that, due to high cost involved in production, problem of expertise and environmental factors Ghana lost out in the competition.

In Ghana, the area of land for oil palm production currently is estimated at 330,000Ha indicating extensive expansion of the oil palm sector (International Plant Nutrition Institute, 2015). Out of this area under cultivation, smallholder cover about 80% (266,100Ha) (Anaglo et al., 2014). Currently, the annual total crude palm oil production in the country amount to 495 MT and total consumption estimated at 760,000 MT and the amount imported from elsewhere into the country estimated at 300,000MT giving an indication of shortfall (Osei-Amponsah, Aglets, Swanzy & Stomph, 2018). MASDAR (2011) projected that the present deficit in the supply of CPO will grow from 32,000 MT (160,000MT of Fresh Fruit Bunch-FFB) to 127000MT in 2014 as deficits to be filled.

Kwaebibirem Municipality is considered as a major oil palm producing area in Ghana and dominated by smallholder farmers cultivating

between 0.405-2Ha areas of land for their livelihood (Anaglo et al., 2014). Anaglo et al. (2014) noted that in Kwaebibirem Municipality, a number of improved production practices were introduced into the Municipality by the Ministry of Food and Agriculture. These included the use of certified oil palm planting materials, disease and pest management practices, use of cover crops, weed management strategies, fertilizer management strategies, pruning and harvesting. However, Anaglo et al. (2014) established that private smallholder farmers are unable to use the practices.

It is expected that farmers will utilize the aforementioned practices to increase the yield of the crop thereby improving their income level and livelihood. Ofosu-Budu and Sarpong (2013) however, reported that in Kwaebibirem Municipality, smallholder oil palm farmers on average achieved productivity levels of about 3MT Fresh Fruit Bunches (FFT)/Ha, which is far below the productivity level of 18-20MT FFB/Ha expected at the valley bottom. Besides, International Plant Nutrition (2015) also recorded an average yield of 3MT of Fresh Fruit Bunches FFB/Ha achieved by smallholder oil palm farmers in the Municipality. Further, Adjei-Nsiah et al. (2012) found that, at major production seasons in Kwaebibirem Municipality, smallholder farmers sell Fresh Fruit Bunches and crude palm oil at a loss; thus, adversely affecting the level of their income and livelihood.

The background provided suggests a certain level of livelihood vulnerability of the farmers in the Municipality which requires necessary attention and action to rectify the situation. Currently, there is limited research and information on the vulnerability of smallholder oil palm producers and specifically those in the Kwaebibirem Municipality to inform decisions on

how to improve the productivity of the crop and the livelihood of the farmers in the Municipality for national development.

Purpose of the Study

The purpose of the study to investigate the vulnerability and adaptive capacity of smallholder oil palm farmers in the Kwaebibirem Municipality of Ghana.

Objectives of the study

To achieve the general objective, the following specific objectives formulated to:

1. analyse the vulnerability factors that smallholder oil palm farmers in the Kwaebibirem Municipality of Ghana are exposed to;
2. determine the sensitivity of the vulnerability to the livelihood of the farmers;
3. identify the adaptive capacity of the farmers to the vulnerability of the area; and
4. ascertain the perceived level of vulnerability of the farmers (vulnerability index of the farmers).

Research Questions

1. What vulnerability factors are oil palm farmers exposed to?
2. What vulnerability is the livelihood of the farmers' sensitive to?
3. What are the adaptive capacities of the farmers to the vulnerability of the area?
4. What are the perceived levels of vulnerability of the farmers?

Significance of the Study

The study will provide vital information to the Ministry of Food and Agriculture to plan, design and implement strategic and sustainable programmes to revitalize agriculture as a whole and also to ensure the aids of smallholder oil palm farmers regarding their farming business thereby minimizing the level of their livelihood vulnerability. The study will serve as a catalyst that will streamline CSIR-OPRI, Agricultural Extension and the farmers' linkages in terms of the flow of information for the betterment of the smallholder oil palm farmers.

Knowing information about smallholder oil palm farmers' exposure to vulnerability, sensitivity and adaptive capacity can provide a basis for AEA to devise reliable training strategies that end up building the capability of the farmers (knowledge and skill) so that they can do things on their own in the face of vulnerability. Furthermore, the study will provide information that can inform government and non-Governmental organizations' policies aimed at promoting the oil palm industry and improving the livelihoods of smallholder farmers in Ghana. The findings shall also inform further research work on livelihood vulnerability and adaptive capacity of smallholder oil palm farmers in Ghana.

Definition of Terms

Smallholder farmers in this study is defined as farmers with farm sizes between 0.405Ha to 2Ha of land.

Vulnerability in this study is defined as a degree to which a farm-based livelihood system is exposed to (exposure elements) shock, seasonality and

trend, its sensitivity and the capacity to adapt, (modified from IPCC, 2001) or unable to cope with the adverse effect of shock, seasonality and trend.

Exposure in this study is defined as the degree to which a farm-based livelihood system is susceptible to (exposure elements) shocks, seasonality and critical trend (modified from IPCC, 2001). The exposure means the frequency of the occurrences of the element or their severity.

Sensitivity in this study refers to the degree to which a farm-based livelihood system is affected either negatively or positively by the (exposure elements) shocks, trend, and seasonality (modified from, IPCC, 2001). It is the effect of shock, trend, and seasonality on the farm-based livelihood asset or the assets based of the farmers (e.g. low yield, low income, low productivity, lack of access to adequate water).

Adaptive Capacity in this study represents the ability of smallholder farmers to employ livelihood strategies and to enable them to adjust to shocks, seasonality and critical trend, to cope with consequence and to take advantage of the opportunity (modified from IPCC 2001).

Delimitation

The study sought to consider both Kwaebibirem Municipality and Denkyembour District for the investigation but the research was limited to only Kwaebibirem Municipality and focus was placed on private smallholder oil palm farmers. The study was also limited to the livelihood vulnerability and adaptive capacity of the smallholder oil palm farmers.

Limitations

The study used data that originated from farmers' self-assessment. Information about exposure, sensitivity and adaptive capacity resulted from the farmers' opinions, perceptions, and experiences regarding their farming practices since proper records were not kept by these smallholder farmers.

Organization of the Study

The study is organized into five chapters; Chapter One is the Introduction, which covers the background to the study, statement of the problem, general objective, and specific objectives, research questions, significance of the study, delimitation, and limitations of the study. Chapter Two dealt with the relevant theoretical, empirical and conceptual frameworks of the study. Review of the relevant concepts, theories, empirical and conceptual reviews provide salient information to guide the studies. Chapter Three constitutes the methodology which includes the research study area, population, research design, sample size and sampling procedure, instrumentation, data collection procedures, and data processing and analysis.

Chapter Four consists of the analysis and discussion of results as well as key findings, whilst Chapter Five includes the summary, conclusion, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter presents related literature that underpin the entire research study. It explores information on oil palm such as the history of oil palm, the evolution of oil palm industry in Ghana and the role of various successive governments in developing the oil palm sector. It also discusses economic importance of oil palm to the individual, local, national and international economies, the uses of oil palm, palm oil for food purpose, palm oil used in non-food product, other product derived from oil palm, returns from oil palm production. The chapter also focusses on the concept and empirical review of the objectives of the study. This includes, the exposure to vulnerability of the farmers, sensitivity of the vulnerability to the livelihood of the farmers, (that is how the exposure elements affect the farm-based livelihood assets or the assets base of the farmers) which is the five types of the livelihood assets, the adaptive capacity of the farmers, concept of vulnerability and concept of shocks, seasonality. The chapter also includes the theoretical review and conceptual framework of the study.

History of Oil Palm

Oil palm was initially illustrated by Nicholas Jacquine in the year 1763 before it became a major cultivated crop and hence the name *Elaeis guineensis* Jacq. The crop spread in both northern Senegal and southern Angola and extended to eastern Zanzibar and Madagascar. The level of production of the crop is obtained in the area of high rainfall between7N and 7S from the equator (Verheye, 2002). In Africa, the oil palm belt passes the

southern latitude of Sierra Leone, Guinea, Ivory Coast, Togo, Ghana, Benin, Nigeria, Equatorial Guinea, and Congo. The East and South-East Africa is very dry and not conducive for the crop's performance and therefore, the crop appeared at altitudes below 100m beside lake or watercourse with optimal rainfall.

The crop established itself on the eastern coast of Madagascar because of the favourable local climate (Verheye, 2002). The crop has spread to the rest of developing countries of similar climatic conditions from its centre of origin. Such developing regions are Latin America, Southern Asia and Oceania Papua New Guinea (Jacquemard, 1998). Besides, the oil palm belongs to the genus *Elaeis* due to its productive nature and yield as economic value. Harvesting each hectare of oil palm, a year-round gives annual production average of 10 tons of fruit which yields 3,000kg of pericarp oil and 750kg of seed kernel which is also 250kg of high-quality palm kernel oil including 500kg of palm kernel meal. Regarding the world vegetable oil supplied, approximately 23% of the oil were generated from oil palm in the form of palm oil (Paranjothy, 1989).

The evolution of the oil palm industry in Ghana

The ruling British colonial administration did not give much regard to the oil palm plantation in Ghana. The development of the plantation system was first introduced into Ghana by the Dutch in the beginning of the eighteenth century. Between the eighteenth and nineteenth centuries, several Dutch plantations were established near the coast (Dickson, 1969). Carrere (2010) noted that, apart from plantation established by the Dutch, there were other plantations developed by the German and British at the later part of the

nineteenth century and in the early part of the twentieth century after the Oil Palm Ordinance was passed in 1913 including plantations, developed at Butre, Sese and Winneba. The introduction of the ordinance gave the government the power to give the palm oil processors the right to extract palm oil from the mesocarp of the palm fruit using locally made milling machines. The plantation system did not exist for long as the result of political insecurity in the country caused by wars between tribal groups and sheer rivalry that took place among the Europeans for territorial control. Dickson (1969) highlighted that the poor or negative attitude shown to the system by the British, the Dutch gained control over the European effort to colonize Ghana and that led to the collapse of the plantations during the pre-colonial era.

Oil palm industry in Ghana after independence

There was a policy change during the post-independence period with much attention on developing plantations especially oil palm and rubber. The changed policy continued throughout military coup d'état in 1966 and which promoted state-owned and state-operated plantation. According to Carrere (2010) the state-owned plantation was not economically viable due to capital constraints, improper planning, poor management, political interference and the rigid nature of central government system of control. The policy ended up aggravating rural standards of living by taking possession of peasant fundamental natural resources especially the arable land with little compensation and economic disturbance linked with the destruction of natural vegetation for the establishment of plantation as monoculture. These eventually ended in selling of some state-owned plantations, others were

abandoned after the palm trees had been felled, the practice that expedites replacement of original forest by savanna vegetation.

Besides, efforts were made to revamp the rest of the plantation under the decentralized state control system to appear more viable ventures. Furthermore, a new policy emerged which was directed toward plantation development, intended to embrace private enterprise, foreign aided government venture and joint government-private projects after the 1981 coup d'état. The policy brought about three major commercial plantation estates, Ghana Oil Palm Development Corporation situated in Kwae in the Eastern Region which government of Ghana established through foreign aids, Twifo Oil Palm Plantation Ltd situated in Twifo Prafo/Ntafrewaso in the Central Region which is government/private owned and Benso Oil Palm Plantation Ltd situated in Benso/Adum Banso which is also government /privately owned plantation estate. Gyasi (1992) noted that these large commercial plantations were established to grow oil palm and to produce palm oil in large quantities from the palm fruit as vegetable oil. Oil palm as an agro-industrial crop and had various use was a leading crop in terms of foreign exchange earnings and fetched the country (Ghana) a huge income. The crop was cultivated on a small piece of land in the area where the crop was established near littoral at the beginning of nineteenth century to the early part of twentieth century. The three commercial estates were developed on land expropriated from smallholder farmers by government. The idea behind the establishment of the three plantation was to ensure that such companies (GOPDC, TOPP, and BOPP) would encourage peasant oil palm producers in the hinterland attached to nucleus estate such that, the peasant would also

assist in sustaining the palm oil processing mill situated at the centre of the plantation (Carrere, 2010).

The establishment of the three plantation estates since 1977, has been a tremendous development and has contributed enormously to the expansion of the size of oil palm plantation in Ghana from 18,000 hectares to 103,000 between 1970 and 1990 and 24 percent as a growth per annum has restored the prestige of oil palm as an important commercial crop. It has also hastened the development of palm oil in terms of production and other agro-processing industries.

President Special Initiative on oil Palm

To promote the oil palm sector in Ghana, Presidential Special Initiative as government policy was introduced to shape oil palm plantation and palm oil export in 2004. The programme sought to cultivate about 100,000Ha of oil palm plantation over a period of five years in six regions of the country including the establishment of 12 nurseries tasked to nurse 1.2 million seedlings of high yield oil palm to be supplied to interested farmers who qualified for an investment of US S3.4 million.

Gyasi (2008) revealed that the Oil Palm Research Institute (OPRI) of the Council for Scientific and Industrial Research (CSIR) was mandated to supply annually, two million transplantable oil palm planting materials of high-yield. In 2008 only about 30,000 hectares of land had been cultivated due to inadequate funding and also farms that had been established were not properly maintained and cared for and were exposed to pest attack, weed competition and consequently low yield of the plantation. Poor maintenance of the established farms was the general problem across all the regions where

the programme was initiated. Similarly, the collapse of various nursery centres established to supply seedlings because of poor funding and negligence of successive governments for the continuation of the project after 2008 (Asante, 2012).

Economic importance of oil palm

Casson (2000) highlighted that the oil palm industry is labour intensive and therefore offers job opportunity for the local dwellers and boosts the level of employment. There are thousands of villagers in Ghana with no prospects for getting a job, but they are secure through oil palm industry development (MASDAR, 2011). Besides, oil palm can help emerging countries and people of low income to climb out of poverty. Also, sustainable agriculture such as establishment of oil palm plantation its expansion and development provides the owners of large and small scale plantations and the workers a ways of improving their living standard (World Growth, 2011).

The World Bank (2010) considered oil palm as an important commodity that can play a role to promote economic development in developing countries and to secure a high quality of living for the rural folks when socio-economic, political and environmental risks and others are dealt with to ensure food security globally. The World Bank (2010) revealed that in Indonesia oil palm industry engages as many as three million people and six million across the world. The economic support derived from palm oil and other beneficial products obtained from the plantation give an indication of profitable income sources and numerous employment opportunities for the people of Malaysia all the years round (Basiron, 2011).

Subsequently, harvesting fresh bunches as a day work can furnish one an income greater than US 30 dollars. In an area where people survive on two meals a day costing only US4 dollars, an income of that nature is profitable. According to Sulaiman, Abdullah, Gerhauser and Shariff (2010) no one should be denied of good quality life or living as beggar as long as he or she has the desire to spend an hour working in a day in oil palm or rubber plantation. As reported by Malaysia Palm Oil Council, (2011) people of Malaysia enjoy full employment and that, there can be a labour shortage existing in the plantation. Generally, women dwelling in villages engage in processing and selling products of the farm.

Agro-processing on small-scale is a pillar to reducing poverty in rural settings and oil palm trees yielding high generate raw materials for the start of cottage industries (Poku, 2002). Furthermore, processing palm oil provides reliable job opportunity and way of living for women in remote environments in Africa. Wakker (2006) reported that, in Indonesia, about 1.7-2 million people are into oil palm sector as working force. It is also estimated by industry players that, based on the broad benefit, the oil palm sub-sector has profited as many as six million people and have been relieved of poverty (Goenadi, 2008).

Uses of oil palm

Palm and kernel oil, as key products derived from oil palm have been variously used. Chemically and nutritionally they are not related. There is equal proportion of saturated and unsaturated fatty acids in palm oil and palm kernel oil consist of mainly saturated fatty acid. Palm oil is said to resist oxidation since it naturally contains antioxidant carotenoids and vitamins E

(MPOC, 2011). According to MPOC (2011), the crude palm (CPO) and crude kernel oil are easily turned into liquid and solid components utilized for another purpose. Palm and kernel oil have wider range in their application, explicitly 80% is used for food purposes while the remaining are for non-food purposes (Roila & Salmiah, 2000).

Palm oil for food purpose

According to World Bank (2010), Palm oil is widely consumed globally and represents 60 percent of vegetable oil merchandised internationally. USDA (2010) noted that, 74 percent of the world palm oil is used for food purposes while 24 percent is reserved for industrial use. Though palm oil is tarnished for health-wise (Lam, Tan, Lee & Mohamed, 2009) the claim is disproven by Malaysia Palm Oil Council (MPOC) that, palm oil is good for human health and hence for consumption due to numerous nutrients and essential vitamins (MPOC, 2011).

The argument raised by Basiron and Weng (2004) was that palm oil can be eaten and healthy Also palm oil is good as frying oil because it is resistant to quality reduction caused by oxidation. Palm oil is used to fry chips derived from potato, fries, and doughnut (Sumathi, Chai & Mohamed, 2008). According to Basiron and Weng (2004), palm oil is considered as the main ingredient of shortening margarine and used normally as additive in confection like ice cream, mayonnaise coffee, whipping cream, filled milk, and fat spread commonly consumed by people. Nutritionally, palm oil is free from fat and can be mixed with trans fatty acid formulations (Gee, 2007).

The palm oil used in non-food product

Oil palm is considered as one of the major crops from which we obtain biofuel and fetch the world adequate monetary returns. Under conducive and ideal management conditions, over 20tons of fresh fruit bunches can be obtained from a hectare of land if the palm varieties undergo appropriate breeding programme excluding the palm kernel oil (Poku, 2002). Besides, the use of palm and kernel oil in non-food products represent about 20% but give high economic value (Basiron & Weng, 2004).

Basiron (2005) noted that regarding the total biomass of the oil palm tree, the fibre and cellulosic materials which constitute 90% serve as biofuel production while the oil derived represents 10 percent. Palm oil is used as ingredient in soap preparation and personal care products like cosmetics and toiletries. Also as a constituent in lubricants, greasers, printing ink, drilling mud and as inert ingredient in pesticide formulation (Mekhilf, Siga & Saidur, 2011). Furthermore, palm oil is used as biofuel (Basiron, 2005). Mekhilef et al. (2011) stressed that the refined palm oil can be directly used as biodiesel or converted into methyl ester as well as a blending material in petroleum diesel to obtain diesel fuel.

Other products derived from Oil Palm

There are several products that can be derived from different parts of the oil palm beside the palm oil. There is 4kilogram of biomass produced from a kilogram of palm oil obtained (Sulaiman et all, 2010). Besides the fruit bunches contained third of the dry weight and the trunk and fronds materials represent two-third of the dry weight. Also, during the replanting, 75 tons of the dry biomass is generated per hectare (Basiron & Weng, 2004). The bunches which are empty are normally used as mulch for soil fertility

improvement. Subsequently, about 25 percent of the biomass is nutrient-rich mulch for improving soil fertility (Fairhurst and Muter, 1999) or can be burnt to generate energy (Subranamian, May, Muhammed, Hashim, Tan, & Puah, 2010). The pressed palm cake and sludge that remained after clarification of crude palm oil are also used as fertilizer as well as animal feed.

Returns from Oil Palm Production

The land used to develop oil palm is smaller than what is required to establish other crops from which we obtain the oil. Besides to generate a ton of oil from oil palm, 0.26 Ha of land is required while crops like soybean require, 2.2Ha, sunflower 2Ha, and rapeseed needs 1.5Ha of land to fetch the quantity of oil derived from oil palm (Ofosu-Budu & Sarpong, 2013). With reference to energy generation ratio comparison, Oil palm produces 10 times more than energy it consumes, while 2.5 is delivered by soybeans and 3 given by ripe oilseed. More so, palm oil production is more suitable than the production of oil derived from vegetable such as soybeans and ripe seed. Considerably, less energy is used in its production and small area of land is required to produce more oil per hectare. Under ideal climatic conditions and good field management practices high-yielding oil palm varieties are capable of yielding 5 tons of palm oil per hectare annually.

Wahid, Abdullah and Henson (2005) stressed that, in the major palm oil-producing countries, on average, 3 to 4 tons of mesocarp oil is obtained from oil palm per hectare and that outweighs the yield of other oilseed crops. According to Belcher, Imang and Achdiawan (2004), analysis was conducted on rattan, rubber and oil palm in East Kalimantan, Indonesia regarding the computation of net present value and certain financial benefits as an indicator

for each crop. The study investigated the diverse use and how the forest products in East Kalimantan were managed due to pressure developed on traditional land being used as a results of several factors and policies made by the government. It was revealed that, land use for oil palm development was the best choice looking at the profit margin regarding a unit of area coverage relative to ratta and rubber. Goenadi (2008) is of the view that, in Indonesia, yield potential of oil palm was high from 6 to 7 tons per hectare due to the good and favourable climate. However, in 2008 the average productivity level of oil palm ranged between three to four tons per hectare. In Indonesia to boost the productivity level of oil palm does not require any additional land if the decision to achieve the potential yield set. Returns from the use of land for oil palm production are profitable relative to the use of the land differently for a new venture.

According to Goenadi (2008) a 2007 report prepared for Stern Review estimated returns from land used for establishing oil palm and it was found to range from $US960/ha to $US3340/ha. This was compared with smallholding of rubber, rice, cassava and timber harvesting which yielded $US72/ha, $US28/ha, $ US19/ha, and $US1099/ha respectively. The cost incurred in producing oil palm is very low relative to other oil-producing crops and there is a considerable amount of palm oil derived from small areas of land used (Yuosoff & Hansen, 2007). It was also highlighted that the proceeds on capital, land and labour gives a very great income for the producer who is into it and the country as well. According to Thoenes (2006) there is less production cost in developing oil palm plantation in unit area relative to competing oil-producing crops. For example soybeans oil is cheap although

but has 20% higher production cost, (cost of labour incurred in producing soybeans per unit is more exorbitant than oil palm).

Concept of livelihood

A livelihood is a set of activities, the available assets, and access that together define a living that a person achieved (Ellis, 1998). Also livelihood is defined as a way people make a living, which is based on capacity, assets, and activities. In individual perspective, it is the capacity of the person to have access to life necessities, which include water, shelter, food, and clothing. Thus, all actions that end up finding food resources, shelter, clothing, water and other basic needs for man to survive are referred to as a livelihood. Davis, Wilson, Brock-Martin, Glover, and Svendsen (2010) noted that at most 90% of rural dwellers engaged in farming activities. They also reported that 70% of the income a household obtained in Africa especially in the rural regions comes from agricultural business, and in Asia and Latin America 50% of the income achieved is recovered from agricultural ventures. Besides, in those rural regions, small-scale on-farm business, fishing, animal rearing and off-farm income-generating venture are some of the known sources of livelihoods for the survival of the dwellers especially the search for income. As a result of differences brought about by wealth possessions and related ability including access to opportunity, the rich people are able to acquire all the basic needs with little or no difficulties while the poor are powerless to have such basic needs that would improve the living standard. Therefore, the implication is that the livelihoods of the poor keep on deteriorating and finally end in poverty trap. In view of that, to reduce poverty or the effort in eradicating it

needs a different approach which is sustainable livelihood which can guarantee a person's survival.

