SPATIAL ANALYSIS OF OIL PALM EXPANSION IN GHANA: A CASE STUDY OF THE SOCIOECONOMIC IMPACT ASSESSMENT OF OIL PALM EXPANSION IN EJISU JUABEN MUNICIPALITY

By

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DECLARATION

I hereby declare that this submission is my own work towards the MSc and that, to my best of knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text

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ABSTRACT

Land cover change and its associated socioeconomic impacts on livelihood are often analysed separately or with one "driving" the other. Quite recently in Ghana, the oil palm sector has expanded tremendously, positioning the country as an oil palm producing country in West Africa and at the global level. This has been achieved through efforts such as the President's Special Initiatives (PSIs) on oil palm. The expansion in oil palm plantations/ farms has impacted on the environment spatially. This expansion in oil palm has also impacted on the affected communities socioeconomically. The main objective of this research is to analyse the spatial distribution of agricultural land (oil palm plantations/ farms and staple annual food crops) and the associated socioeconomic impact on communities in the Ejisu Juaben Municipality. Supervised classification of multi-temporal Landsat TM 1986 and ETM 2010 imagery was the main method used to determine land cover types in the study area. Questionnaire administering and group discussions were conducted on a total of 349 farmers (319 oil palm farmers from four zones constituting 26 communities and 40 non oil palm farmers from 4 communities). Linear regression was employed to model the relationship between sizes of oil palm farm, mean distance travelled from home to oil palm farm and total land owned by the farmer against the annual income received by farmer from their farms. Generalized Linear Model (GLM) was used to model the expansion/ spread of oil palm with time in the study area. Sizes of oil palm farm, mean distance travelled from home to oil palm farm, total land owned by the farmer and annual income received by farmer from their farms were modelled with time in years to predict the trends of the spread of the oil palm to assess its sustainability with all other influencing factors such as demand and supply of palm oil being constant. The results of the models predicted an unsustainable expansion of oil palm in the study area. In the same direction, both male and female engaged in staple annual food crops received less income from their farms as compared to oil palm farmers. The supervised classification produced five land cover types namely; forest, open forest, farmland, oil palm and built-up/ bare with an overall classification accuracy of 84.21%. The total area of forest and farmland decreased by 27.9% and 40.6% respectively whiles oil palm, open forest and built-up/ bare increased by 844.6%, 951.2% and 89.8% respectively from 1986 to 2010. The expansion in oil palm plantations/ farms and changes in the other land cover types were evident on the 1986 and 2010 Landsat classified maps compared. The study revealed that the expansion in oil palm has socioeconomic impact on the livelihoods of the communities involved. Employment creation and improvement in income levels was evident from the results of the research. The expansion in oil palm has negative impacts on food production in the study area. About 6.5% of total farmland has been lost to oil plantations/ farms and therefore affecting annual food crop production.

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Dedication

I happily dedicate this piece of work to all mothers, especially Akosua Sisi. This is the reward of your hard works over the years up to this stage of my life. I love you Mum.

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LIST OF ACRONYMS AND ABBREVIATIONS

ERDAS	Earth Resource Data Analysis System
ETM	Enhanced Thematic Mapper
GHS	Ghanaian Cedis
GIS	Geographic Information system
GLM	Generalized Linear Model
GPS	Global Positioning System
GSS	Ghana Statistical Service
JOM	Juaben Oil Mills
JOPOCOS	Juaben Oil Palm Out-growers Cooperative Society
MA	Millennium Ecosystem Assessment
NTFPs	Non Timber Forest Products
OPRI of CSIR	Oil Palm Research Institute of Centre for Scientific and Industrial Research
PSI	President's Special Initiative
RSPO	Round table on Sustainable Palm Oil
SPSS	Statistical Package for Social Science
TM	Thematic Mapper

1 INTRODUCTION

1.1. Background

Agricultural activities are the bastion of rural households in Ghana (Gyasi, 1976). Growth in the agricultural sector is a potential driver to poverty alleviation (World Bank 2009). The agricultural sector is a major contributor to the economy of Ghana (Gyasi et al., 1995). The sector employs more than 58% of the country's population in the form of subsistence and plantation farming; including oil palm, cocoa, citrus, etc. (Ghana Statistical Service, 2003). This has necessitated the plantation sector, most especially the oil palm industry to realise a major boost through the President's Special Initiative (PSI) since the year 2003 (Duku, 2007).

Oil palm is one of the most rapidly increasing tropical crops of the world as stated by Fitzherbert et al. (2008) and also, categorised as one of the major cash crops contributing to Ghana's Gross Domestic Product (Gyasi, 1992). Oil palm is indigenous to West Africa and found in countries such as Ghana, Nigeria, Togo, Cameroon and Ivory Coast (Gyasi, 1992). Like other countries of the world, Ghana is recognised to have a long history of palm oil production, processing and use. The expansion in oil palm therefore, has the potential to yield positive socio-economic benefits to local people of Ghana as acclaimed by Wilcove & Koh (2010) that, oil palm is and has been a profitable crop and as such, its expansion can yield positive socio-economic benefits to local people through; increased employment opportunities, improved infrastructure and higher income levels. At the national level, oil palm expansion yields indirect poverty alleviation benefits through government allocation of tax revenues and increased monetary stability through foreign exchange earnings (Jurgens et al., 2010).

However, there are also potential negative impacts as a result of the expansion in oil palm, including loss of access to land for food production. This has resulted in the reduction in food production, loss of the benefits of mixed livelihood strategies, and loss of environmental services from natural forests (e.g. water, game, medicinal plants) due

to the replacement by oil palm plantations (Chemsain Konsultant, 2000). According to Wilcove & Koh (2010), oil palm has continued to expand across the tropics and as a result, making its expansion the greatest immediate threat to biodiversity. Also, the expansion in oil palm coupled with migration of people to these areas in search of employment in the oil palm sector has the potential to accelerate the loss of land ownership to locals of such communities (Gyasi, 1976; Gyasi, 1994; Braimoh, 2009). In addition to other negative impacts as caused by the expansion in oil palm, it is equally important to note that, the lands for the establishment of these plantations are croplands forcefully taken from the local communities (Gyasi, 1994). Compulsory land acquisition powers have been used extensively in Ghana since colonial times as one of the means by which the State get access to land for developmental projects (Larbi et al., 2004; Gyasi, 1994). A typical example of compulsory land acquisition is the means by which land was acquired for the establishment of the plantations owned by the Ghana Oil Palm Development Company (GOPDC) in the 1970's (Gyasi, 1994) by the then Ghana Government at the time.

Not until the 1970s when oil palm plantations establishment started, the smallholder oil palm farms was the main system for farming oil palm in Ghana (Gyasi, 1992). With the advent of the plantation development, the government of Ghana in joint venture with foreign investors established three major plantations namely; GOPDC located at Kwae near Kade, the government/privately owned Twifo Oil Palm Plantations Ltd. (TOPP) located near Twifo Praso/ Ntafrewaso; and the government/privately owned Benso Oil Palm Plantations Ltd. (BOPP) located near Prestea-Adum Banso (Gyasi, 1992; Gyasi, 1994). The total planted area of oil palm increased, from about 17,820 hectares in the 1970,s to 102,513 hectares in the 1990's (National Investment Bank, 1987; Gyasi, 1992). Area under production in Ghana was 304,000 ha by the year 2004 with smallholders having 80% of this land under oil palm (OPRI of CSRIR, 2010; Duku, 2007).

Due to the growing demand for palm oil for both domestic and commercial purposes, the situation has stimulated a dramatic increase in oil palm plantation development in the entire middle and southern parts of Ghana (OPRI of CSIR, 2010; Gyasi, 2003). This has

raised serious concerns on the sustainability of the plantation system in oil palm production in the country (Gyasi, 2003; Gyasi, 1992). The Ejisu Juaben Municipality is one of such areas that have records of rapid expansion in oil palm cultivation. Figure 1.1 shows the oil palm plantations areas and other emerging oil palm belts in the country.

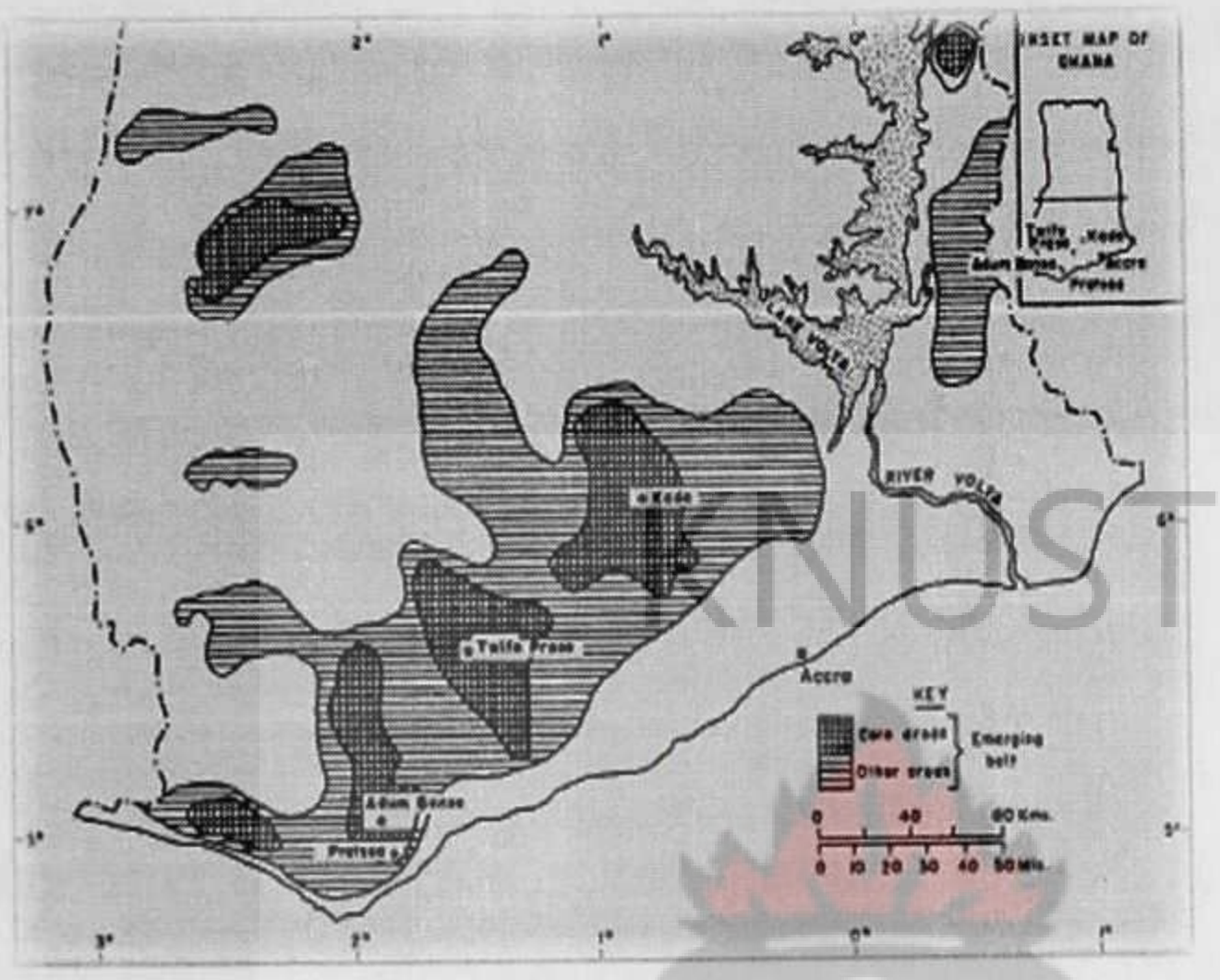

Figure 1.1: Oil palm plantation areas and other emerging oil palm belt in Ghana

Source: (Gyasi, 1994)

The President's Special Initiative on oil palm development was established due to the fact that the Ghanaian economy has been dependent mainly on the export of cocoa, timber and non-renewable extractive minerals such as gold, diamond and bauxite (Duku, 2007). These resources have witnessed price fluctuations in the international commodity markets and thereby subjecting the country to unstable economy. In the quest of the government attempts to stabilize the economy, the PSI on oil palm as one of the attempts was launched in June 2003 with the following specific objectives;

- To make the oil palm industry, one of the key drivers for economic growth and rural poverty alleviation.
- To promote national growth and development and wealth creation in rural communities in Ghana.

- To sustain employment generation in rural communities to reduce rural-urban drift
- To attract foreign investment particularly in areas of downstream processing.

The PSI on oil palm was to become a new mechanism of economic growth and development in the country with the short term target of developing 20,000 hectares of oil palm and a long term target of establishing 300,000 hectares of oil palm in the next 25-30 years. The PSI on oil palm was to achieve its objectives through; formation of Farmer-Based Organization (FBOs) which will assist farmers grow from subsistence to commercial farming and through the integration of the PSI on oil palm into the Ghana Poverty Reduction Strategy (OPRI of CSIR, 2010).

1.2. Land tenure, ownership, access and loss in the agricultural sector of Ghana

The fundamental importance of land to society, especially agrarian ones such as Ghana, cannot be gainsaid. From a socio-economic perspective, the most crucial aspects of land are its extent, quality and how readily people may have access to or acquire it for farming and other economic activities (Gyasi, 1994).

Land tenure is a societal institution (organizations, rules, rights and restrictions) that governs the allocation and use of land and its associated resources (Cumming and Barnes, 2007). Land tenure is defined as the mode by which land is held or owned, or the set of relationships among people concerning the use of land and its products (Payne, 1997). According to Lamptey (2009) land tenure is classified as private (freehold), state, open access and communal (customary).

Customary land tenure is defined as the right to use or dispose of use rights over land which does not involve any form of force, nor on the evidence certain by the government statues, but rather on the fact that they are considered genuine and lawful by the community (Simpson, 1976).

Communal land ownership is described as the system whereby land is collectively owned by an extended family, clan or community of ancestrally related people, with the control or administration vested in the leader or his appointee (Arko-Adjei, 2011). The leader or

appointee with the power vested in him/her may give out portions of the land to the community or non-community members to be used on an individual basis, on a more or less nucleated family basis, on a co-operative basis or through some other such recognized arrangement, for variable lengths of time (Gyasi, 1994).

In the traditional set-up of Ghana, land is generally owned communally by people having common descent or owing allegiance to a symbol of collective authority, e.g. The 'stool' among the Akans of southern Ghana and 'skin' among the people of the three northern regions of the country (Ollenu, 1962; Pogucki, 1962; Bentsi-Enchill, 1964; Parsons, 1971; Gyasi, 1994; Arko-Adjei, 2011).

As a result of the traditional set-up of Ghana, membership of community or family constitutes the basic medium of access to land and as such individual members are supposed to enjoy free inheritable rights over the communal land on the basis of kinship, i.e. membership of the community without discrimination to the communal ownership.

Strangers or non-members may have access to the communal land through the transfer of rights of use by the land-owning community, usually through the leader, chief or occupant of the stool or skin. The accessibility aspect is of special interest because in every country, the system by which rights over land are held shapes agricultural production (Dunning, 1970).

As a result of modernization in recent years, the system was modified to incorporate land sales and more tenancy arrangements in response to growing demand for agricultural land, including oil palm land for the production of palm oil and palm kernels as increasingly lucrative exports (Gyasi, 1994).

With regards to loss of land as defined by Gyasi (1994) and Wakker (2000) in the context of this study; it is the situation in which land belonging to locals in the community is forcefully taken over by plantation companies through the government without paying the due compensation to the people. Another definition according to Gyasi (1994) is the case where land belonging to locals is converted to oil palm but in this case the farmers are supplied with inputs from the plantation company to cultivate only oil palm and sell

the proceeds to the plantation company instead of the normal mixed cropping for subsistence. This is the type of land loss which predominates in the study area.

1.3. Problems of oil palm expansion and deforestation in Ghana

Forest loss is the major problem of oil palm expansion in Ghana (Duku, 2007). Forests are lost and degraded mainly because people modify forested landscapes in a range of ways to derive socioeconomic and livelihood needs (Carpenter et al., 2006). These include agricultural conversion, wood and Non Timber Forest Products (NTFPs) extraction and infrastructure extension. Factors that cause deforestation and degradation are termed drivers of deforestation (Rademakers et al., 2010). The Millennium Ecosystem Assessment (MA) defined a driver as human induced factor that directly or indirectly causes a change in an ecosystem (Carpenter et al., 2006; MA, 2005). According to Rademakers et al. (2010), there are two kinds of drivers of deforestation; direct and indirect drivers. Direct drivers of deforestation are those that directly lead to forest decline. For instance excessive logging or forest conversion to agriculture fields such as oil palm plantation. The indirect drivers result from remote causes such as increase in human population. Deforestation in Ghana is caused by both direct and indirect drivers (Kufuor, 2004; Agyarko, 2001). Similarly direct causes of deforestation in the case of Ejisu Juaben Municipal are mainly clearing for agriculture, settlements and illegal use of resources with increased growth rate in human population in the municipality as an indirect cause (Asubonteng, 2007).

A large number of rural poor depend on forests for a wide range of goods and services and as such the conversion of forests to oil palm plantations may have adverse impacts on their livelihoods and culture. Oil palm mills require the companies to have access to sizeable tracts of land that are likely to be mono-cropped and as a result, depriving local people of the benefits derived from mixed livelihood strategies. When forests are replaced with oil palm plantations, communities lose access to timber for construction, bush meat, water, fibre, fruits and spiritual grounds (Benefoh, 2008). Also, communities lose the autonomy and self-sufficiency associated with traditional subsistence practices and may become dependent on the market fluctuations of oil palm prices and the purchasing practices of oil palm mills (Belcher et al., 2004).. Also according to RSPO

(2006), the gender implications of the oil palm industry on employment, land use and access need to be explored in greater detail since the participation of women in oil palm plantation farming is hindered and requires pro-active strategies

1.4. Indicators of oil palm expansion as source of employment and as a driver of deforestation and reduction in food production.

Agricultural production is found to be a major cause of deforestation in the world and a leading driver of biodiversity loss in the tropics (Primack & Corlett, 2005). Mattison and Norris (2005) also argued that ''the fate of biodiversity is intimately linked to the use of land for agricultural production''. Quite recently, the impacts of some major agricultural crop commodities including cocoa (*Theobrom cacao*), coffee (*Coffea arabica*) and oil palm (*Elaeis guineensis*) on biodiversity have become a major issue of international conservation interest among researchers (Donald, 2004; Rice & Greenberg, 2000). Oil palm is among the world's most important agricultural exports and a major earner of foreign income for countries that dominate in its production (Gyasi, 1992). The crop is grown in lowland tropical forests, mainly in biodiversity hotspots (Myers et al., 2000). It is estimated that, over 636,000 households are involved in its cultivation nationwide and generating about 8.75 million Ghana Cedis (OPRI of CSIR, 2010). The oil palm is one of the driving forces of the rural agribusiness and agro-industries (Asase et al., 2009). The oil palm farming and other related activities such as harvesting, processing and marketing has been identified to create more jobs than food crop farming for the rural poor. However, the crop has been identified as a major contributor to deforestation at the forest-agriculture interface in Ghana (Asase et al., 2009).

It is however important to note that, to be able to assess the impact of the expansion in the oil palm plantation on employment, certain indicators needs to be measured and compared to ascertain the claim that expansion in oil palm creates employment and improves the income levels of those involved. These indicators are introduced below.

- Number of people per household employed directly or indirectly in the cultivation, harvesting, processing and marketing of oil palm. This will allow the identification of total populace employed on oil palm compared to other agricultural sectors such as cocoa, citrus, etc. and the public sector.

- Number of people per household employed in non oil palm related activities but rather in the production of staple food crops. The outcome of the measurement or quantification of this indicator will be correlated with the previous indicator stated above.
- Number of people per household employed on both oil palm and non oil palm related activities.

The expansion in oil palm has resulted in the partial or complete takeover of previously existing staple food crop farms by oil palm plantation and impacting negatively on food production. Proper assessment of the impact of the expansion in oil palm on food production will be feasible by measuring the indicators elucidated below.

- Total land owned by farmers; thus, the farmer owns the land for farming or there is other type of land tenure arrangement on the cultivated by the farmer.
- Sizes of oil palm farm land; thus, to identify how much of total land owned is put into the cultivation of oil palm
- Sizes of food crop farm lands; thus, to identify how much of total land owned is put into the cultivation of staple food crops.
- Distances from home to their farms; thus, to examine the distance a farmer will have to travel to transport produce to the oil palm mill or market. Mostly the preferred type of farming system is rather close to home and road for easy transportation (Wakker, 2005).

The above indicators to be measured will be meaningful by dividing the study area (farms) into zones based on proximity to market and oil palm processing mill. The twenty six communities were divided into four zones namely; Juaben East, Juaben West, Atia and Odumase. Similar approach has been used by JOPOCOS since the year 2003 in calculating transport fares charged by drivers who transport produce from farms to the JOM.

1.5. Research problem and justification

Forest areas in Ejisu Juaben Municipal of Ghana are undergoing rapid depletion (Benefoh, 2008). Urbanization, human population growth, increased local communities'

livelihood dependency on the forest and its resources, agriculture intensification and expansion in oil palm are the ultimate causes of forest depletion (Backeus, 2006).

A research by Asubonteng (2007) looked at the prevalent causes of land use/cover transfer and the links to socioeconomic factors that drive those transfers and concluded that urbanization and agricultural expansion are the main drivers of change in Ejisu Juaben. Another study by Benefoh (2008) concluded that expansion in agricultural land is mainly due to increase in oil palm and cocoa expansion in the area.

