CONSERVATION OF DURA OIL PALM IN AGROFORESTRY SYSTEMS IN THE SUNYANI WEST DISTRICT OF THE BRONG AHAFO REGION OF GHANA

BY

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(BSC. AGRICULTURAL TECHNOLOGY, UDS)

OCTOBER, 2012

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MASTER OF SCIENCE IN AGROFORESTRY

BY

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DECLARATION

I, Ofori Kwakye hereby declare that this dissertation, "Conservation of Dura Oil Palm in Agroforestry Systems in the Sunyani West district of the Brong Ahafo region" for a second degree in the Kwame Nkrumah University of Science and Technology is the results of my own research and that no submission for a degree has ever been made for a degree programme in this university or elsewhere. The work of others which served as source of information for my study has been duly appreciated, with references to their authors.

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Head of Dept Name	Signature	Date

DEDICATION

This work is dedicated to the memory of my late father, Mr. Yaw Ofori

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A research such as this requires whatever possible to be successful, and that is why I feel this study will be incomplete without my expression of gratitude to those who have helped in making this research a reality.

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ABSTRACT

This study was carried out in the Sunyani West District of the Brong Ahafo Region. The aim was to determine the factors that could contribute to the conservation of dura oil palm. Eight communities were selected for this study. Both primary and secondary data were collected. Primary data was collected through the administration of semi-structured questionnaire to 80 farmers randomly selected from population of 410 farmers. Secondary data was obtained from existing literature and journals as well as Ministry of Food and Agriculture. The information obtained from the socio-economic survey was analyzed using Statistical Package for Social Sciences (SPSS). Cross tabulation and Chi-square test were used to compare and test some important variables such as age, gender, education and household size on dura conservation. The study revealed that two types of agroforestry systems can contribute to dura oil palm conservation. These were agrisilvicultural and apiculture. Arisilvicultural system emerged as the highest (62.5%) and apiculture as the least (27.5%). Four agroforestry technologies were considered under agrisilvicultural system to contribute to dura conservation. These were cocoa agroforest (50%) plantation crop combination (31%), improved tree fallow (12.5%) and trees on croplands (6.5%) and some of the management practices that farmers carry out to ensure dura oil palm conservation include; dura left during land preparation (100%), weeding (95%), bushfire control (81), pruning (51%) and dura left in tenera plantations (50%). The major constraints hindering farmers in an attempt to conserve dura oil palm were; demand of the dura trees for wine tapping (98%), land scarcity/fragmentation (89%), inadequate knowledge about conservation (83%), bushfires (78%), lower yields (78%), long maturity period of dura (69%) and lack of financial support (49%).

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Dura Oil Palm *(Elaeis guineensis)* originated in the tropical rain forest region of West Africa. The main belt runs through the southern latitudes of Cameroon, Côte d'Ivoire, Ghana, Liberia, Nigeria, Sierra Leone, and Togo and into the equatorial region of Angola and the Congo (Hartley, 1988). During the 14th to 17th centuries some palm fruits were taken to the Americas and from there to the Far East. The plant appears to have thrived better in the Far East, thus providing the largest commercial production of an economic crop far removed from its centre of origin (Ekpa, 1995). Dura oil palm is rich in carotenoids, (pigments found in plants and animals) from which it derives its deep red colour, and the major component of its glycerides is the saturated fatty acid palmitic; hence it is a viscous semi-solid, even at tropical ambient, and a solid fat in temperate climates. Because of its economic importance as a high-yielding source of edible and technical oils, the Dura oil palm is now grown as a plantation crop in most countries with high rainfall (minimum 1600 mm/yr) in tropical climates within 10°N of the equator (Syed *et al.*, 1982). The palm bears its fruit in bunches varying in weight from 10 to 40 kg. Individual fruits range from 6 to 20 gm, are made up of an outer skin (the exocarp), a pulp (mesocarp) containing the palm oil in a fibrous matrix; a central nut consisting of a shell (endocarp); and the kernel, which itself contains an oil.

The primary unit of production of the palm oil industry is the farm where the oil palm tree is cultivated to produce palm fruits. There are also wild groves of oil palm. Farm units are of different sizes and may be classified as small, medium, and large-scale estates (Clay, 2004). World demand for vegetable oils is rising sharply, from 100 million tonnes in 2005 to an estimated 150 million tonnes in 2020, as the world population continues to grow and the standards of living increase in many developing countries (Kwarteng, 2005). The role of oil palm as a supply of relatively inexpensive and versatile edible oil is, therefore, expected to become ever more prominent (Matthäus, (2007). With best practices for cultivation and processing, it can produce 4–6 times more oil/ha than any of the other oil crops, in an economically and environmentally sustainable manner. Extrapolations from crop-growth models suggest that the physiological potential for oil yield of oil palm may well be 12–14 tonnes per hectare against present maximum yields of 7 t/ha (Teixeira *et al.*, 1993).

The new possibility of clonal propagation is an important factor in this respect. The main drawback of oil palm is the difficulty of cost-effective mechanization of harvesting (Maley and Chepstow-Lusty, 1991). Hence, availability and cost of labour may well become limiting factors in producing countries with improving standards of living (Abdullah *et al.*, 2005).