Rural livelihood diversification

It is diverse activities that a person undertake so that, the level of the social life, position and living standard may improve (Ellis, 1996). It is an attempt that a person will make in order to live and build up income with ability to be resilient in terms of shock, including, disaster and diseases (Khatun & Roy, 2012). Ellis (1999) revealed that, in the past decade, agriculture serving as major source of living for rural inhabitants had declined and taken over by off-farm income-generating ventures. Some individuals solely depend on the off-farm ventures while others rely on both business activities. In sub-Saharan Africa, households' dependency on farming declines when income level increases.

Subsequently, in India and other parts of the sub-Saharan region, most farmers tend to engage in different business activities than solely depend on agriculture knowing clearly that, the households are not supported and sustained by farming business. The situation is commonly found in countries like Uganda, Kenya, Nigeria, and Malawi. Petty-trading including hawking, sale of used cloth, parts of vehicles, scraped metal, goods, and already made foods are on the increase. The upscaling of these small businesses had also led to prevalence of theft beyond control since people are eager to make wealth. Ellis (1996) emphasised that, if a person has diverse sources of income-generating ventures, it is likely that, such an individual will survive better financially than individuals or households with single source of livelihood. On the other hand, there are some individuals or households who rely on single

sources of income but the income level is good to cater for them and well established in life and they are beneficial to their neighbours and relatives as well.

Types of livelihood assets

According to Bebbington (1999), the livelihood approach is mainly about people. Therefore, understanding accurately and realistically the strength of people; that is assets or capital is important to analyse the way individuals manage to use assets positively to achieve livelihood results. DFID (1999) noted that livelihood assets are building blocks from which people generate livelihoods. The productivity of a household is determined by the household assets position. Generally, the assets endowed with a household defines livelihood strategies. The health and educational status of a person affects his or her ability to partake in viable non-farm jobs and on-farm activities for satisfactory returns. Education also enhances learning of technologies which are new and gives physical capability of most agricultural labour, while productivity in agriculture can be influenced by health and nutrition.

The existence of and access to capital is crucial which determines the choice that people may or may not make. The livelihood approach assumed that households or people need a set of assets that will enable them to achieve livelihood outcomes, a single group of assets is insufficient to enable one to obtain multiple livelihood objectives pursued by the households or a person. This is manifested in the life of a poor household or a person with little access to a given set of assets. In this case, they have to devise a way to nurture and combine assets at their disposal in innovative ways for survival (DFID, 1999).

The capital or livelihood assets of the sustainable livelihood framework are made up of five assets namely, natural, human, physical, financial and social assets. Thus sustainable livelihoods largely depend on access to and control over these assets.

Natural assets

Natural assets are a pivot for many economic activities that people pursue to earn a living. They include living organisms, water, air and land essentials for people to survive or live well. To emphasize, natural capital is also known as natural resources (Barbier & Hochard, 2014: Ellis, 1996, 2000).

Physical assets

Physical assets assist people to change materials from the raw state to final goods that are consumable or non-consumables (Ellis, 2000). They include buildings, fertilizer, planting materials, that help in doing both on-farm and off-farm business activities. If physical assets are available, people in agriculture can increase productivity and household income will increase. With physical assets, work can be done very quickly and households or individuals can diversify livelihood strategies. In production decisions, physical capital or assets are said to play some vital roles. To increase farm production, individuals need to have a set of physical assets. Physical capital also signifies planting materials, equipment, infrastructure, and productive resources that possessed by individuals, households, the business sector or a country itself (Bebbington, 1999).

Human capital

According to Ellis (1996), human capital is an attribute of a person including knowledge and skill, attitudes and habits that work together to

enable one to create wealth or influence his or her community. One can get knowledge if the education involves learning creativity, training, or experience. Besides, a person's health status that enables him or her to excel in physical activities as well as mental work is also considered as human assets. Through education people or individuals are exposed to aspects of life situations such as readings necessary to improve and to acquire skill and knowledge. Human capital is built if individuals are exposed to education and therefore, information is accessed by reading books and published papers essential to enable them to develop their talent and learn new things and skills.

An individual can express his or her view in writings once that individual is able to write. Skills are developed through education; individuals will acquire skills if educated. In this case an individual who has had education is likely to have improved skills and knowledge than an individual without any education in life. There are skills which one possesses and are passed on from generation to generation which necessarily not acquired through education, such in-born skills are called talents. Artistic skill does not need education but individual who is artistically equipped is to have an education so that the natural skill is further built up or boosted. For example, people with no education able to exploit market that is inaccessible. In spite of household education and skill attainment, they need to have good health. An individual who is sick does not have the capacity to work and to excel in wealth creation for his or her own benefit and for the benefit of others. Sickness can engender disruption to household status.

Social assets

According to Ellis (2000), social capital can make a person, community, and organisation more productive. Social capital involves association, traditions, values, and norms that define interaction among people in a particular community. The network system in society brings connectivity between people and can make business productive since cost involved in production reduces through cooperation. Association and bond within a particular community make individuals feel that they are important and useful to the community. The tie enables a person to access information, for example, to have access to loan for the community project or to carry out individual farming or non-farming activities.

Financial assets

Financial capital is monetary value or wealth that enables individuals to have other forms of business and diversified the business strategies and enhance skill resulting in building the income level of the business. According to DFID (1999), financial capital is the resources that individuals make use to gain or obtain their livelihood goals. Financial capital has two main sources, the available stocks which is savings which people can hold in different forms such as cash, bank deposit, or liquid assets like livestock. The regular inflows of money include earned income and remittance.

Socio-demographic and farm characteristics of the farmers

Age of farmers

The decisions of farmers to adopt new technologies are positively or negatively influenced by age (Gbegeh & Akubuilo, 2013). According to Adesina and Forson (1995), the experience of older farmers in farming enable them to examine the nature of new technologies than youth in farming and

therefore, likely to adopt the technology. Conversely, adult farmers tend to be avoiding risk and less flexible than younger farmers and there is likelihood of not adopting new technology .Age of a person determines his or her level of vulnerability. Cutters (1995) is of the view that elderly and individuals of low income are more vulnerable to shocks. These category of people are unable to cope and respond to hazard or shocks because they are in disadvantaged position regarding social, economic and political independence.

Sex of the farmers

The demographic and socio-economic characteristics that relate to vulnerability do intersect because of social identities, peoples' position and the group they belong. According to Flato, Muttarak and Pelser (2017) households headed by females in South Africa is economically vulnerable to climate variability than households headed by males not because of their low level of education and their economic disadvantage, but also by virtue of their gender difference in access to social networks. Therefore, households led by females are likely to have high vulnerability to climate due to their gender as well as their social-economic disadvantage brought about by single-headed households.

In addition, in United State of America, it is reported that, women and ethnic groups who are in the minority position are perceived to having higher risk than males who are white because of their social and formal decision making power that have been reduced and that makes them vulnerable to climate risk (Sattefield, Mentz and Slovic, 2004). However in Sweden where both women and men have equal opportunity and life chances virtually there is no gender disparity in terms of perceived risk (Olofsson & Rashid, 2011).

Women are denied property rights as a result of social barriers (Gbegeh & Akubuilo, 2013), they therefore possess fewer capabilities and resources than men (Marenya & Barret, 2007). Thus, capability of women is weaken regarding labour-intensive agricultural innovations. However, according to Nhemachena and Hassan (2007) households headed by females are likely to undertake climate change adaptation strategies. On the other hand, FAO (2010) noted that women who were into agriculture in Northern Asian countries constitute 5% whiles women in sub-Saharan African countries constitute 15%.

The educational level of farmers

According to Muttarak and Lutz (2014), consistent evidence from empirical studies reveals that household and individuals having higher average level of education have lower vulnerability to natural disasters. Hoffman and Muttarak (2017) also noted that, in a situation where there is disaster-free experience, individuals who are highly educated are able to prepare in advance because of their better abstraction skills to anticipate the consequence of a disaster. Striessnig, Lutz and Patt (2013) highlighted that, communities and countries having higher average level of education do experience lower losses in human lives from climate-related disasters. Thus education can have positive externality in terms of reducing vulnerability to climate change.

In addition, it is assumed that education and endowment of human capital can likely enhance the embracing of new technologies thereby alleviating the adverse consequence of vagaries of the weather on the farmers (Nkonya, Pender, Kaizzi, Kato, Mugarura, Ssali and Muwonge, 2008).

Gbegeh and Akubuilo (2013) stressed that education helps the household in accessing and conceptualizing relevant information and to make innovative decisions. However, attainment of higher education can serve as hindrance to adoption since it provides alternative livelihood strategies. With regard to education, Afari (2001) reported that most Ghanaian crop farmers have had no formal education (never been to school), using primitive farming tools like cutlass, hoes and other conventional farm tools.

Household size

Household sizes that provide available labour may influence positively new technology adoption as it reduces labour constraint (Marenya & Barret, 2007). Nkonya et al. (2008), noted that the large number of labour that perform farm activities in Africa regions are supplied by farm-family rather than hiring, thus inadequate family labour coupled with inability of the farmer regarding hiring of labour can serve as constraints to adoption practice. On the contrary, households with a large number of family members may be compelled to push part of the labour force to carry out non-farm income-generating activities so that income can be earned to ease consumption burden posed by large family sizes. Nkondze, Masuku and Manyantsi (2013) revealed that in Swaziland mostly households' vulnerability was influenced by household characteristics such as number of members who are ill, number of employed members, numbers who are dependants and the size of the household. Household sizes classification conducted by Ghana Statistical Services (2006), described single as one (1) person, small household consist of two (2) persons, medium considered to have three to five (3-5) peoples, large household is made up of six to eight (6-8) peoples and very large

households pegged from nine (9) and above. According to Ghana Statistical Service (2008) the mean household size in Ghana is pegged at household of four (4) peoples considered as medium.

Farm size

Marenya and Barrett (2007) reported that access to information and farmers' decisions to adopt are influenced by farm size. As acreages of crops increases, it leads to exposure to lack of information on specific crop management practices, since the technologies are marketed to large farms. Apart from risk and transaction and information cost linked to innovation, there is limitation on farm sizes that hinder smallholders from adapting (Gbegeh &Akubuilo, 2013). Households having access to formal extension education, farmer to farmers' education in the form of extension and available climate information about future, stand a greater chance of adjusting their farming activities and to respond well to climate variability (Nkonya et al., 2008).

Gbetibouo (2009) is of the view that farmers who receive information from extension services, are able to foreseen changes that take place in climate since they are given information in relation to weather. Besides, technical information delivered by extension services proved important to potential adopters. However, farmer – extension linkage appeared to be very weak in many parts of sub-Saharan Africa and most of the agricultural extension information is spread through farmer -farmer contact (Adesina & Forson, 1995).

Farming experience of farmers

The age of the farmers can be used as a proxy to determine their experience (Wiredu, Gyasi, Marfo, Asuming-Brempong, Haleegoah, Asuming-Boakye & Nsiah, 2010). This means a farmers experience would increase as he or she is becoming older in the farming business. The decisions of farmers to adopt new technology are influenced by age (Gbegeh & Akubuilo, 2013). According to Wiredu et al. (2010) age has positive effect on the yield of crops from the study conducted on rice cultivation in Ghana. This suggests that farmers" experience in rice production increases their knowledge in the practice, thus has positive reflection on the yield realized.

Djauhari, Djulin, and Soejono (1987) also noted that adoption of new technology is correlated with the age and experience of the farmers when determining the relationship between age and frequency of adopting high-yielding variety of maize by the study sample. Adesina and Forson (1995), noted that, the experience of older farmers enables them to examine the nature of new technologies than youth in farming and therefore, likely to adopt farm practices. Categorizing farming experience, Omoniyi and Adebanjo (2012) are of the view that, farmers who are into farming for less than ten years are described as less experienced and those above ten years in farming are considered as experienced which can be used to categorize the farmers.

Age of farm

The relationship between yield realised by the farmers and cost of input is important. The age of the crop, kind and pattern of arrangement of plant as well as the level of resources used determines the yield of the crops. Besides, the production capability of the trees and their ability to withstand diseases give insurance to productivity. In addition, the age profile of tree-

stock is considered very important in terms of assessing potential production as yield varies with age (Dand, 1999). Based on yield profile of oil palm trees, Danso (2019) categorized the oil palm in terms of reproductive life into three stages, early-stage with age range between four to ten (4-10) years, the economic stage which is between eleven to seventeen (11-17) and the declining stage, eighteen to forty (18-40) of the plant lifecycle.

Exposure to vulnerability of smallholder oil palm farmers

Exposure is a component of vulnerability and generally a degree to which the system gets contact with disturbances or subject to a particular perturbation (Adger, 2006). However, Bohle (2001) identified differences between exposure and coping by defining exposure as an external aspect of vulnerability and coping the internal dimension. Exposure as differing from sensitivity and capacity to adapt is a relationship between a system and disturbances. Besides, exposure is considered an integral part of vulnerability because a system without exposure to disturbing factor is defined as non-vulnerable. The differences existing between sensitivity and capacity to adapt and exposure are drawn using clear and simple examples like flood (Bohle, 2001). The insecure home is severely struck by a flood than the solid type (sensitivity). Frequently, the weak home is struck by the flood because it is situated in a place often susceptible to flooding (exposure). Families with readily available resources has different ways of repairing the havoc created by the flood (adaptive capacity). The greatness of the eventual impact is dependent on how intense or permanent is the flood (the attribute of perturbation).

Farmers' exposure to risk and the inability to prevent or mitigate and cope with the effect of shocks, trends, and seasonality reduces the income and well-being of households. Thus, income is an important outcome of livelihood and a major determinant of the well-being of farmers (Ellis**,** 1998). The vulnerability can also be termed as the likelihood that a person's level of welfare will go below the benchmark at a given period of time in future although the person is not poor now (Hoddinott & Quisumbing, 2003). Also it is the effect of prevailing shocks like drought, fall in price of farm commodity and any financial crisis (Dutta, Foster & Mishra, 2011).

Irrespective of multiple exposures to shocks and stresses by smallholder farming systems, its persistence demonstrates a capacity to adapt (adaptive capacity) (Engle, 2011). In this study, exposure is defined as a degree to which a farm-based livelihood system is susceptible to shocks, seasonality and critical trend as espoused by the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2001). The IPCC AR4 framework was developed to provide an understanding of the adverse effect of climate change. However the framework can be applied to the understanding of live livelihood vulnerability and adaptive capacity of socio-ecological system including farming. The IPCC AR4 framework constitutes exposure, sensitivity, potential impact, adaptive capacity and vulnerability of socio-ecological systems (Figure 1). In the framework, for vulnerability to take place, a system must be first exposed to a factor (perturbation) and then would lead to sensitivity followed by the potential impact. The process is moderated by adaptive capacity of the social system to determine the level of vulnerability of the system (society and environment)

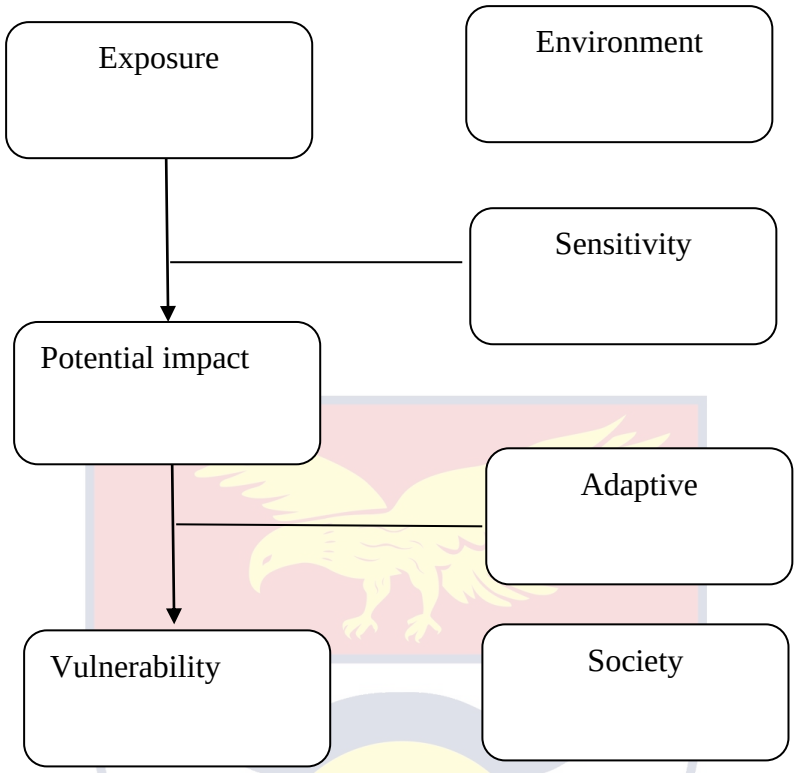

Figure 1: IPCC AR4 framework on vulnerability assessment

Source: GIZ, 2017

Exposure: this is initial events of system vulnerability and it is a degree to which a system is susceptible to the adverse effects of climate change, which includes climate variability and extremes. From the broader perspective and in the context of this study, exposure is referred to the degree to which farm-base livelihoods system is susceptible to shocks seasonality and critical trends. Here, the perturbations or (disturbances) will be as results of shocks seasonality and critical trends.

Sensitivity: in the context of climate, is the degree to which a system is adversely or beneficially affected by climate-related stimuli. From the broader perspectives and in the context of this study, it is a degree to which farm-based livelihood system is negatively or positively affected by shocks,

seasonality and the critical trends. Sensitivity may be either direct or indirect. In terms of direct effects, it is related to a change in crops yield as the result of a change in the mean, range or temperature variability. The indirect may be due to havoc caused by the frequent increases in coastal flooding.

Potential impact: the impacts of climate change are the effects of climate change on the natural and human systems. From the broader perspectives and in the context of this study, it is the effect of shocks, seasonality and critical trends on the livelihood assets of the smallholder oil palm farmers.

Adaptive capacity: means the ability of a system to adjust to climate change which includes, climate variability and extremes, to moderate potential damages, taking advantage of opportunities or to cope with the consequences. From the broader perspective and in the context of this study, adaptive capacity is the ability of the farmers to adjust to shocks, seasonality and critical trends and to cope with its consequences and taking advantages of opportunity.

Vulnerability: is a function of the character, magnitude, and rate of climate changes and variation to which a system is exposed, its sensitivity and its adaptive capacity. From the broader perspective and the context of this study, vulnerability is degree to which farm-based livelihood system is exposed to shocks, seasonality and critical trends, its sensitivity and capacity to adapt. Besides, vulnerability can also be explained based on the views of other proponents. According to Smit and Wandel (2006) the concept of vulnerability has been used in different research traditions but consensus on its meaning has not been reached. Adger (2006) examining the evolution of approach to vulnerability concluded that, vulnerability constitutes exposure to

perturbation or external stresses, sensitivity to perturbation and capacity to adapt. Generally, vulnerability like resilience considered as being specific to the disturbances that interfere with the system; in other words, a system can be vulnerable to certain perturbation and not to others.

Furthermore, vulnerability is also viewed as being susceptible to harm, a potential for change or transformation of the system in the face of perturbation. Kasperson, Kasperson, Tunner, and Hsich (2003) are of the view that, the term "vulnerability" does not have universally accepted definition. On the basis of that, the word is used differently by different disciplines to explain their areas of concern. Studies on epidemiology define vulnerability as the degree to which an exposed unit is susceptible to being harmed by exposure to a perturbation or stress, in conjunction with its ability (or lack thereof) to cope, recover or adapt (become a new system or go extinct).

In contrast, poverty and development literature, which focuses on social, economic and political conditions, defines vulnerability as an aggregate measure of human welfare that integrates environmental, social, economic, and political exposure to a range of harmful perturbations. FANRPAN (2011) defines vulnerability as the inability to withstand the adverse impact of exposure to stresses or shocks associated with environmental and social change, as well as the absence of the capacity to adapt to the impact.

Adger and Kelly (1999) define social vulnerability as the exposure of groups or individuals to stress as a result of social and environmental change, where "stress" refers to unexpected changes and disruptions to livelihoods. Furthermore, in economic literature (poverty and development literature),

vulnerability can also be termed as the likelihood that a person's level of welfare or good living will go below the yardstick or benchmark at a given period of time in future although the person is not poor now (Hoddinott & Quisumbing, 2003).

Socio-ecological system: comprises both natural and human systems upon which climate change, including climate variability and the extreme have an effect. The concept is further expatiated by highlighting on the following vulnerability exposure factors, such as shock, seasonality and the critical trend. According to DFID (1999) the vulnerability context is the external environment in which people exist. The livelihood of people and the broader available assets are fundamentally affected by shocks seasonality and critical trends over which they have limited or no control. Besides factors which constitute the vulnerability context is considered important since they have direct impact on the assets position or status of the household and choices they have to make when pursuing the necessary livelihood goals or outcomes.

Shocks such as (floods, storms, and civil conflict) can destroy valuable assets. According to DFID (2001), shocks are unexpected, intense and distressing events that have sudden and adverse impact on the livelihood of people. These factors can force people to abandon their homes or residence and dispose of cultivating land as a coping strategy. Furthermore, international economic shocks such as rapid change in exchange rate and terms of trade can have significant impact on the very poor.

Beets (1990) revealed that drought is a natural shock that can constrain crops' yield and can also affect approximately 80% of the area covered by

crops with serious consequences upon the household livelihood. He added that minor drought can produce negative effects on particularly tropical regions with humid conditions where soils are of bad quality and inability to store adequate water for crops to uptake. DFID (1999) emphasized that, shocks like conflict, economic shocks, health shocks (human and livestock/crops) and natural shocks such as earthquakes, produce adverse effect on farming activity than on employment in urban centres, and therefore, vulnerability to these risks is likely to lead to poverty and socioeconomic position, influenced by social dimensions such as income levels, assets ownership, ethnicity, age, class, and gender. Climate change is another area that serves as a threat to agriculture and IPCC (2007) reported that historical climate records for Africa show increased warming rate since the 1960s with warming of approximately 0.7 degree Celsiu over most of the continents during the twentieth century. Climate will unequally influence the livelihood of the people who are poor and will strike the poor farmers harder and unfairly strike those farmers because of their little contribution to the causes (World Bank, 2007).

According to Twigg (2001), seasonality is described as certain periods of the year. Seasonality includes seasonal shift in prices, production, and workload of the farmers, employment opportunity and health, among other. Trends tend to be moving slowly and mostly mild transformations that take place in the broader environment. The direction of the event that is accurately monitored or tracked. The trend can be population trend, natural resources trend and national and international economic trends (Chambers & Conway, 1992). The trend can also emanate as trend in governance and technological trend. Giving an example such as changes in the price of a particular

international commodity, tend to affect the people who are into its production, processing or engage in the commodity's export but will impact less on the commodity's producers and those who engage in trading the commodity at the local market level. Besides, Twigg (2001) also viewed trends as a movement or direction in which certain events occur and which affect the livelihood of the peoples. Trends persist for longer period and usually extend to a large area.

Kahan (2008) highlighted that, in developing countries, farmers are frequently exposed to the uncertainties of weather, prices and disease i.e. farmers do not know whether rainfall will be good or bad over a given season, price they will obtain for produce to be sold and they do not know whether their crops will be infested by diseases and pest.