There is therefore the need to accurately detect the magnitude and extent to which other land cover types have been converted to oil palm. This is to enable the assessment of oil palm expansion and its socioeconomic impacts on society and hence predict the sustainability of the oil palm plantation system in Ghana as far as access to land is concerned. Also to this effect is to ascertain the success realized by the PSI so far.

Specifically, conversion from one land cover type to oil palm is contributing to loss of land to locals and its associated socioeconomic impact to society due to the rapid oil palm expansion (Gyasi, et al., 1995). The spatial analysis and the socioeconomic impact assessment of oil palm expansion on the livelihoods of affected local communities in the country have not yet been studied after the PSI on oil palm. It is against these backgrounds that the socioeconomic impacts of oil palm expansion in the Ejisu Juaben Municipality is worth studying.

1.6. Research outcome/ contrbution

The outcome of this research is expected to contribute to knowledge in the following way:

- Serve as input in developing livelihood support schemes that will satisfy local resource needs with minimum harm on ecological functions in oil palm growing areas.

- Serve as reference data/ material for the development of land use policies in Ejisu Juaben Municipality and as a guide to the Forestry Commission for the conservation and management of forest resources.
- Deepen understanding on how land cover change can affect livelihood socioeconomically.
- Contribute to the building of scientific knowledge in the assessment of socioeconomic impacts of oil palm using GIS and remote sensing applications.
- Serves as input to be considered in planning and allocation of government budget that seek to improve the living standards of the Ghanaian populace in the agricultural sector.
- Produce a distribution map of oil palm plantation farms and staple food crop farms in the Ejisu Juaben Municipality

1.7. Overall objective

The overall objective of this research is to investigate the effect of land cover changes on the affected communities as a result of the rapid expansion in oil palm and assess its socioeconomic impacts on the local communities of the Ejisu Juaben Municipality

1.7.1. Specific Research objectives

- To examine how much land has been converted to oil palm plantations.
- To assess the effect of oil palm plantations expansion on food production.
- To assess the effect of oil palm plantations expansion on employment.
- To assess gender and age group proportions of oil palm farmers in the study area.

1.7.2. Specific Research Questions

- What are the changes in land cover types in the study area between 1986 and 2010?
- What is the spatial distribution of oil palm expansion in the study area?
- What are the effects of oil palm plantation development on food production?
- What is the employment creation and improvement in income levels of oil palm farming communities as compared to non oil palm farming (annual staple food crops) communities
- What is the demography of gender and ages of oil palm farmers in the study area?

1.7.3. Hypothesis

- H_0: There is a positive relationship between oil palm plantation expansion and improvement in income levels of farmers

  H_1: There is no significant relationship between oil palm plantation expansion and improvement in income levels of farmers

- H_0: There is a positive relationship between oil palm plantation expansion and reduction in annual staple food crop production.

  H_1: There is no significant relationship between oil palm plantation expansion and reduction in annual staple food crop production.

1.8. Research approach/ methodology

The research commenced with an extensive literature review of existing knowledge in key areas of the subject of study. These include; concept of the PSI, land tenure, land acquisition, land loss and access types, oil palm and its influence on culture, causes of deforestation and finally the socioeconomic impacts of oil palm on society with particular consideration to impact on food production, employment and improvement in income levels. The main purpose of the desktop study was to identify existing knowledge gaps and subsequently define and formulate research problem, objectives and questions. This was followed by the selection of the study area which was made easier as a result of researcher's familiarity and knowledge of the area.

Initial logistical needs were assessed and those that were required were procured. This included; satellite images, maps, Ipac with GPS, compass and digital camera. Image pre-processing was done and followed with field validation. The field activities involved validating data from the remotely sensed land cover spectral classes (ground truth), random sampling of farmers and the administering of questionnaire and interviews of these farmers. This was meant to obtain the information on the involvement of the different age classes and gender of the oil palm farmer and also on the key areas of the subject of study mentioned in the previous paragraph. Data from the field activities were processed and analysed to produce the results for the discussion and conclusion chapters of the thesis.

1.9. Structure of thesis

This piece consists of seven (7) sections namely; introduction, materials and methods, results, discussions, conclusions and recommendations, references and appendices. The introduction section presents an overview of research problem formulation and defining research objectives. Extensive search of scientific literature in the subject area was done to put the problem in proper perspective.

Following the introductory section of the thesis report is the materials and methods employed in the implementation of field activities specific to each objective. This section highlights on description of study area, data, software and hardware used and a detailed account of the procedures followed the methods.

The third section presents results obtained subsequent to the implementation of the methods. The results are arranged according to each specific objective that seeks to answer each specific research question. The discussion of the results was dealt with in chapter four and the conclusions and recommendations were tackled in chapter five. References and appendices were addresses in chapters six and seven respectively.

2 MATERIALS AND METHODS

2.1 Selection of Study Area

2.1.1 Location of Ejisu Juaben Municipality and Justification

The research was conducted in the Ejisu Juaben Municipality in the Ashanti Region of Ghana. The municipality is a tropical rainforest region in the middle belt of the country. The study area lies within Latitude 1° 15' N and 1 ° 45' N and Longitude 6° 15'W and 7° 00'W. Ejisu-Juaben Municipality is positioned in the central part of the Ashanti Region and shares boundaries with six (6) other Districts within the Region. To the North East and North West of the Municipal are Sekyere East and Kwabre Districts respectively, to the South are Bosomtwe-Atwima-Kwanwoma and Asante-Akim South Districts, to the East is the Asante-Akim North Municipal and to the West is the Kumasi Metropolitan. The District stretches over an area of 637.2 square kilometres and constitutes about 10% of the entire Ashanti Region (Ministry of Local Government and Rural Development, 2006).

The area has experienced rapid expansion in oil palm and the increasing population and high incidence of poverty in the study area according to the 2000 population census is exerting pressure on the forest ecosystem in the study area (Asubonteng, 2007; Benefoh, 2008).

The study was concentrated in the Juaben Traditional Authority (Stool Land) portion of the Municipality where the rapid land cover conversion to oil palm is more prominent and the south of the Juaben traditional Authority (Stool land) where there is not much of expansion in oil palm but rather in annual staple food crops.

The study area constituted thirty (30) communities; 26 in the oil palm communities and 4 in non oil palm communities. The communities were selected based on the following criteria; communities where the expansion in oil palm is prominent and rapid and those communities where there is no rapid expansion so as to be able to establish a clear

comparison in the assessment of the socioeconomic impact on society. The location of the study area; Ejisu Juaben Municipality is shown in Figure 2.1 below.

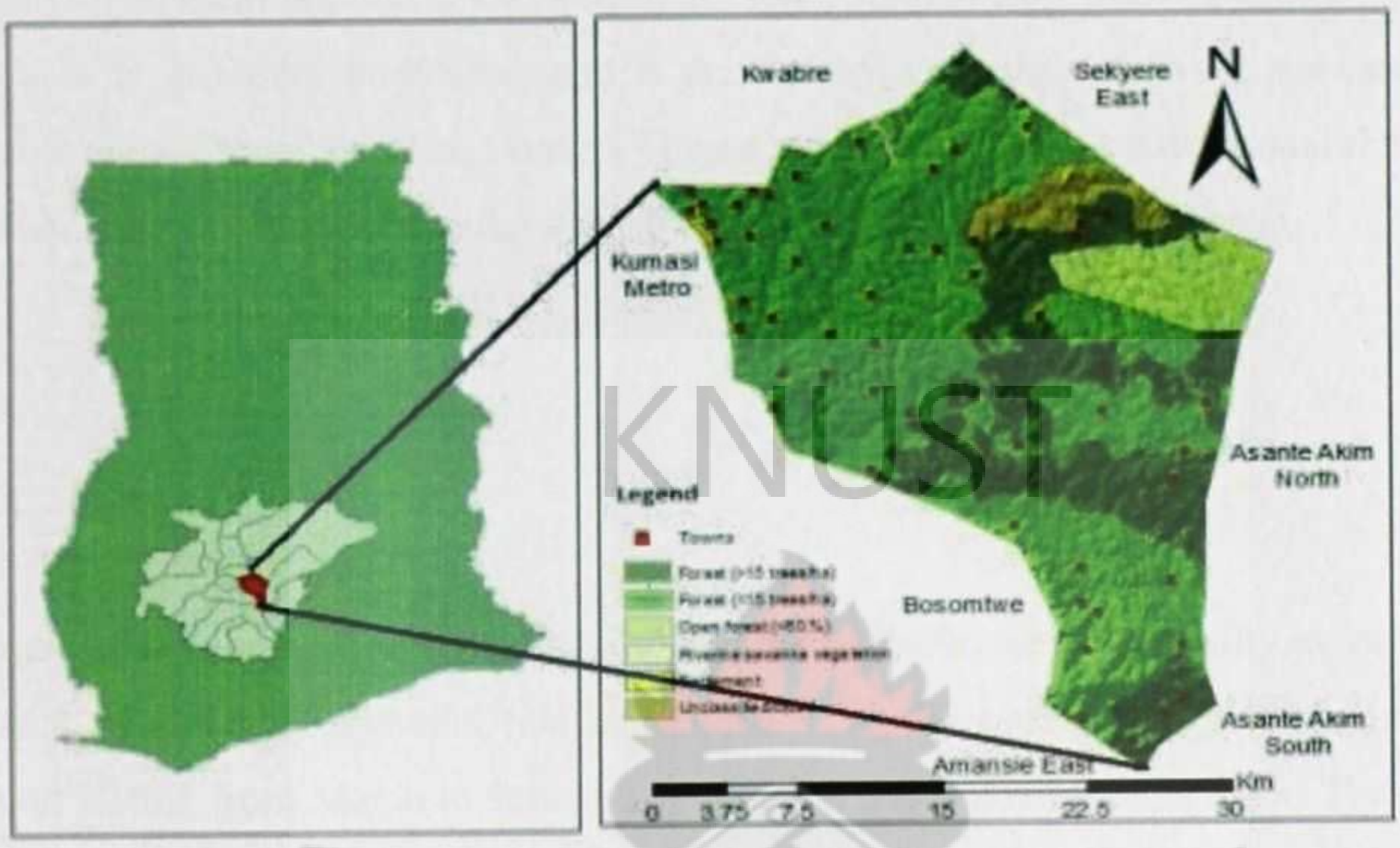

Figure 2.1: Location of Ejisu Juaben Municipality in the Ashanti Region of Ghana.

2.1.2 Demographic characteristics

The population of the municipality as of the year 2000 was 124,176 according to the Ghana Statistical Service (2003) and estimated at 144,272 by year 2006. The population of the Ejisu Juaben Municipality continues to grow at the rate of 2.5% and currently stands at 162,306. The growth in population is attributed to the considerable expansion in the peri-urban towns in the municipality. Currently, it has four urban settlements namely, Juaben, Besease, Bonwire and Ejisu being its capital. These four towns account for 28.2% of the total population in the municipality with Ejisu; the municipal capital accounting for 11.6%. The population growth rate of 2.5% is putting pressure on the available natural resources and as such resulting in the conversion of agricultural land into residential use in the peri-urban areas.

2.1.3 Topography and drainage

The Ejisu Juaben Municipality falls within the forest dissected plateau terrain region. This region is underlain by the pre-cambrain rocks of the Birimian and Tarkwaian formations. It rises from about 240 metres to 300 metres above sea level (Ministry of Local Government and Rural Development, 2006; Asubonteng, 2007; Benefoh, 2008). The area is generally undulating and is drained by a number of rivers and streams. Notable among them are Oda, Bankro, Hwere, Anum, and Baffoe. Occasional flooding is experienced in the inland valleys along the river basins in the rainy season.

2.1.4 Climate

Climate as is the case for most of the middle belt in Ghana, the municipality experiences tropical rainfall, i.e. bi-modal rainfall pattern. It is characterized by double maxima rainfall lasting from March to July and again from September to November. The mean annual rainfall is 1200mm. Temperatures range between 20°C in August and 32°C in March. The humidity is fairly moderate but quite high during rainy seasons and early mornings (Ministry of Local Government and Rural Development, 2006).

2.1.5 Vegetation and soil

The Ejisu Juaben Municipality is positioned in the moist semi deciduous forest vegetation zone as stated by (Hall and Swaine, 1976). The area has large patches of homogeneous forest cover used as reserves and commercial timber production. The Bobiri Forest Reserve is found in the municipal and has a total area of 54.6 square kilometres serving production, tourism, research, and conservation purposes. The reserve is one of the richest in terms of biodiversity in Ghana. The reserve is floristically diverse and endowed with large quantities of economic timber species including *Terminalia superb, Aningaria robusta, Triplochiton screloxylon, Nesogodonia papaverifera, Entandrophragma angolensis,* etc. (Bureau of Integrated Rural Development, 2001).

The off-reserve areas consist of annual crops, cash crops, forest patches, fallow lands, grassland and riparian vegetation. One very important thing to note is that forest patches in the off-reserve are unsustainably logged by legal and illegal loggers. *Chromolena ordorata* is the most abundant species within the off-reserve and as such the most predominantly logged tree species.

Eight soil types have been identified in the Ejisu Juaben Municipality. These are; the Granite based Kumasi-Offin Compound, Bomso-Offin Compound and Swedru-Nsaba Simple Associations; Birrimian rock base Bekwai-Oda Compund, Kobeda-Eschiem-Sobenso-Oda Complex and Atunkrom-Asikuma Association; Tarkwaian based Juaso-Mawso Association and finally the superficial deposits based Boamang-SukoSimple Association (Gaespenu and Associates, 1996). It is important to note that all the above mentioned soil types can support agriculture of all kinds ranging from annual crops to cash crops (Benefoh, 2008)

2.1.6 Agricultural and Economic situation

Agriculture is the major occupation of the people of Ejisu Juaben Municipality by virtue of its percentage employment. The sector employs 55.6% of the total employed labour force. Agriculture is however divided into two major types; crop farming and mixed farming. Crop farming is the dominant agricultural activity in the Municipality. About 94 % of the farmers are into crop production and the remaining 6% are into mixed farming. The favourable climatic conditions and the geophysical characteristics of the area support intensive crop farming. These and other factors such as the availability of arable lands account for the high crop production. Most of the food crops are grown mainly to be sold for income and the rest to be consumed by the family. Tree crops such as cocoa and oil palm and citrus are the major cash crops cultivated in the area and are grown mainly for commercial purposes (Ministry of Local Government and Rural Development, 2006).

2.1.7 Land tenure system

The land tenure system practiced in the study area is a combination of the customary, communal, sharecropping systems described in the previously in section 1.2 and finally the sale/ purchase system which comprises the following sub-categories:

1. Pure sharecropping, subdivided into:
    - 'Abunu'; where the returns from the farm or the farm itself are shared equally between the land 'owner', or 'landlord', and the tenant.
    - 'Abusa'; where the returns or the farm itself are shared in the ratio of one-third to the 'landlord' and two-thirds to the tenant.
    - 'Abunan'; where the ratio is one quarter to three-quarters to landlord and tenant respectively.
2. Pure lease/ rent; where on payment of a fee the land was acquired and used for a period typically ranging between twenty-five and fifty years.
3. A combination of lease and sharecropping, where the land was acquired for a set period for a fee and cultivated on a sharecropping basis.
4. Purchase, involving the absolute transfer of ownership for a money consideration (Gyasi, 1994).

However, the current pure sharecropping category being practiced in the study area is quite different. Presently, it is the oil palm farmland which is shared between the farmer and the land owner as described in the previous. In this situation the farmer stays on the land until the palm trees are over grown and fell to be used for palm wine and after which the ownership is transferred back to the actual land owner.

2.2 Materials

2.2.1 Data

Two multi-temporal near anniversary Landsat satellite images; Landsat Thematic Mapper (TM) 1986 and Landsat Enhanced Thematic Mapper (ETM) 2010 (January and

February, Level 1 B with path/ row 194/55) of less than 10% cloud cover were acquired and used for this study. The images were acquired from the ITC database based on availability and suitability in terms of seasonal compatibility. These satellite images were used for the classification of land cover types and change detection.

Topographic map of rivers and roads of the study area were acquired from the Ghana Survey Department and used in the field to collect ground control points for geo-referencing, classification and accuracy assessment. Semi-structured questionnaire were used to collect the socioeconomic data of farmers in the area

2.2.2 Software and tools

ERDAS Imagine 9.2, ENVI 4.2, ArcGIS Desktop Version 9.3, Minitab, SPSS, Microsoft Office Excel 2007, Word 2007, PowerPoint 2007, Visio 2010 and EndNote X4 were the softwares used in this study. ERDAS Imagine 9.2 and ENVI 4.2 were used for image pre-processing, image classification and accuracy assessment. ArcGIS 9.3 was used for the GIS analysis while Minitab, SPSS and Microsoft Office Excel were used for the statistical analysis. Microsoft EndNote X4 was used for referencing while Microsoft Office Word, Power point and Visio were used for thesis write-up and presentation.

The tools/materials used for this research include; Ipac with GPS, Suunto compass and Digital camera. The Ipac with GPS was used for navigation and picking ground control points. The Suunto compass was used for determining directions on the field whiles the digital camera was for taking photographs of the study area and during fieldwork.

2.3 Methods

2.3.1 Flow Chart of Method

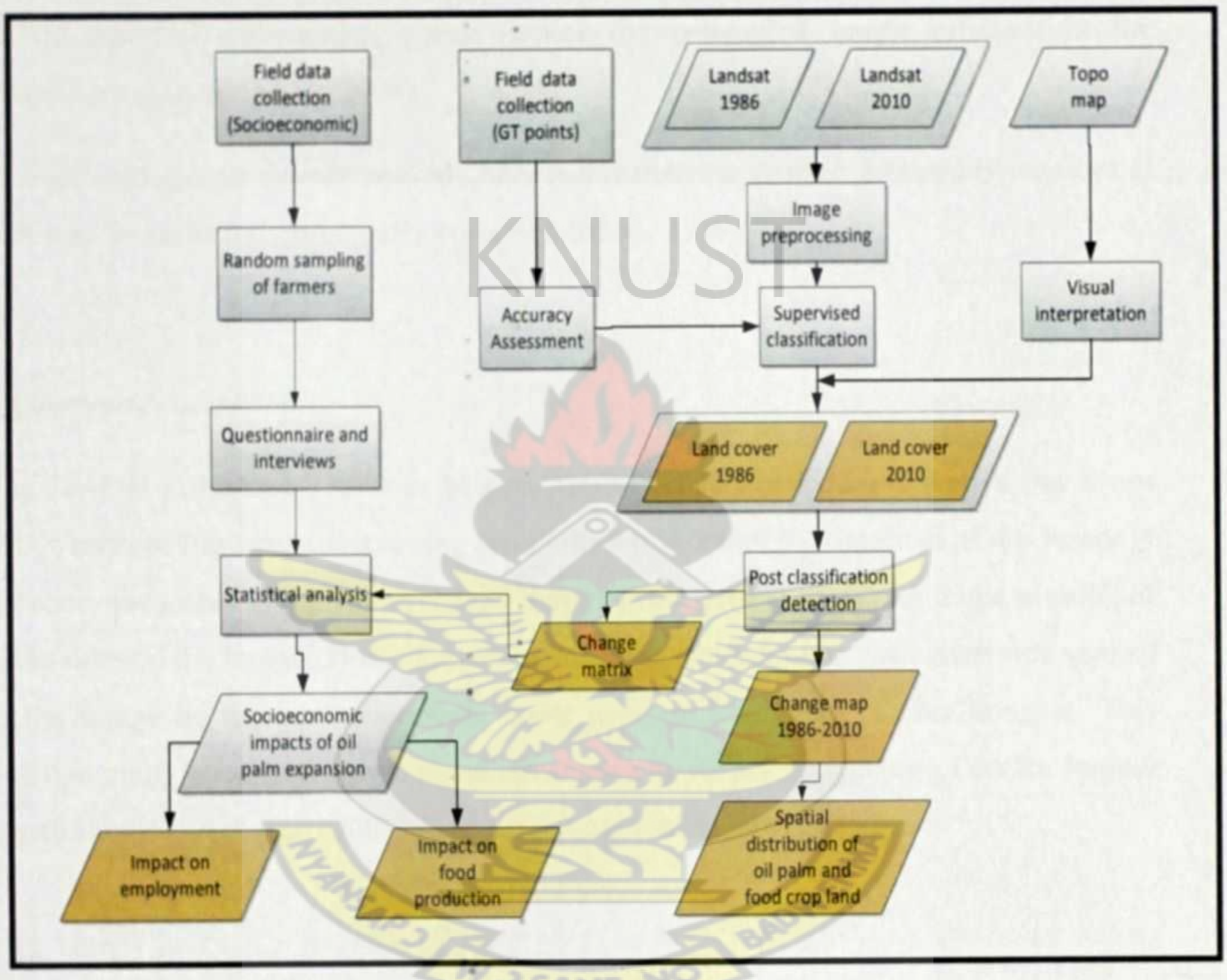

Figure 2.2: Flowchart of research methods.

2.3.2 Image Pre-processing

Geometric correction procedures were used to register each pixel to real world coordinates. The two Landsat satellite images were obtained originally in the global coordinates; UTM zone 30/WGS84. The ETM 2010 image was georeferenced with 30 pairs of points picked at river confluences and road intersections from the river and road layers on the digital topographic maps respectively. These were subsequently co-registered to the TM 1986 image. Attua et al. (2001) used 30 ground control points to georeference SPOT images successfully in their studies.

The two landsat satellite images were then resampled to 28.5*28.5m pixel size using the nearness neighbour resampling method with ERDAS Imagine 9.2 version in order to preserve the original image radiometry. Serra et al. (2003), Yuan et al (2005), Asubonteng (2007) and Benefoh (2008) used similar resampling methods in their respective studies successfully. The nearness neighbour resampling method assigns the DN values of the closest original pixel to the new pixel without being changed and retains all the spectral information which makes the resampled image efficient in the classification (Kerle et al., 2004)

In multi-date image dataset analysis, it requires that the images obtained by sensors at different times be radiometrically corrected (Mass, 1999).

Radiometric correction

The Landsat Enhanced Thematic Mapper (ETM) 2010 obtained had lots of line drops which had occurred due to recording problems when one of the detectors of the sensor in question had either given wrong data or stopped functioning, resulting in the plotting of black lines on the image. This is known as striping. A radiometric correction was applied to the image by the use of periodic noise removal function in Erdas Imagine. This function automatically removes noise effect such as stripes by applying Fourier domain transformation. Benefoh (2008) used similar approach.

2.3.3 Field data collection (ground truth points and socioeconomic)

The field data collection for this project was in two forms. The first part was the land cover (ground truth) data collection which was used for the change detection. The second part was the survey through questionnaire and interviews which was also used for the socioeconomic impacts assessment of the expansion in oil palm farms.

Ground truth point collection

Ground truth data were collected from each of the predominant land cover types using a GPS device. A total of 235 points were sampled from the field by purposive sampling based on accessibility. The locations of the 235 points were selected in order to ensure adequate representation of the different land cover types of the area (Nkyi, 2005). Waterlogged and restricted areas were excluded from the sampling because of lack of adequate accessibility. The field data were divided into training data and testing data. The training data was used for the classification and the testing data was used for the accuracy assessment/ validation. The research area was classified into five major land cover types namely; forest, open forest, farmland, oil palm and built-up/ bare. The reason for these classifications is that, the five classes are the major or predominant land cover types in the study area.

Socioeconomic data collection

The socioeconomic aspect of the data collection involved two processes; random sampling of farmers and administering of semi-structured questionnaire and interview to farmers within communities with and without oil palm farms.

There are 629 farmers in the out-grower group from 26 oil palm growing communities within the study area. These farmers were further grouped under four zones namely Juaben West Zone, Juaben East Zone, Atia Zone and Odumase Zone. A total of 319 farmers were randomly selected from these zones and interviewed. Data were collected on indicators for measuring employment (no. of people per household employed on oil palm, non oil palm and both as well as on their annual income received) and on food production (sizes of oil palm farm land, distance from home to farms and total land owned by farmers). The data that were collected were used for the socioeconomic impact assessment. Appendix 1 shows the semi structured questionnaire used for this research.

The number of farmers in each of the oil palm growing communities was not even. Some communities had less than 15 farmers while others had 15 and above. As a result, farmers to be interviewed were selected by picking up the first 15 people to be counted from each oil palm farming community as they appeared at the association's office for their

quarterly meeting (those communities with more than 15 farmers). For the communities with less than 15 persons, all the oil palm farmers were selected and interviewed.

For the non-oil palm growing communities (Piase, Yeboah, Kwaso, Koroase), 40 farmers were sample for interview. The area was randomly divided into four blocks and in each of the blocks, a village/ town was selected by writing the names of all the villages in each block on pieces of paper and then folded. One of these folded papers was randomly selected. The town/ village on the paper selected was the place from which the farmers were to be interviewed. The process was repeated for all the four blocks. A total of 10 farmers from each of the four towns/ villages so picked were selected to be interviewed. The selection was done by assembling the farmers and numbering on paper from one up to the number of farmers available and kept in a bowl. Farmers were asked to pick at random from the numbered papers in the bowl. Those farmers who pick from 1 to 10 were the sample to be interviewed.

In total, 359 farmers (319 oil palm farmers and 40 staple food crop farmers) were interviewed based on questionnaire for the research. GPS coordinates (x and y) of some interviewed farmers' farms were taken to show the distribution pattern of food crop and oil palm farms in the study area.

Secondary data from Juaben Oil Palm Out-growers Cooperative Society (JOPOCOS) and GSS were also collected. Secondary data of the entire oil palm farmers of JOPOCOS were obtained from the office of the out-grower association. The secondary data included; farm sizes, ages of farm, locations of farm and farmers' bank details. Secondary data on population growth, housing and infrastructural development in the study area based on the 1970, 1984, 2000 and provisional result of 2010 census were obtained from GSS for analysis. Appendix 2 shows the data on the out-grower group from JOPOCOS.

2.3.4 Image classification (Supervised classification)

Image classification also known as image segmentation is the process of sorting pixels into a finite number of individual classes or categories of data. In this study, the Landsat

images for the year 1986 and 2010 were classified using supervised classification. A supervised classification method with Maximum Likelihood classifier algorithm was used in this research because of the researcher's familiarity with the study area. The classification was done by importing the Landsat image into ERDAS Imagine. Image signatures were then developed using the image areas of interest (land cover types to be classified) with training data (140 points). The ground truth data acquired gave knowledge of the data to select pixels or land cover features. The Landsat images were classified into five classes namely; Forest, Open forest, Farmland, Oil palm and Built-up/ bare in the signature editor. The approach discussed is consistent with that elaborated by Westinga (2004).

2.3.5 Accuracy assessment

This study adopted confusion/ error matrix and Kappa statistic accuracy methods. Accuracy assessment was carried out using testing data (95 points) purposefully collected from the field. In order to increase the accuracy of land cover mapping of the two images, ancillary data from visual image interpretation were integrated into the initial image classification using GIS. Visual interpretation of the two images was done using onscreen digitizing mode. The resulting polygons of land cover types were rasterised in GIS and further incorporated into the classified land cover spectral classes.

The accuracy report was presented in the form of error/ confusion matrix that indicated the overall, producer and user accuracies. The classification results also included error of commission which related to the probability that pixels were correctly classified and error of omission which also related to the probability that a pixel is denoted to a class. Another characteristics used to assess accuracy was the kappa (k) statistics that determined the extent at which classification results surpass random assignment of pixels (Lillesand et al., 2004)

2.3.6 Post classification change detection

Change detection is the process of identifying differences in the state of a phenomenon or an object or by observing it at different times (Singh, 1989). It is used to highlight or identify significant differences in imagery acquired at different times; playing an important role in the lifecycle of GIS features and providing the capability to update feature data based on new imagery (ERDAS, 2008)

The classified images for 1986 and 2010 were used as the data to run the changed detection process. Using the **Interpreter** in the menu of Erdas Imagine, the matrix operation in ArcGIS analysis menu was used to perform the change detection. The Matrix operation allowed for the two classified images to be inputed and compared. The output showed the changes in the two images and what each land cover was converted into.

Several studies including Shalaby & Tateishi (2007), Sedogo (2007), Asubonteng (2007), Benefoh (2008) and Binlinla (2011) used post classification change detection methods which resulted in thematic maps presenting land cover transfers between the different images and with a change matrix.

2.3.7 Statistical analysis

To answer the research questions and addressing the specific objectives of this study, a number of explanatory and test statistics were used. Correlation and regression were the main statistical analysis used in this research. Correlation expresses relationship between two or more variables to see how closely they are associated.

The field data and secondary data were entered and coded into a data base in SPSS and Microsoft Excel. The size of oil palm farmland, mean distance travelled from home to the oil palm farms and total land owned by the farmer were correlated to annual income of farmers. Linear regression was employed to model the relationship between these variables. The association between the variables was tested using Pearson correlation coefficient (r). The square value of the correlation coefficient is referred to as coefficient of determination and denoted by (R^2) was also calculated.

Following from the methods described by Boyce and McDonald (1999) a Generalized Linear Model (GLM) was used to model the expansion/ spread of oil palm with time in the study area (that is to predict responses for the dependent variable). As such, the previously mention indicators were used to model the trend analysis of the spread of the oil palm against a period of time (320 years) to predict the sustainability of the oil palm sector with all other influencing factors such as demand and supply of palm oil at the global level being equal. All statistical analysis were done with Minitab, SPSS and Excel at 0.05 confident interval/ level. The statistical analysis performed is shown in appendix 4 and their respective graphs detailed in Figures 3.12, 3.13, and 3.14. The oil palm expansion trends are illustrated in Figures 3.15, 3.16, 3.17 and 3.18.

3 RESULTS

3.1 Land cover types classification and change detection between 1986 and 2010

3.1.1 Land cover classification

The supervised classification produced two land cover maps from the TM 1986 and ETM 2010 Landsat images of the study area. The classification categorized the area into five land cover types as elaborated in Table 3.1 below. The 1986 and 2010 classified land cover maps of Ejisu Juaben Municipality are shown in Figures 3.1.

Table 3.1: Description of the main land cover types/ classes in the study area.

Land cover type/class	Description
Forest	Forested areas predominantly covered by trees with close canopy and height reaching 15m and above. It includes the Bobiri Forest Reserve and matured fallow lands in the surrounding landscape.
Open forest	These are areas predominantly covered by tress with or without close canopy less than 15m height. Citrus and cocoa farms and other tree plantations such as teak are included in this category. It also includes areas where timber extraction activities are on-going.
Farmland	Areas covered with a mixture of staple crops that include maize, plantain, cocoyam, rice and cassava on a single plot of land in the study area.
Oil palm	Areas predominantly covered with oil palm plantations (*Elaeis guineensis*) on single plot of land in the study area.
Built-up/ bare	Areas dominated with buildings, roads and other human infrastructure, as well as exposed soils resulting from human activity or natural causes.

Adopted and modified from Asubonteng 2007.

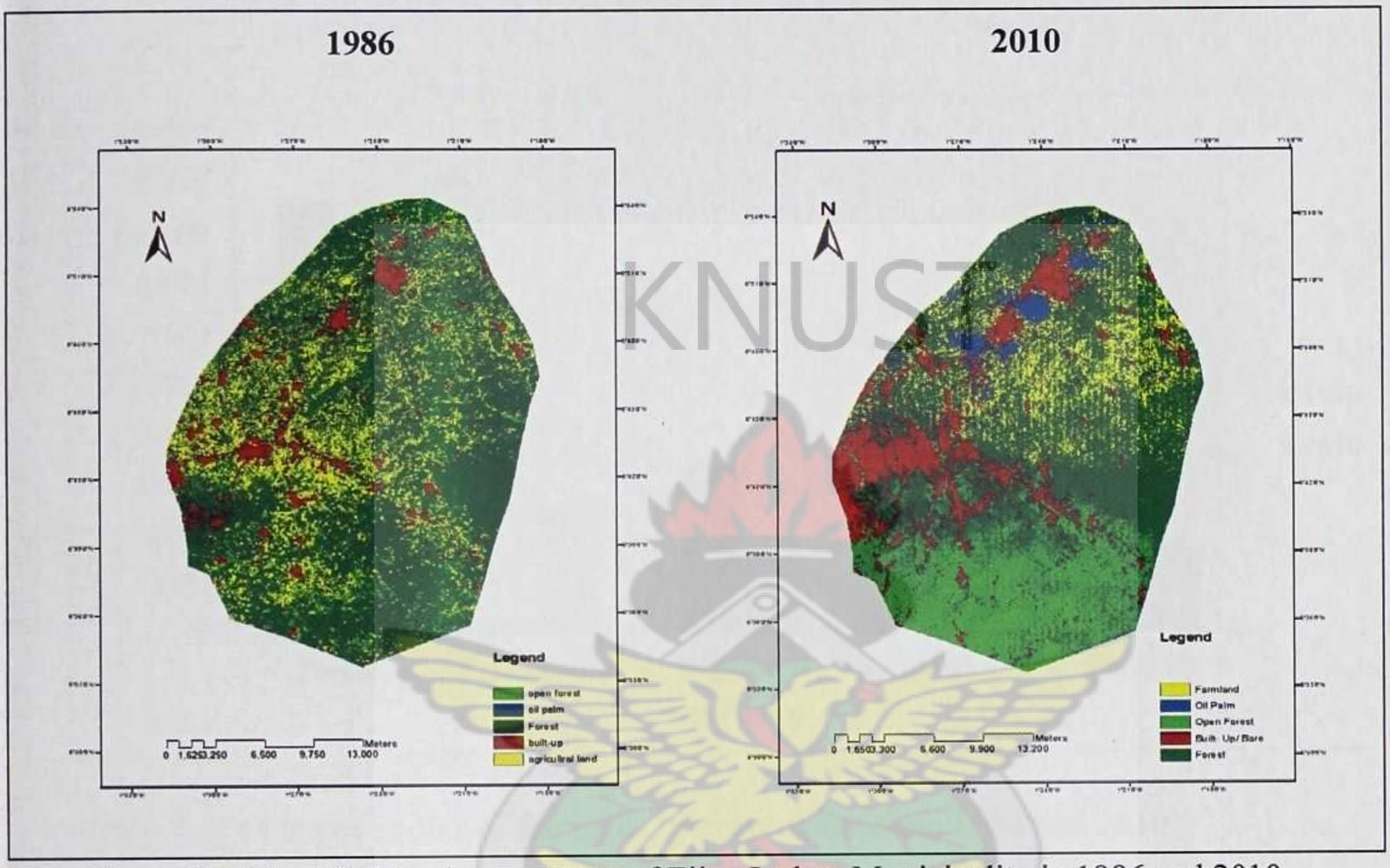

Figure 3.1 Classified land cover maps of Ejisu Juaben Municipality in 1986 and 2010

According to the 1986 land cover thematic map (Figure 3.1) above, table 3.2 and figure 3.2 below; forest is the most dominant land cover type (65.2%) and it is predominantly found in the northern, eastern and southern parts of the study area. These areas have relatively less of human activities. Farmland occupies 25.2% of total land area and it is spread around the built-up/ bare areas which occupies 7.2% of the study area. Oil palm covers the least (0.6%) area of land and it is distributed evenly in the entire study area. Open forest is predominantly found in the southern part of the study area and occupies 1.8% of the entire land used for this research.

In reference to the 2010 land cover map (Figures 3.1), Table 3.2 and Figure 3.2 below, forest occupied 46.9% of the entire study area. Forest is dominant in the northern and eastern parts of the study area. Open forest occupies 19.3% and is very prevalent in the

southern part of the study area. Farmland (14.9%) is found in the central and north-eastern part of the study area. Built-up/ bare (13.7%), is prevalent in the western and northern part of the study area. Oil palm is the least (5.2%), and found as homogenous patches. It is in close proximity to built-up/ bare and predominantly found in the northern and north-western parts of the study area.

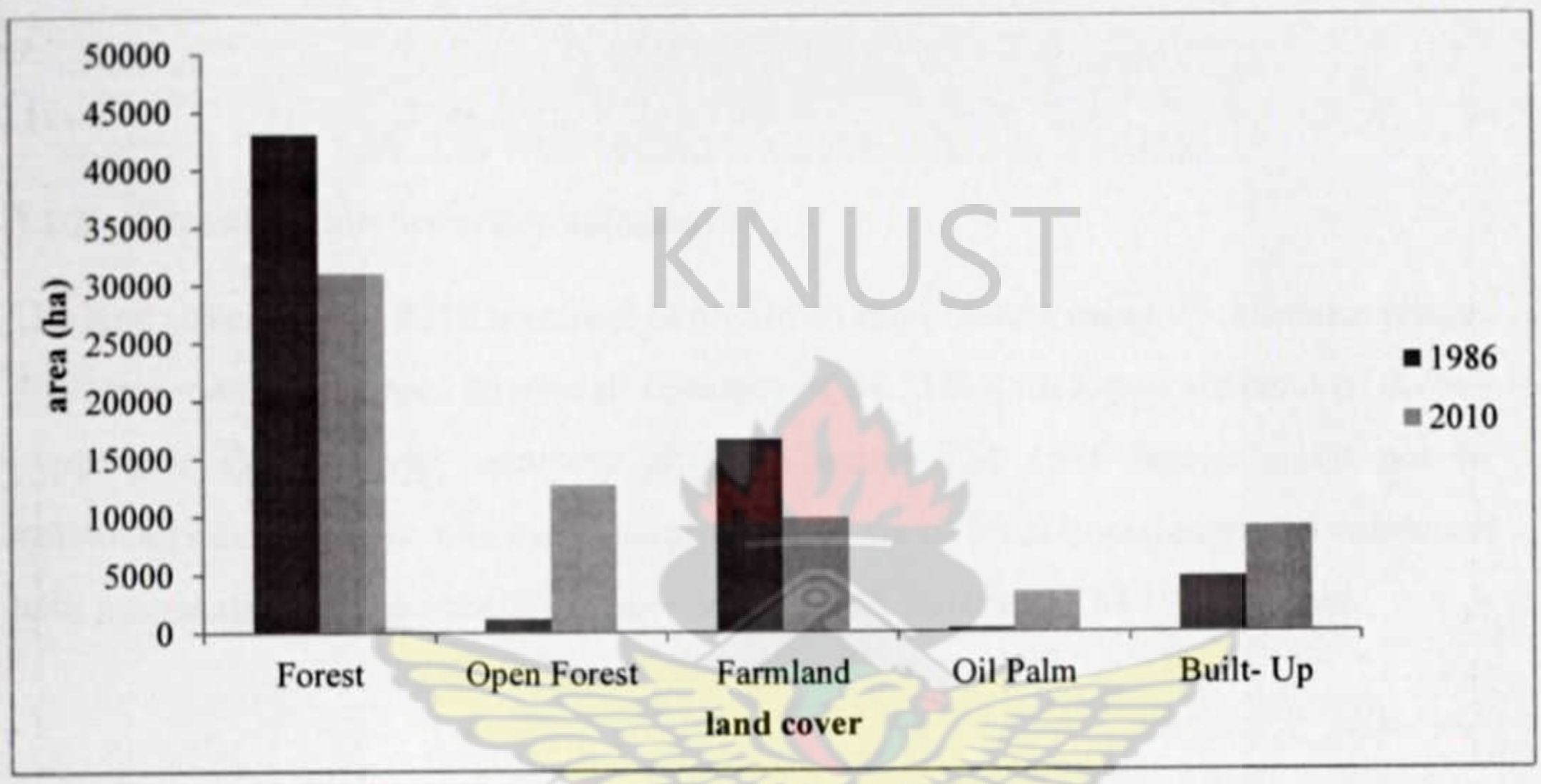

Figure 3.2: Changes in size of the land cover types between 1986 and 2010.

Table 3.2: Land cover change matrix

Land cover classes	1986		2010		Difference	
	ha	%	ha	%	Ha	%
Forest	43123.9	65.2	31081.6	46.9	-12042.3	-27.9
Open forest	1213.3	1.8	12754.2	19.3	11540.9	951.2
Farmland	16656.6	25.2	9895.4	14.9	-6761.2	-40.6
Oil palm	363.8	0.6	3436.2	5.2	3072.4	844.6

Land cover classes	1986		2010		Difference	
	ha	%	ha	%	Ha	%
Built-up/ bare	4766.3	7.2	9046.4	13.7	4280.1	89.8
Total	66213.9	100.0	66213.8	100.0		

3.1.2 Classification accuracy assessment

The land cover map of 2010 was used to obtain an error matrix using 95 reference points. The error matrix produced an overall accuracy of 84.21% with kappa statistics of 0.7668 (Appendix 3). However, accuracy of the Landsat TM 1986 image could not be statistically assessed but was ascertained with the use of local knowledge and validation with information on ''no change areas'' in the ETM 2010 and TM 1986 images.

3.1.3 Land cover conversions between 1986 and 2010

The comparison between 1986 and 2010 land cover maps revealed various degrees of changes in the study area resulting from multiple transfers among different land cover classes. Generally, all five land cover types experienced various degrees of change in size from 1986 to 2010.