Morton (2007) noted that in the tropics, farmers who grow crops on small-scale face large number of risks in the farming business, which include pest and disease outbreaks, extreme weather events, and market shocks, among others which tend to weaken the food of the household and income as security. Wilhite (2000) is of the view that drought affects practically all climatic regions and more than one-half of the earth is prone to drought each year. Nagayet (2005) revealed that there are many farmers worldwide who cultivate a small area of land and are directly exposed to sun and extreme heat (temperature). Agriculture for Food Security 2030 (AgriFoSe2030), 2018) revealed that, in sub-Saharan Africa, smallholder farmers face labour shortage during a key period that strongly influences yield and poor weed control which results in high competition for nutrients, water and light and consequently low yield.

Kamara (2004) found that in Kenya, market reforms and globalization have changed marketing opportunity, the reforms target large scale farmers and neglect small-scale farmers thus reducing their linkage to market and leaving the farmers with few financial sources) indicating smallholder farmers' exposure to irregular market access. IFAD (2013) noted that, globally, smallholder farmers faced unprecedented increasing competition for land and water, changing markets, rise in fuel and fertilizer price (inputs) and climate change. Also, they are exposed to unpredictable price fluctuation due to globalization of food system. Although the impact of such shocks differs depending on type of crops grown, level of specialization and the nature of household food consumption, (IFAD, 2013).

Malik and Nazli (1999) highlighted that, smallholder farmers face limited access to credit and hinders them to adopt modern technologies in the farming sector. Also, farmers lacking resources does not only hinder the attainment of high productivity, but reduces their levels of consumption. Bunei, Auyas, and Romo (2016) revealed that, across Africa, produce theft is a problem that persists, which poses a serious threat to food security and development of livelihood thus, indicates that farmers are exposed to theft in their production activities. According to the Rockefeller Foundation (2013), post-harvest food loss in Africa has multi-dimensional challenges that reduce approximately the income of 470 million farmers and 15% income of other value chain actors therefore, manifest that farmers are exposed to post-harvest loss after harvesting.

Carrand and Hartl (2010) revealed that women who are farmers and grow crop on small-scale in tropical Africa confront major labour constraints,

especially in areas of limited access to labour resources, technologies and tools. Wiggins, Henley and Keats (2015) are of the view that in sub-Saharan Africa farmers who largely rely on market are likely exposed to market risk and supply chains which is rigidly manipulated by formidable firms.

Asombobillah (2011) emphasized that, besides the challenges in accessing finance for agriculture, farmers face the difficulty of finding reliable and qualified agricultural extension support. Hayward and Botha (1995) noted that in developing countries, smallholder farmers face constraints like limited access to land, farm, and non-farm resources, financial inaccessibility, mechanization inaccessibility, transport facilities, lack of support from extension and research institutes and favourable market inaccessibility.

The sensitivity of vulnerability to livelihood of smallholder oil palm farmers

Sensitivity is an internal dimension of vulnerability. It is a degree to which a system (both natural and human) adjust to disturbances without long term suffering or significant alteration expressed by the system (Adger, 2006). Luer (2005) combined sensitivity and exposure and defined it as a degree of responsiveness of the system to the external disturbances. He added that the system should have the capacity to withstand any changes and restore to earlier state when the disturbances are moderated or offset.

According to IPCC (2001), sensitivity is the degree to which a system is affected either adversely or beneficially by climate stimuli. These effects are direct and indirect. Direct, for example, changes in crop yield has a link with variation in mean temperature while indirect may be devastation associated with coastal flooding due to rise in sea level. Gallopin (2003) in his

opinion defined sensitivity as a degree to which the system is altered and adversely affected by internal or external disturbances or combination of disturbances. This is measured based on the degree of transformation that occurred on the system depending on the intensity of the disturbance. In the simplest form, it only clarifies whether or not the system is sensitive to a given factor. In this study, sensitivity is defined as a degree to which a farm-based livelihood system is affected either negatively or positively by (exposure elements) shocks, seasonality and critical trend (modified from IPCC, 2001). Besides low yield, low income, low productivity, lack of access to adequate water, lack of knowledge and skill of oil palm production practices, lack of access and ownership of land, low price for produce (Fresh, Fruit Bunches), inability of the farmers to adopt improved practices/technologies due to credit constraints, inability of the farmers to purchase adequate pesticides, inability to acquire sufficient simple farm implement, inability of the farmers to afford inorganic fertilizer and inability of the farmers to form an association represent the sensitivity. The effect of the vulnerability (exposure element) on the farm-based livelihood (assets) is reviewed below.

Effect of diseases and pest, erratic rainfall, temperature and drought on yield

According to Kerin, (1994) one-fifth of crops produced in the world are devastated by herbivorous insects annually. The reason for the pest build-up is the creation of man manipulated habitats that seek to satisfy man's needs and where crops selections are based on certain qualities such as large size, high yield, nutritious value and crops densely growing in confined place. This condition does not only meet human needs, but also serves as a conducive

environment for pest escalation at the same time. Verheye (2010) is of the view that oil palm is susceptible to many pests and diseases and the aspects seriously affected are the yields and the economic profit. Besides, to achieve good growth and satisfactory yield, the crop requires well-distributed rainfall throughout the year without being interrupted by little or prolonged dry season with stable temperature. However, prolonged droughts lasting for 2-3 months do not only destroy the vegetation growth but adversely alter the yield and number of developing fruit bunches. Hartley (1988) noted that high water deficit (drought) can lead to excessive production of male inflorescence with a consequent reduction in sex ratio in oil palm (the proportion of female inflorescence to the total number of inflorescence produced. Lamade, Bonnot and Poeloengan (1996) revealed that an increase in mean temperature from 24 degrees Celsius to 27 degrees Celsius reduces total dry matter production by 16% and yield by 1.1 tons while prolonged low minimum temperature less than 21 degree Celsius leads to inflorescences abortion before anthesis and delay the ripening of fruit bunches (Hartley, 1988).

Effect of frequent weeds growth on yield

The study of Mohamad, Wibawa, Mohd, Adam, Abdul, Yahya and Mohammad (2010) revealed that in oil palm cultivation, weed management is an important practice. There are types of weeds, including, sedges, broadleaves, and grasses that undergo changes based on the stages of development of arable crops and can create an environment conducive to promoting a particular weeds emergence. Young oil palm is sensitive to competition from weeds because weeds tend to overgrow the growing palm tree if immediate action is not taken to arrest their vigorous emergence

(Ofosu-Budu, Zutah, Avaala, & Baafi, 2014). The effect of weeds competition in cropland, grassland, and natural areas are enormous and can reduce both foods for human and feeds for animals (Rai, Scarborough, Subedi & Lamichhane, 2012). Shackleton, McGarry, Fourie, Gambiza, Shackleton, and Fabricious (2007) noted that invasive weeds impact negative consequence on native crops and ecosystems. The activities of this exotic weeds ultimately result in economic damage. The severe loss of agricultural production has been recorded in many parts of the world where both agriculture and economic losses have been assessed (Borokini & Babalola, 2012). Also Pimental, McNair, Janecka, Wightman, Simmonds, O'connell and Tsomondo (2001) indicate costs associated with the negative impacts of invasive weeds at a global scale to be 1.4 trillion per year. Invasive weeds are typical of rapid growth highly reproductive and extensively tolerant their habitat.

Effect of irregular access to the market on income of farmers

Cai, Dai, and Zhou (2012) also highlighted that what contributes to improving smallholder farmers' livelihood is marketing. Besides, access to the market is a problem common in rural communities (Machete, 2004). Reardon (2005) indicated that access to market is a requirement for the rural areas since the farmers have to experience the benefit of agriculture growth therefore, smallholder engagement in accessing market is important. Gummesson (2002) postulated that most rural communities are unable to make their living standards better because they are not in good position to access markets. He added that the main reason why some smallholder farmers who have the ability to till land and bring into existence surplus produce but still in poverty is because of non-existence of access to profitable markets and

therefore, this forces the farmers to dispose of produce to buyers at dictated price leading to income loss.

Effect of price decrease on the income of farmers

Mchopa, Kazungu, and Ndiege (2012) defined price fluctuation as frquent rise and fall of commodity prices in the market resulting from market's changing situation. Price fluctuation is seasonal since commodities' prices change during certain period of the year as a results of increase in supply and demand. Furthermore, it can be a short-lasting event because of a slight change in demand and supply of market commodity. However, it can be a long term situation by virtue of persistent inflation rate which highly influence the prices of products in the market with its effect lasting longer and limits farmers' and buyers' ability to sell or purchase products in the market.

Huka, Ruoga, and Mchopa (2014) noted that Price fluctuation is a problem which is multidimensional and caused by many factors with their combination generate serious consequences for the individual who is vulnerable. High price may appear like good information to the farmers in production, but fluctuation in prices is intensely dangerous since farmers and intermediaries who are into food chain, likely to lose their investment when prices fall. Price increase is normally brought about by what is known as 'market fundamentals'. Demand tends to outstrip supply and hence lead to the increase in price of item offered for sale. In addition, fluctuation in price is not only detrimental to consumers but producers as well. As it is known generally, farmers who are poor do not have adequate initial capital that enable them to cope with such unpredictable event. According to Huka et al. (2014) in developing world, high price of food have not been converted to

desire price in favour of farmers, especially in a situation when non-food items for example, cooking fuel, transportation, fertilizers, rent, kerosene and agricultural inputs always and increasingly getting very expensive. Subsequently, intermediaries also face high transportation costs which they, in turn, pass on to the farmers.

Effect of the high cost of inputs on yield

FAO (2013) highlighted that, for agriculture to develop, it is essential that we make inputs available, affordable, accessible and of good quality. Inputs such as agro-pesticides, seeds and fertilizers are necessary to boost the yield and incomes of smallholder farmers in developing countries. This implies that, input supply is the most important thing in agriculture and rural development. In this regard, it has become a concern to many donors to provide support to enable smallholders to access inputs. Timler, Michalscheck, Klapwijk, Mashingaidze, Ollenburgeer, Falconnier, and Groot (2014) revealed that crop yield tends to be poor due to increased cost of input, lack of quality seeds, and labour constraint.

Effect of the lack of access to credit on human, social, physical and technology use

Foltz (2004) asserted that smallholder farmers' access to credit and other financial services, is a good gesture to bring down poverty, increase productivity on-farm and facilitate farmers moving from subsistence farm level to large scale farming system. Subsequently, credit can help boost the purchasing power of the farmers to get essential productive input and to invest in the farm to cater for operating expenses in the short run while enabling farmers to improve their ability to make profitable investments in the long run

(Conning & Udry, 2007). However, an imperfect credit market that exists as a result of information asymmetry disorganizes farm operations. Feder, Lau, Lin and Luo (1990) suggest that credit rationing and capital market which is imperfect is likely to lead to misapplication of farm input and inadequate use of resources in producing crops. Therefore, this misapplication of resources eventually affects productivity in an adverse way and will lead to low-income if compared with farmers with a given required credit to invest in the farm and the achievable sustainable welfare and food security of the household.

Uaiene, Arndt, and Masters (2009) asserted that farmers who grow crops on small-scale are unable to adopt technology in the face of credit inaccessibility. In China, farmers' ability and education as well as significant effect of productive inputs are weakened by credit constraints. Moreover, resources such as human assets, social assets and physical assets are adversely affected by credit constraints that impact negatively on agricultural productivity (Kinyanjui, 2018).

Effect of incidence of theft on the income of farmers

Famers in remote areas especially those in Africa over a decade were not experiencing theft problem as it seldom occurred and in case it happens, its intensity considered minimal. Besides many leave their keys in the machines used on farm and not anxious that their crop would be stolen in their absence of the farm. According to Chiwona-Karltun, Lemenih, Tolera, Berisso, and Karltun (2009), crimes against farm operations across Africa is increasing. Criminals tend to descend into rural regions particularly in Africa to engage in rich stealing, taking advantage of insecure environment, and rural hot product.

Bonei, Auya, and Rono (2016) are of the view that stock thefts are persistent problem across Africa which pose a threat to food security and development of people livelihoods. Gichamo (2011) reported beans theft which is pressing problem than soil fertility management in Ethiopia. In Kenya, green stealing of maize is the serious problem while countries like Uganda, Madagascar and vanilla theft is prevalent which prompt farmers to harvest their crop before period of maturation. In Ghana as reported by Inkoom and Nanguo (2011) crop theft is a serious problem and especially over 21.5 percent of dry season irrigation farms are victims of thefts which consequently affect yield. Besides, country like Zimbabwe, experiences theft of sheep and moringa (leaves and protein seed highly valued for food and health benefits) which causes both financial and psychological stresses (Nel & Davies, 1999).

Effect of reduced quality of fresh fruit bunches on the price of the farmers

Research has indicated that the quality of FFB reduces when bruised since Free Fatty Acid in the part of the fruit injured increases suddenly to sixty percent in an hour. Also Fresh Fruit Bunche should be conveyed to the processing centre as early as possible in 24 hours after harvesting. Delay in transporting harvested fresh fruit bunches, from the field affects the quality of FFB (weight loss and microbial infection) or enhances its deterioration (Poku, 2002) thereby affecting pricing of the bunches.

Quality of palm fruit is judged by the content of free fatty acids and a rate of oil extraction. To generate good marketable and attractive fruit bunches for sale on the farm, smallholders are putting diligent efforts to devise an appropriate way for handling fresh fruit bunches to avoid any damages and

bruises inflicted during handling of the produce on the field. Furthermore, fruit bunch quality is determined through the observation of categories such as young fruit, ripe fruit, and overripe fruits. In addition, a well ripe bunch is the one with reddish and orange colour and has some fruit detached and fallen on ground under the mother palm tree. Young fruit contributes zero oil component (Sharif, Taib, Yusof, Rahim, Tobi & Othman 2017).

Abdul and Tan (1989) revealed that bunches having a long stalks and immature bunches surely reduce rate of oil extraction. They also found that it is essential for the FFB to be carefully selected so that good fresh fruits bunches are cut with special knife and gather based on standard of ripeness thereby promoting the quantity and quality of the palm and kernel oil and that help to determine the purchase price and to receive worthy price.

Effect of unavailability of labour on oil palm productivity

According to CFA (2016) agricultural industry requires adequate labour to perform its operations but farmers continue to experience labour shortage considered to be a pressing issue. Labour unavailability can serves as impediment in agriculture. Labour scarcity affect productivity level of the farmer who has chosen farming as the main sources of livelihood. It is considered as a vital input in farming but its availability is impaired through migration (Deshingkar, 2003). Grover (2014) is of the view that, the incidence of urbanization and drastic movement of rural folks to search for better jobs and opportunities in cities has led to labour shortage in agriculture sector which is undermining farming business upon which people achieve their livelihoods.

Effect of farmers' dependence on marketing agent on the price of fresh fruit bunches (FFB)

Smallholder farmers' poverty may be alleviated depending on the price received for their agricultural produce. As the profitability of the farmers' increases, there is the possibility that they can diversify production, planning related to investment and decision on marketing. They will cultivate in intensive way, engage in the sale of farm produce in large quantity, put money in assets used for production, put into use current farm technology, put into use land not for agricultural purpose or purchase goods at a particular place and sell them at different price to get profit from pricing difference (Jensen, 2010). Farmers in many countries of Africa, can sell farm produce to a market agents who travel from one place to another especially in the village and remote centres to buy farm commodity and finally transport them to the nearest market (Fafchamps & Hill, 2005).

Fafchamps and Hill (2008) noted that many farmers opt for traders buying their products though there is evidence that, the agents take advantage of farmers' negligence of the price in the market and go on to cheat them by giving a low price to products they purchase. Farmers normally prefer traders buying their products on the basis of transportation cost as the main determinant in marketing decisions. Generally, in sub-Saharan Africa, transportation cost is known to be very high making it a critical component of farmers' marketing decisions.

Effect of limited agricultural extension education on knowledge and skill of farmers

Numerous studies relating to education and productivity in the agricultural sector indicate that there is a relationship between education and productivity in agriculture (Asadullah & Rahman, 2009). The relationship that

exists between education and productivity may be either positive or negative. Gasperini (2000) reported that World Bank conducted a survey to determine the relationship between farmers' education and their agricultural efficiency in low-income countries and ascertained that, farmers with basic education were 8.7% more productive than farmers with no education. The findings of the World Bank suggest positive relationship between educational level of farmer and productivity.

Pudasaini (1983) highlighted in a study that was conducted in Nepal on the effects of education on agriculture and found that, education promotes agricultural productivity primarily by improving farmers' decision-making ability and secondarily by elevating their technical efficiency. Technical efficiency means the capability of the farmers making better choices in relation to inputs and making a better economically rational decision. It is clear that agricultural productivity vary with the level of education of the farmers (primary, secondary and tertiary levels of education) (Appleton & Balihuta, 1996).

Weir (1999) emphasizes that formal education does not necessarily affect productivity but rather non-formal education does it in the form extension services and sharing of information from farmers to farmer which has greater influence in the adoption of and the practice of best technology. Pudasaini (1983) is of the view that there are three main ways that extension education raises agricultural productivity: it improves farmers' skill and knowledge, enhances the farmers' ability to obtain, understand and utilize new input and build up overall managerial ability. Therefore, lack of extension education reduces productivity, skill and knowledge of the farmers.

Effect of unavailability of land on access to land

In some countries, access to land for cultivation is a major constraint. The constraint includes insecurity to land tenure, unequal access, and absence of proper mechanism to transfer rights, which have led to underdeveloped agriculture and degraded natural resources (Sulaiman, Abdullah, Gerhauser & Sharif, 2010). There is yield reduction due to intensive cultivation on small plots for many years and thus the cultivating land becomes exhausted. Thamaga-Chitja and Morejele (2014) are of the view that the denial of women of the privilege to access and own land has endangered productivity of agricultural system. They also reported that in South Africa women can obtain right to land through marriage. More so in other countries, women can only inherit land if they have children after the death of their husband and thus discourage them to enter into agricultural production in terms of the use of land.

The adaptive capacity of smallholder oil palm farmers to the vulnerability

In the climate change literature, vulnerability is conceptualized as exposure, sensitivity and adaptive capacity. Future climate projections and impact assessments indicated that smallholder farmers who mainly depend on rainfall will be likely exposed and sensitive to climate changes in future. Besides, in developing countries, smallholder farmers do not have the capacity to adapt because of lack of institutional support that makes them accessible to good technologies, knowledge, and resources necessary to address future challenges brought about by climate change (Rodima-Taylor, Olwig & Chhetri, 2012).

According to Osbahr, Twyman, Adger, and Thomas (2010), research into the human dimensions of environmental change shows that historically, farmers who cultivate small areas of land have adapted to multiple pressures as well as climate hazard, extremes, variability and change, based on management decisions, the use of resources and preferences. Adaptive capacity is generally accepted as a desirable attribute of the systems to reduce vulnerability (Engle, 2011) and to increase resilience (Anderies, Janssen, & Ostrom, 2004). Furthermore, adaptive capacity helps prevent or reduce the effect of the perturbation. But in terms of resilience it builds up the system robustness (Anderies et al. 2004). The capacity to adapt (adaptive capacity) is also considered as both practical actions and recommendation of policy (Jones, Ludi & Levine, 2010).

According to Stringer, Berman, Dixon, and Quinn (2014) adaptive capacity is considered as latent capacity, and it is a prelude to adaptation. Adaptation in broadly is a change which is conducted voluntarily to respond to or to expect and anticipate diverse pressures and transformation that affect the lives of people. Latent adaptive capacity emphasizes the available assets and the institutional arrangement that enable or restrain access to and the use of assets (Berman, Quinn, & Paavola, 2012). In the vulnerability literature, adaptive capacity stresses on things that enhance the adaptability of the system, (i.e. the processes and functions that enable adaptive capacity).

In the resilience literature, adaptive capacity focuses on what is done by a system to enable it to adjust, for example, the property of the system. It requires methods that do not merely look at the resources and institutions that help a system to adjust, but rather recognize what is done by a system to

enable it to adjust (WRI, 2009). Quinn, Ziervogel, Taylor, Takrama and Thomalla (2011) highlighted that productivity, connectivity and diversity are essential properties of the system that exhibit the capacity of farming system to adapt whilst resources and institutions constitute what a system has to enable it to adapt to any disturbances, i.e. the inputs to a system, productivity, diversity, and connectivity are essential properties that show that a system is capable to adapt. In this study, livelihood strategies of the farmers represent adaptive capacity and adaptive capacity is defined as ability of the smallholder farmers to employ livelihood strategies to enable them adjust to shock, seasonality, trend and to cope with consequences and taking advantage of opportunities (modified from IPCC, 2001). Livelihood strategies adopted by oil palm farmers for managing or dealing with the vulnerability are reviewed below.

Livelihood strategy of managing diseases and pest damage

The annual and perennial crops that are cultivated by farmers harbour several pests and diseases and promote emergence of weeds in the field. With regard to arable crops, growing different types of crops over time on the same piece of land likely to alter the developmental stages or life cycle of the pest which in turns reduce pest pressure on the subsequent crop. In perennial crops, the rate of pests build up in the first year determines the level of infestation in the subsequent year. The practice of crop rotation and application of reliable

Management measures will have a temporal impact on the pest in terms of their occurrences in the field (FAO, 2017).

According to Kumari, Kumar, and Narasimba (2018), smallholder farmers use strategies such as improved variety, chemical fertilizer, and

pesticides to cope with diseases and pests. Although studies reveal negative impact of chemical fertilizer and pesticides on the environment when they are overused, the economic-threshold of agricultural pests and diseases, compel farmers to resort to the use of synthetic pesticides. However, to achieve more sustainable farming practices, farmers can rely on organic farming or integrated pest management practices.

Livelihood strategy of frequent weeds growth

Weeds can engender serious losses in farming business due to competition for nutrients, light, and humidity between the weeds and crops with estimated yield loss of 34%. According to Swanton, Nkoa and Blackshaw (2015) about 100 billion US dollars as estimated losses annually resulted from crop damage due to weed competition. There are several ways of managing weeds, which include, using farming systems like crop rotation, cultivation and crop competition. Other weeds management practices which are direct, include mechanical weed control and the use of herbicide as weed control technique. A study conducted by Nkombe, Sangeda, Sibuga and Hermansen (2018) on strategies for weed management in central Tanzania revealed that, the majority (60%) of the farmers uproot or slash the weeds before flowering. However, these methods require enough labour and finance if they are to be done on large scale. Others also mentioned herbicides application and application of fire and early weeding in crop fields.

Livelihood strategy of erratic rainfall, temperature, and drought

Challenges posed by climate change for development are considerable (Thornton, Jones, Owiyo, Kruska, Herrero, Kristjanson, Notenbaert, Bekele & Omolo 2006). Therefore, it is more essential to assess the effect of climate

change on the environmental, social system and economics assets (Hulme, Doherty, Ngara, New, & Lister, 2001). Furthermore, a high level of vulnerability and low adaptive capacity in Africa is attributed to factors like limited finance and institutional arrangements, low per capita gross domestic product (GDP) and high rate of poverty. In connection with sub-Saharan Africa, it is predicted to be hit hard by global warming due its experience of high temperature and low precipitation, dependency on agriculture and low adoption of modern technology (Kurukulasuriya, Mendelsohn, Hassan, Benhin, Deressa, Diop, Eid, Yerfi Fosu, Gbetibouo, Jain, Mahamadou, Mano, Kabubo-Mariara, El-Marsafawy, Molua, Ouda, Ouedraogo, Sene, Maddison, Seo, & Dinar, 2006).