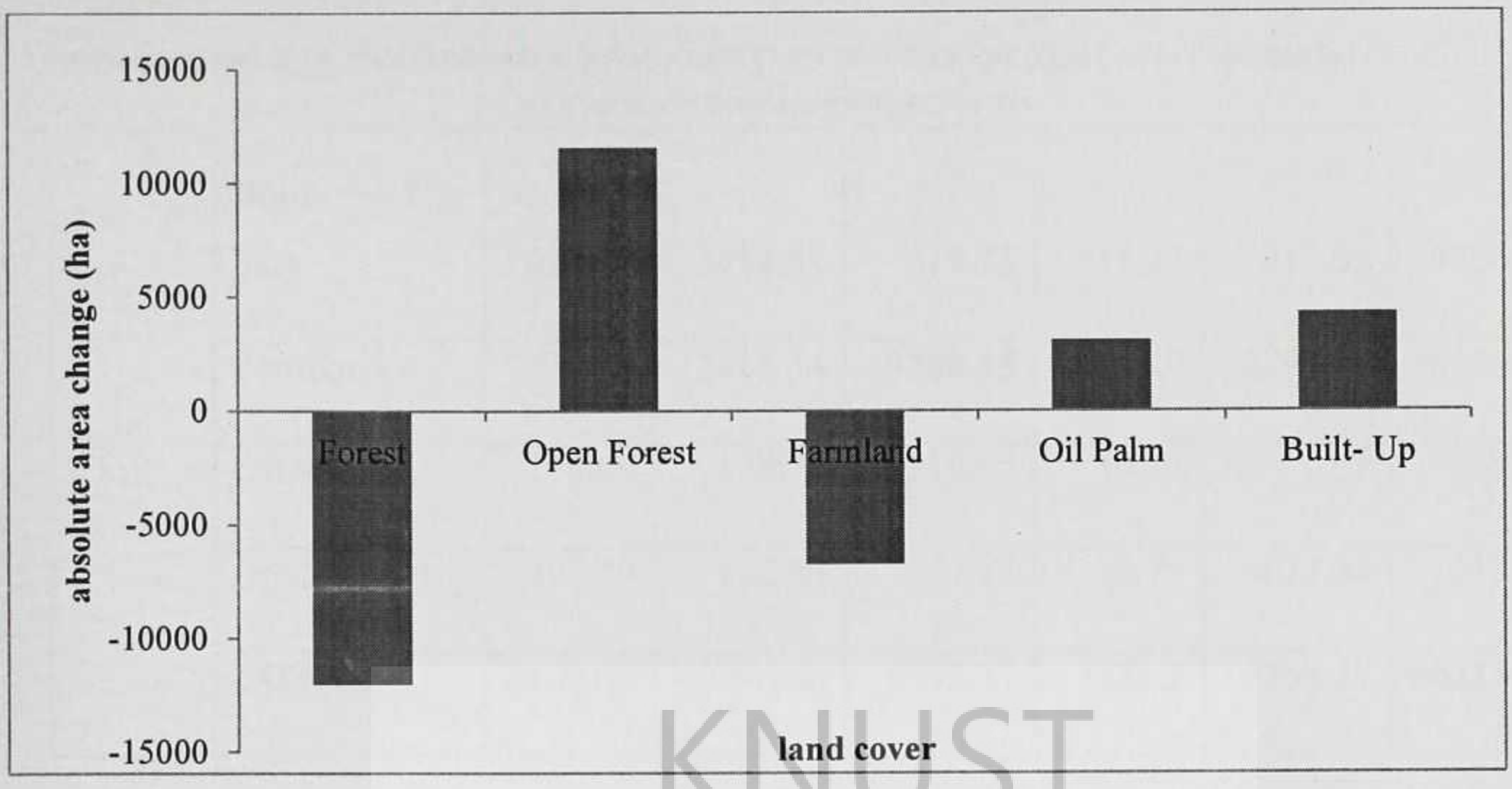

Figure 3.3: Individual land cover size contributions to total change from 1986 to 2010

Table 3.2 and Figure 3.3 shows that forest and farmland decreased in size whiles the remaining three land cover types; open forest, built-up/ bare and oil palm increase in size from 1986 to 2010. These three land cover types increased in size over the 24 years period at various degrees. Oil palm plantations experienced a tremendous increase from 363.78 ha in 1986 to 3436.2 ha in 2010. Forest decreased in size by 27.9% from 43123.9 ha in 1986 to 31081.6 ha in 2010.

The diagonals of Table 3.3 shows proportions of the land cover types that remained unchanged and formed 43.7% of the total area under consideration. The major land cover conversions from 1986 to 2010 in the study area are spatially represented in Figure 3.4.

Table 3.3: Land cover conversion matrix

	2010						
	Landcover	Forest	Built-Up/ bare	Farmland	Oil Palm	Open Forest	**TOTAL**
1986	Forest	**21901.6**	3398.58	6125.31	2174.58	9613.8	43213.87

Built- Up/ bare	1021.68	**3072.51**	319.23	135.27	217.62	4766.31
Farmland	7576.47	2414.34	**3288.15**	1079.28	2298.33	16656.57
Oil Palm	174.06	28.35	119.97	**40.32**	1.08	363.78
Open Forest	407.79	132.66	42.75	6.75	**623.34**	1213.29
TOTAL	31081.6	9046.44	9895.41	3436.2	12754.17	**66213.82**

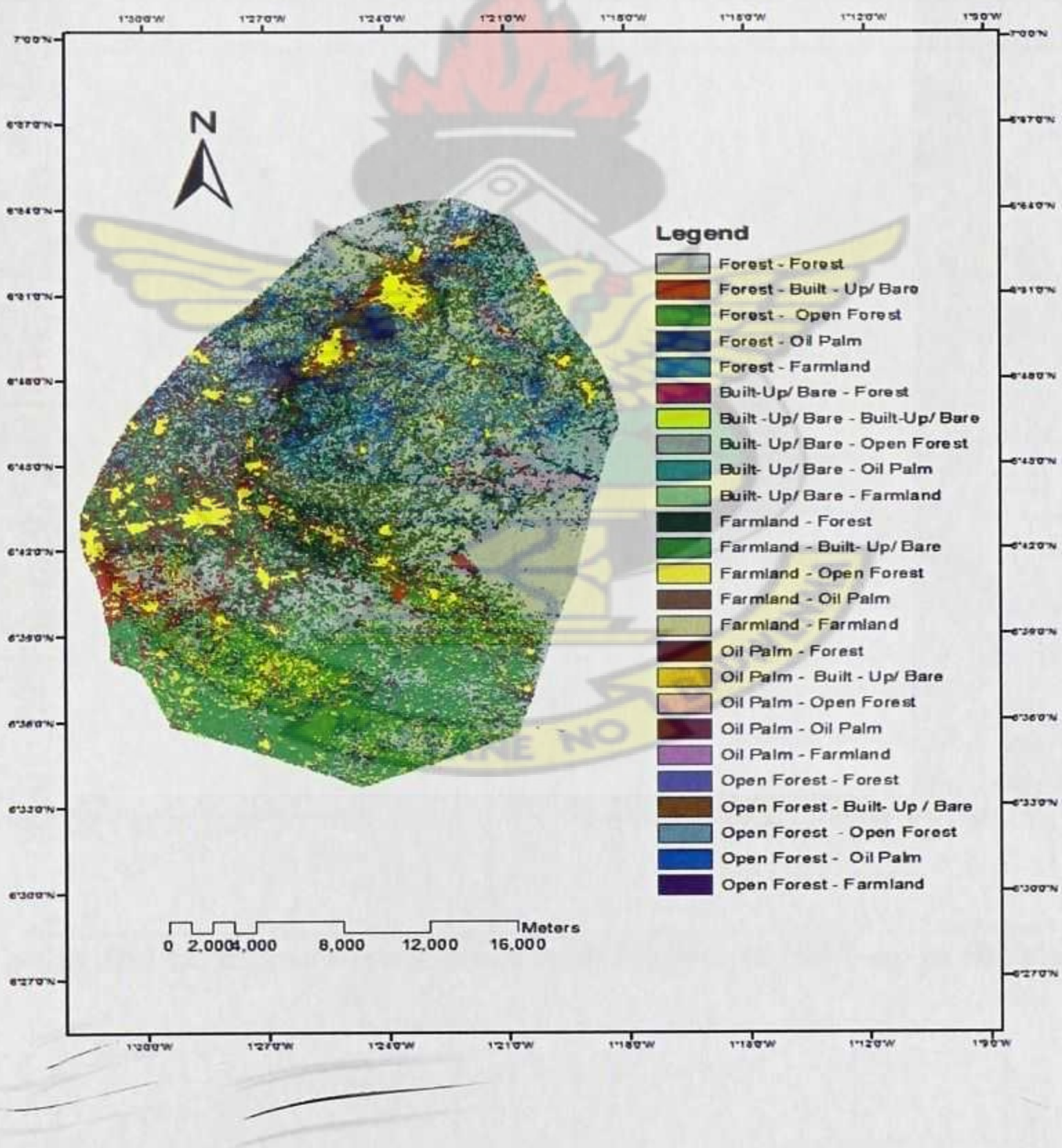

Figure 3.4: Major land cover conversions in Ejisu Juaben Municipality from 1986 to 2010

3.1.4 Spatial distribution of oil palm and farmland with respect to built-up

The survey (questionnaire) revealed that farmers preferred to cultivate their oil palm farms close to roads and built-up area for easy transport of produce during harvest periods. It was also evident from the survey that almost every oil palm farmer also cultivated some annual staple food crop mostly close to their oil palm farms. This is evident as the 2010 map (Figure 3.5) spatially represents the claim. However, the 1986 map shows an even distribution of oil palm in the entire study area in relatively smaller areas. Farmlands on the other hand are also close to built-up areas.

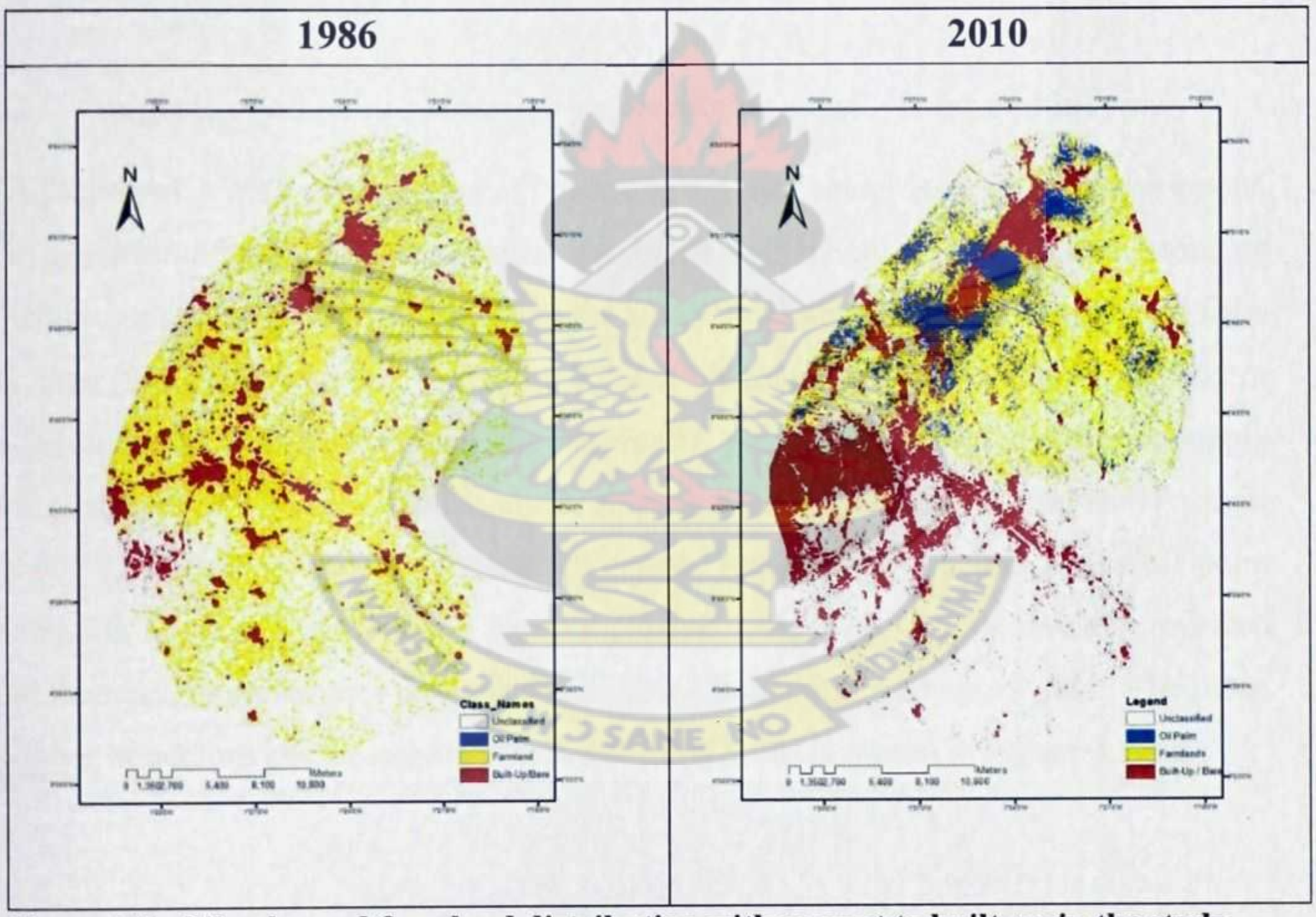

Figure 3.5: Oil palm and farmland distribution with respect to built-up in the study area.

3.2 Socioeconomic impacts of oil palm plantation

Quantitative data obtained from the survey confirmed that agriculture and its related activities such as basketry, broom making, hunting, gathering, etc. as the main means of subsistence at the study sites. With a vast 80% contribution to total household income

levels, investment in agriculture (mainly cocoa, oil palm, rice and staple food crop farming) is a viable means of mitigating poverty, reducing rural-urban drift and improving food productivity and supply at the study site. There were clear indications that the expansion of oil palm plantations at the study site has had profound and tremendous positive impact since its inception in the local communities. Notable among the identified benefits from the respondents were increased employment/ income opportunities, improved infrastructural development, and increased land value. This notwithstanding, expansion of oil palm plantations according to the locals in the affected communities have had significant negative impacts on environmental or ecosystem services, land access for other agricultural activities and food production in general.

3.2.1 Impacts of oil palm plantation expansion on employment and income.

Employment - With unemployment becoming a major social issue to the government, the inception of the oil palm business has made tremendous contribution to reducing unemployment rates particularly among the youth. Sources of information gathered from the interview confirmed that more than 75% of the total rural population are directly or indirectly employed in the cultivation, harvesting, processing, marketing and the supply chain aspects of oil palm plantation development. Meanwhile, in all the study zones; Juaben East, Juaben West, Atia and Odumase, males generally had larger oil palm plantation farms compared to the females (Figure 3.6). However, the research revealed that there are more females than males per house hold employed on oil palm. The mean number of persons per household employed on oil palm is shown in Figuer 3.10.

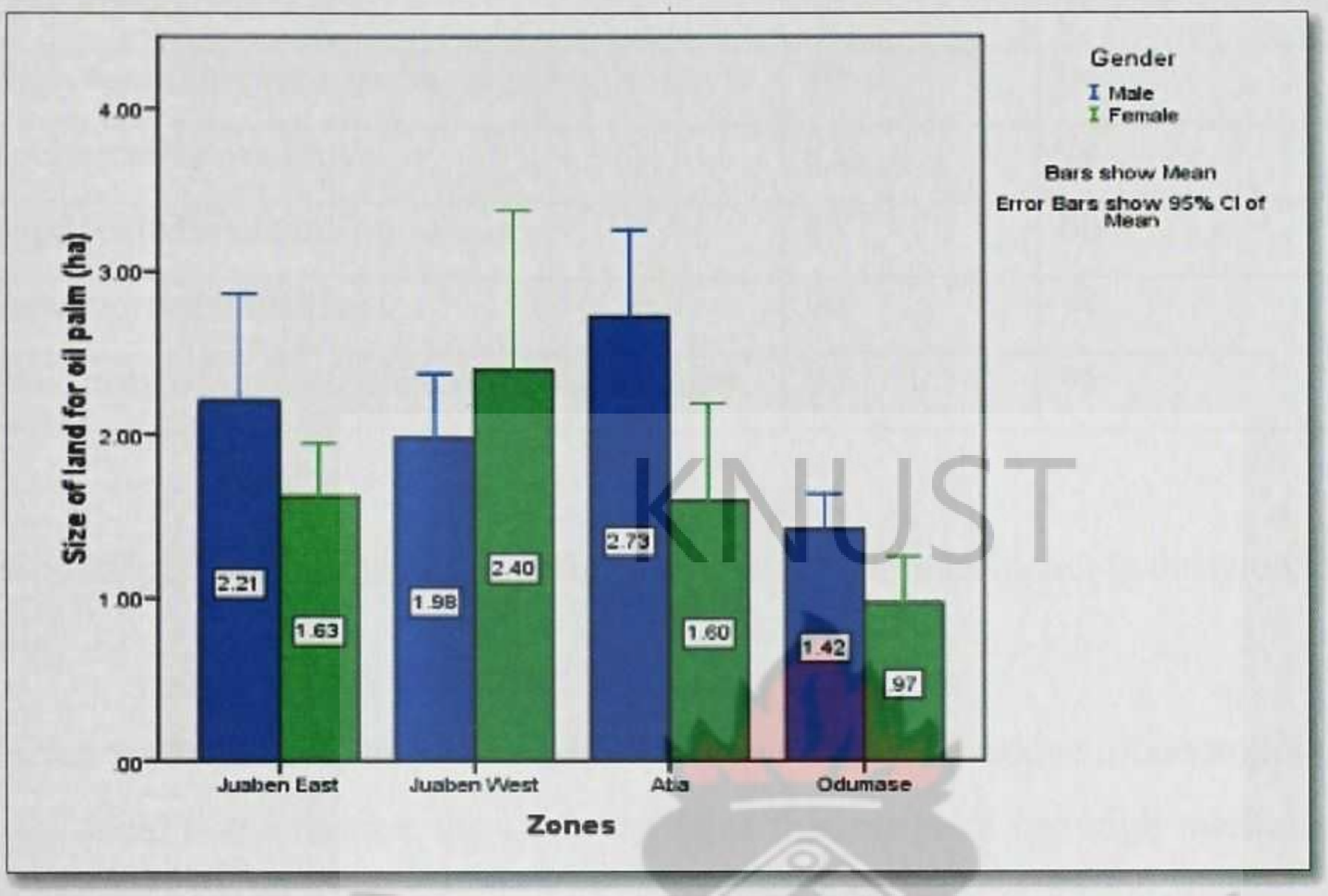

Figure 3.6: Sizes of land invested in oil palm plantations at various study zones

The study revealed that at least 70% of people in every household are directly employed in oil palm plantation. With the private businesses employing just a few of the locals in the processing and marketing of oil palm products, the majority of the rural population have 100% sole ownership or partnership (the different land tenure described in chapter 1) with other local folks at the farm production or plantation level. A complete shift from staple food crop production to oil palm production was evident among the local communities with males in the majority (Figure 3.6). The research revealed that a number of factors actually motivate the local communities into oil palm farming rather than other farming systems. The identified factors motivating the increased adoption of oil palm plantation among the local communities are shown in Table 3.4

Table 3.4: Factors influencing decision to adopt oil palm plantation

Factor	**Percentage of respondents (%)**			
	Juaben East	Juaben west	Atia	Odumase
Market value for oil palm	80	76	92	89

Factor	Percentage of respondents (%)			
	Juaben East	Juaben west	Atia	Odumase
Reduced risk of losses	71	67	72	80
Low management cost	58	72	71	66
High economic returns on oil palm products	90	94	90	90
Technical-know-how	83	74	77	72
Support from extension officers	85	80	81	78
Provision of incentives	90	94	90	88
Proximity of farm to processing mill/ home.	95	95	87	80

Respondents' reasons assigned to the motivating factors influencing decision to adopt oil palm:

Market value for oil palm – compared to other dominant arable monocropping systems in the local communities, the study revealed that oil palm has high market value both locally and abroad.

Reduced risk of failure or losses – unlike annual crops used in most indigenous cropping systems, oil palms when well established show relatively long resistance to drought, fire, diseases and relatively poor soil conditions which are prevalent in the study areas. This notwithstanding, the initial establishment requires intense agronomic cultural practices that could be labour demanding.

Low management cost – with reduced disease infestations and increased resistance to poor soil conditions and drought, oil palm management are relatively cost-effective when fully established.

Technical know-how – farmers are comfortable with their level of technical management skills in the oil palm business. Private enterprises directly dealing with farmers provide training support to farmers by employing extension officers.

Provision of incentives – with the Juaben Oil Mills (JOM) as the main plantation company in the area, incentives in the form of improved seedlings, insecticides, and transport for transporting the produce is provided by the company.

Proximity of farm to processing mills/ home – with JOM as the main processing mill/ company in the area, transporting of produce to the mill is very smooth due to the good roads leading to the Juaben Township. The fact that almost all the communities within the various zones are relatively closer to Juaben is thus a contributing factor.

Income - The study revealed that income generation from oil palm plantations was more than four times that derived from staple food crop production (Figure 3.7). Males generally had higher incomes from the oil palm plantation whiles females enjoyed higher incomes from the staple food crop production (Figure 3.7). As depicted in Figure 3.8, majority of farmers engaged in the oil palm business earn above GHS2000 per annum whiles the majority of staple food crop growers earn less than GHS1000 per annum. Although farmers are engaged in other secondary income generating activities such as basketry, broom production, etc., these incomes generated are earnings classified under those earnings from oil palm. Figure 3.9 shows detailed representation of sizes of land put into oil palm and annual staple food crops (farmland). Annual income of average persons per household employed on oil palm is shown in Figure 3.10. The study revealed that majority (74%) of oil palm farmers earn above GHS1000 per annum from their oil palm farms whiles the remaining 26% receive less than GHS1000 (Figure 3.11).