According to Fosu-Mensah, Vlek, and Manschadi, (2010), farmers in Ghana have been perceived to adapt to changes in climate. In Ethiopia recommended coping strategies to mitigate negative impact of climate was to promote livestock ownership among folks in farming, plant early-maturing and varieties of crops that tolerate drought, invest in irrigation and strengthen research institutions (Deressa & Hassan, 2009). In Ghana, Fosu-Mensah et al. (2010) reported that crop diversification and changing planting dates for crop plants are the common two strategies used by the farmers against rainfall and temperature variability and drought. Besides, in Zimbabwe, crop and livelihood diversification was the main coping strategies adopted in the risk of crop failure and livelihood vulnerability (Gukurume, 2013).

Livelihood strategy of irregular access to market

Regarding lack of market access by the oil palm farmers, to mitigate the adverse circumstances they face, particularly in the local market, farmers

choose to engage in contractual agreements and as they do that, they take advantage of opportunities like additional income earning, guaranteed market, inputs supply and delivery of knowledge (Masakure & Henson 2005). Their study also indicates that, intensions of the farmers to engage in contractual arrangement depend on yardsticks such as farm size, amount of land reserved for export crop production, nature of market access and amount of income achievable from export crops.

Chauca (2010) highlighted that, adopting a particular pattern of farming, peasant farmers should be aware that, labour structure, market linkage of peasant farming' are not consistent process and therefore necessitate diverse market position and peasant farmers cultivating market-oriented crops developed from breeding technologies process are determinant of peasant heterogeneity. In rural Andes, in dealing with market constraints, Walsh-Dilley (2013) revealed that, smallholder farmers combined local, non-market activities, cooperative and international markets involvement to create feasible, social and ecological livelihood strategy. Quinoa farmers in San Juan, Bolivia apply the strategy of exchange of labour while seeking the opportunity gained from the quinoa market that remunerate. Such practices serve as multi-functional strategies that promote production and form of social insurance against market uncertainty (Walsh-Dilley, 2013). In Kwaebibirem Municipality of Ghana, most oil palm farmers sell their produce to the processing companies, though there is a delay in paying the farmers at the stipulated time established by the farmers. Other farmers resort to selling to Kramers (artisanal processors) and which attract small amount of money and

sometimes, these kramers are unable to buy in large quantities especially at peak production seasons (Manley & Van Leynseele, 2019).

Livelihood strategy of price decreasing

With reference to the strategies to curb price fluctuation, Somnuek, Maja and Gunbuhel's (2016) study show that, oil palm farmers in Thailand employed diversification of cropping system and combination of on-farm and off-farm income activities to respond to fluctuation in cash crop commodity prices. In addition, farmers engage in labour mobility systems since return from non-farm labour were higher than returns from agricultural activities. Kasem and Thapa (2011) explained that, crop diversification is an important option to reduce or minimise poverty in South Africa and Southeast Asia. Barret, Reardon and Webb (2001), indicated that in Africa on-farm diversification is the way of alleviating poverty and vulnerability for small scale family farms. Furthermore, Koczberski and Curry (2005) found that in Papaua New Guinea, oil palm farmers diversified farming production sustain household income security and to regulate the risk bought about by fluctuation in oil palm prices.

Livelihood strategy of high cost of input

Price of inputs for cultivation, agriculture implements and consumer goods keep increasing than the price realised for outputs from agriculture due to the introduction of structural adjustment programmes in Africa and consequently undermines the production of smallholder farmers (Carswell, 1997). This has impacted negatively on linkage in terms of agricultural produce flow. Therefore, the poorest group have entered into different kinds

of livelihood strategies such as non-farm activities, urban agriculture and migration

Rural households are predominantly engaging in non-farm income generating business and ventures as self-employment. The estimated total income achieved from non-farm income recorded between 25 and 45 percent in Sub-Saharan Africa and more than 60% in Latin America and Southeast Asia (Reardon, Berdegue & Escobar, 2001). Barrett, Bezuneh, Clay and Reardon (2004) highlighted that, to diversify income sources is the sure means of climbing out of poverty especially when the achieved income exceed agricultural output and thereby contribute to reduce vulnerability.

However, for smallholder farmers facing different types of market and assets constraints, entering into different kinds of non-farm activities can be anticipated. A study by Diyamett, Diyamett, Jovita and Mabala (2001) indicated that in Marawe Kyura 86% of the respondents and in Lotima, 97.6% depend largely on both farming and non-farming business. Furthermore, in the two cities, agriculture is the main occupation for the poor while well to do people take a keen interest in non-farm activities. According to Kibadu, Lerise, Mbutolwe and Mushi (2001) young generations are able to engage in multiple activities than old ones.

Livelihood strategy of lack of access to credit

Farmer's access to credit is limited as the result of credit market imperfection especially in low income countries and thus this compels households to unwillingly adopt inefficient strategies that lead to a lasting negative consequence on their future well-being. Subsequently, crop failure caused by rainfall variability can force farmers to sell available assets for

consumption. In certain situations, the value of assets may reduce if shocks persist for relatively long periods and this may lead to irreversible productive assets loss and hence make households suffer risk of poverty. Limited credit access together with farmers facing climate shocks will compel households to shift from engaging in high-risk but more lucrative activities to low risk but low-income generating activities and which will result to unsustainable livelihood and a vicious circle of poverty (Humphreys & Verschoor, 2004).

Lianto (1993) indicated that smallholder farmers in Philippines contact informal money lenders for credit irrespective of high interest rate due to minimum requirement, flexibility, quick preparation, the issuing of the loans timely and the demand of no conventional form of security. World Bank (2000) reported that, in the Philippines during the year 1998, 38% of the farmers, acquired a loan but 11% of the households borrowed from formal financial institutions. Furthermore, at the occurrence of unanticipated situation, for instance, unfavourable weather and sickness households immediately sell assets and obtain money from family members and other informal sector (Chowdhury & Garcia, 1993).

Livelihood strategy of incidence of theft

The Food and Agricultural Organization (FAO) defines praedial larceny as the theft of agricultural produce. Food and Agricultural Organization indicated that, there are several factors that facilitate the growing spread of praedial larceny. According to (FAO, 2013), vulnerable and poor household directly consume 35% of stolen produce in the Caribbean. Besides buyers tend to have little or no interest in the legitimacy of food source due to daily imbalance that exist between demand and supply of fresh food. It is

reported that, Praedial larceny has negative impact on agricultural development affecting 98% of farmers in the Caribbean states. Asogwa and Okwoche (2012) are of the view that market centralization can minimize crop theft in rural settlements. Also, programmes focusing on alternative livelihood, public education, communication and good legislation can reduce praedial larceny (FAO, 2013). Barclay, Donnermeyer, Doyle and Talary (2001) found that in Australia farmers are able to adjust to crime. This is achieved where series of changes are done to farming practices. Such practices include deliberate action to increase family labour than to use non-family workers, effort to lock stores, planned effort to mark properties with intention to make theft difficult to discourage the thieve from re-selling the stolen item and to help the police to identify owners of property when items stolen are recovered. Barclay et al. (2001) also found out that, one farm preventive measure in Australia was to own dogs on the farm to minimize theft on the farm.

Livelihood strategy against reduced quality of produce (Fresh Fruit Bunches)

The Free Fatty Acids content of uninjured oil palm fruit is 0.2-0.7% before harvesting, and rises to 1% in 24 hours after harvesting (Corley & tinker, 2003). There is a damage to the fruit cell wall due to bruises resulting from inappropriate fruit handling. The study of Turner and Gillbank (2003) revealed that, the Free Fatty Acids content of harvested bunches with bruises build up from 1% to 6% within 20 minutes. On the contrary, Fresh Fruit Bunches should not have FFA level more than 3% during processing in order to get a crude palm oil (CPO) with FFA content not more than 5%. The height

of palm trees and the bunch weight predispose harvested bunches to bruises when fall on hard ground or hard materials below the tree.

Oil palm fruits are perishable and lose weight after harvesting and thus, the farmers need to sell the harvested fruit and to receive payment as early as possible while ensuring that they are transported to the processing centre. Besides, in a situation where roads connecting to farms are impassable, farmers rather experience loss of produce and achievable income which makes it difficult for the farmers to invest in farm operation (Poku, 2002). Poku (2002) noted that, fruit bunches must be processed into oil 48 hours after harvesting to help obtain palm oil with low content of free fatty acid. He also noted that fresh fruit bunches should be transported as early as possible to the mill centre after harvesting to check quality loss of the FFB. Poku reported that, small-scale farmers in West Africa process their fresh fruit bunches using local methods to extract the oil for consumption or offer for sale to processors. Also, in the lean production season small-scale farmers sell to small-scale processors.

Livelihood strategy against farmers depending on marketing agent

Farmers tend to rely on middlemen who extract huge profit from them as well as traders. From weaker bargaining positions, farmers negotiate price for their produce due to lack of outside buyers, lack of patience, high transportation cost, risk aversion and the perishable nature of crops (Oczkowski, 2004). In addition, farmers face significant institutional and infrastructural related hurdles when pursuing attractive price for perishable farm produce. Such infrastructural hurdles include, transportation and storage infrastructure which prevent them from taking their produce to distant market

which rather offer better market. According to da Silva and Rankin (2013) several measures which include, contract farming, group farming and collective marketing are made available in many regions of the world to scale down uncertainty that small farmers face in search of buyers and good price.

Jensen (2007) reported that, an ICT based technique that has been introduced has enabled fishermen to get buyers who would purchase their fish and that has solved fish spoilage. In northern Ghana, farmers were given information about market situation, and price for their maize and groundnut crops increased by 10% and 7% respectively. Haile and Kalkuhl (2016) noted that farmers in Ethiopia are able to avoid price expectation error due to their access to ICT information and hence help them to efficiently allocate their crop production decision. Svensson and Yanagizawa (2009) indicated that in Uganda farmers obtained 15% higher farm gate price when they took advantage of crop-price information from marketing centres made available through radio in various district. It is reported by Nakasone (2013) that the price of perishable crops that farmers in Peru received has been increased through their access to price information managed by SMS service.

Livelihood strategy of limited agricultural extension education

Agricultural extension service is the most common way of knowledge and skills transfer to farmers (McDowell, 1929). According to Anderson and Feder (2003), the objective of agricultural extension service includes information provision, and farmers' education such that core technologies can be applied to farm practice. However, adopting new technologies in Africa is a challenge; the lack of knowledge make it difficult for the farmers to apply

the improved method in the region (Morris, Kelly, Kopicki & Byerlee, 2007). In other words, the low adoption rate of technologies resulting from limited information and other factors bring about poor outcomes. Various studies have found that, agricultural extension has limited impacts on farm income in dealing with agricultural productivity in many African countries (Rivera, Alex, Hanson & Birner, 2006). In other words, the function of agricultural extension service in developing countries is still weak.

Mbo'o-Tchouawou and Colverson (2014) found that farmer-to-farmer information delivery system that Farmers Group Network initiated in Tanzania has increase participation of women in networking and they are able to take part and influence decision making. The approach of the group was to emphasize on diverse issues of the farmers and the need to empower them for their participation and to prioritize their problems and apply practical solutions that their researchers devise. Onyibe (2001), noted that, in Nigeria, Women in Agriculture (WIA) Extension Programme as a farmer group was formed to strengthen women farmers in agriculture access to Extension Advisory Services in rural areas.

The women in agriculture extension workers assist women to establish group farms and to give advice on how to market agricultural produce and educate members on appropriate productive techniques. Herbel (2010) revealed that, in India, there is a Self –Employed Women's Association's (SEWA) model which carries out extension approach with the aim of empowering poor and self-employed women farmers in rural regions who create more opportunities and contribute to self-reliance through inclusive women's groups.

Livelihood strategy of unavailability of labour

It is reported that (FAO, 2003) 65% of land as an estimated figure is prepared by hand power in sub-Saharan Africa. Animal traction, plays an important role in certain farming systems, such as maize farming of eastern and southern Africa representing 25% of land preparation in sub-Saharan Africa and the use of tractor for land preparation constitute 10% of harvested area.

A projection made by FAO Agricultural and Food Engineering Technologies Service (FAO, 2003), that there would be few modifications in the system of farm power input in many countries in sub-Saharan Africa. This means the use of human and animal power will permanently feature as sources of power since man continues to till the land for crops and animals' production. Thus, man cannot do in terms of cultivation without human power. However, the two variables are endangered by poor nutrition, illness and death as well as preferences developed for large-scale farming at the expense of subsistence farming and the shifting from the use of land in search of alternative livelihood. Furthermore, households depending on human power are extremely vulnerable to the loss of labour due to the devastating impact of HIV/AIDS on the rural livelihood in many parts of the Africa with the loss of agricultural workforce representing 10% (FAO, 1995).

FAO (2003) found that, in sub-Saharan Africa many farm households and communities adopt strategies of accessing non-farm sources of income or remittance or hire extra power (labour) to help carrying out key farm operations. Besides, some farm households avoid cash payment but would work together in informal groups to exchange labour or make the payment in

kind (FAO, 2003). Also, Farmers adopt labour saving technologies by borrowing from neighbours or sharing with others or joining groups or buying cheap quality tools.

Livelihood strategy of unavailability of land

There is an existence of small farm size due to land fragmentation caused by inheritance and the rapid growth of population. In densely populated regions, there is the tendency of scarcity of land and could not give substantial support to household's income (Marenya, Oluoch-Kosura, Place, & Barrett, 2003). The scarcity of land indicates that, agriculture is not the only source of income in agrarian community, therefore, dwellers in rural centres cannot climb out of poverty solely on growth in land productivity.

FAO (2004) noted that in the Volta region of Ghana, most of the land are vested in lineage and farmers acquire land through lineage. The lineage head, normally men, treat the land as common land and give right to every member of the lineage for use. In this case, the land may be utilized by the lineage member throughout their lives provided the lineage head is paid homage and norms and traditions of the group are respected at all times. Also in Ghana farmers can acquire land through descent systems which also refers to direct genealogical lineage, which comprises matrilineal and patrilineal descent of landholding (FAO, 2004).

The matrilineal descent is a system of relationship in which inheritance is tracked or identified through mothers and blood relatives. The patrilineal descent; is a system of relationship in which inheritance is determined or tracked through fathers and blood relatives. A study conducted by Asamoah and Owusu-Ansah (2017) revealed that, in Ghana, 25.1% of cocoa farmers

acquire land through *abunu* sharecropping system and 24.8% acquire land as a gift, 22.6% through inheritance while 10.9% through family land.

Theoretical Underpinning

To understand the phenomenon of vulnerability in this study, the theory of entitlement as espoused by Sen (1981) was used to explain the main causes of famine or reduction in food production such as drought, flood or pest. This is consistent with Adger and Kelly (1999) who adopted the theory to bring an understanding of individual or social groups' vulnerability to climate change and their adaptation in a given environment. The following sections explain how the theory is linked to the study.

Theory of entitlement

According Sen (1981) the theory of entitlement was used to explain the main causes of famine or reduction in food production such as drought, flood or pest. He defined entitlements as the set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she faces. They are source of income or welfare achieved by an individual or group. It enables a person to expresses his or her claim for something with a given right or opportunities in society. Besides, entitlements are genuine and rightful resources accessible and available to individual or group, generated through their own production, assets or mutual arrangement. Thus, to empower and entitle a person means that, the person has the capability to exercise his or her freedom to boost the capacity in dealing with vulnerability (Adger, 2006).

Farmers pursuing livelihood goals experience stress in their farming business**.** In attempt to understand how the individual and group respond to, recover from or adapt to any external stress or disturbances placed on their livelihoods and well-being, the theory of vulnerability as related to entitlement was used to explain livelihood vulnerability and adaptive capacity. According to IPCC (2001), the concept of vulnerability is defined as a function of the character, magnitude, and rate of changes and variation of a situation to which a system is exposed, its sensitivity and its adaptive capacity. The vulnerability of any social groups in farm-based livelihood system such as smallholder oil palm farmers in Kwaebibirem Municipality of Ghana in this study may be influenced by resources available and the entitlement within a given location for their livelihood survival. According to Adger (2006) individual may fall on or be entitled to resources to respond to, recover from or adapt to any external stresses. These necessary resources are the natural, physical, financial, social and human resources exploited by individuals or social groups to achieve their livelihoods objectives which include, increased income, improved wellbeing, reduced vulnerability and improved food security. Sen (1981) is of the view that, the extent of individual or group entitlement to the use of resources, measures the ability of the individual or the group to cope with or adapt to stress.

Adger and Kelly (1999) noted that, in order to determine level of vulnerability with a given stress, there is the need to define what we called the architecture of entitlement. Sen (1993) stressed that, entitlement is not effectively exchanged among rural folks and that there is no social security or transfer of entitlements which has led to unprecedented natural calamity. For

instance, livelihood vulnerability to shocks takes place or occurs when real income and wealth of individual or group is insufficient. However, the prescribed and normative response to vulnerability is to reduce the individuals or group exposure, enhance coping capacity, increase resilience and enhance damage control through private and public entitlement (Watts & Bohle, 1993). This means individuals or groups with narrow entitlement to resources is likely to suffer poverty due to low adaptive capacity to reduce sensitivity.

Conceptual Framework

The conceptual frame work for the study was adapted from the IPCC AR4 framework for the understanding of livelihood vulnerability and adaptive capacity of farm-based livelihood system, in this case, smallholder oil palm farmers in Kwaebibirem Municipality. Based on the objectives of the study, the conceptual framework focused on three key components of the IPCC framework namely, exposure, sensitivity, adaptive capacity and the farm-based livelihood vulnerability system (Figure 2*)*

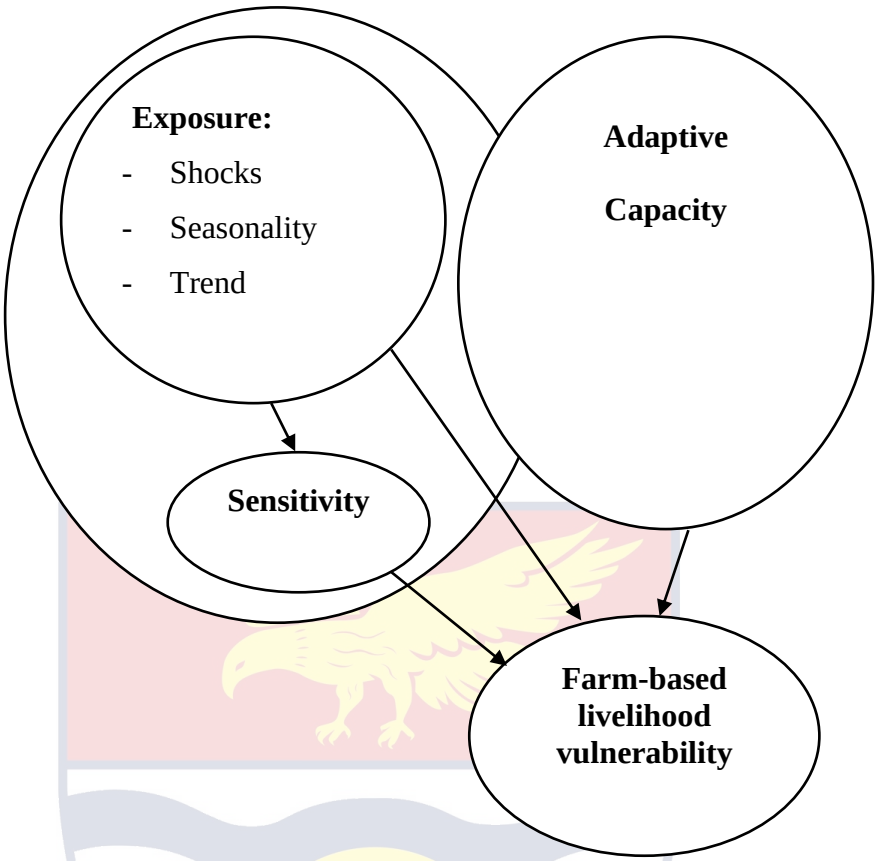

Figure 2: Conceptual Framework of the study

Source: Adapted from IPCC AR4, 2001

To determine the level of livelihood vulnerability of a farm-based system, the system must first be exposed to a factor and in severe cases may lead to sensitivity; where the system is adversely affected. The adaptive capacity of the system stands to reduce exposure and sensitivity of the system hence vulnerability. Exposure in this study is defined as a degree to which a farm-based livelihood is susceptible to shock, seasonality and the critical trend.

The exposure is deemed as external dimension and characterize the frequency of occurrences of shock, seasonality and critical trend which the farm-based livelihood system is prone to and likely lead to sensitivity. Each of the exposure elements are also composed of other variables for example,

under the shocks, we have diseases and pest, frequent weeds growth, erratic rainfall, temperature, drought, cost of inputs, theft among others. In connection with, seasonality, the constituent elements are fluctuation in prices of fresh fruit bunches and lack of access to credit.

Components of critical trend are, unavailability of labour, dependency on agent to sell fresh fruit bunches, unavailability of land, limited extension training, and lack of access to credit. Exposure is viewed as a component of vulnerability because, farm-based livelihood which is not subject to any disturbance or stimuli would be considered non-vulnerable. In relation to vulnerability, exposure precedes sensitivity. For example in an agro-ecological region where there is constant outbreak of disease and pest, crops of that disease and pest are likely to be attacked and farm-based livelihood is at stake.

Sensitivity is also a principal component of vulnerability. It is an internal side of vulnerability. It is a response of farm-based livelihood system to the vulnerability exposure factors. Sensitivity in this study is defined as a degree to which a farm-based livelihood system is affected either adversely or beneficially by shock, seasonality and critical trend. Sensitivity does not mean only negative effect, but also includes positive ones because the occurrence of certain climate shocks (high temperature) may be beneficial to some growing crops that provide livelihood for farm-based livelihood systems. Furthermore, sensitivity also contributes to vulnerability. This is because, any adverse effects a factor produced on the system with weak defence on the part of the systems may lead to vulnerability. This can be illustrated with the following example, a farmer's farm with frequent pest infestation without solid

measures taken would experience crop loss. Therefore, yield decline as a result of pest damage represent sensitivity. In this case, the more farm-based livelihood system's sensitivity increases the higher the vulnerability.

Adaptive capacity is a farm-based livelihood system ability to reduce vulnerability based on its desirable attributes. It considers the resources that a farm-based livelihood possesses and how best to put them into operation to mitigate or deal with vulnerability. Though adaptive capacity is a component of vulnerability, it is negatively related to vulnerability thereby building the capacity of a system for adaptation. In line with the entitlement theory, a system must have right and/or opportunities (more that physical resources-entitlements) that should enable it to respond to improve or maintain its state. Thus, in adaptive capacity, action taken by farm-based livelihood system is said to be important because having resources alone may not be enough to determine a system attributes such, as productivity, diversity and flexibility. The productivity of a system is the ability of the system to utilize the available resources to enter into other farming ventures. For example a farmer depending on oil palm production as the main source of livelihood can engage in maize, rice as well as vegetable production and if any of the production venture fails, he/she and the family can depend on the rest of the existing farming business for survival. By so doing, a system has many choices to make and that creates diversity and diversity result in flexibility.