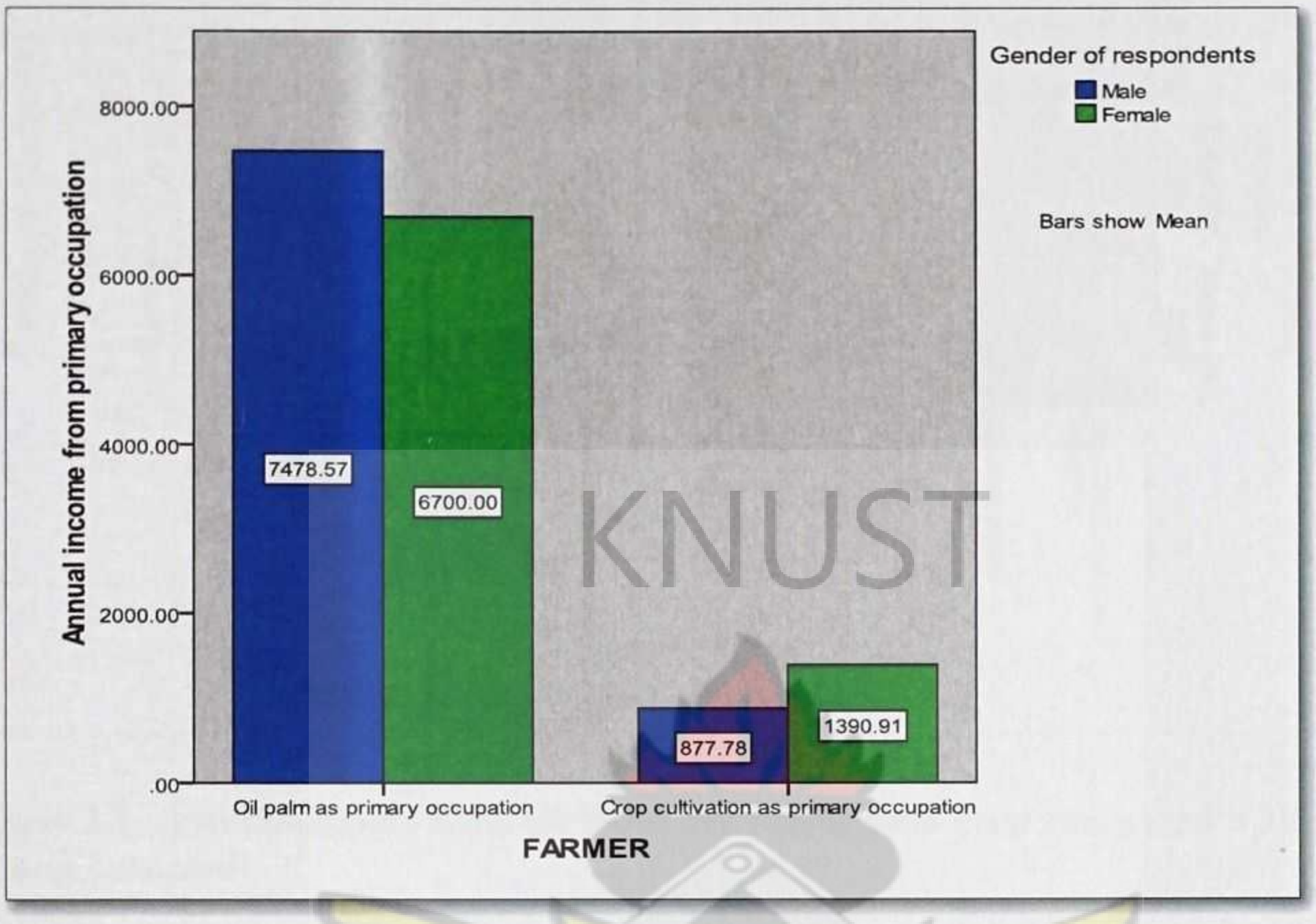

Figure 3.7: Annual income (GHS) from oil palm plantation and staple food crop production

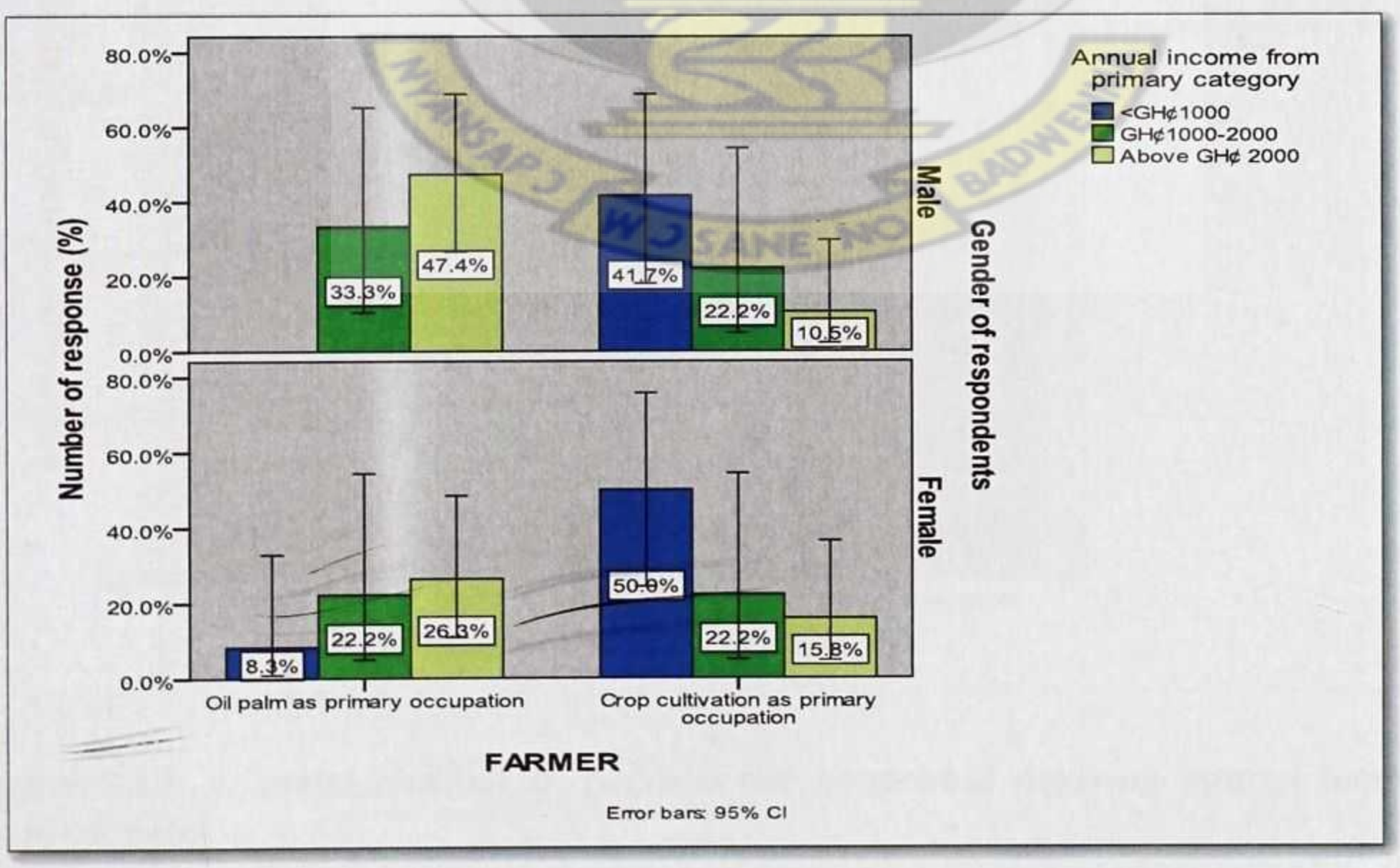

Figure 3.8: Detailed annual income of respondent from oil palm and staple food crop

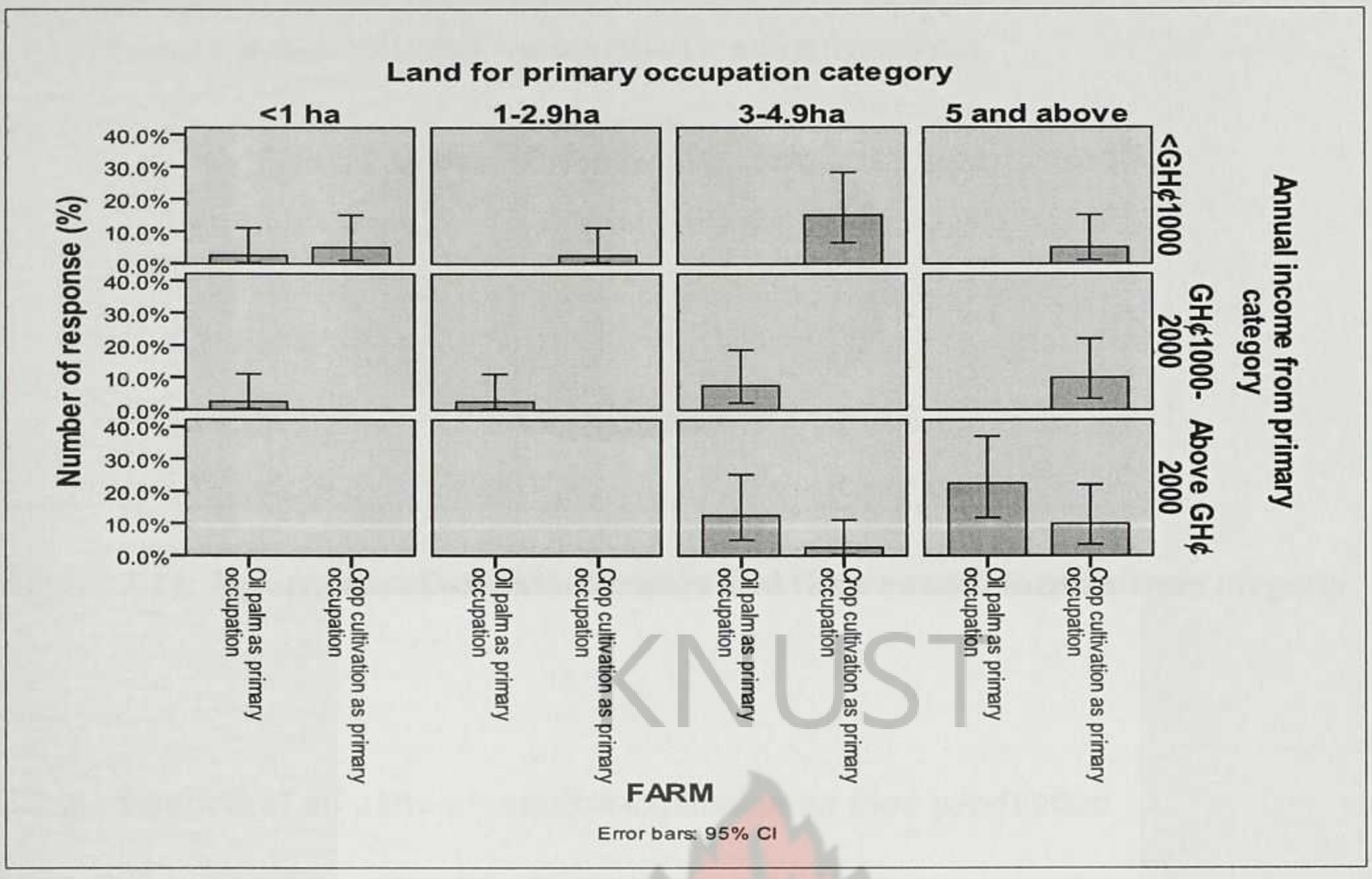

Figure 3.9: Annual income from oil palm and staple food crop compared with size of land occupied.

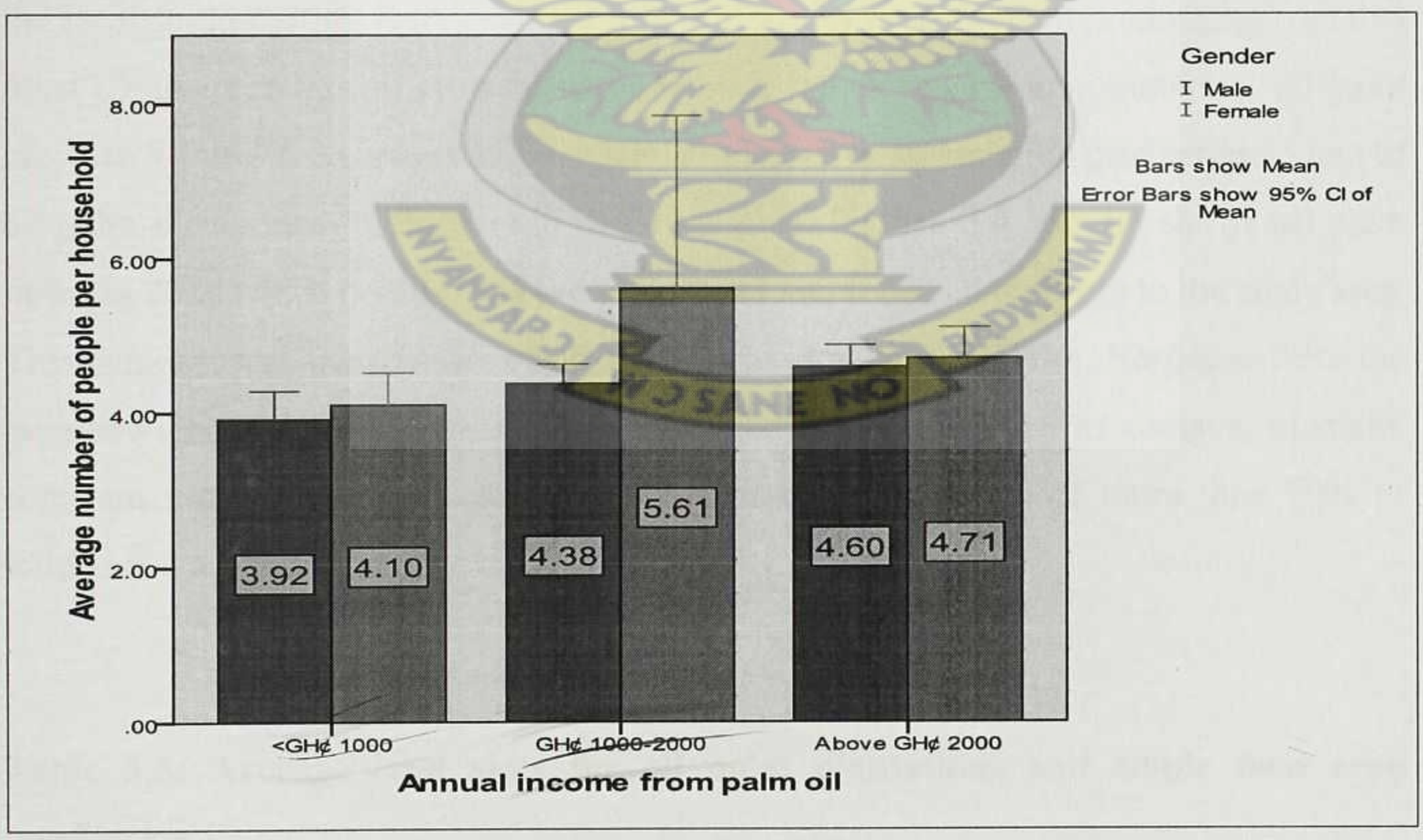

Figure 3.10: Average number of persons per household deriving annual income from oil palm

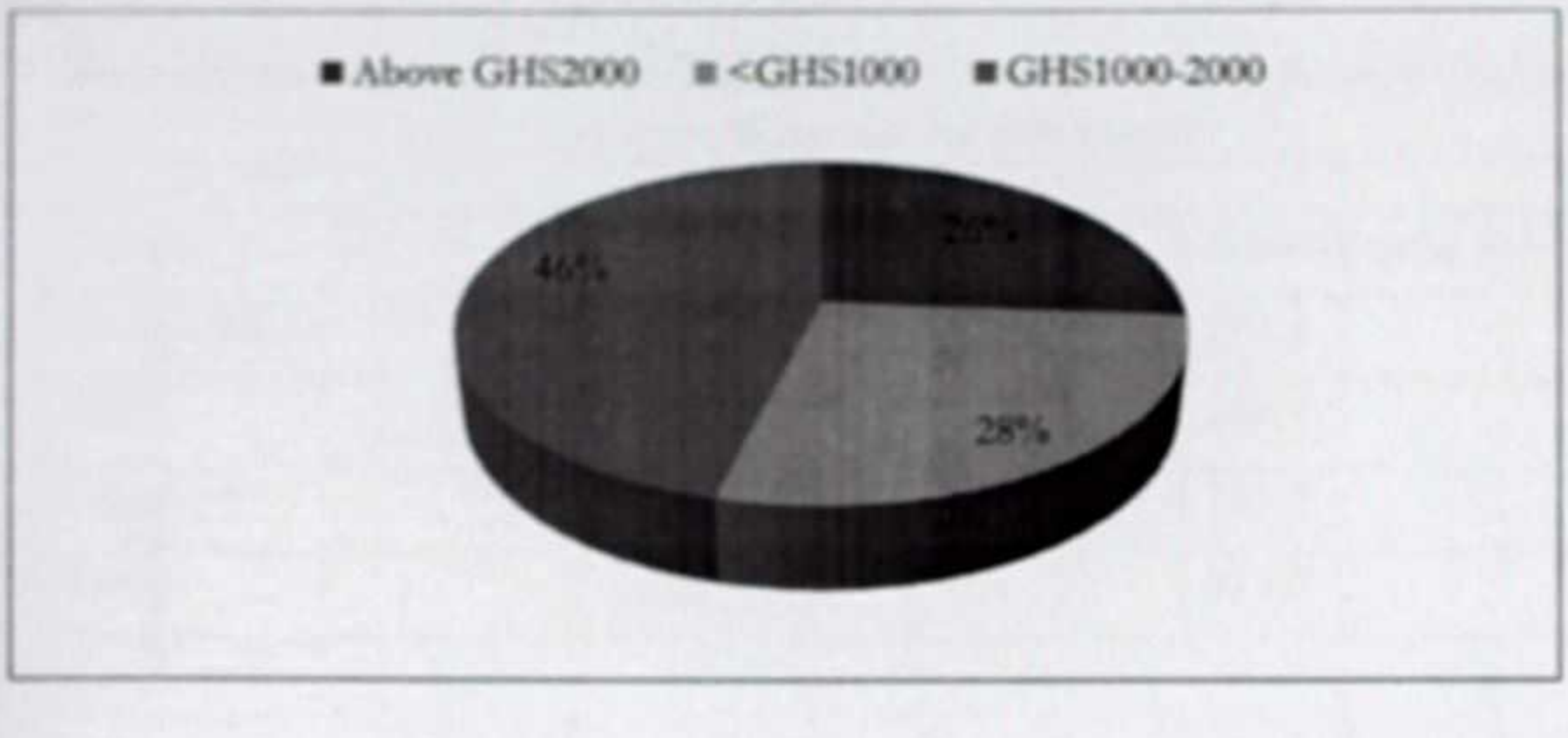

Figure 3.11: Percentage of oil palm farmers and their annual income from oil palm.

3.2.2 Impacts of oil palm plantation expansion on food production

With increased interest in oil palm projects, investments in annual staple food crop productions have reduced dramatically. Larger proportions of lands (6.5%) previously used in annual staple food crop production have been invested into oil palm plantations (Table 3.3 and Figure 3.4). Despite the fact that subsistent agriculture is still prevalent in the local communities, it was evident from the survey (questionnaires administered) that most commercial annual crop farms have been transformed into commercial oil palm projects. Table 3.5 compares average land sizes used in annual crop production to that of oil palm plantations by farmers in the study area. Figures 3.4 and 3.5 shows oil palm farms in 2010 which on the 1986 were farmland and forest cover types in the study area. This demonstrates the transfer of other land cover type to oil palm. Response from the interview showed reduced production of major food crops such as cassava, plantain, cocoyam and maize in the district leading to the importation of more than 60% of foodstuff during market days in the municipality.

Table 3.5: Average land sizes for oil palm plantations and staple food crop production

Zones	Oil palm land (ha)	Annual crop land (ha)
Juaben west	238.08	178.1

Zones	Oil palm land (ha)	Annual crop land (ha)
Juaben East	256.23	201.3
Atia	322.31	244.6
Odumase	230.59	191.9
Total	**1047**	**815.9**

3.3 Oil palm expansion with income and sustainability trends prediction

Income prediction trend - linear model of size of oil palm farm owned by farmers against total annual income of the farmers, total land owned by the farmer against total annual income of the farmers and mean distance travelled from home to oil palm farm by farmers against total annual income of the farmers, revealed the following trends in the correlation and regression graphs of Figures 3.12, 3.13 and 3.14 respectively.