Summary

A comprehensive review was done on literature relevant to the study. The review considered the history and evolution of oil palm industry in Ghana, the role of various governments in developing the oil palm sector, the

economic importance of oil palm. The review also focused on the concept of livelihood, livelihood diversification and types of livelihoods assets including natural, physical, human, financial and social assets. Besides, socio-demographic and farm characteristics of the study were also highlighted. They include, age, sex, level of education, size of the household, farm size, age of the plantation and source of planting materials. Furthermore, concept and empirical review on farmers' exposure to vulnerability, sensitivity of the vulnerability to the livelihood of the farmers, adaptive capacity of the farmers to the vulnerability to the area were reviewed. Finally, description of IPCC and the study conceptual framework were also carried out. Exposure is a degree to which a system is subject to a particular disturbance. It also measures the frequency and severity of the occurrence of the factor. Sensitivity measures the degree to which a system is adversely or favourably affected by the factor. The higher the sensitivity the higher the level of vulnerability. The ability of the systems to adjust to the disturbing factor and to cope with the consequence depend on the systems adaptive capacity. The adaptive capacity in others words what a system has and what it does to reduce vulnerability.

CHAPTER THREE

RESEARCH METHODOLOGY

Introduction

Chapter three captures a description of the study area, methods, and processes used in collecting and analysing data for the study. The methodology includes, the research design, study area, population, sampling procedure, data collection instruments, data collection procedure and data processing and analysis.

Research Design

The study used cross-sectional survey with quantitative measurement to gather relevant information from the respondents of the study. Survey research is a method of descriptive research used for collecting primary data based on verbal or written communication from a representative sample of individuals or respondents of the target population. It is also a social scientific research which focuses on people, the vital information about the people, beliefs, opinions, attitudes, motivation and behaviour (Mathiyazhangan & Nandan, 2010). They also stated that, social scientific nature of survey research is dependent on the nature of its variables and these are classified as sociological facts, opinions and attitudes. The sociological facts are the attributes of individuals and includes sex, income, political and religious groups that one belongs to, socio-economic status, education, age, occupation.

The physiological variables comprise the opinion and attitudes as well as behaviour of the people. Isaac and Michael (1997) confirm that survey research can be used to answer questions that have been raised or to solve problems that have been observed. They added that, survey research is used in

assessing needs and setting goals, for finding out whether or not specific purposes have been met and establishing baselines to which any future comparison can be made. Kraemer (1991) distinguished between survey research and other research types based on three characteristics. According to Kraemer (1991), survey research is quantitatively used to describe specific aspects of a given population and these aspects are directed at identifying the relationships among variables. He indicated that data collected from the target people are subjective and finally survey research focuses on selected samples from populations whose findings can be relied on for generalization. In defining the scope of the study, both dependent and independent variables are considered in the survey research to draw conclusions.

McIntyre (1999) revealed the strength of survey as a tool for gathering data from large samples of the population. In survey, the researcher can include types and number of variables to be studied and minimal investment is needed to carry out and easy to generalize (Bell & Opie, 2002). Salant and Dillman (1994) highlighted that, survey only provides estimates for the true population, not exact measurement.

Pinsonneault and Kraemer (1993) identified that, surveys are not suitable when it is required to understand the historical context of the phenomenon. He also observed that there can be biases in case of lack of response from the study's participants or response received may not be accurate and ultimately respondents may find themselves very difficult to examine their own behaviour or to recall circumstances that surround their behaviour.

Study Area

The Kwaebibirem Municipality is one of the 11 Municipalities in the Eastern Region of Ghana. The Municipality has Kade as its capital. According to the 2010 Population and Housing Census (PHC), the Municipality had a population of 113,721, with 42.7% of the total population dwelling in urban areas and 57.3 percent in rural areas. Males constituted 49.0 percent of the population and females represented 51.0 percent. The greater number of the population in the Municipality were youth (39.4%) indicating a broad based population with less elderly persons (5.0%).

Majority (70.8 %) of households in the Municipality were into agriculture. In the rural communities, six out of ten households (61.2%) were agricultural households while in the urban localities, 38.8 percent of households were engage in agriculture. Besides, (97.9%) of the households in the Municipality were involved in crop farming while poultry (chicken) keeping dominated in terms of animal rearing in the Municipality. According to Osei-Amponsah (2013), there were over 13,000 farmers who were into oil palm cultivation in the Municipality. The Municipality lies less than five hundred metres (500) above sea level.

Kwaebibirem is located in the tropical region which experiences double maxima rainfall pattern with two distinct dry and wet seasons. Temperature ranges between a minimum of 25 degrees Celsius and a maximum of 30 degrees Celsius, average temperature is usually between 26.5 to 27 degrees Celsius.

The vegetation is Semi-Deciduous forest consisting of three-layer plants with a dense undergrowth. The different species of trees that make up

the entire vegetation includes, herbs, shrubs and weeds. However, human activities in the form of cultivation, lumbering and extraction of fuel wood, mining and others are deteriorating the original vegetation.

Kwaebibirem is characterized by three major soil associations that have developed over the lower Birimean soil type. These soil types are Bekwai-Oda, Birimean-Chichiwere and Atiwa-Asikuma-Asum Association. Gold, bauxite, diamond and other natural mineral resources are endowed in these soil associations in the district. These soil types are also suitable for various food and cash crops production. Major food crops commonly grown in the Municipality are, maize and rice, cassava, plantain, cocoyam and yam. Tree crops such as cocoa, coconut. Coffee, citrus and oil palm are also grown, but the most widely grown crop in the Municipality is the oil palm which provides livelihoods for a large number of the indigents. Kwaebibirem Municipality was selected for this study because, it is considered as the major oil palm growing area in Ghana. Besides, smallholder farmers were insecure due to myriad of production constrain (Anaglo et al., 2014) and the average yields achieved by smallholder farmers were 3MTFFB/Ha far below the potential yield of 18-20MTFFB/Ha (International Plant Nutrition, 2015) obtained at low lying areas.

Population

The study used the population of smallholder oil palm farmers in the Kwaebibirem Municipality. Kwaebibirem Municipality was selected because it is considered to be the major oil palm growing area in Ghana (Anaglo et al., 2014) and oil palm is dominantly cultivated in the Municipality than any other crops. In all, a sample size of 204 respondents were selected from population

of 420 (sample frame) smallholder private farmers with farm size between 0.405Ha to 2Ha of land.

Sampling and Sample Size

According to Salant and Dillman (1994), selecting sample size depends on the population size, its homogeneity, and its cost of use. The participants for the study must be randomly selected; they must have an equal (or known) chance of being included. They also emphasized that what is to precede sample selection is to know the target population as narrowly as possible.

Attewell and Rule (1991) also made a suggestion that it is essential to use a theoretical sample. The theoretical samples purposively select organizations that exhibit the desired features that a researcher's study focuses on. Although the theoretical sample is not random selection, individual respondents from that sample can be selected at random to achieve an expected number of respondents.

Best and Kahn (1998) confirm that there is no fixed number or percentage of subjects that determines the size of an appropriate sample. They added that a particular sample size is contingent upon the nature of the population, the type of data to be collected, the analysis to be carried out and resources such as funds that will be required for the study. Frankel and Wallen (2000) revealed that descriptive research, especially correlational study, should have a minimum of 100 subjects or respondents while causal-comparative study a minimum of 30 respondents.

In determining a sample size from a given population like oil palm farmers in Kwaebibirem Municipality, the study used Krejcie and Morgan's

(1970) table of population and sample to facilitate the selection. In all 204 oil palm farmers were randomly selected as respondents in the study.

Sampling Procedure

To determine an appropriate sample size for the study, a sample frame of 420 smallholder oil palm farmers was collected from the office of Department of Agriculture at the Municipal level. From this sample frame, a sample size of 201 was determined using Krejcie and Morgan table for population and sample size. To select the sample, multi -stage sampling technique was used. Kwaebibirem Municipality consist of twelve operational areas. For the first stage, six (6) operational areas were selected out of the twelve, using simple random lottery technique. In the next stage, simple random lottery technique was again used to select six communities, one from each operational areas, based on intensity of oil palm production. The community selected were Kade, Pramkese, Asuom, Nkwatanan, Abaam and Subi (Table 1). To select farmers from the communities, a proportionate sampling technique was used and the numbers rounded to the next whole number to obtain a sample size of the 204 higher than the expected 201 (see Table 1). Thus, using the simple random sampling based on the lottery method, a sample size of 204 smallholder oil palm farmers was selected from an accessible population of 225 farmers for the study.

Table 1: *Population and Sample size of Smallholder Oil Palm Farmers in the Municipality*

Communities	Total number of farmers	Estimated proportion	Sample size
Kade	50	(44.7)	45
Asuom	45	(40.1)	41
Pramkese	40	(35.7)	36
Nkwantanan	35	(31.3)	32
Abaam	30	(26.8)	27
Subi	25	(22.3)	23
Total	**225**		**204**

Source: Field survey, Oteng (2019)

Data Collection Instruments

Data-collection tools are described here as instruments and the mode of constructing them as 'instrumentation.' The instrument was preceded by the introductory section stating the purpose of data collection and the usefulness of the study for the study population. It was also designed to depict the assurance of confidentiality of the responses from the study participants.

The study used a structured interview schedule to collect data from the target small scale oil palm farmers in the district. To achieve face validity, the researcher thoroughly examined the questionnaire items (questions) until they were fit to measure the domain and to meet the objective of the study. Content validity was examined by the study supervisor and other experts and researchers to determine the appropriateness of the instrument to measure the domain and also whether it was in line with the study objectives.

The structured interview schedule consisted of four questions categories (Appendix 1). Category one (1) focused on the social demographic characteristics of the target participants of the study. The demographic

characteristics include age, size of the household, gender, level of education and others. Category two (2) considered the analysis of the exposure to vulnerability of the smallholder oil palm farmers and was aided by five (5) point Likert- type scale (ranging from, very low to very high). Category three (3) measured the sensitivity of the vulnerability to the livelihood of the farmers using the five (5) point Likert type scale (ranging from very low to very high) based on the opinion, perceptions and the view of the target farmers. Category four (4) measured the adaptive capacity of the farmers to the vulnerability of the area.

Since respondents did not have accurate records (secondary data) the instrument was used to elicit data from the opinion, perception, and experience of target oil palm farmers in the Municipality.

Pre-testing of Research Instrument

To ensure the reliability of the data collecting instrument (interview schedule) and to correct unforeseen anomalies in the responses from the participants of the study, a pre-testing was conducted. The pre-testing or pilot-testing was carried out in the Denkyembour District which has similar characteristics as the Kwaebibirem Municipality.

A minimum of 30 oil palm farmers from the District were selected to respond to the questionnaire items administered by the researcher. Data collected through the interview schedule was analysed using SPSS (Statistical Package for Social Science) version 21 and to compute Cronbach's alpha reliability coefficient to determine the internal consistency of the items presented on the Likert-type scale. Computed values ranging from 0.7 to 0.8

indicate that the instruments are reliable to measure the study population (Mohajan, 2017).

Pre-testing or pilot testing enables the researcher to deal with shortcomings or mistakes in the research instruments to improve reliability in advance before it is ready to use on the population of interest to facilitate the researcher's study.

Table 2: *Reliability coefficients of the Research Instrument*

Construct	Number of items	Cronbach's Alpha
Exposure	15	0.720
Sensitivity	21	0.701
Adaptive capacity	30	0.863

Source: Author's construct, Oteng (2019)

Data Collection Procedure

The researcher was the principal interviewer using an interview schedule for the study. The face and content validated instrument was used to collect data originating from the target farmers' self- assessment. (Farmer self-assessment approach). The farmers were selected randomly from the six communities of six selected operational areas of the district. Individual face to face interview as data collection method was used to collect relevant data from the respondents. Places of meeting between the researcher and the respondents were home and on the farmers' farm field. Meeting on farmers' field for data collection provided the researcher the opportunity to familiarize with events on the field and to generate further discussion for comprehensive data.

Eliciting information from participants was done in the local dialect and the responses were ticked or written on the questionnaires. Data was

collected from appropriate number of oil palm farmers for a period of one and half months from 14th April to 30th May 2019.

Data Processing and Analysis

Data collected from target respondents was analysed using SPSS version 21. Objective 1 was analysed using Principal Component Analysis, Composite Livelihood Vulnerability Index and Cluster Analysis. In relation to objective 2 Principal Component Analysis, Composite Livelihood Vulnerability Index and Cluster Analysis were used for the analysis. For the analysis of objective 3 Principal Component Analysis, Composite Livelihood Vulnerability Index and Cluster Analysis were used to analyse the response of the farmers. For objective 4, Composite Livelihood Vulnerability Index and Cluster Analysis were used for the analysis of the response of the farmers. The components of vulnerability such as exposure, sensitivity and adaptive capacity were analysed using composite livelihood vulnerability index. It involves calculating an index for each individual farmer by aggregating data from the farmers' response on a set of indicators. The normalized value was rescaled from 0 to 1, for exposure, sensitivity, adaptive capacity and the levels of vulnerability of the farmers (Czucz, Torda, Molnar, Horvath & Botta-Dukat, 2009, Eakins & Bojorgquez-Tapia, 2008). The formular (Czucz et al., 2009) was used to calculate the livelihood vulnerability index.

$$index_{Si} = \frac{S_i - S_{min}}{S_{max} - S_{min}}$$

Using the formula, index s_i represent the normalized value for the farmers based on the set of indicators, S_i is the actual value for the farmer where S_{min} and S_{max} are the minimum and maximum respectively.

The normalized values were averaged to give sub-indices for exposure, sensitivity and adaptive capacity. The Sub-indices were combined to calculate a composite vulnerability index by using an additive (averaging) approach:

$$V = \frac{E + S + (1 - AC)}{3}$$

Using the formula, V, E, S and AC represent the vulnerability, exposure, sensitivity and adaptive capacity of the farmers respectively.

Variables of the Study

1. The dependent variable that was considered in the study is the livelihood vulnerability of smallholder oil palm farmers.
2. The independent variables of the study were vulnerability exposure factors and adaptive capacity of the smallholder oil palm farmers. The vulnerability exposure factors are made up of the following indicators:

(i) **Shocks indicators:** Insect pest, Frequent weeds growth, Erratic rainfall, Temperature, Drought, High cost of inputs, Theft, Reduced quality of Fresh Fruit Bunches

(ii) Seasonality: Decrease in the price of Fresh Fruit Bunches, Irregular access to the market.

(iii) Trend: Unavailability of labour, Dependency on an agent to sell Fresh fruit bunches, Unavailability of land, Limited extension training, Lack of access to credit.

Summary

A cross-sectional survey was used to collect information from the study sample. Kwaebibirem Municipality was selected for the study. A maximum of 204 oil palm farmers were selected for the study using simple random technique. Six out of twelve operational areas in the Municipality

were selected and from each of the six operational areas one community was selected to constitute six communities from which data was collected. The structured interview schedule was used to solicit information from the target study respondents. Face and content validity were also carried out before the use of the data collection instrument. Pre-testing was done in Denkyembour District to determine the internal consistency of the research instrument. Composite livelihood vulnerability index was used to calculate index for exposure, sensitivity, adaptive capacity of the farmers. Principal component and cluster analysis were also employed in the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

Chapter four captures the results and discussion of the study. The chapter is organised into five parts. Part one highlights key socio-demographic and farm characteristics of the study's respondents. Part two deals with the exposure to the vulnerability of smallholder oil palm farmers. Part three discusses the sensitivity of the vulnerability to the livelihood of the smallholder farmers. Part four deals with the adaptive capacity of the smallholder farmers to the vulnerability of the area and the last part considers the level of vulnerability of the smallholder farmers.

Socio-Demographic and Farm-Characteristic of the Smallholder Oil Palm Farmers

The key socio-demographic and farm characteristics of the smallholder farmers considered in the study include Age, sex, level of education, Household size, Farm size, farming experience, Age of the farm, Sources of planting material and Tonnage from the Farm. These are discussed in the following paragraphs.

The farmers were categorized into youth (18-35 years), adults (36-60years) and elderly (above 60 years) based on the United Nations (2006) classification. The results of the study indicated that 84% of the farmers were adults and 13% were elderly whiles 3% were youth 18-35 years (Table 3). The mean age of the farmers was approximately 52 years lower than the national average age of (55 years) of farmers (MOFA, 2011). The small number of youth in oil palm industry is attributed to high initial capital associated with

plantation development, land unavailability and the less lucrative nature of the industry. It is more essential to create conducive atmosphere that would encourage the youth involvement in the industry. Besides, mean age of 52 years points to ageing farmers in the oil palm industry in the study area. This supports MoFA's (2011) report that farmer's population in Ghana is ageing.

With reference to the sex distribution of the smallholder oil palm farmers, 69.1% of the farmers were males while 30.9% were females. The result revealed that more men are into oil palm production than women in the Municipality (Table 3).

Table 3*: Socio-Demographic and Farm Characteristic of the Smallholder Oil Palm Farmers*

Demographics	**Frequency**	**Percentage**	**Cum Percent**
Age of the farmers			
Youth (18-35)	5	3	3
Adult (36-60)	172	84	87
Elderly (>60)	27	13	100.0
Total	**204**	**100.0**	
$\bar{x}$ =51.5, SD= 7.55, Min = 33, Max = 71			
Sex			
Male	141	69.1	69.1
Female	63	30.9	100.0
Total	**204**	**100.0**	
Levels of Education			
No formal education	20	9.8	9.8
Primary	5	2.5	12.8
Middle School Cert	135	66.2	78.4
Secondary	36	17.6	96.1
Tertiary	8	3.9	100.0
Total	**204**	**100.0**	
Household sizes			
2 (Small)	2	1.0	1.0
3-5 (Medium)	81	40.0	41.0
6-8 (Large)	115	56.0	97.0
9 and above (very large)	6	3	100.0
Total	**204**	**100.0**	
$\bar{x}$ =5.7, SD= 1.4, Min= 1, Max= 12			

Source: Field survey, Oteng (2019)

In relation to the levels of education of the respondents, the results showed that, 66.2% of the farmers attended middle school, 17.6% had secondary education, 9.8 % had no formal education, 3.9% had tertiary education while 2.5% had attended primary school. The results show that majority (.90.2%) of smallholder farmers in Kwaebibirem Municipality have had some level of formal education and can be considered literate (Table 3). This agrees with the Ghana Statistical Service (2014) report that puts the literate population of the Kwaebibirem Municipality as 84.7%.

In connection with the household size of smallholder oil palm farmers in Kwaebibirem Municipality, the farmers were classified into small, medium, large and very large size households based on categorization conducted by Ghana Statistical Services (2006). The findings show that, 56% of the farmers had large household size, 40% had medium household, 3% had very large household while 1% had small household (Table 3). The mean household size six (6) of the respondents was higher than the National average of four (4) reported by Ghana Statistical Service, (2008). The household size of smallholder oil palm farmers in Kwaebibirem Municipality is therefore large ranging between 6-9 persons.

The study defined the smallholder farmers considered in this research work as farmers with farm sizes ranging from 0.405Ha- 2Ha. The results show that 37% cultivated 2Ha of land of oil palm, 31% had 1.2Ha, 21% possessed 1.6Ha, 9% owned 0.81 Ha and 2% had plantation sizes of 0.405Ha (Figure 3). The results reveal that greater number of the respondents cultivated 2Ha' land of oil palm in the municipality.

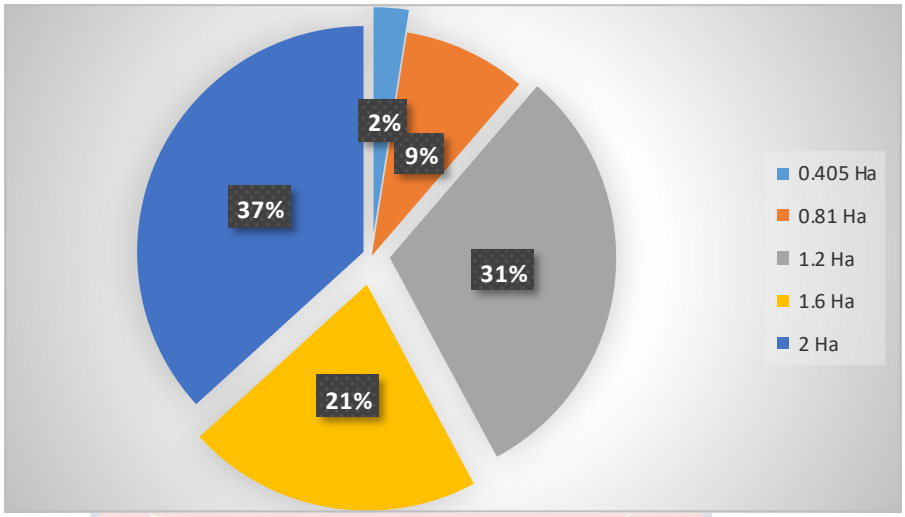

Figure 3: Frequency Distribution of Farm Sizes of the Respondents

Source: Field survey (2019)

In this study, smallholder oil palm farmers were categorized based on farming experience's classification by Omoniyi and Adebanjo (2012). The results show that oil palm farmers in the study area were experienced farmers. Eighty-eight per cent (88%) of them had cultivated oil palm for 10 years and above) while 12% had done it for 1 to 9 years (Figure 4).

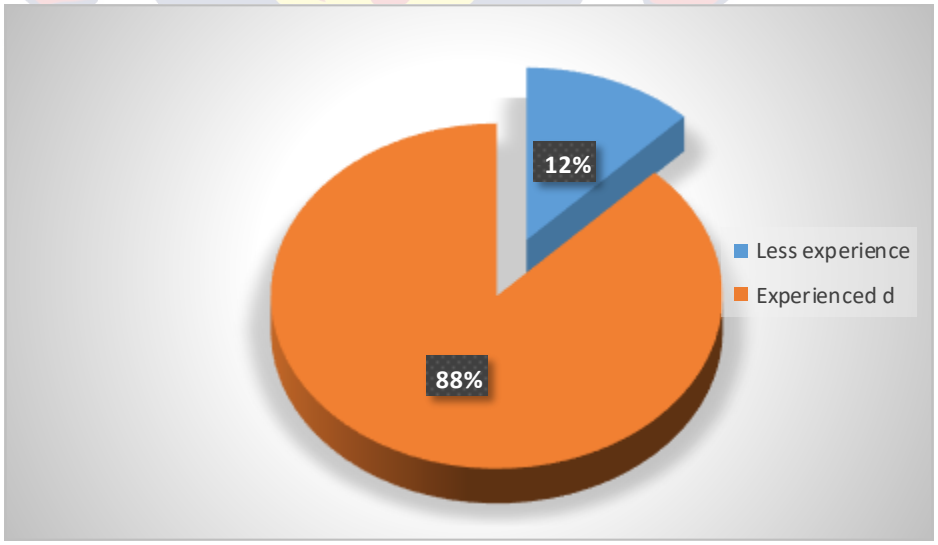

Figure 4: Farming Experience of the Respondents

Source: Field survey (2019)

The oil palm plantation of the smallholder farmers were classified into early, economic and declining stage based on the categorization made by Danso (2019), in relation to the reproductive life of the oil palm tree. The result indicated that, 54% of the plantation (11-17yrs) were in the economic stage, 38% were in the early stage (4-10yrs) while 8% had emerged into declining stage (Table 4). It appears in result that, greater number of the farmers' plantation are in the economic stage of reproductive life. It is a stage in which yield is at a peak to all the farmers to recover any investment made regarding their farming business.