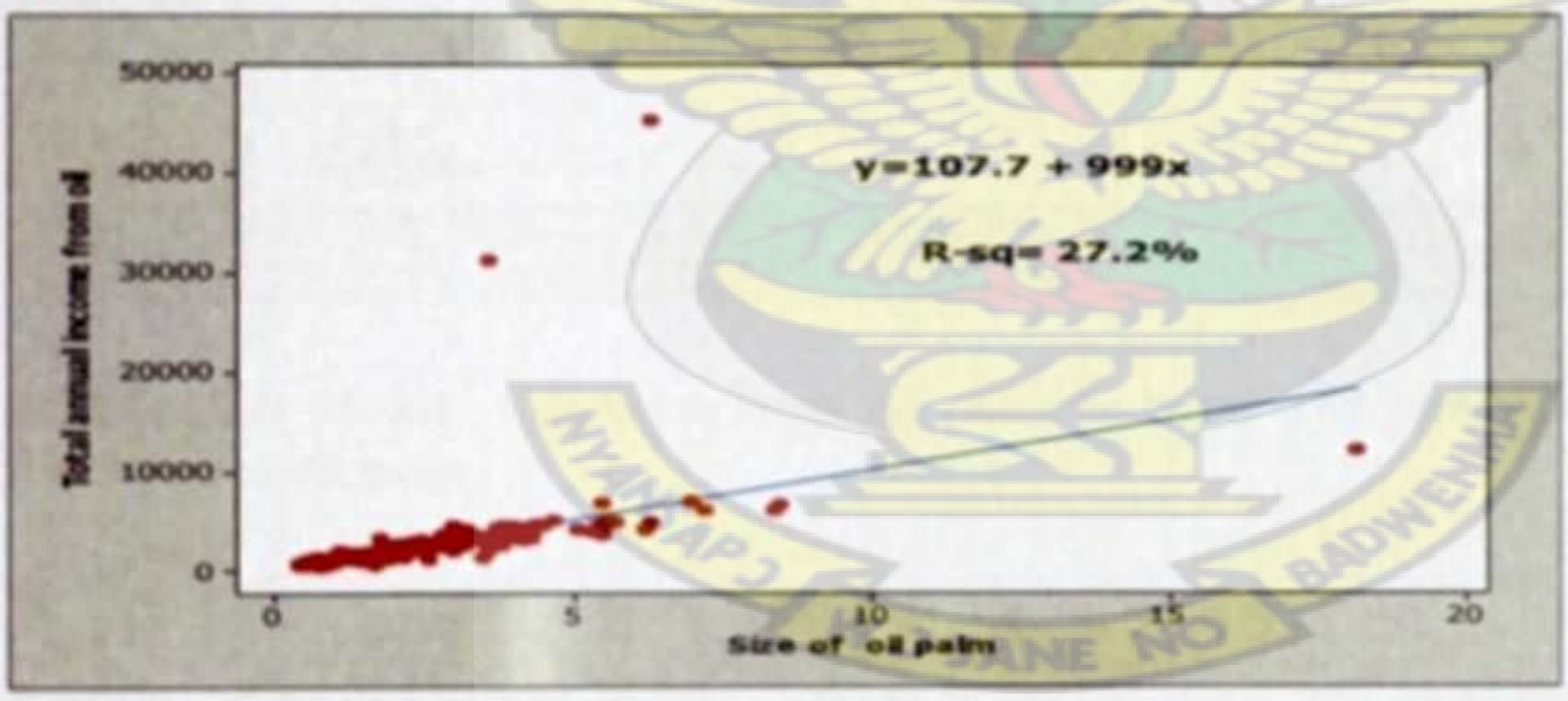

Figure 3.12: Model of size of oil palm farms owned by farmers and total annual income (GHS) from oil palm

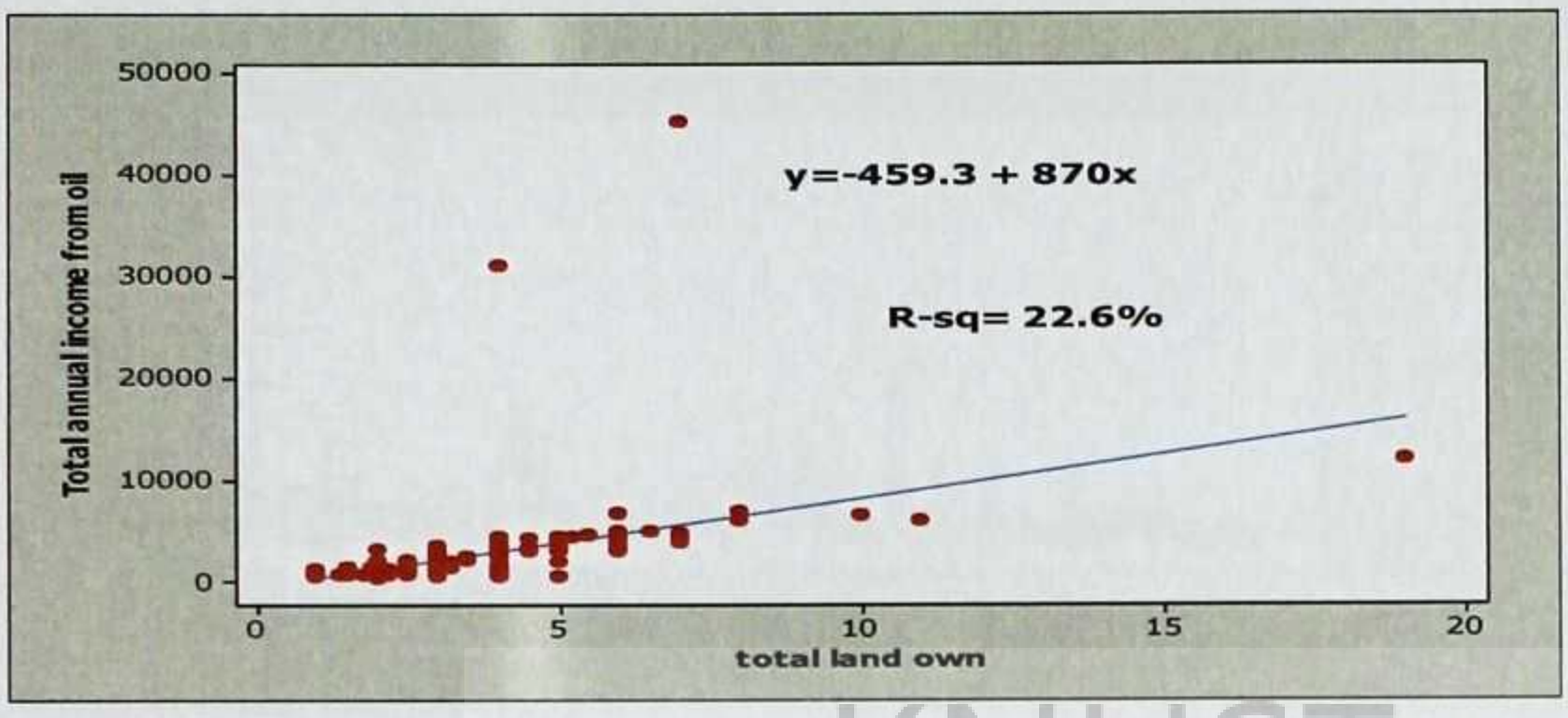

Figure 3.13: Model of total land owned by farmers and total annual income (GHS) from oil palm

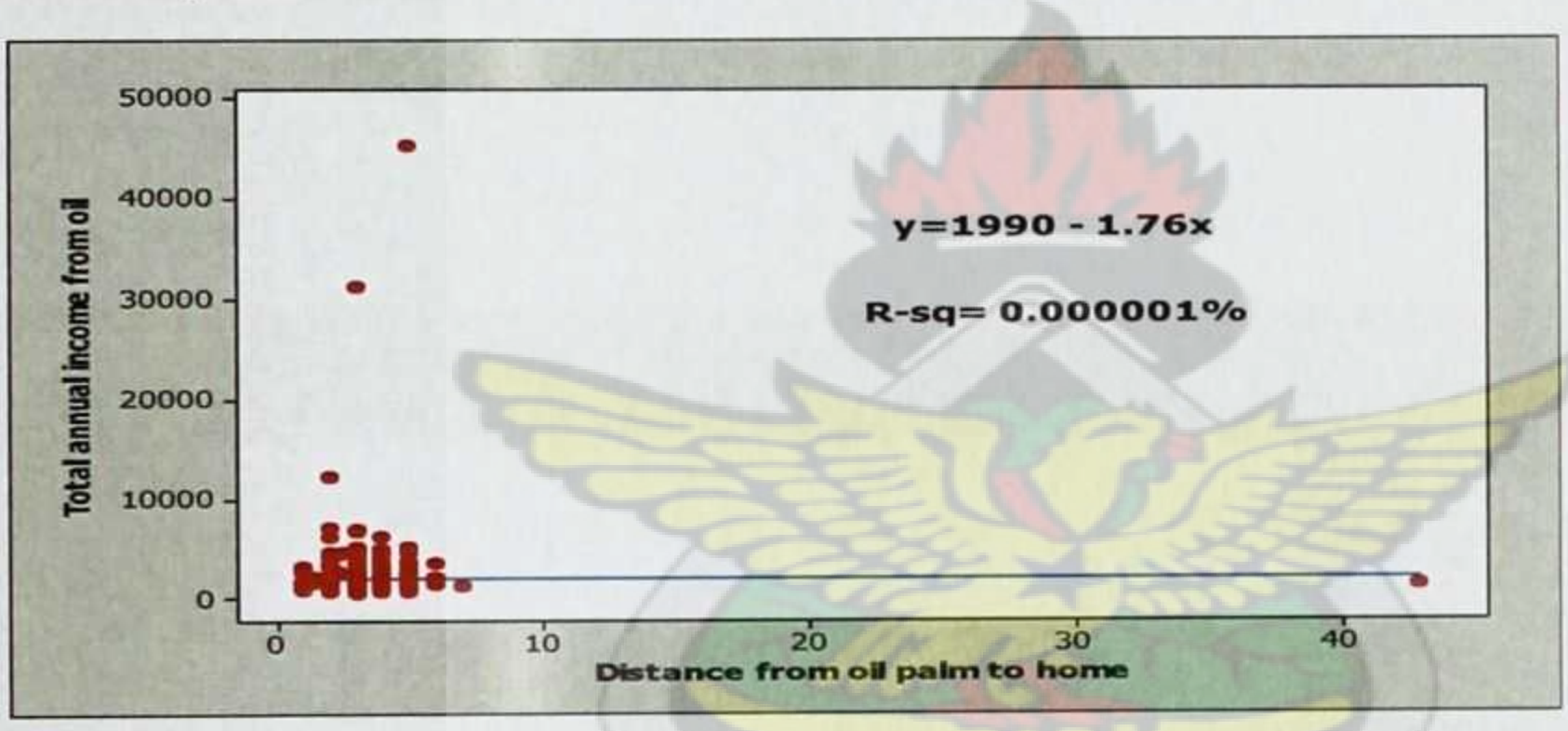

Figure 3.14: Model of distance from oil palm to home and total annual income (GHS) from oil palm

Sustainability prediction trend - similar to the previous, the trend analysis of the expansion in the oil palm plantation development and its sustainability in the Ejisu Juaben Municipality was modelled using the following parameters; size of oil palm farm against time in years, size of total land owned against time in years, total annual income from oil palm against time in years and finally distance travelled from home to oil palm farm against time in years. The above models are demonstrated below in Figures 3.15, 3.16, 3.17 and 3.18 respectively. Figures 3.15, 3.16 and 3.17 revealed a negative trend. However, Figure 3.18 demonstrated a positive trend to explain that the distance that a farmer will have to travel to his/ her farm and for that matter distance to transport produce to the mills will increase over time.

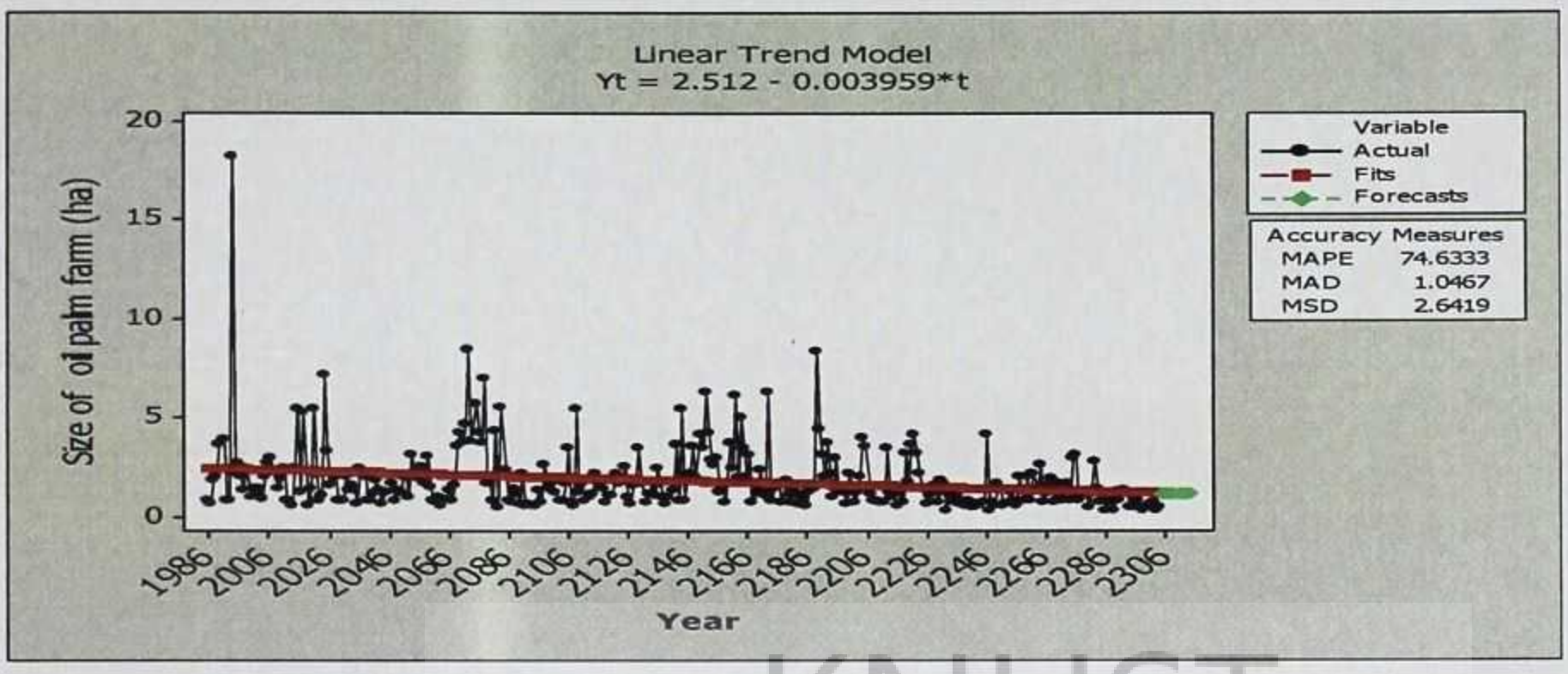

Figure 3.15: Model of distance from oil palm to home and total annual income (GHS) from oil palm

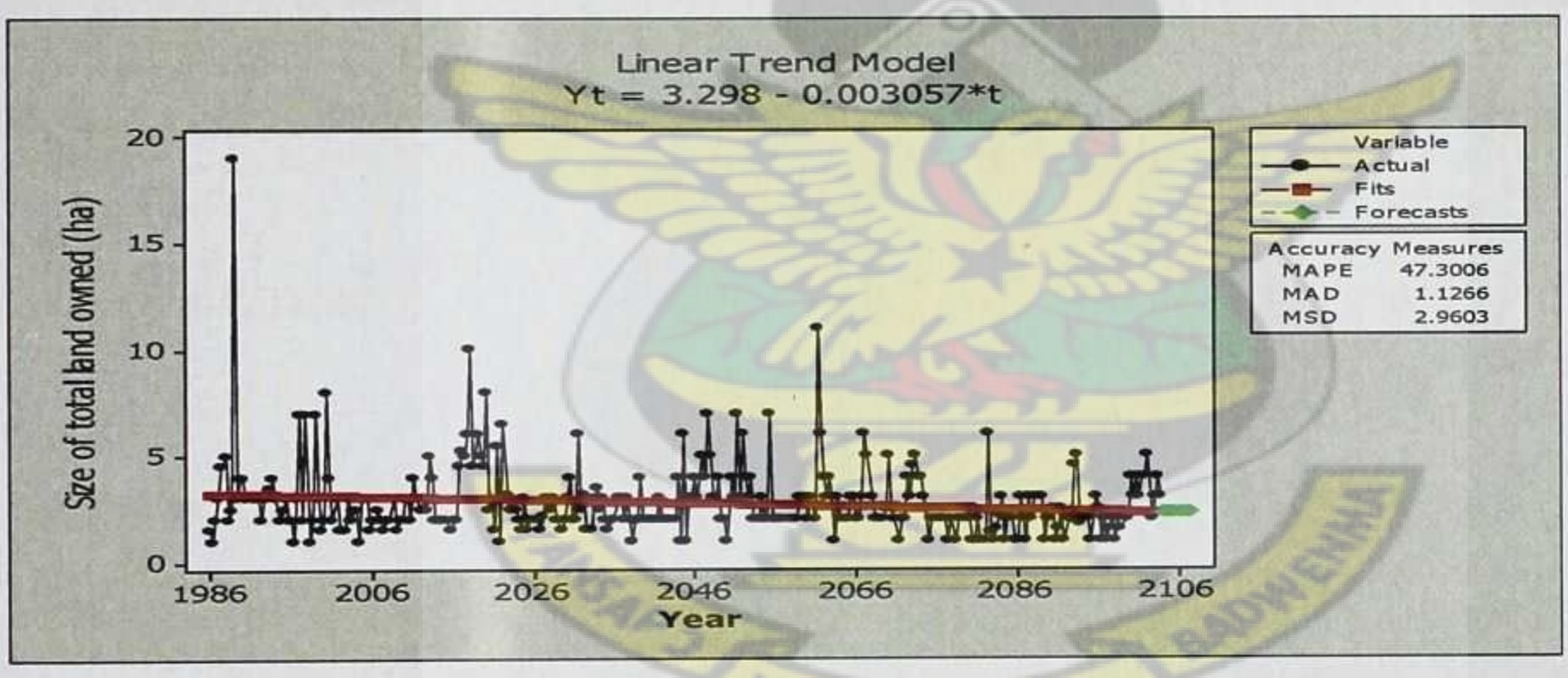

Figure 3.16: Linear trend model of size of total land owned and time in years

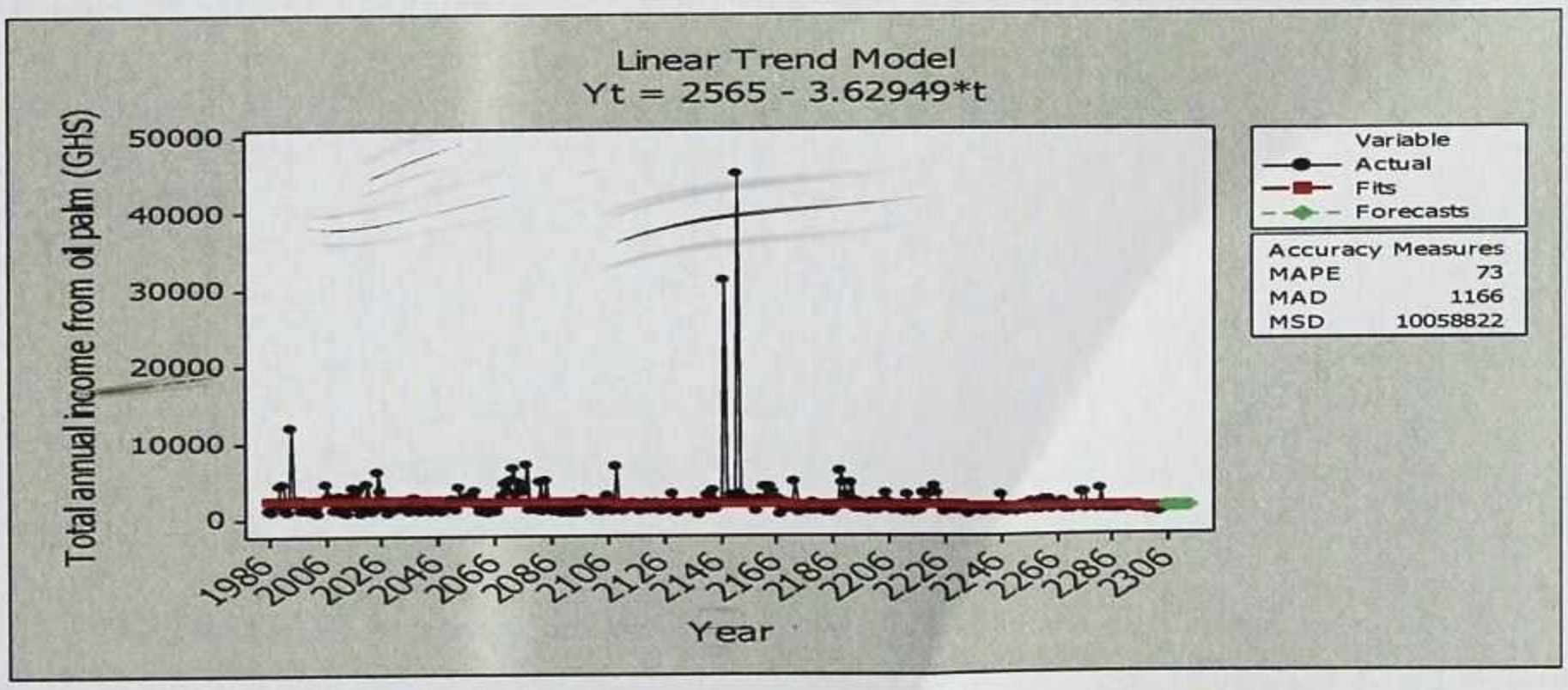

Figure 3.17: Linear trend model of total annual income from oil palm and time in years

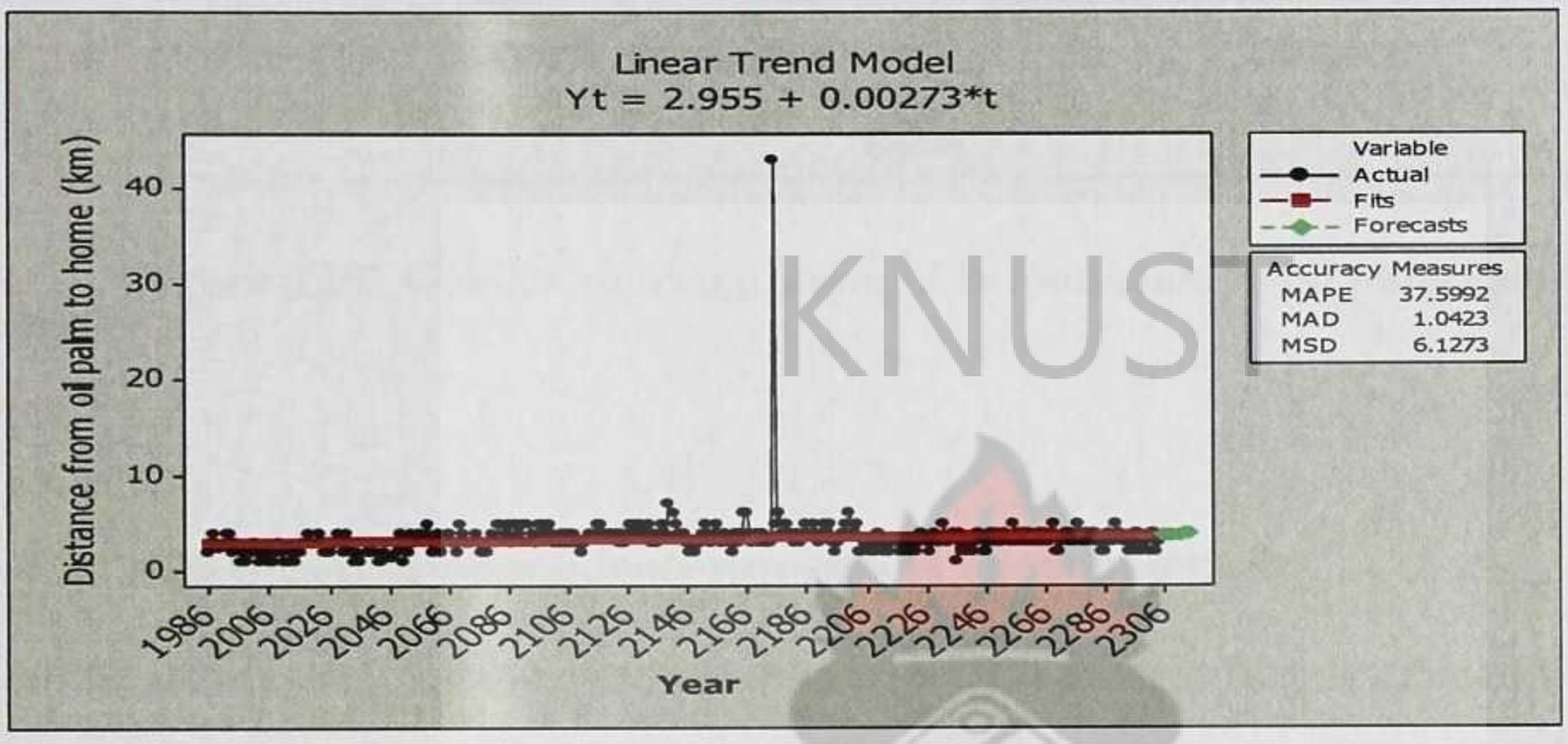

Figure 3.18: Linear trend model of distance from oil palm to home and time in years

3.4 Demography

3.4.1 Gender representation of respondents involved in oil palm farming

In all the zones within the study area both males and females of different age classes were encountered. Figure 3.19 shows the gender distribution of respondents interviewed in the four zones. It was evident from the data that oil palm is highly patronized by males across the four zones. Female participation was less than one-third of the males in most of the zones.

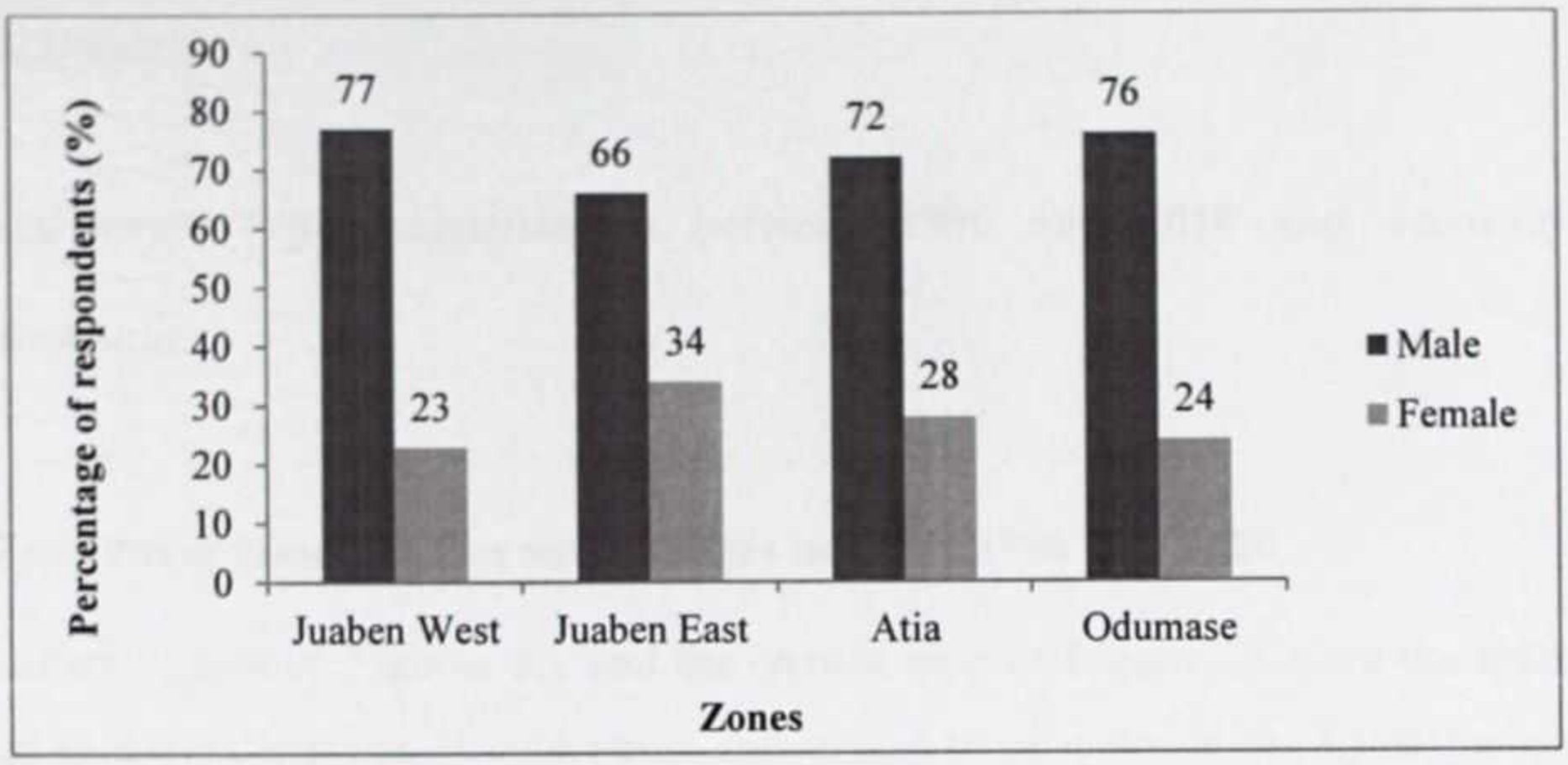

Figure 3.19: Gender representation of respondents in oil palm farming

3.4.2 Age classes of respondents involved in oil palm farming

In all the study sites, age distribution ranged from 30 to above 70 years. Meanwhile, most respondents were between 41 to 50 years across the various zones (Figure 3.20).

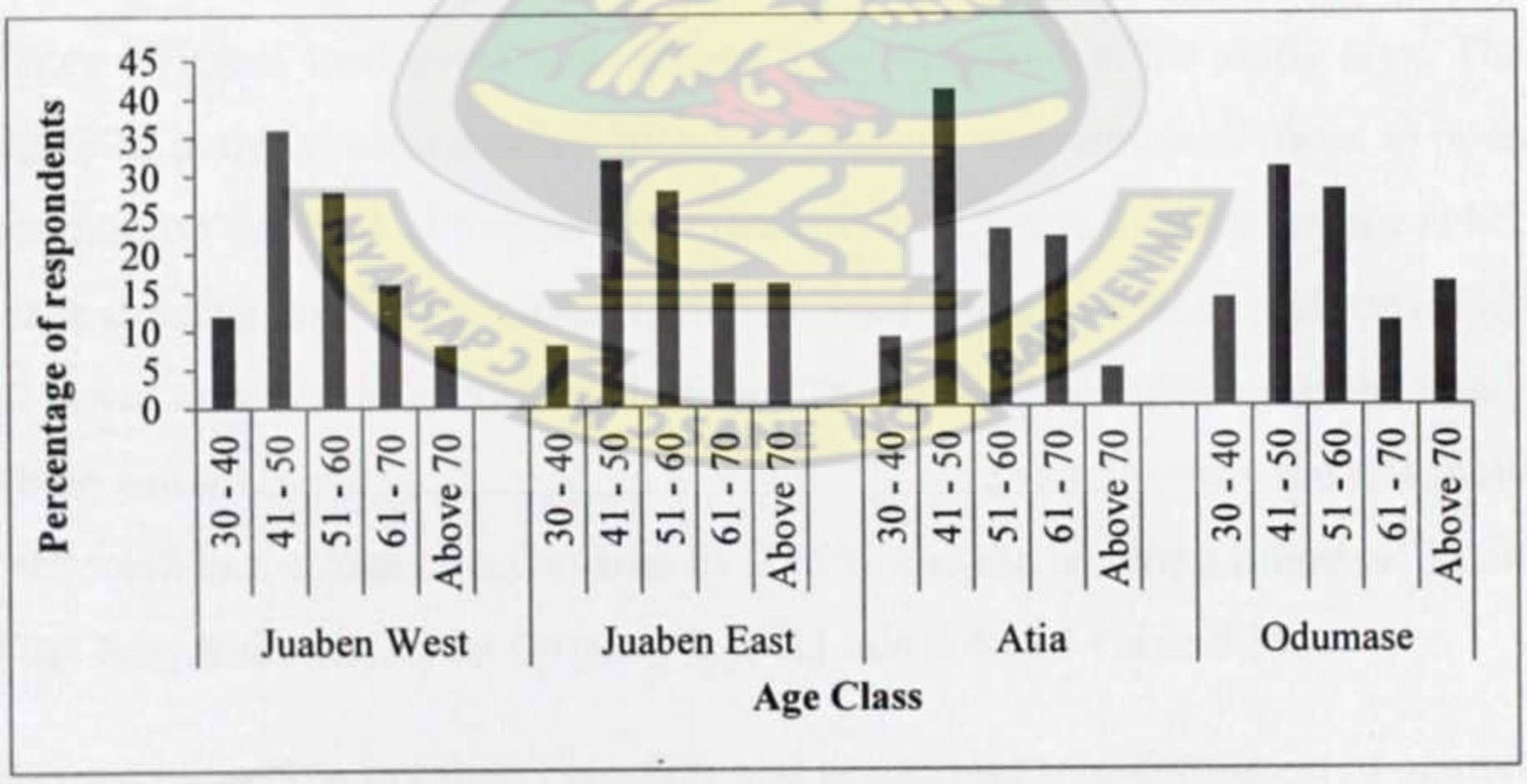

Figure 3.20: Age classes of respondents involved in oil palm farming

4 DISCUSSION

4.1 Land cover types classification between 1986 and 2010 and accuracy assessment

4.1.1 Land cover classification and changes between 1986 and 2010

The classified images of Figures 3.1 and the change map of Figure 3.4 were the main tools used in the monitoring of land cover conversion to oil palm in the Ejisu Juaben Municipality. Over the 24 years (1986-2010) study period, the study area experienced land cover conversions of multifaceted nature mainly due to oil palm, built-up/ bare and open forest expansion. A research by Asubonteng (2007), in the same municipality concludes that agriculture and urbanisation are the main causes of land cover change in the area. Human activities related to urban expansion prevailed more prominently in areas associated with existing settlements and roads (Lo and Faber, 1998). Agricultural expansion activities also featured in close proximity to built up/ bare (Benefoh, 2008). This is confirmed in the socioeconomic survey which also revealed the establishment of oil palm farms close to communities and roads as one of the factors why local adopted oil palm. Three different land cover conversions were observed in the study area. The first was exhibited in the gradual modification and eventual conversion of forest to open forest. Depending on the type of human activities involved, open forest areas are either converted back to forest land or permanently transformed into urban land (built-up). This trail of land cover conversion is commonly found in the southern portion of the study area where both annual staple food cropping and built up/ bare expansions were relatively high. This reflected in the loss of forest area by 27.9% and the resultant increases in oil palm, built up/ bare and open forest (Figures 3.1, 3.3 and 3.4 and Table 3.3).

The second conversion type involves complete and permanent transformation of natural vegetation (forest) to built-up/bare and oil palm which are mainly urban and oil palm plantations respectively. It is generally observed close to existing built-up and agricultural areas especially at the north-eastern part of the study area (Figures 3.1, 3.4 and 3.5).

The third conversion scenario is the gradual transformation of farmland to open forest. This scenario of conversion is generally due to the period allowed for depleted farms to fallow. This is more prominent in the southern part of the study area (Figures 3.1 and 3.4). These observations discussed above confirmed the land cover patterns recognized by Lambin *et al.* (2003), Braimoh (2006), Asubonteng (2007) and Benefoh (2008).

4.1.2 Classification accuracy assessment

The overall land cover classification accuracy of the 2010 Landsat image was 84.21% with kappa statistics 76.7%. The accuracy level of this study was lower than the 85% and 86% classification accuracy standards used by Campbell (2002) and Benefoh (2008) respectively. However, the accuracy of this research was about 8% improvement of the study by Asubonteng (2007) and Sedego (2007). The analysis with kappa statistics revealed that 76.7% of the whole classification was in agreement with the reference data (points) used for the assessment and leaving the remaining 23.3% to chance. Kappa at this level is considered moderate. However, the lower accuracy is due to inherent errors in the field point collected in 2011 to assess the classification of an image taken in 2010. It is worth noting that a good accuracy result is as good as the training area and reference data (Lillesand &Kiefer, 1994). The difficulty in removing haze (Asubonteng, 2007) and line strips from the image is however likely to be a contributing factor. The classification accuracy of the 1986 could not be statistically assessed because of the unavailability of reference data. However, views gathered from the local people on the historical land cover types of the study area coupled with information derived from the ''unchanged'' areas in the 1986 and 2010 Landsat images helped in the rough assessment of the classification accuracy.

4.2 Socioeconomic impact of oil palm expansion

4.2.1 Impacts of oil palm plantation expansion on employment and income

Oil palm expansion increased employment creation in the oil palm growing communities as compared to non-oil palm growing communities. This is evident in the decrease in unemployment figures in the four zones that were considered in the study. This is attributed to the fact that JOM employs over 300 people as permanent and temporal workers. The provision of electricity to the Juaben Health Centre by the JOM has resulted in the upgrade of the health centre to a hospital status. This has directly and indirectly created employment for the people in the area. Expansion in the transport business and improved infrastructural development including schools, roads, good housing, telecommunication, etc. has brought about a reduction in the rural-urban migration because of the employment created during the construction stages and permanent work at these places. Lo and Faber (1998) suggested that adequate income, decent housing, education, health services and good physical environment are important indicators of social well-being and quality life. The finding above confirms the outcomes of the study by McCusker et al., (2006). A research conducted by Jurgens et al., (2010), in Indonesia confirmed that the expansion in oil palm also yield indirect or national level poverty alleviation benefits through government allocation of tax revenue and increased foreign exchange earnings. This is consistent with the findings in this research at Ejisu Juaben Municipal of Ghana.

Statistics from the World Food Programme has shown that average peasant (food crop) farmers in the country earn and depend on less than one (1) US Dollar per day. However, Figures 3.7, 3.3 and 3.9 have demonstrated that the annual income of oil palm farmers was more than four times that earned by these annual staple food crop farmers. The annual income of above GHS1000 generated from oil palm by farmers is expected to contribute to the improvement in the standards of living. This amount exceeds the minimum wage payable to those employers of the service sector. The 2010 Ghana Government Budget read to the Nation reveals the above claim (Ministry of Finance and Economic Planning, 2010). A study by Kessler et al. (2007) assessed the socioeconomic

impact of selected agro-commodities in several production countries and the outcome of their study corresponded with the findings of this research. However, Jurgens et al., (2010), concluded from their research on oil palm expansion in Indonesia that the quantitative data on socioeconomic benefits are few and those that exist are not conclusive.

In Ghana males are heads of their families and as such greater responsibilities of providing funds for the family lies on them. It is therefore expected that male farmers earn enough to be able to take care of their families. The results of the research in Figure 3.8 demonstrate that the earnings of all male oil palm farmers is above GHS1000 per annum whiles some females earn less than GHS1000. This is to explain that males earn more income than female in the oil palm farming as a business. This finding from the study thereby puts the male farmers in a position to be able to shoulder their responsibilities in their families. Also to note is that majority (74%) of oil palm farmers earn above GHS1000 per annum from their farms whiles the remaining 26% receive less than GHS1000 (Figure 3.11) and as such making these farmers self reliance in terms of funds.

4.2.2 Effects of oil palm plantation expansion on food production

Although large scale oil palm plantation or the expansion in oil palm farming might appear to be attractive because of their ability to accelerate agricultural production and agro-industrial growth, they are basically vulnerable and have adverse effects on traditional landholdings, natural environment and land-use rights on food and fuel production (WRM, 2010). The research revealed that forest and farmland reduced by 27.9% and 40.6% respectively between 1986 and 2010. The expansion in oil palm reduced arable farmland by 6.5% and forest by 5.1%. This makes the rapid expansion in oil palm a treat to food production and biodiversity at large (Fitzherbert et al., 2008). This land which previously (1986) was forest and farmland from which locals derived mixed livelihood (wild fruits, bush meat, wild yam, etc.) had been replaced with oil palm in 2010 (Benefoh, 2008).

Even though the study revealed that oil palm farmers could afford to buy staple food and sustain a living from revenue gained from their oil palm farms, there was the evidence of shortfall in life expectancies such as ability to pay kid school fees, good health care etc. in the non oil palm growing communities. A general shortage of local staple foods in the study area was encountered in the findings of the research. This has resulted in the importation of about 70% of the food basket from other places into the study area during market days as claimed by statistician at Ejisu Juaben Statistical Services Division (pers. com.)

The vulnerability of the monoculture palm farms to insect pests and disease attacks usually spread to the neighbouring staple food crops and as result render these annual food crops at risk to destruction and in effect resulting in the reduction of food production (Gyasi et al., 1994; WRM, 2010). The above situation was encountered during the survey when one maize farmer in the non oil palm growing community (Yeboah) reported of the total destruction of his maize farm by birds and attributed the cause to a relatively nearby oil palm farm in an oil palm growing community (Boamadumase), where the birds have constructed their nests and lived. This makes it a clear situation that these birds live in oil palm farm because of easy access to their building materials and consequently migrated to the maize farm to feed.

Meanwhile, the vulnerability of the monoculture oil palm farms instead of the intercropping system of farming has adversely affected the food production and consequentially the nutrient level of the soil. The survey conducted in the study revealed that the land tenure systems practiced and the principles of the JOM (main supplier of incentive such as farm inputs, extension services, transport for produce, etc.), does not allow for intercropping the oil palm with staple food. This finding does not conform to the notion drawn by Netting, (1993) and Wąkker (2005), that oil palm in West Africa is intercropped with staple foods such as cassava, maize, etc.

The forest land cover in the study area reduced by more than 27.9% to the benefit of oil palm, built-up/bare and open forest (Table 3.2 and Figures 3.4). However, Human Development Index (HDI) developed by the United Nations Development Programme

(UNDP) estimates that about 90% of the world's poor depend on forest for a portion of their food supply (World Bank, 2004; USAID, 2006). Ghana in this instance is no exception but rather, the deforestation and the associated growing cost and scarcity of forest products such as fuel and "bush meat" have had adverse impact on the local communities; both oil palm and non oil palm growing communities in the entire study area. Shackleton & Shackleton (2004) remark that depending on circumstances; forest products may offer both "daily net" and "safety net". The daily net describes everyday use, with products meeting current household needs, offering a reliable source of income for instance to pay for kids school fees or purchase agricultural inputs. A safety net on the other hand comes into play when other sources of household income, for instance plantations fail to meet dietary shortfalls, or whenever a quick cash option is required (McSweeney, 2003). To this effect, loss of access to NTFPs in the case of the study area where forest land cover has been lost to other land cover types, most especially oil palm (Table 3.3 and Figure 3.4) implies adverse effects on livelihoods of the locals. However, the net livelihood impacts are generally less easy to distinguish, as there is a lack of standardized assessment methodologies (Shackleton & Shackleton, 2004).

4.3 Trends in oil palm expansion in the study area.

In reference to the results from the survey (questionnaire), oil palm takes about 56% of the total agricultural land leaving the remaining 44% for food crop production and other farming systems (Table 3.5). It was also evident from the finding that agricultural land expanded over the 24 years period (Table 3.2) and in which case the expansion in farmland and oil palm plantation farms were in close proximity to built-up/ bare (Figures 3.1). The above finding confirms the result that proximity of oil palm farms to homes/ mills (built-up/ bare) is one of the factors why the local adopted oil palm (Table 3.4).

The trend in expansion of oil palm over an extended period revealed that the current trend of its expansion in Ejisu Juaben Municipal is not sustainable. This is demonstrated when total annual income derived from oil palm was modelled against time and the result revealed a negative trend (Figure 3.17).

It was also revealed that the distance travelled by famers to oil palm farms will increase with time (Figure 3.18). This trend is against the fact that proximity of oil palm farm to mills/ homes was one of the reasons why locals adopted oil palm farming (Table 3.4).

Another trend evident in the study area with the expansion in oil palm is that there is predicted reduction in size of oil palm farm and sizes of total land owned by the individual local farmers over a period of time (Figures 3.15 and 3.16). It was clear that the land tenure system practiced as described in the introduction chapter of this study has impact in the reduction in access to land. These observations confirmed trend in land acquisition for oil palm production in Ghana recognized by Gyasi (1994).

4.4 Demography

4.4.1 Gender representation of respondents in oil palm farming

The gender distribution of respondents revealed that there was greater number of male than female in the oil palm farming in all four zones that the study was conducted (Figure 3.19). The census data also revealed that there are more males than females in municipality (GSS, 2003) and this is due to the rapid urbanization in the nearby Kumasi Metropolis where the females prefer to be engage in hawking and also trade in the other sectors of the oil palm such as selling the fruits and palm oil for domestic purposes instead of oil palm farming to earn their living (GSS, 2010). Even though more males are involved in oil palm farming, Figure 3.10 also confirms that there are more females than males per household earning their living from oil palm. This can be attributed to the engagement of females in the marketing and supply chain of the oil palm. The preceding finding confirms the report by the Ejisu Juaben Municipal Assembly (GSS, 2010).