Table 4**:** *Frequency Distribution of Age of the Farms of the Smallholder Farmers*

Age of the farms	Frequency	Percentage	Cum Percent
4-10(Early stage)	77	38.0	38.0
11-17(Economicstage)	111	54.0	92.0
18-40 (Decliningstage)	16	8.0	100.0
	204	**100**	

$\bar{x}$ = 12.4, SD=3.3, Min=4 , Max= 22,

Source: Field survey, Oteng (2019)

Source of planting materials is critical to the development of successful oil palm plantation because, it can influence the crop's tolerance to disease and pests, and ultimately crop yields. The study therefore sought to identify various ways that smallholder oil palm farmers in the study area sourced their planting materials (Figure 5). The results show that, 59% of the farmers purchased their planting materials from Oil Palm Research Institute (OPRI), 27% sourced their materials from Ghana Oil Palm Development Corporation (GOPDC) and the rest (14%) from Private Nursery Operators. This results where majority of the smallholder farmers were acquiring their

planting materials from Oil Palm Research Institute is similar to the findings of Adjei-Nsiah et al. (2012) that most oil palm farmers in Ghana prefer to use certified seedlings and seed nuts from Oil Palm Research Institute for plantation development. This implies that smallholder farmers in Kwaebibirem Municipality are aware of the benefits of the use of certified planting materials to establish their plantations.

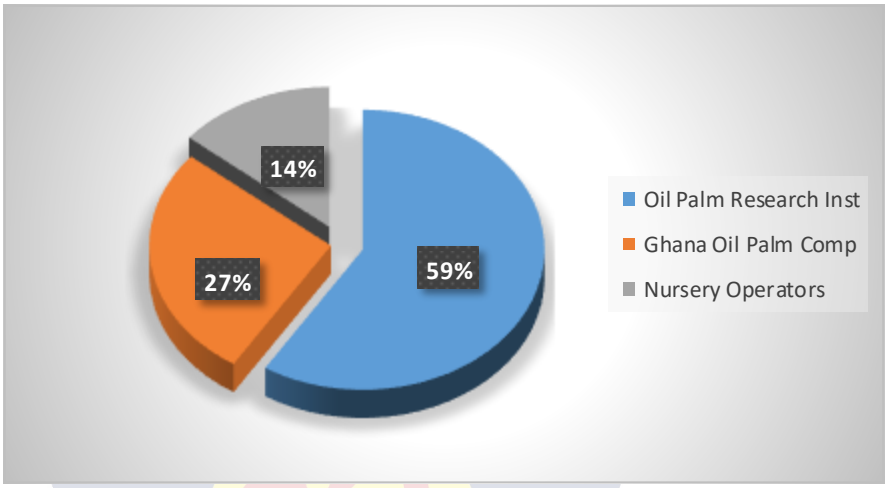

Figure 5: Frequency Distribution of Sources of Planting Materials of Respondent

Source: Field survey (2019)

The study sought to determine the average yield of Fresh Fruit Bunches (FFB) achieved by the smallholder farmers per year (production season) for 1 hectare (2.5acre). From the results, 73.5% of the farmers achieved 2MT of FFB/Ha during the production season, 19.1% obtained 1MT/Ha while 7.4% received 3MT/Ha. The results depict that, majority of the farmers achieved 2MT FFB/Ha which is below the productivity level of 18-22MT/Ha expected from a valley bottom or low -lying area (Ofosu-Budu, 2013). This low productivity of the crop in the study area corroborate with the findings of Ofosu-Budu (2013) who reported an average yield of 3MT/Ha in a production season. This however, contradicts the expectation that farmers' use

of improved planting materials leads to improvement yields, given that majority of them used certified planting materials from the Oil Palm Research Institute (Table 5). Because, improved varieties have an association with management practices, it could mean that the farmers were not applying the needed management practices such as correct planting distance, pruning, growing cover crops, application of fertilizer, proper weed management practices and timely harvesting. Besides, there may be other identified exposure (external) factors (e.g. rainfall, temperature) beyond the farmers' control in the municipality. Meanwhile commercial plantation like GOPDC achieved productivity of 14MT FFB/Ha (Osei-Amponsah et al., 2018). The following paragraph presents the rainfall and temperature situations in the study area.

Table 5: *Frequency Distribution of Tonnage of Bunches per year for two and half acres of land (1 hectare) in production season*

Tonnage	**Frequency**	**Percentage**	**Cum Percent**
1 Ton	39	19.1	19.1
2 Tons	150	73.5	92,6
3 Tons	15	7.4	100.0
Total	204	100.0	

Source: Field survey, Oteng (2019)

Table 6 gives accrued maximum rainfall, maximum and minimum temperature and water deficits from 2014 to 2018 obtained from CSIR-OPRI Meteorological station. An interaction of rainfall and temperature and their resultant effect of water deficits can lead to poor crop yields (Hartley, 1988).

In the year 2014, rainfall amount recorded was 2179.8/mm, maximum and minimum temperatures were 31.2 and 20.7 degree Celsius respectively and associated water deficit was 225.0 using as a benchmark for the

subsequent years. In the year 2015, rainfall recorded was 1416.1mm indicating a significant shortfall, maximum and minimum temperatures were 31.0 and 20.7 degree Celsius respectively showing constant direction while estimated water deficits was 240.2 showing an increase in water deficit. Besides, in the year 2016, the estimated rainfall amount was 1466.8mm indicating an increase in rainfall amount compared to the amount recorded in 2015, maximum and minimum temperature were 31.6 and 22.2 respectively showing an escalation while water deficits recorded was 190.4 showing a decrease in amount compared to the figure recorded in 2016. In the year 2017 rainfall recorded was 1792.4mm higher than the amount witnessed in 2016, though still below the benchmark in 2014. Maximum and minimum temperatures were 31.7and 21.7 degrees Celsius respectively with slightest increase in maximum temperature with decrease in minimum temperature compared to 2016 with a significant increase in water deficits 282.6.

Finally, rainfall recorded in the year 2018 was 1994.4mm, showing increasing direction over the past two years 2016 and 2017. Maximum and minimum temperature were 32.2 and 22.2 degree Celsius respectively showing an escalation compared to the figure recorded in 2017 while water deficit was 188.4 showing a decrease compared to the figure recorded in 2017. On average, rainfall amount recorded between 2014 and 2018 was 1769.9mm indicating a shortfall. Maximum and minimum temperatures were 31.5 and 22.2 degrees Celsius respectively beyond the favourable limit while water deficit estimated was 225.32 indicating an increase. The trend seems not favourable and likely to adversely affect the yield of the framers' plantations in the Municipality. It is reported that oil palm does well between 24^{o}C and

28°C annual temperature (Zevan, 1967), and between 2000mm and 2500mm evenly distributed annual rainfall (Hartley, 1988). This condition may impact on the productivity of oil palm production in the study area as discussed earlier regarding exposure to external factors (Table 6).

Table 6**:** *Meteorological Date on Rainfall and Maximum and Minimum Temperature and Water Deficit from 2014 to 2018*

Years	**Rainfall (mm)**	**Max (°C)**	**Min (°C)**	**Water Deficits**
2014	2179.8	31.2	20.7	225.0
2015	1416.1	31.0	20.7	240.2
2016	1466.8	31.6	22.2	190.4
2017	1792.4	31.7	21.7	282.6
2018	1994.4	32.2	22.2	188.4
Total	**8849.5**	**157.5**	**107.5**	**1126.6**
Average	**1769.9**	**31.5**	**21.5**	**225.32**

Source: OPRI, Meteorological (2019)

Factors Explaining Smallholder Oil Palm Farmers' Exposure to Vulnerability

To identify variables that explain smallholder oil palm farmers' exposure to vulnerability in Kwaebibirem Municipality, it is important to determine how the variables of exposure to vulnerability correlate with each other and best explain exposure to vulnerability in the study area. To do this, the fifteen exposure to vulnerability variables were subjected to Principal Component Analysis (PCA) using varimax rotation with Kaiser Normalization with the help of SPSS version 21. Pallant (2005) defined PCA as a technique for data reduction that captures or takes a broader set of variables and determines a way of reducing or summarizing it using smaller set of factors or components.

To check whether the sample is big enough, the Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity were also done. The KMO coefficient found was 0.796 which is greater than the acceptable value of 0.600 (Kaiser 1974), and the Bartlett test of Sphericity was 705.202 at a P-value of 0.000. Pallant (2005) noted that, for the factor analysis to be appropriate, Bartlett test of Sphericity should be significant at $p < 0.05$ (Bartlett, 1954). A decision to retain the number of factors that explain farmers' exposure to vulnerability was based on Kaiser Criterion (1960) and scree test techniques (Cattell, 1966).

Using the Kaiser Criterion, according to Hair, Anderson, Tatham and Black (1998) factors with an eigenvalue greater than 1are retained. Regarding the use of scree test, according to Pallant (2005), it involves plotting each eigenvalue of the factors and inspecting the plot to find a point at which the shape of the curve changes direction and becomes horizontal. Considering the scree plot (Figure 6) there was a clear break between the sixth and the seventh factor. However, the eigenvalue of the sixth factor is less than the acceptable value established by Kaiser and therefore cannot be retained. In all, five main factors were retained for further investigation. They included: Factor 1, institutional constraint, consisting of five variables; Factor 2, seasonal shocks, consisting of three variables; Factor 3, marketing constraints, made up of two variables; Factor 4, human-induced shocks, made up of two variables; and Factor 5, climate shocks with one variable. These 13 variables out of the 15 that were retained had factor loading of 0.6 and above and cumulatively contributed 61.669% of the variance (Table 7). The five factors are discussed further in the following sections.

Table 7**:** *Factor Analysis of Exposure to Vulnerability of Smallholder Oil Palm Farmers in Kwaebibirem Municipality*

Components	Loadings	Eigenvalues	% of Variance
C.1: Institutional constraints		3.929	
Limited extension training	0.762		26.191
Lack of access to credit	0.737		
Irregular access to market	0.711		
Unavailability of land	0.698		
Decrease in price	0.637		
C2: Seasonal shocks		1.890	
Erratic rainfall	0.762		12.598
Frequent weeds growth	0.762		
Drought	0.670		
C3: Marketing constraints		1.307	
Dependency on marketing agents	0.851		8.715
Reduced quality of fresh fruit bunches	0.828		
C4: Human-induced trend		1.118	
Theft incidence	0.732		7.456
Unavailability of labour	0.713		
C5: Climate shock		1.006	
Temperature	0.911		6.710
Cumulative percentage of the variance Explained			61.669

Kaiser-Mayer-Olkin (KMO) value= 0.796, Bartlett's Test of Sphericity (705.202) p=.000 Rotation Method: Varimax with Kaiser Normalization

Source: Field survey, Oteng (2019)

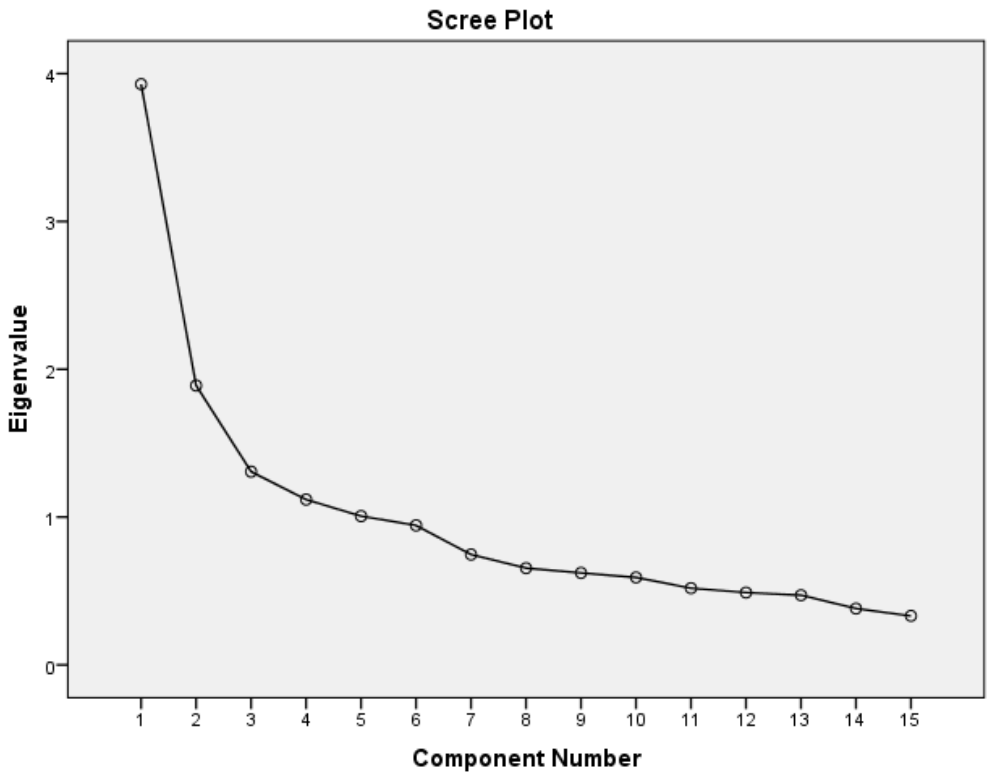

Figure 6: Eigenvalues of Factors Explaining Farmers' Exposure to Vulnerability Factors

Source: Field survey (2019)

Factor 1: Institutional constraints

The institutional constraints highly explained 26.191% of the variance of the farmers' exposure to vulnerability in the study area, with eigenvalue of 3.929 (Table 7). Five variables contributed to this, but limited extension training was the variable with the highest factor loading of 0.762. Decrease in prices contributed the least 0.698 amongst the five key factors under institutional constraints. The finding is in line with the view of IFAD (2013) which noted that smallholder farmers are exposed to unpredictable price fluctuation due to globalization of food system. The finding corresponds to the study of Asombobillah (2011) who emphasized that, besides the challenge in accessing finance for agriculture, farmers face the difficulties of finding

reliable and qualified agricultural extension support. The result consistently agrees with the study of Malik and Nazli (1999) who highlighted that, smallholder farmers faced limited credit accessibility or capital constraints which hindered the adoption of more efficient and modern technologies in the farming sector. The result is also in agreement with the findings of Hayward and Botha (1995) who noted that in developing countries smallholder farmers face constraints like limited access to land, farm, and non-farm resources, financial inaccessibility, mechanization inaccessibility, transport facilities, lack of support from extension and research institute and favourable market inaccessibility.

The result further confirms the study of Kamara (2004) who found that market reforms and globalization have changed marketing opportunities in Kenya. The reforms target large scale farmers at the neglect of small-scale farmers thus reducing their linkage to market leaving the farmers with few financial sources.

Factor 2: Seasonal shocks

Seasonal shocks accounted for 12.598% of the variance explained in terms of the farmers' exposure to vulnerability in the study area. It consisted of three items with eigenvalue of 1.890. Erratic rainfall and frequent weed growth both recorded the highest factor loading of 0.762. The variable with the lowest loading 0.670 was drought. The result is in line with Kahan (2008) who noted that farmers in developing countries are frequently exposed to uncertainty of weather, prices, and diseases. The study is in agreement with the findings of AgriFoSe2030, (2018) which stated that in sub –Saharan Africa farmers face poor weed control which results in high competition for

nutrients, water and light can lead to low yield. The result supports the view of Wilhite (2000) who stressed that drought affects practically all climate regions and more than one-half of the earth is prone to drought each year (Table 7)

Factor 3: Marketing constraints

Marketing constraints explained 8.51% of the variance regarding the farmers' exposure to vulnerability in the study area. It was constituted by two variables with an eigenvalue of 1.307. The variable dependency on marketing agents contributed the highest factor loading of 0.851. The variable reduced quality of fresh fruit bunches extracted factor loading of 0.828. The result is in agreement with Wiggins, Henley and Keats (2015) who are of the view that in sub-Saharan Africa, farmers who largely rely on markets are likely exposed to market risk and supply chains which is rigidly manipulated by formidable firms. The findings confirm the view of Rockefeller Foundation (2013) which stressed that post-harvest food loss in Africa has multi-dimensional challenge that reduces approximately the income of 470 million farmers and 15% income of other value chain actors which indicates that smallholder farmers are exposed to post-harvest losses (reduced quality of fresh fruit bunches).

Factor 4: Human-induced shocks

Human-induced shocks accounted for 7.456% of the variance of farmers' exposure to vulnerability in the study area. It is made up of two variables with eigenvalue of 1.118. Theft incidence was the variable with the highest factor loading of 0.732. The variable with the lowest loading 0.713 was unavailability of labour. The result corresponds to the findings of Bonei, Auya and Rono (2016) who revealed that, across Africa, stock theft is a persistent problem, which poses a serious threat to food security and

livelihood development. The results also agree with AgriFoSe2030 (2018) which revealed that in sub-Saharan Africa, smallholder farmers face labour shortage during key periods of production which strongly influence yield.

Factor 5: Climate shocks

Climate shocks explained 6.710% variance in terms of the farmers' exposure to vulnerability in the study area. It consisted of one item with eigenvalue of 1.006. It recorded the highest factor loading of 0.911 among variables explaining farmers' exposure to vulnerability in the study area. The study agrees with the view of Nagayet (2005) who revealed that large numbers of people worldwide are farmers who are directly exposed to sun and extreme heat (high temperature).

Classification of Farmers based on Level of Exposure to Vulnerability

The exposure indices of the smallholder farmers in the Kwaebibirem Municipality were subjected to cluster analysis to identify their level of exposure to vulnerability in the Municipality. The farmers were categorized into three clusters: cluster 1, cluster 2 and cluster 3 with the mean indices of the clusters as 0.50 (moderate), 0.73 (high) and 0.23 (low) respectively (Table 8). The results from the ANOVA of the clusters showed that the differences amongst the clusters were significant with *f*-value of 387 at p= 0.00.

Table 8**:** *Classification of the Farmers based on their Level of Exposure to Vulnerability*

Clusters	**Frequency**	**Percentages**	**Means of Exposure Index**
Cluster 1	113	55.3	0.50
Cluster 2	61	30.0	0.73
Cluster 3	30	14.7	0.23
	ANOVA		
df			201
F			387
P-Value			0.00

Exposure index scale: 0 (no exposure) – through - 0.5 (moderately exposed) – to- 1(highly exposed)
Source: Field survey, Oteng (2019)

From the cluster (Table 8), more than half (55.3%) of the farmers were moderately exposed to vulnerability exposure factors, 30% were highly exposed while 14.7% were lowly exposed to vulnerability exposure factors. Although the exposure indices of the farmers ranged from 0.23 to 0.73, the majority of the farmers were between moderate to high (Figure 7). The implication is that oil palm farmers in Kwaebibirem Municipality were generally exposed to moderate to high vulnerability factors including institutional constraints, seasonal shocks, market constraints, human-induced trends and climate shock (see Table 7).

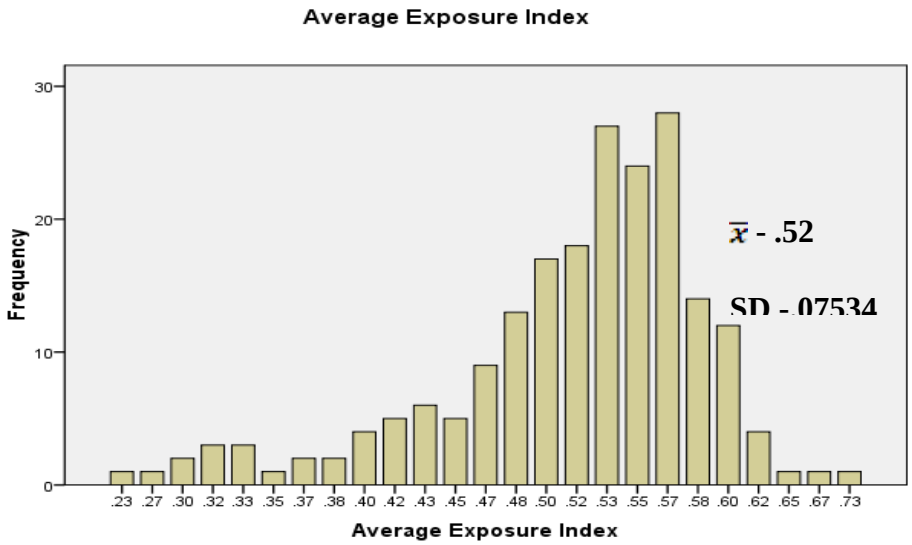

Figure 7: Distribution of the farmers based on their vulnerability exposure

Source: Field survey (2019)

Factors Explaining Sensitivity of Vulnerability to the Livelihood of Smallholder Farmers

To determine factors that explain the sensitivity of vulnerability to the livelihood of smallholder oil palm farmers in the Kwaebibirem Municipality, the twenty one sensitivity to vulnerability variables were subjected to Principal Component Analysis using varimax rotation with Kaiser Normalization using SPSS version 21.

To examine whether the sample was big enough, for the PCA, Kaiser-Mayer-Olkin measure of sampling adequacy and Bartlett's Test of Sphericity were carried out. KMO coefficient obtained was 0.765 which is greater than the recommended value of 0.6 established by Kaiser (1974) while the Bartlett test of Sphericity was 1420.424 with P-value of 0.000. According to Pallant (2005), for the factor analysis to be considered appropriate, Bartlett test of Sphericity should be significant at $p < 0.05$ (Bartlett, 1954). A decision to retain the number of factors that explain the sensitivity of vulnerability to the

livelihood of the farmers' was based on Kaiser Criterion (1960) and scree test techniques (Cattell, 1966).