4.4.2 Age classes of respondents involved in oil palm farming

The age distribution in all the study sites ranged from 30 to above 70 years with majority of the respondents aging between 41 to 50 years across the various zones (Figure 3.20).

This scenario is attributed to the fact that oil palm is recognised as source of pension benefit for aging farmers who would not be very much active in food crop farming seen by many as laborious during old age. As a result, the locals prefer to go into oil palm as they grow older and hence that reflection. The fact that there is a good representation of those from 51 to 60 confirms the above claim. Meanwhile, farmers who were above 60 years were moderately represented from the findings of the research. It was evident from the findings that there were no farmers into oil palm below age 30 years. However, observation by researcher revealed that the younger generation (aged between 15 and 30) preferred rice farming to other farming practices. This could be attributed to the fact that most people within that age group do not own land and prefer the land tenure practice used for rice cultivation where by the rice could be cultivated three times within a year. The findings above are largely consistent with the economy demand theory explained by Ojedaa (2007) and validated by Benefoh (2008).

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 What changes have occurred in land cover types in the study area between 1986 and 2010?

- Five (5) dominant land use/ cover types (i.e. forest, open forest, farmland, oil palm and built-up/ bare) exist in the study area.
- Forest and farmland decrease in size whereas oil palm, open forest and built-up/ bare increased over the 24 years period.
- Oil palm increased in size by 844.6% from 363.78 ha in 1986 to 3436.2 ha in 2010.
- Oil palm on the average gained land from all the other land cover types between 1986 and 2010.
- Built-up/ bare and oil palm expanded in close proximity to each other.

5.1.2 What is the trend of oil palm expansion?

- Oil palm was established in close proximity to built-up/ bare.
- The expansion in oil palm resulted in forest depletion and reduction in farmland leading to the loss of access to land for other food crops due to the tenure system practiced.
- The current trend of expansion in oil palm is not sustainable as food production and income levels of farmer will decrease with time.

5.1.3 How has oil palm plantation development contributed to employment creation and improvement in income levels?

- More than 75% of the total rural population are directly or indirectly employed in the cultivation, harvesting, processing, marketing and the supply chain aspects of oil palm plantation development
- Oil palm expansion increased employment creation in oil palm growing communities as compared to non oil palm growing communities.
- Farmers who cultivated both oil palm and annual staple food crops had greater percentage of their annual income contribution generated from their oil palm farms than with the annual staple food crops (i.e. GHS1000 and above and less than GHS1000 respectively).

5.1.4 What are the effects of oil palm plantation on food availability?

- The expansion in oil palm has contributed to the reduction of total land put into annual staple food crop cultivation (farmland) by 40.6% from 1986 to 2010.
- The reduction in the land for annual food crop cultivation has resulted in the reduction in food production leading to about 70% importation of the food basket in the municipality during market days from other parts of the country.
- The prices of staple food have increased as a result of the cost incurred in transporting from other locations to the municipality. However the research confirmed a trade-off in this situation as a result of the relatively high income generated from oil palm.
- The deforestation and the associated growing cost and scarcity of forest products such as fuel and "bush meat" have had adverse impact on the local livelihoods; both oil palm and non oil palm growing communities in the entire study area.

5.2 Recommendations.

The following recommendation are made based on the findings of the research:

- Further detailed statistical study for the development of suitable method of validating classification accuracy of old satellite images is of importance since the old method/ practice of using local knowledge and ''unchanged areas'' in satellite images for validation is apparently unaccountable and subjective.
- The research considered sizes of oil palm farm, mean distance travelled from home to oil palm farm, total land owned by the farmer and annual income received by farmer from their farms to model the trend analysis of the spread of the oil palm with time in years to predict the sustainability of the rapid expansion in oil palm plantation sector. Other indicators such as topography/elevation, soil types and nutrient levels should be considered in future researches of the study area.
- The research concluded that deforestation as caused by the rapid expansion in oil palm has resulted in the growing cost and scarcity of forest products such as fuel and "bush meat" have had adverse impact on the local livelihoods. Further studies on the impact of oil palm expansion on biodiversity could be explored.
- The research revealed that farmland and forest decreased in size while the others; oil palm, built-up/ bare and open forest increased. Further expansion in oil palm plantation in the study area should be extended into open forest areas instead of the farmland and forest which serve to provide food, fruits, building materials, etc. for the locals of such communities

REFERENCES

Agyarko, T. (2001). Country Report – Ghana: FOSA Working Paper (12): ForestrSector Outlook Studies. FAO./docrep/003/567/AB567E.

Arko-Adjei, A., (2011). Adapting land administration to the intitutional framework of customary tenure: a case of peri-urban Ghana. ITC, Enschede.

Asase, A., Ofori-Frimpong, K. and Ekpe, P. K., (2009). Impact of cocoa farming on vegetation in an agricultural landscape in Ghana.

Asubonteng, K. O., (2007). Identification of land use/ cover transfer hotspots in the Ejisu Juaben Distric, Ghana. ITC, Enschede.

Attua, E. M., Laing, E., (2001). Land cover mapping of the Densu Basin: interpretation from multispectral imagery. Bulletin of Ghana Geograhical Association.

Backeus, I., Petterson, B., Stomiquist, L., and Ruffo, C., (2006). Tree Communities and Structural Dynamics in Miombo (Brachystegia-Julbernardia) Woodland, Tanzania. Forest Ecology and management, 230: 171-178.

Belcher, B., Rujehan, Imang,N.and Achdiawan, R. (2004). Rattan, rubber and oil palm: cultural and financial concideration for farmers in Kalimantan. Economic Botany 58: S77-S87.

Benefoh, D. (2008). Assessing the effects of land - use or cover change on ecosystem services in Ejisu - Juaben district, Ghana : the case study of carbon sequestration. ITC, Enschede.

Bentsi-Enchill, K. (1964). Ghana Land Law: an exposition. Analysis and critique. London: Sweet & Maxwell.

Bilinla, J., (2011). Spatial Analysis of Human Acyivities in and Around Protected Areas. A case study of Kakum Conservation Area (KCA), Ghana. ITC Enschede.

Braimoh, A. K. (2009). Agricultural land-use change during economic reforms in Ghana. *Land Use Policy, 26*(3), 763-771.

Bureau of Intergrated Rural Development, 2001. Tropenbos Ghana Programme research site community survey (final report), KNUST, Kumasi.

Campbell, J. B., (2002). Introduction to Remote Sensing. Tylor and Francis, London 621 pp.

Carpenter, S. R and De-Fries, R. D. T. (2006). Millennium Ecosystem Assessment Research Needs. Science; 314: 257-258.

Chemsain Konsultant (2000). Environmental Impact Assessment (EIA). Guidelines for Oil Palm Plantation Development.

Cumming, G. S. and Barnes, G. (2007). ''Characterrizing land tenure dynamics by comparing spatial and temporal variation at multiple scales.'' Landscape and Urban Planning 83(4):219-227.

Donald, P. F. (2004). Biodiversity impact of some agricultural commodity production systems: Conservation Biology: 18, 17–37.

Duku, M. H. (2007). *Status of biofuel development in Ghana.* Paper presented on bifuels from Palm Oil: Emerging Technologies and their Assessments, Kualur Lumpur, Malaysia.

Dunning, H. C. (1970). 'Land reform in Ethiopia: a case study in non-development', UCLA Law Review 18 (2), 271-307. Reproduced as LTC Reprint97, Madison, Wis.: Land Tenure Center, University of Wisconsin.

Fitzherbert, E. B., Struebig, M. J., Morel, A., Danielsen, F., Brühl, C. A., Donald, P. F., et al. (2008). How will oil palm expansion affect biodiversity? *Trends in Ecology & Evolution, 23*(10), 538-545.

Gaespenu and Associates, (1996). A Medium Term Development Plan for Ejisu Juaben District (1996-200).

Ghana statistical service, (2010). Provisional analysis of the 2010 population and housing census, accra.

Ghana statistical service, (2003). 2000 population and housing census, accra.

Gyasi, E. A., (1976). 'Population presures and change in traditional agriculture: case study of farming in Sekesua-Agbelitsom, Ghana'. *Bulletin fo Ghana Geographic Association 18, 68-87.*

Gyasi, E. A., (1992). ''Emergence of a new oil palm belt in Ghana.'' *JESG (Journal of Economic and Social Geography) 83 (1), 39-49.*

Gyasi, E. A., (1994). The Adaptability of African Communal Land Tenure to Economic Opportunity: The Example of Land Acquisition for Oil Palm Farming in Ghana. International African Institute.

Gyasi, E., Agyepong, G. T., Ardayfio-Schandorf, E., Enu-Kwesi, L., Nabila, J. S., & Owusu-Bennoah, E. (1995). Production pressure and environmental change in the forest-savanna zone of Southern Ghana. *Global Environmental Change, 5*(4), 355-366.

Gyasi, A. E., (2003). *The environmental impact and sustainability of plantations in Sub-Saharan Africa: Ghana's experiences with oil palm plantations:* UNU Press.

Hall, J. B. and Swaine, M.D., (1976). Classification and ecology of closed-canopy forests in Ghana. The Journal of Ecology, 84(3): 419-428.

Hayes, D. J. and Cohen, W. B., (2006). Spatial, spectral and temporal patterns of tropical forest cover change as observed with multiples scales of optical sattelite data. Remote Sensing of Environment, doi:10. 1016/j.rse.2006.07.002.

Jurgens, E., Brown, T., Leitmann, J., van Hofwegen P., Shetty, S. and Mitchell D., (2010). Environmental, Economic and Social Impacts of Oil Palm in Indonesia: A Synthesis of Opportunities and Challenges. Indonesia.

Kerle, N., Janssen , L. L. F. and Huurneman, G. C. (Editors), 2004. Principles of Remote sensing ITC Education Textbook Series, 2. ITC, Enschede.

Kessler J. J., Rood T., Tekelenburg T. & Bakkenes M., (2007). Biodiversity and Socioeconomic Impacts of Selected Agro-Commodity Production Systems, The Journal of Environment and Development, vol. 16, no. 2, June 2007.

Kufuor, K.O. (2004). New institutional economics and the failure of sustainable forestry in Ghana: Natural Resources Journal 44 743- 760.

Lambin, E. F., Helmut, J. G., Lepers, E., (2003). Dynamics of landuse and landcover change in tropical regions. Annual Review Environment Resources 28, 205-241.

Lamptey, F., (2009). Participatory GIS Tool for Mapping Indegenous Knowledge in Customary Land Tenure Dynamics: Case of Periurban Northern Ghana. ITC Enschede.

Larbi, W. O., Antwi, A., & Olomolaiye, P. (2004). Compulsory land acquisition in Ghana--policy and praxis. *Land Use Policy, 21*(2), 115-127.

Lillesand, T. M. & Kiefer, R. W., (2004). Remote sensing and Image Interpretation, 5th Ed.: John Wiley and Sons Ltd. Chichester, UK.

Lillesand, T. M., and Kiefer, R. W., (1994). Remote sensing and Image Interpretation (4th Ed.).New York: Willey.

Lo and Faber (1998). Remote Sensing of the Environment: an earth resource perspective.

MA. (2005). United Nations Millennium Ecosystem Assessment and Human well-being: D.C.7 Island Press Washington.

Mass, J. F., (1999). Monitoring land cover change: a comparison of change detection techniques. International Journal of Remote Sensing, vol. 20, No. 1, 139-152.

Mattison, E. H. A. & Norris, K., (2005). Bridging the gaps between agriculture policy, land- use and biodiversity: Trends Ecology and Evolution. 20(11), 610–616.

McCusker, B., and Carr, E. R. (2006). The co-production of livelihoods and land use change: Case studies from South Africa and Ghana. University of South Carolina, Columbia, SC 29208, United States.

McSweeney, K. (2004). Tropical forests as safety nets: The relative importance of forest products sales as smallholder insurance in Eastern Honduras. Conference on Rural Livelihoods, Forests and Biodiversity;12 - 23 May, 2003, Bonn, Germany.

Ministry of Finance and Economic Planning, (2010). The 2010 Ghana Government Budget Address to the Nation.

Ministry of Local Government & Rural Development, (2006). Ghana Districts. Retrieved 18 August, 2011 from http://www.ghanadistricts.com/districts/?r=2&=21&rlv=location

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B. & Kent, J. (2000). Biodiversity Hotspots for Conservation Priorities: Nature, 403(6772), 853-858.

National Investment Bank (1987). ''An Agro-industrial Study: the oil palm industry.'' Accra, mimeo.

Nkyi, K. A., (2005) (unpublished). Lecture notes on sampling in remote Sensing and GIS for Natural Resources Management. KNUST, Kuamsi.

Netting McC.R., (1993). Smallholders, householders: farm families and he ecology of intensive, sustainable agriculture, Stanford University Press, Stanford, 1993.

OPRI., CSIR., (2010). Report on the President's Special Initiative (PSI) on oil palm (2003-2009), Kade-Kusi, Ghana.

Ojedaa, M. I., Mayer, A. S., Solomon , Barry D. (2007). Economic Valuation of Environmental Services Sustained by Water Flows in the Yaqui River Delta. doi: 10.1016/j.ecolecon.2007.06.006.

Ollenu, N. A. (1962). Principles of Customary Land Law in Ghana. London Sweet and Maxwell.

Parsons, K. H. (1971). ''Customary Land Tenure and the Development of African Agriculture.'' LTC Paper 77, Madison, Wis.: Land Tenure Center, University of Wisconsin, reproduction of FAO Report No. RP 14, Rome: FAO.

Payne, G. (1997). Urban land tenure and property rights in developing countries: a review. London, Intermediate Technology.

Pogucki, R. J. H. (1962). ''Notes on codification of land law and registrationof title to land'', Ghanaian Bulletin of Agricultural Economics 2 (1), 21-5.

Primack, R.. & Corlett, R. (2005). Tropical Rainforest: An Ecological and Biogeographical Comparison. Blackwell Science Ltd, Oxford. 319pp.

Rademakers, K., Eichler, L., Berg, J. & Havlik, P. (2010). Study on the evolution of some deforestation drivers and their potential impacts on the costs of an avoiding deforestation schemes: Directorate-General for Environment, European Commission Rotterdam.

Rice, R. A. & Greenberg, R.. (2000). Cocoa cultivation and the Conservation of Biological diversity: Royal Swedish Academy of Sciences. Ambio. 29(3), 167-173.

Round table on Sustainable Palm Oil, (2006). Draft Guidance Version 4.

Sedogo, C. A., (2007). Assessing the Impact of Urban Expansion and Land-cover within the landscape of Kumasi Metropolitan Area, Ghana International for Geo-information Science and Earth Observation, Enschede, 55 pp.

Serra, P.., Pons, X. and Sauri, D., (2003). Post classification change detection with data from different sensors: Some Accuracy Considerations. International Journal of Remote Sensing, 24, (16): 3311-3340.

Shackleton, C.M. & Shackleton, S.E. (2004). The importance of non-timber forest products in rural livelihood security and as safety nets: a review of evidence from South Africa. South African Journal of Science 100 (11 & 12):658 -664.

Shalaby, A., & Tateishi, R. (2007). Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt. *Applied Geography, 27*(1), 28-41.

Simpson, S. R. (1976). ''Land Law and registration.'' Cambridge University Press. London, UK.

Singh, A. (1989). Digital Change Detection Techniques using Remotely Sensed Data. International Journal of Remote sensing. 10, 989-1003.

USAID. (2006). Issues in Poverty Reduction and Natural Resource Management: USAID Washington, DC.

Van der Geest K., Vrieling, A. & Dietz, T. (2010). Migration and environments in Ghana: a cross-district analysis of human mobility and vegetation dynamics. International Institute for Environment and Development (IIED).107 vol. 22(1): 107–124. Environment and Urbanization.

Wakker E., (2000). Funding Forest Destruction. The Involvement of Dutch Banks in the Financing of Oil Palm Plantations in Indonesia, AID Environment, Greenpeace Netherlands, March 2000.

Wakker E., (2005). Greasy Palms. The social and ecological impacts of large-scale oil palm plantation development in Southeast Asia, Friends of Earth, January 2005.

Westinga, E., (2004). Mannual of land cover mapping and monitoring. ITC, Enschede, the Netherlands.

Wilcove, D., & Koh, L. (2010). Addressing the threats to biodiversity from oil-palm agriculture. *Biodiversity and Conservation, 19*(4), 999-1007.

World Bank, (2009). Public Expenditures In Agricultural Research And Development, Policy Note.

World Bank, (2004). World Development Report: Attacking Poverty: World Bank, Washington DC.

WRM, (2010). The Bitter Fruit of Oil Palm: Dispossession and Deforestation, Maldonado 1858, Montevideo, Uruguay.

Yuan, F., Kali, E. and Sawaya , (2005). Land cover classification and change analysis of the Twin Cities (Minnesota) Metropolitan Area by multi-temporal landsat remote sensing. Remote Sensing of Environment, 98 (317-328).

APPENDICES

Appendix 1: Semi-strucrure questionnaire

LAND COVER CHANGE ASSOCIATED WITH THE RAPID EXPANSION. QUESTINNAIREFOR LAND OWNERS AND FARMERS. X……Y……..			
Section 1: personal details		**village name……date……**	
Gender: m f	Age…….	Family title:	
Marital status…...	No. of hse/hold…… (m……f….)	No. of dependants…….	
Section 2: history and background			
Ownership of land	Have you lost land to oil palm	How (1 or 2)	
Type of tenure……..		Size……..	
Land problem in your view……..			
Section 3. Socioeconomic activities			
Type of production system…….			
Size of farm: oil palm…….crops……..others……..			
Size of total land owned……..			
Distance of farm from home……..	Employment per hse/hold: 1.oil palm…… 2.non-oil palm……. 3. both……. 4.unemployed……..		
Why that production system……..			
Use of produce: 1. Domestic 2. Commercial 3. Both 4. Others			
Sources of income…….. Total annual income from; 1……2……3……others……			
How much land do you need to meet your need…			
Are you able to get access to land if you need…			
Are you able to buy land if you need to……			
Compared to other land use is oil palm better option in terms of income?.....			
Section 4 land cover changes (lcc)			
Are you aware of the land cover conversions……			
What are the major drivers…… Perception of lcc; past……present…… future…… Will you encourage oil palm expansion……			
Other information in your view.....			

Appendix 2: Shows the various out-grower groups of the study area

ZONE	COMMUNITY	HECTARAGE	NO. OF FARMERS
Juaben East	Abetim	49.38	18
	Nkyerepoaso	48	30
	Juaben	92.24	49
	Kokodie	12.8	8
	Ofoase	8.17	7
Total	Odoyefe	11.69	8
	Krofofrom	33.95	23
		256.23	**143**
Odumase	Nobewam	78.43	51
	Bomfa	49.47	26
	Odumasa	8.41	11
	Odumase	30.21	25
	Agyareago	16.72	11
	Bomiriso	5.07	4
Total	New Koforidua	31.42	22
	Kyekyrwere	10.86	15
		230.56	**165**
Atia	Atia	231.89	146
	Boankra	10.64	3
	Kubease	29.78	17
	Duapompo	6.96	7
Total	Boamadumase	43.04	29
		322.31	**202**
Juaben West	Juaben (West)	140.96	60
	Dumakwai	28.98	22
	Ankaasei	21.13	15
	Apemso	11.01	8
	Bamang	20.38	12
Total	Ntunkumso	15.62	10

		238.08	**128**

Source: JOPOCOS

Appendix 3: Accuracy assessment.

ERROR MATRIX

	Reference Data					
	Forest	Open forest	Farmland	Oil palm	Built-up/ bare	Total
Forest	16	2	1	1	0	20
Open forest	1	26	1	0	0	28
Farmland	1	1	17	1	0	20
Oil palm	0	2	2	16	0	20
Built-up/ bare	0	1	1	0	5	7
Total	18	31	22	18	5	95

ACCURACY TOTAL					
Class name	Reference total	Classified total	Number correct	Producers accuracy	Users accuracy
Forest	18	20	16	88.89%	80.00%
Open forest	32	28	26	81.25%	92.86%
Farmland	22	20	17	77.27%	85.00%
Oil palm	18	20	16	88.89%	80.00%
Built-up/ bare	5	7	5	100.00%	71.42%
Total	95	95	80		

Overall Classification Accuracy = 84.21%

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.7658

Conditional Kappa for each Category

Class Name	Kappa
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Forest	0.7589
Open Forest	0.7647
Farmland	0.8330
Oil palm	0.7589
Built-Up Areas	0.6987

Appendix 4: Results from statistical analysis

Correlations

		Annual income	Size of land for oil palm	Average distance from home to oil palm farm	Total size of land own
Annual income	Pearson Correlation	1	.522**	-.001	.476**
	Sig. (2-tailed)		.000	.981	.000
	N	319	319	319	319
Size of land for oil palm	Pearson Correlation	.522**	1	-.027	.934**
	Sig. (2-tailed)	.000		.632	.000
	N	319	319	319	319
Average distance from home to oil palm farm	Pearson Correlation	-.001	-.027	1	-.064
	Sig. (2-tailed)	.981	.632		.256
	N	319	319	319	319
Total size of land own	Pearson Correlation	.476**	.934**	-.064	1
	Sig. (2-tailed)	.000	.000	.256	
	N	319	319	319	319

**. Correlation is significant at the 0.01 level (2-tailed).