Using the Kaiser Criterion, according to Hair, Anderson, Tatham and Black (1998) factors with an eigenvalue greater than 1are retained. Regarding the use of scree test, according to Pallant (2005), involves plotting each eigenvalue of the factors and inspecting the plot to find a point at which the shape of the curve changes direction and become horizontal. Considering the scree plot there was a clear break between the fifth and the sixth factor (Figure 8) in all five main factors were retained for further investigation. They include Factor 1 natural assets loss consisting of six variables. Factor 2 financial assets loss consisting of three variables, Factor 3 human assets loss is made up of three variables, Factor 4 production loss made up of two sets of variables and Factor 5 physical asset loss has two variables. These 16 variables out of 21 that were retained had factor loading of 6 and above and cumulatively contributed to 55.619 % of the variance (Table 9). The five factors are further discussed in the following section

Table 9: *Factor Analysis of Sensitivity of the Vulnerability to the Livelihood of Smallholder Oil Palm Farmers*

Components	Loadings	Eigenvalue	% Variance
C1: Natural assets loss		5.066	
Low income by price decrease	0.806		24.122
Low income by irregular access to market	0.718		
Limited access to land by land unavailability	0.671		
Yield reduction due to recurrent drought	0.665		
Yield reduction due to the high cost of inputs	0.651		
Fruit bunches reduction due to erratic rainfall	0.608		
C2: Financial assets loss		2.451	
Low price by depending on marketing agent	0.893		11.671
Low price by reduced quality of fruit bunches	0.850		
Yield reduction by the insect pest	0.778		
C3: Human assets loss		1.587	
Limited knowledge by limited extension training	0.699		7.559
Limited skill by limited extension training	0.699		
Not a member of association due to lack of access to credit	0.660		
C4: Production loss		1.353	
Yield reduction by frequent weeds growth	0.631		6.442
Yield reduction by high temperature	0.614		
C5: Physical assets loss		1.224	
Inability to buy the required quantity of pesticides due to lack of access to credit	0.691		5.826
Inability to use improved technologies due to lack of access to credit	0.677		
Cumulative percentage of the variance explained			55.619

Kaiser-Mayer-Olkin (KMO) value= 0.765, Bartlett's Test of Sphericity (1420.424) p=.000
Rotation Method: Varimax with Kaiser Normalization
Source: Field survey, Oteng (2019)

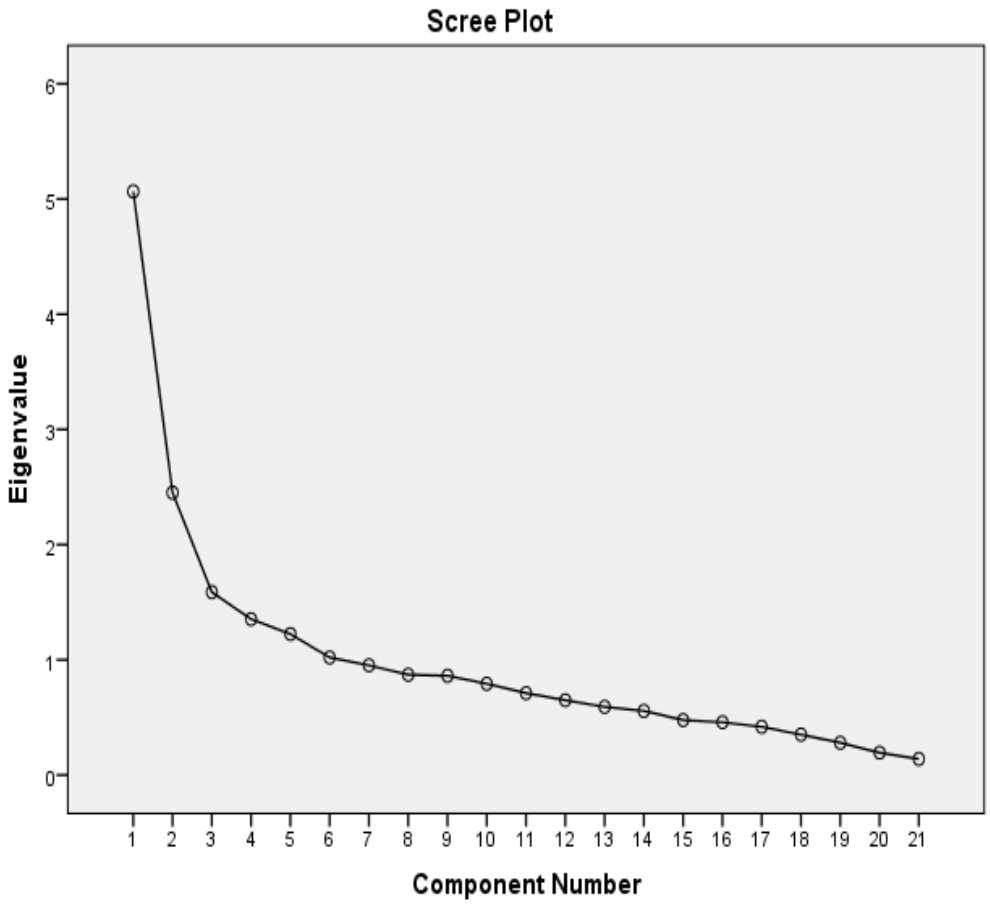

Figure 8: Eigenvalues of Factors Explaining Farmers' Sensitivity to Vulnerability Factors

Source: Field survey (2019)

Factor 1: Natural assets loss

Natural assets loss explained the highest (24.122%) of the variance regarding the sensitivity of vulnerability to the livelihood of the farmers in the study area. It consisted six variables with an eigenvalue of 5.066. Low income by price decrease recorded the highest factor loading of 0.806. The variable fruit bunches reduction due to erratic rainfall extracted the least factor loading of 0.608 among the six variables under the loss of the natural asset (Table 9).

The findings agree with the view of Gummesson (2002) who noted that many smallholder farmers produce in surplus, but are still trapped in poverty because of non-existence of access to profitable markets and

therefore, are forced to dispose of their products to buyers at dictated prices leading to income loss.

The findings also agree with Huka, Ruoga and Mchopa (2014) which pointed that, price fluctuation is extremely dangerous since farmers and agents who are into the food chain risk to lose their investment when price fall. The study supports Timler, Michalscheck, Klapwijk, Mashingaidze, Ollenburgeer, Falconnier, Kuivanen, Decheermaeker and Groot's (2014) who noted that crop yield tends to be poor or become low due to high cost of input. The findings corroborate the findings of Sulaiman, Abdullah, Gerhauser and Sharif (2010) that, in some countries access to land for cultivation is a major constraint. The study found insecurity to land tenure, unequal access and absence of proper mechanism to transfer right as the major land constraints. These have led to underdeveloped agriculture and degraded natural resources in the study area. The findings also confirm the study of Hartley (1988) who noted that high water deficit (drought) can lead to excessive production of male inflorescence and consequently reduction in sex ratio in oil palm. The study further agrees with the findings of Verheye (2010) who stressed that the crop requires well-distributed rainfall throughout the year with stable temperature without being interrupted by little or prolonged dry season. The prolonged drought lasting for 2-3 month does not only destroy the vegetation growth but adversely alters or declines the yield and developing fruit bunches.

Factor 2: Financial asset loss

Financial assets loss accounted for 11.671% of the variance in terms of sensitivity of vulnerability to the livelihood of the farmers in the study area. It consisted of three items with an eigenvalue of 2.451. The variable low price

by depending on marketing agent contributed the highest factor loading of 0.893. The variable yield reduction by insect pest attack recorded the least factor loading of 0.778 among the three main variables under financial asset loss. The result of the study agrees with Verheye (2010) who found that oil palm is sensitive to many pests and diseases and seriously affected are the yields and the economic profit. Subsequently, the result substantiates the findings of Fafchamps and Hill (2008) who noted that many farmers opt for traders buying their products though there is an evidence that, the agents take advantage of farmers' negligence of the price in the market and go on to cheat them by giving low price to the product they purchase.

Factor 3: Human asset loss

Human asset loss explained 7.559% of the variance in terms of sensitivity of vulnerability to the livelihood of the farmers in the study area. It constituted three variables with an eigenvalue of 1.587. Limited knowledge due to limited extension training contributed highest loading of 0.699. Not a member of association due to lack of access to credit was variable with the lowest factor loading of 0.660. The finding corroborate the view of Pudasaini (1983) which highlighted that lack of extension education can reduce productivity, skill and knowledge of the farmers. Also confirm the study of Kinyanjui (2018) who indicated that resources such as human, social, and physical capital are affected by credit constraints that affect agricultural productivity.

Factor 4: Production loss

Production loss accounted for 6.442% of the variance regarding sensitivity of the vulnerability to the livelihood of the farmers in the study area and. It consisted of two variables with eigenvalue of 1.353. The variable yield reduction by frequent weeds growth contributed to the highest factor loading of 0.631. The variable with the lowest factor loading 0.614 was yield reduction due to temperature. The result corresponds with the view of Rai, Scarborough, Subedi and Lamichhane (2012) who revealed that the effect of weeds competition in cropland and grassland and natural areas are enormous and can reduce both foods for human and feeds for animals. It is also in line with the findings of Lamade, Bonnot and Poeloengan (1996) who noted that an increase in mean temperature of 24 degrees Celsius to 27 degrees Celsius reduces total dry matter production by 16% and yield by 1.1 ton.

Factor 5: Physical asset loss

Physical asset loss accounted for 5.826% variance concerning the sensitivity of vulnerability to the livelihood of the farmers in the study area. It consisted of two variables with eigenvalues of 1.224. The inability to buy required quantity of pesticides due to lack of access to credit contributed highest loading of 0.691. The variable that recorded the lowest factor loading of 0.677 was inability to use improved oil palm practices or technologies due to lack of access to credit. The result confirms the study of Kinyanjui (2018) who indicated that resources such as physical capital is affected by credit constraints that affect agricultural productivity. Uaiene, Arndt, and Masters (2009) asserted that farmers who grow crop on small-scale are unable to adopt technology in the face of credit inaccessibility.

Classification of farmers based on their levels of sensitivity to vulnerability factors

The sensitivity indices of the smallholder farmers in the Municipality were fed into cluster analysis to determine their level of sensitivity to the vulnerability factors. The farmers were classified into three clusters: cluster 1, cluster 2 and cluster 3 with the cluster means indices, 0.27, 0.54 and 0.81 respectively (Table 10). Cluster 1 denotes low, cluster 2 signifies moderate and cluster 3 indicates high. Besides, the result from the ANOVA of the cluster analysis showed significance with *f* -value of 350 and p= 0.00. This indicates that there is a significant difference among the cluster means indices upon which farmers were classified.

Table 10: *Classification of farmers based on their level of sensitivity to vulnerability exposure factors*

Clusters	**Frequency**	**Percentages**	**Means of Sensitivity Index**
Cluster 1	27	13.2	0.27
Cluster 2	123	60.3	0.54
Cluster 3	54	26.5	0.81
	ANOVA		
df			201
F			350
P-Value			0.00

Sensitivity index scale: 0(no sensitivity) – through - 0.5 (moderately sensitive) – to- 1(highly sensitive)
Source: Field survey, Oteng (2019)

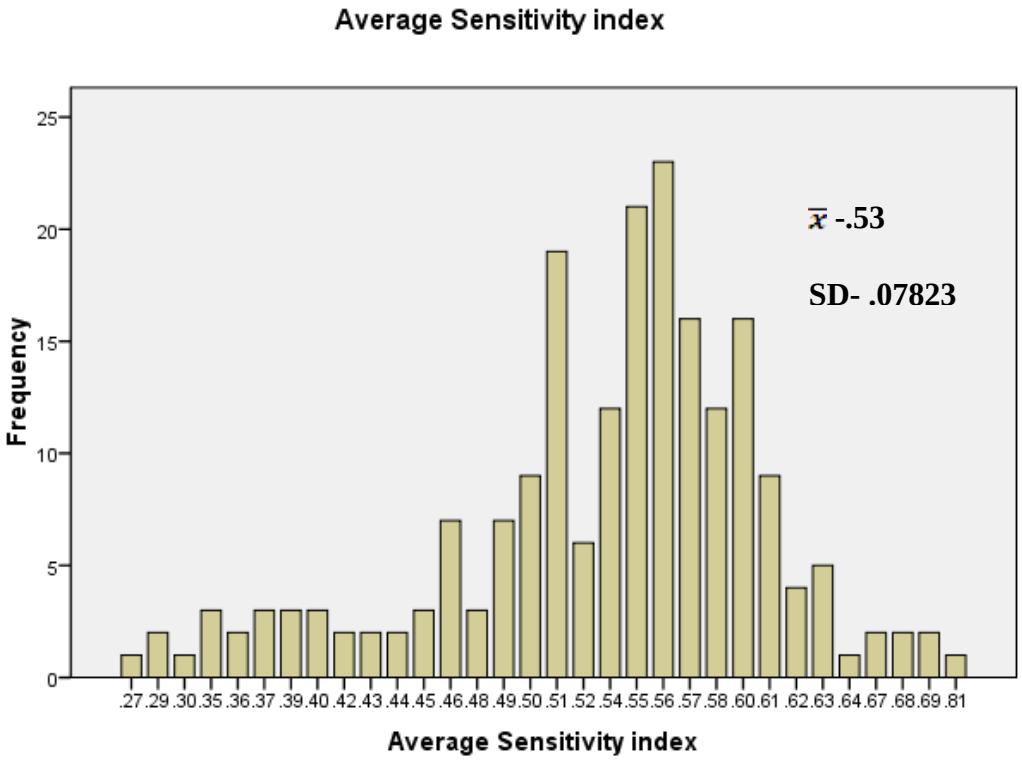

Figure 9: Distribution of farmers based on their levels of sensitivity to vulnerability factors

Source: Field survey (2019)

From the cluster (Table 10), more than half (60.3%) of the farmers were moderately sensitive to vulnerability factors, 26.5% were highly sensitive while 13.2% were lowly sensitive to vulnerability factors. The sensitivity index of the farmers ranged from 0.27 to 0.81. However, the majority of the farmers were between moderate to high (Figure 9). This implies that generally in Kwaebibirem Municipality, smallholder oil palm farmers are moderate to high sensitive to vulnerability factors (vulnerability exposure factors). This means, the farmers is moderately to highly affected adversely by the vulnerability exposure factor including natural assets loss, financial asset loss, human assets loss, production assets loss and physical asset loss (see Table 9).

Factors Explaining the Adaptive Capacity of Smallholder Oil Palm Farmers

Principal Component Analysis was performed on thirty sets of variables to identify factors that measure the adaptive capacity of smallholder oil palm farmers in the Kwaebibirem Municipality. Varimax rotation was used with Kaiser Normalization with the help of SPSS version 21 (Table 11). To find out whether the sample is big enough to carry out the PCA, Kaiser-Mayer-Olkin measure of sampling adequacy and Bartlett's Test of Sphericity were done. KMO coefficient obtained was 0.617 which is greater than the recommended value of 0.6 pegged by Kaiser (1974) and the Bartlett test of Sphericity was 1420.424 with P-value of 0.000. Pallant (2005) stressed that, for the factor analysis to be considered appropriate, Bartlett test of Sphericity should be significant at, $p < 0.05$.

A decision to retain a number of factors that explain the adaptive capacity of smallholder oil palm farmers to the vulnerability factors of the Municipality was premised on Kaiser Criterion (1960) and scree test techniques (Cattell, 1966). Using the Kaiser Criterion, according to Hair, Anderson, Tatham and Black (1998) factors with eigenvalue greater than 1 are retained. Regarding the use of scree test, Pallant, (2005), indicated that, it involves plotting each eigenvalue of the factors and inspecting the plot to find a point at which the shape of the curve changes direction and becomes horizontal. Considering the scree plot, there was a clear break between the eleventh and the twelfth factor (Figure 10).

Table 11: *Factor Analysis of Adaptive Capacity (livelihood strategies) of the Smallholder Farmers to the Vulnerability of the Area*

Component	Loadings	Eigenvalue	%variance
C1: Farm practices strategy		3.402	
Changing planting time	0.822		11.341
Hand-pick insects and kill	0.634		
C2: Institutional strategy		2.390	
Descent system of landholding	0.745		7.966
Sell fruit bunches to the processing company	0.722		
Engage in an informal group (Nnoboa)	0.683		
C3: On and off-farm strategies		2.062	
Slashing of weeds	0.721		6.873
Engage in non-farm income activities	0. 602		
C4: Information strategy		1.663	
Rear other farm animals	0.756		5.544
Farmer to farmer contact	0.682		
C5: Intervening strategy		1.55	
Watch farm with gun	-0.782		5.190
C6: Selling strategy		1.410	
Sell fruits bunches at the farm gate	0.694		4.699
C7: Transacting strategy		1.272	
Abunu system of landholding	0.801		4.240
C8: Marketing strategy		1.217	
Rely on the market price information	0.765		4.058
C9: Chemical control strategy		1.188	
Insecticides spraying	-0.793		3.962
C10: Organizational contact strategy		1.106	
Contacting oil palm Research Institute	0.773		3.685
C11: Certified material use strategy		1.074	
The use of improved Oil Palm variety	0.776		3.580
Cumulative percentage of the variance explained			61.137

Kaiser-Mayer-Olkin (KMO) value= 0.617, Bartlett's Test of Sphericity (889.801) p=.000 Rotation Method: Varimax with Kaiser Normalization
Source: Field survey, Oteng (2019)

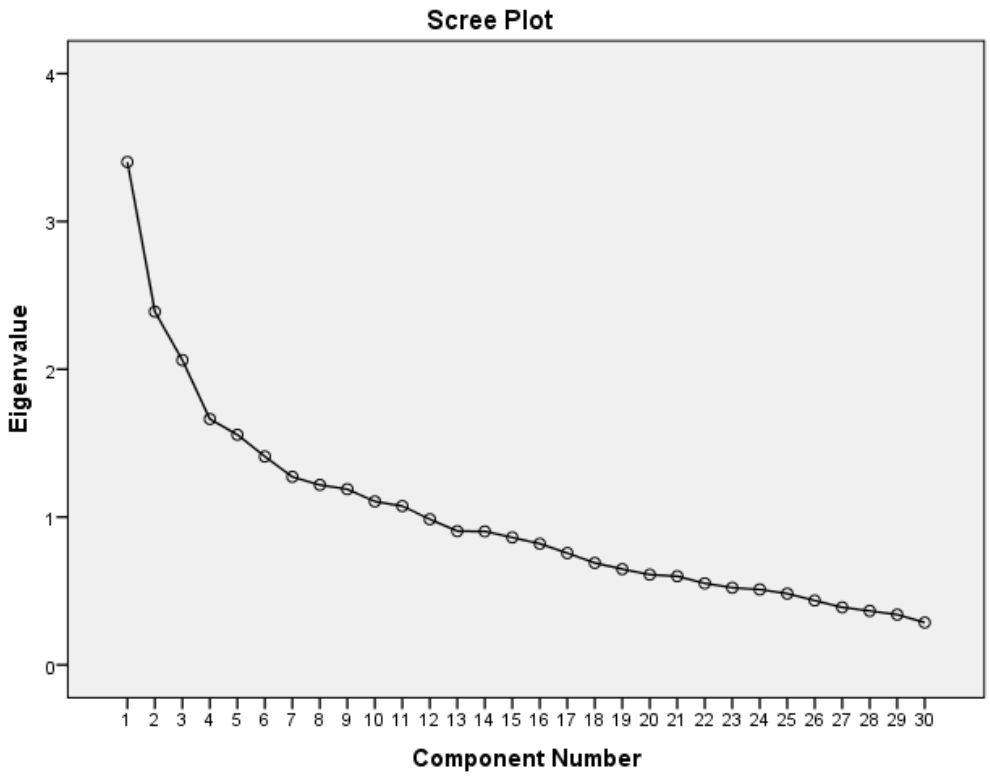

Figure 10: Eigenvalues of the Factors explaining the adaptive capacity of the farmers

Source: Field survey (2019)

In all, eleven factors were retained for further investigation. They include Factor 1, farm practices strategy consisting of two variables, Factor 2, institutional control strategy constituting three variable, Factor 3, on and off-farm strategy is made up of two variables, Factor 4, informational strategy is composed of two variables. Factor 5, intervening strategy is made up of one variable. Factor 6, selling strategy consisting of one variable. Factor 7, transacting strategy is made up of one variable. Factor 8, marketing strategy consisting of one variable. Factor 9, chemical control strategy consisting of one variable. Factor 10, organizational contact strategy is made up of one variable. Factor 11, certified material- used strategy consisting of one variable. Cumulatively they all contributed to 61.137 % of the variance. These

16 variables out of 30 that were retained had factor loading of 6 and above. The eleven factors are discussed further in the following section.

Factor 1: Farm practice strategy

Farm practice strategy; explained 11.341% of the variance in terms of the farmers' adaptive capacity to the vulnerability in the study area. It consisted of two variables with eigenvalue of 3.402. Changing planting time was the variable with highest factor loading of 0.822. Variable hand-pick insect and kill contributed lowest loading of 0.634 (Table 11). The study is in agreement with the findings of Fosu-Mensah, Vlek and Manschadi (2010) who reported that, crop diversification and changing planting dates for crops plant are the common two strategies used by farmers in Ghana against rainfall and temperature variability and drought.

Factor 2: Institutional control strategy

Institutional control strategy explained 7.966% of the variance regarding farmers' adaptive capacity to the vulnerability in the study area. It consisted of three items with eigenvalue of 2.390. The variable descent system of landholding contributed the highest loading of 0.745. The variable engaging in informal group recorded lowest loading of 0.683. The result is consistent with the findings of FAO (2004) which affirmed that Ghanaian farmers can acquire land through descent systems which also refers to direct genealogical lineage, which comprising matrilineal and patrilineal descent of landholding.

The findings confirm the study of Manley and Van Leynseele (2019) who found that, in the Kwaebibirem Municipality of Ghana, most oil palm farmers sell their produce to the companies, though there is a delay in paying

the farmers at the stipulated time established by the farmers. Other farmers resort to selling to Kramers (artisanal processors) and which attract small amount of money and sometimes, these Kramers are unable to buy in large quantities especially at peak production season. The result substantiates the study of FAO (2003) which reported that farm households avoid cash payments but would work together in informal groups to exchange labour or make payments in kind (FAO, 2003) (Table 11).

Factor 3: On and off-farm strategy

On and off-farm strategy explained 6.873% of the variance of the farmers' adaptive capacity to the vulnerability in the study area. It was constituted of two variables with an eigenvalue of 2.062. The variable slashing recorded the highest loading 0.721. Engaging in non-farm income activity contributed the lowest loading of 0.682. The results agree with the findings of Nkombe, Sangeda, Sibuga and Hermansen (2018) who conducted a study on strategies for weed management and found that in central Tanzania majority (60%) of the farmers uproot or slash the weeds before flowering. The study supports the findings of Diyamett et al. (2001) which revealed that in Marawe Kyura 86% of the respondents and in Lotima 97.6% rely on a combination of farming and non-farming activities.

Factor 4: Information strategy

Information strategy accounted for 5.544% of the variance in terms of the farmers" adaptation to the vulnerability in the study area. It consisted two variables with eigenvalue of 1.663. The variable rear other farm animals contributed the highest loading of 0.756. The variable with lowest loading (0.756) was farmer to farmer contact. The result is similar to the study of

Deressa and Hassan (2009) who recommended coping strategies to mitigate negative impact of climate to include encouraging livestock ownership, planting early-maturing and drought-tolerant crops varieties, investment in irrigation and strengthening research institutions. It also supports the study of Mbo'o-Tchouawou and Colverson (2014) who found in Tanzania that, farmer-to-farmer extension developed by the Farmers Group Network promoted women's participation in networking and decision-making.

Factor 5: Intervening strategy

The intervening strategy explained 5.190% of the variance of the farmers' adaptive capacity to the vulnerability in the study area. It consisted of one variable with eigenvalue of 1.557. The variable recorded a loading of -0.782. The result confirms the study of Barclay et al. (2001) who also found that one farm preventive measure in Australia was to own dogs on the farm though ineffective in minimizing theft on the farm.

Factor 6: Selling strategy

The selling strategy explained 4.699% in terms of the farmers' adaptive capacity to the vulnerability in the study area. It consisted of one variable with eigenvalue of 1.410. The variable farm gate sale contributed a loading of 0.694. The result agrees with the view of Svensson and Yanagizawa (2009) who noted that in Ugandanq farmers obtained 15% higher farm gate price when they took advantage of crop-price information from marketing centre, made available through radio in various districts.

Factor 7: Transacting strategy

Transacting strategy accounted for 4.240% of the variance regarding the farmers' adaptive capacity to the vulnerability in the study area. It

consisted of one variable with eigenvalue of 1.272. The variable 'Abunu' system of landholding contributed a loading of 0.801. The result of the study is similar to the findings of Asamoah and Owusu-Ansah (2017) who revealed that in Ghana, 25.1% of cocoa farmers acquire land through *abunu* sharecropping system.

Factor 8: Marketing strategy

Marketing strategy explained 4.058% of the variance of the farmers' adaptive capacity to the vulnerability in the study area. It constituted of one variable with an eigenvalue of 1.217. The variable (rely on marketing price information) recorded a loading of 0.765. The study supports the findings of Jensen (2007) who reported that in northern Ghana, farmers were delivered with market information service, and price received for their maize and groundnut crops increased by 10% and 7% respectively.

Factor 9: Chemical control strategy

Chemical control strategy explained 3.962% of the variance concerning the farmers' adaptive capacity to the vulnerability in the study area. It was made up of one variable with an eigenvalue of 1.188. The variable insecticide spraying contributed a loading of -0.793. The result is in line with the study of Kumari, Kumar and Narasimba (2018) who found that, smallholder farmers use strategies such as improved variety, chemical fertilizer, and pesticides to cope with diseases and pest.

Factor 10: Organizational contact strategy

Organizational contact strategy accounted for 3.685% of the variance concerning the farmers' adaptive capacity to the vulnerability in the study

area. It consisted of one variable with eigenvalue of 1.106. The variable contacting Oil Palm Research Institutes contributed a loading of 0.773.

Factor 11: Certified material use strategy

Certified material use strategy explained 3.580% of the variance in terms of the farmers' adaptive capacity to the vulnerability in the study area. It consisted one variable with eigenvalue of 1.074. The variable the use of improved oil palm variety recorded a loading of 0.776 (Table 11). The study is in line with the finding of Ngigi (2009) who found that, smallholder farmers in Ghana, Nigeria, Senegal and Burkina Faso used drought-resistant variety as strategy against climate change.

Cluster analysis was performed on the livelihood strategies of the smallholder farmers using their indices to determine their levels of the use of the strategies against the vulnerability of the area.

Table 12: *Classification of farmers based on their adaptive capacity*

Clusters	**Frequency**	**Percentages**	**Means of strategies Index**
Cluster 1	106	52	0.48
Cluster 2	51	25	0.62
Cluster 3	47	23	0.33
		ANOVA	
Df			201
F			419
P-Value			0.00

Strategies index scale: 0(no strategy) – through - 0.5 (moderate strategy) – to- 1(high strategy)
Source: Field survey, Oteng (2019)

The farmers were grouped into three clusters: cluster 1, cluster 2 and cluster 3 with the cluster mean indices of 0.48, 0.62 and 0.33 respectively. Cluster 1 denotes moderate, cluster 2 signifies high and cluster 3 indicates low. Besides the result from the ANOVA of the cluster analysis depicted

significant with *f* -value of 419 and p= 0.00. This signifies that, there is a significant difference among the cluster mean indices on which farmers were classified.

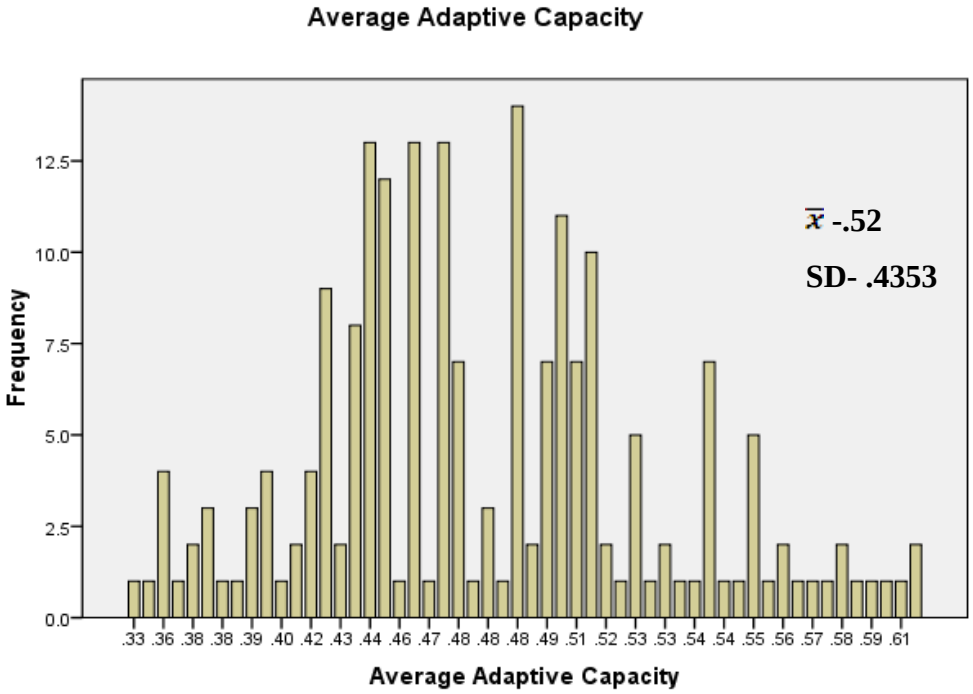

Figure 11: Distribution of farmers based on their use of livelihood strategies (adaptive capacity index)

Source: Field survey (2019)

From cluster (Table 12), 52% of the farmers moderately used livelihood strategy, 25% highly used strategies while 23% lowly used livelihood strategies in dealing with vulnerability (exposure factors). Although farmers' livelihood strategy indices ranged from 0.33 to 0.61, the majority of them were within moderate strategies use (Figure 11). The implication is that, generally smallholder farmers' in Kwaebibirem Municipality, moderately used livelihood strategies in the face of vulnerability factors including, farm practice strategy, institutional control strategy, on and off-farm strategy, informational strategy, intervening strategy, selling strategy, transacting

strategy, chemical control strategy, organizational strategy and certified planting material used strategy.

Level of Vulnerability of Farmer

The livelihood vulnerability indices of the smallholder farmers were subjected to cluster analysis to place them based on their level of vulnerability. Farmers were placed in three clusters: cluster 1, cluster 2 and cluster 3 with the cluster mean indices, of 0.49, 0.35 and 0.64 respectively. Cluster 1 denotes moderate, cluster 2 signifies low and cluster 3 indicate high. Besides, the result from the ANOVA of the cluster analysis showed significance with f -value of 381 and p= 0.00. This signifies that there is a significant difference among the cluster means on which farmers were classified.

Table 13**:** *Classification of Farmers based on their levels of Vulnerability*

Clusters	**Frequency**	**Percentages**	**Means Index of Vulnerability**
Cluster 1	94	46	0.49
Cluster 2	26	13	0.35
Cluster 3	84	41	0.64
	ANOVA		
df			201
F			381
P-Value			0.00

Vulnerability index scale: 0(no vulnerability) – through - 0.5 (moderately vulnerable) – to- 1(highly vulnerable)
Source: Field survey, Oteng (2019)

From the cluster (Table 13), 46% of the farmers were moderately vulnerable, 41% were highly vulnerable while 13% were lowly vulnerable. Although livelihood vulnerability indices of the farmers ranged from 0.35 to 0.64, a greater number of the farmers were between moderate to high, which

means, farmers' livelihood vulnerability ranged from moderate to high (Figure 12). Thus, it can be concluded that generally smallholder oil palm farmers in Kwaebibirem Municipality were moderately to highly vulnerable. They can reduce vulnerability by enhancing their use of livelihood strategies (Adaptive capacity) which literature (Maiti, Jha, Garai, Nag & Chakravarty, 2014) has indicated can reduce sensitivity.

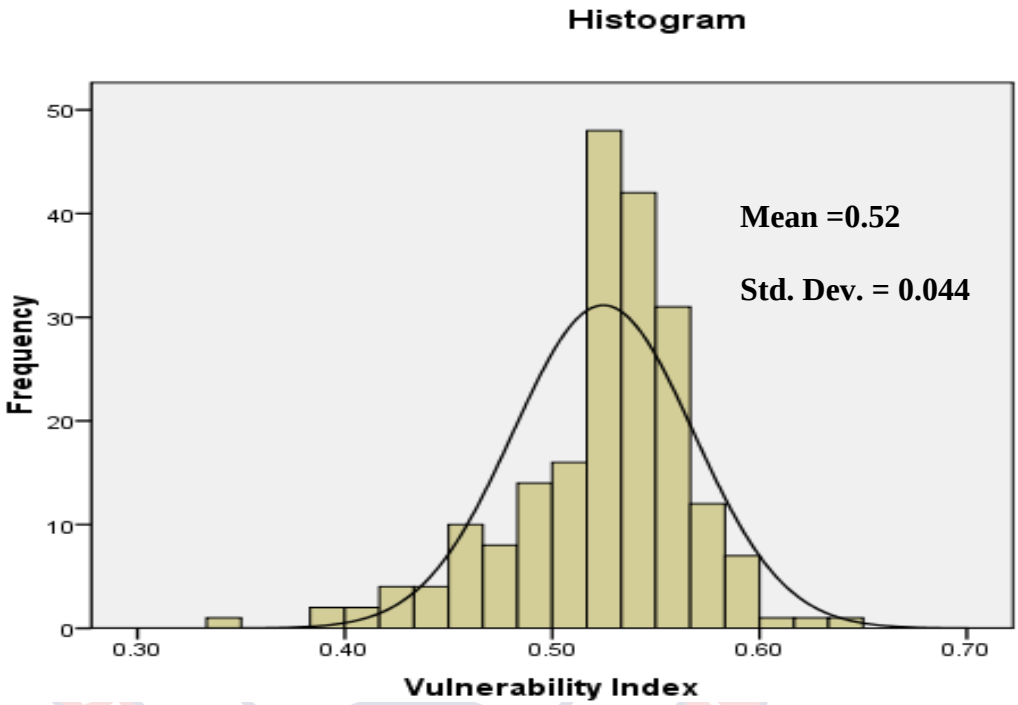

Figure 12: Distribution of farmers based on their level of vulnerability

Source: Field survey (2019)

High vulnerability to climate change and climate variability has been a problem of the African continent (Boko, Niang, Nyong, Vogel, Githeko, Mendany, Osman-Elasha, Tabo &Yanda, 2007; Mashizha, 2019) especially, in rural areas among smallholder farmers (Menike & Arachchi, 2016) and the least educated (Muttarak & Lutz, 2014).

Summary

The study focused on the socio-demographic and farm characteristics of the respondents. It also considered the exposure of the farmers to vulnerability, sensitivity of the vulnerability to the livelihood of the farmers, adaptive capacity of the farmers to the vulnerability of the area and the level of livelihood vulnerability of the farmers. It was revealed that majority of the farmers were in the adult stage with smaller number of youth participation in oil palm cultivation. Besides, males engaged in oil palm production more than their female counterparts in the Municipality. Also majority of the farmers had had formal education and only few respondents did not attend school. It was shown that a greater number of the farmers' plantation was in economic stage to give the farmers a better yield and also in the Kwaebibirem Municipality, most of the farmers purchased certified planting materials from CSIR-OPRI for plantation establishment and greater number of the farmers in the Municipality obtained 2MT of fresh fruit bunches from their plantation. Subsequently, farmers' exposure to vulnerability factors ranged from moderate to high. The smallholder farmers' sensitivity to the vulnerability exposure factor ranged from moderate to high. Farmers moderately used strategies in dealing with the vulnerability exposure factors. Finally, their vulnerability also ranged from moderate to high.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Introduction

Chapter five summarised, concludes, and offer relevant recommendations and implications of the study.

Summary

The study sought to determine livelihood vulnerability and adaptive capacity of smallholder oil palm farmers since several studies pointed out smallholder farmers in sub-Saharan Africa as the most vulnerable group. A cross-sectional survey design was used. Frequency distribution, Principal Component Analysis, Composite Livelihood Vulnerability Index and Cluster Analysis were employed for the analysis of primary data collected from two hundred and four (204) respondents.

The study area (Kwaebibirem Municipality) was selected using purposive sampling and the appropriate sample size was obtained using simple random sampling technique. Pre-testing was conducted in the Denkyembour District of Ghana and data collection was done by the researcher. The following are the key finding from the study.

The majority of the farmers in oil palm production in the Municipality were adults and dominated by males. Besides, majority of them had formal education. They also had large household sizes greater than the national average of four (4). Most of the farmers were experienced in the oil palm business with plantations of about 2Ha. A greater number of these plantations were in their economic stage. Most of the farmers used certified planting materials from CSIR-OPRI for their plantation. However, the average yield of

the Fresh Fruit Bunches FFB achieved per hectare per year by the farmers was only 2MT far below the expected yields of 18 to 20MTFFB/Ha.

From the analysis of the exposure to vulnerability of the smallholder oil palm farmers in the Municipality, farmers' exposure to vulnerability factors ranged from moderate to high. The vulnerability exposure factors include institutional constraints, seasonal shocks, marketing constraints, human-induced trend and climate shocks. The institutional constraints factor best explained (26.19%) the farmers' exposure to vulnerability.

From the assessment of the farmers' sensitivity of vulnerability exposure factors to their livelihood, the farmers' sensitivity to the vulnerability exposure factor ranged from moderate to high. The farmers' sensitivity of vulnerability was related to the following livelihood factors: natural assets loss, financial assets loss, human assets loss, production assets loss and physical assets loss. The natural asset loss factor best explained (24.12%) the farmers' sensitivity.

From the identification of the adaptive capacity of smallholder farmers to the vulnerability of the Municipality, farmers' adaptive capacity to the vulnerability factors was found to be moderate. The adaptive capacity of the farmers includes, farm practices strategy, institutional controlled strategy, on and off-farm strategy, information strategy, intervening strategy, selling strategy, transacting strategy, chemical control strategy, organizational strategy and certified planting material use strategy. Farm practices strategy factor best explained (11.34%) the farmers' adaptive capacity to the vulnerability in the Municipality.

From the analysis of the perceived levels of vulnerability of the farmers, their vulnerability ranged from moderate to high. The farmers were unable to put into use the improved oil palm management practices or technology such as correct planting distance, timely pruning, growing cover crops, application of fertilizer, proper weed management practices and timely harvesting. Besides, the number of Agricultural Extension Agents was limited to deliver specific agricultural training programmes to improve the knowledge and the skills of the farmers regarding their farming practices.

Conclusions

From the findings, the following conclusions are made:

1. The livelihood vulnerability context of smallholder oil palm farmers in the Kwaebibirem is characterised by (a) aging male farmers who are generally educated and use certified oil palm planting materials, (b) low oil palm yields although most of the plantations are in their economic stage, (c) limited extension services and access to credit from formal financial institutions, and (d) limited use of improved oil palm management practices due to inadequate capital.
2. Smallholder oil palm farmers in the Kwaebibirem municipality are vulnerable with vulnerability index ranging from moderate to high.
3. The farmers are exposed to the following vulnerability factors, institutional constraints, seasonal shocks, marketing constraints, human-induced trends and climate shocks in a decreasing order of importance.
4. The farmers are sensitive to vulnerability factors in the area, with the predominant consequences being natural asset loss, financial assets loss,

human assets loss, production loss and physical assets loss in a decreasing order of importance.

5. The adaptive capacity of the farmers to the vulnerability of the area is moderate, and the key livelihood strategies employed to manage the sensitivities and vulnerability include: farm practices strategy, institutional controlled strategy, on and off-farm strategy, informational strategy, intervening strategy, selling strategy, transacting strategy, chemical control strategy, organizational strategy and use of certified planting, in a decreasing order of importance.

Recommendations

Based on the findings and conclusions, the following recommendation are made:

1. The Oil Palm Research Institute (OPRI) with the mandate to provide scientific and technological support for the development of oil palm in Ghana, should collaborate with the Department of Agriculture in the Kwaebibirem municipality to provide extension education to extension agents and farmers on oil palm good agricultural practices, especially with regards to fertilizer application, cover crop establishment, proper weed management practices, timely pruning and harvesting and use of recommended planting distance.
2. The Ministry of Food and Agriculture should collaborate with the Ministry of Youth and Sports and other relevant ministries to formulate policies that will make agriculture and more specifically oil palm production attractive to the youth to sustain the oil palm industry.

3. The Department of Agriculture at the Municipality should assist the smallholder oil palm farmers to establish viable associations (cooperatives) to improve their access to formal credit to enable them invest into improved practices.
4. The Department of Agriculture at the Municipality should explore several media (FM radio, telephone, social media, print media etc.) to increase oil palm extension services to farmers, aimed at reducing livelihood vulnerabilities.

Implications for Extension

As the entitlement theory requires an individual or social group to have a substantial right to an amount of resources to reduce any external stress, has a link with a farmer who needs to be assisted to have requisite and adequate assets to take an action in reducing his or her vulnerability. Therefore, we can attest to the fact that, a farmer with larger amount of resources, is likely to increase his or her adaptive capacity. Conversely, as the theory indicates that, a person with limited resources, is likely to be defenceless, a farmer with limited assets ownership could therefore, have a low adaptive capacity thereby render the farmer vulnerable.

The implications of the findings to agricultural extension targeted at reducing livelihood vulnerability in oil palm production in the Kwaebibirem Municipality include the following:

1. Establishment of formidable smallholder oil palm farmers associations (cooperatives) to facilitate extension training and acquisition of capital for application of improve management practices.

2. Development of targeted media (FM radio, telephone, social media, print media etc.) to increase oil palm extension services to smallholder farmers to reduces vulnerabilities especially, those relating to institutional constraints, seasonal shocks, marketing constraints.
3. Development of youth in agricultural programmes and support services to encourage and attract the youth into oil palm production.
4. Development of targeted agricultural extension programmes for smallholder oil palm farmers aimed at helping them to manage the vulnerability through relevant technical training and linking farmers to financial institutions.

Suggestions for Further Research

The following are suggestions for future research emanating from the study.

1. There is the need to research into livelihood diversification and its influence on the livelihood of smallholder oil palm farmers so that we can identify more livelihood strategy options that can help reduce farmers' vulnerability.
2. The study should also be conducted in other major oil palm growing areas in the country using different research approaches to verify this research finding and to promote the livelihoods of smallholder oil palm farmers.

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APPENDICES

APPENDIX A

UNIVERSITY OF CAPE COAST

DEPARTMENT OF AGRICULTURAL ECONOMIC AND EXTENSION

STRUCTURED INTERVIEW SCHEDULE

This study is for an academic purpose and is in partial fulfilment for the award of Masters of Philosophy in Agricultural Extension on the topic: Livelihood vulnerability and adaptive capacity of smallholder oil palm farmers in Kwaebibirem Municipality of Eastern Region of Ghana. All the information solicited will be solemnly treated in concealment and with confidentiality.

Name of the respondent…….

Please tick (…) where necessary and provide information in the blank spaces.

A. Socio-Demographic Characteristics

1. Age at last birthday……

2. Sex Male [ ] Female [ ]

3. Highest level of education:

a. No formal education [ ] b. Primary [ ] c. Middle school certificate [ ]

d. Secondary [ ] e. Tertiary [ ]

4. Household size ……..

5. Farm size…….

6. Farming experience in years……..

7. Age of the farm……

8. Source of the planting materials:

a. O. P. R. I. [ ] ; b. G. O. P. D. C [ ]; c. Nursery operators [ ] ;

d. Other [ ] state:……..……..

9. How many tons of bunches do you obtain from your oil palm plantation at harvesting per month in the:

a. Major season?.....

b. Minor season?.....

B. Exposure to vulnerability of the smallholder Oil Palm farmers

Please indicate by ticking **[✓]**Yes or No if an item the table is one of your major problems/vulnerability in oil palm farming. If your answer is Yes for an item, continue to indicate its level of occurrence/severity on your farm using the scale: 1= Very low; 2 = Low; 3 = Moderate; 4 = High and 5 = Very high.

Problem	**Occurrence**		**Level**				
	Yes	No	1	2	3	4	5
10. Insect pest							
11. Frequent weeds growth							
12. Erratic Rainfall (Rainfall not regular)							
13. Temperature in terms of (hot weather)							
14. Drought (two –three months of no rainfall)							
15. High cost of inputs							
16. Theft incidence							
17. Reduced quality of fresh fruit bunches							
18. Fluctuation in the prices of fresh fruit bunches							
19. Irregular access to market							
20. Unavailability of labour							
21. Dependency on market agent to sell fresh fruit bunches							
22. Unavailability of land							
23. Limited extension training							

24. Lack of access to credit							

C. Sensitivity of the vulnerability to the livelihood of the smallholder farmers

Please indicate your level of agreement on how the elements considered as your problem have affected the farm-base livelihood assets?

Scale: 1-Verylow 2-Low 3-Moderate 4-High 5-Very high Level of Agreement					
Items	1	2	3	4	5
25. Insect pest attack have reduced the yield of my oil palm Plantation					
26. Frequent weeds growth and their competition has Reduced Fruit bunches on my oil palm trees					
27. Quantity of fruit bunches on Palm trees has reduced due to irregular rainfall Irregular rainfall (erratic rainfall)					
28.Temperature (hot weather) has negatively affected the yield of my plantation.					
29. Recurrent droughts (absence of rain for two month) has decline the yield of my palm trees in the farm.					
30. My crop yield from oil palm Plantation have been reduced due to high cost of inputs					
31. I do not have access to adequate water due to irregular rainfall (erratic rainfall).					
32. Unavailability of labour has reduced the productivity of my farm					
33. I do not have access to land due to unavailability of land					
34. I receive low income from my oil palm production due to price fluctuation					

35. There is low income from my oil palm production due to irregular access to market					
36. I receive low price for my fresh fruit bunches because I depend on market agent in selling them					
37. Theft incidence on farm has reduced the income of my Oil Palm plantation					
38. There is low price for my palm fruit because of quality reduction due to inability to transport them from field within 24 hours after harvesting					
39. I have limited knowledge of oil palm production practices due to limited agricultural extension education or training					
40. I have limited skills of oil palm production practices due to limited extension agricultural extension training					
41. I am unable to put into use the improved oil palm technologies due to lack of access to credit					
42. I am unable to buy required quantity of pesticides due to lack of access to credit					
43. I am not able to acquire sufficient simple farm implement in my oil palm farming business due to lack of access to credit					
44. I am unable to buy fertilizer because of lack of access to credit.					
45. I am not a member of any association due to lack of access to credit					

D. Adaptive capacity of the smallholder oil palm farmers

Please indicate by ticking Yes (….) or No (….) the use of the following strategies and if Yes indicate the frequency of their use against the element of the exposure considered as your problem.

Strategies	**Use**		**Level of Use**				
	Yes	No	1	2	3	4	5
46. Insecticides spraying							
47. Hand-pick insect and kill							
48. Herbicide spraying							
49. Slashing							
50 .Crop diversification							
51. The use of improved oil palm variety							
52. Changing planting time							
53. Purchase inputs of low cost							
54. Engage in non-farm income earning activities							
55. Convey fruits bunches immediately after harvesting							
56. Watch farm with gun							
57 Process palm fruits into palm oil and sell							
58 Process fruit into palm oil and store							
59 Sell palm fruits at a given price							
60 Sell palm fruits to artisanal processors							

61 Sell fruit bunches to processing companies							
62 Contract farming							
63 Farm gate sales							
64 Rely on market price information							
65 Engage in informal group (Nnoboa)							
66 Hire labour elsewhere to do farm activities							
67 Use family labour							
68 Farmer to farmer contact							
69 Contacting oil palm research institute							
70 Listening to local radio programme on agriculture							
71 Rear other farm animals							
72 Descent system of land holding							
73 Abunu system							
74 Own-saving							
75 Collect money from palm oil processors							