Well-established oil palm plantations provide an ecosystem that has some of the characteristics of humid tropical forests (Soh, 1986). Recent studies have shown that the net carbon sequestration by a mature oil palm ecosystem is higher than that of humid tropical forests (Soh, 1986). The negative publicity on palm oil as being an 'unhealthy tropical vegetable oil has been repeatedly proved unjustified by scientific evidence. On the other hand, much needs to be done at national and regional levels, particularly in South-East Asia, to restore the reputation of the oil palm as an ecologically sustainable plantation crop, as this has been severely tarnished in the past decade by poorly controlled expansion causing air pollution and unnecessary destruction of tropical forests

(Teoh, 2002). The 'Roundtable on Sustainable Palm Oil', initiated by stakeholders of the Malaysian palm oil industry in 2003, appears to be a move in the right direction in this respect (Corley and Tinker, 2003). In West Africa the smallholder sector of palm oil producers, processors and traders is increasingly overtaking the privatized formal plantation sector in becoming the main supplier for the ever-growing domestic markets (Ekpa, 1995). Sustainable palm oil production needs to be redefined here, as the best management practices applied in the estate sector may be incompatible with the socio-economic priorities of the smallholders and their families (Ekpa, 1995).

1.2 Problem Statement

Management and conservation of genetic materials over the past decades have not been recognized by majority of people and the burden now is on the conservationist, and as such most genetic species are gradually becoming extinct (Woodruff, 1989). The dura oil palm germplasm is not an exception, as for decades activities for its conservation are taken for granted in Ghana. There is therefore an increase in the use of tenera (a cross between dura and pisifera) over extended areas such as estates/plantation or small-holder outgrower farms and as such the original dura 'genetic base' of the oil palm is gradually becoming eroded.

1.3 Justification

Over the years, farmers have been able to conserve the dura oil palm by the use of some agronomic practices. Daniel (2000) states that, farmers manage their oil palms through strategies such as weeding, pruning and bushfire control. Other management practices that help to conserve the dura oil palm as stated by Anyame (1961) include; leaving the variety during land preparation for farming, protecting the dura from bushfires, farmers leaving few of the dura in their tenera plantations, weeding around dura on fallow lands for domestic consumption and palm wine tapping, and felling of the old ones for the young ones to take over. Unfortunately, all these practices have not been considered in agroforestry systems to ensure the conservation of the dura variety. It is therefore prudent to undertake this study to find out some management strategies in agroforestry systems that could ensure that, the dura oil palm germplasm is protected, and as such the genetic base of the 'oil palm' will not be totally eroded. When the genetic material is eroded and the need arise for the production of another hybrid variety other than the tenera, it would not be possible and hence needs to be protected.

1.4 Aim and Specific Objectives

The aim of the research is to determine agroforestry systems that can contribute to the conservation of the dura oil palm and the specific objectives are:

- To determine the management practices that help in the conservation of dura oil palm;
- To identify agroforestry technologies that can promote conservation of dura oil palm;
- To identify the constraints associated with the management and conservation of dura oil palm.

CHAPTER TWO

LITERATURE REVIEW

2.1 Description of Dura Oil Palm

Dura appears tree like, but grows differently from hardwoods and conifers. Dura oil palm is classified in the family Palmae, lacking the arboreal characteristic of wood, bark and cambium, though they are still frequently referred to as trees (Thomas, 2000). The dura oil palm is a monocotyledon, which grows from the center. It produces one leaf at a time, emerging from the apex, with the leaflets folded against each other. It then spreads its leaflets as photosynthetic ability of the individual leaf develops. The dura palm can live up to sixty-five years and reach a height of 20 meters (Hartley, 1988). In Ghana, it begins to fruit in the fourth year of growth, though genetic manipulation has reduced this in plantation areas (Abdullah *et al.*, 2005).

The fruit of dura oil palm (referred to as palm nut) is a drupe which number in the hundreds. These occur in bunches that develop from a node at the base of the petiole of the leaf. The fruit consists of two main parts, the pericarp and the endocarp. The pericarp, which surrounds the seed, consists of exocarp (skin or shell) and mesocarp (pulp or fiber). The endocarp is the viable seed, which is planted for germination. It is composed of a whitish kernel and a shell. The pericarp produces the more palatable palm oil. From the endocarpic kernel, kernel oil is processed. The oil palm is monoecious. There is no economic use for the male flower of the plant, although it is said to be an indicator of wine production (Anyane, 1966). A palm with a large number of male inflorescences is said to contain relatively little wine. The female inflorescence is where fruiting occurs. A fertilized female flower becomes a bunch. A bunch has several spikletes to which the individual fruits are attached. Individual fruit shapes vary from spherical to ovoid, often seemingly adjusting to the shape of the adjacent fruit. It ranges in size from 2 to 5 cm, and weighs from 3 to 30 grams and varies in color from bright red to a deep purple on the exposed section of the ripe fruit, with a lighter shade of red, orange, or yellow on the encased portion of the fruit (Anyane, 1966). Fruiting of the dura oil palm is highest in the rainy season, with a smaller but notable harvest in the minor season. Fruit production is low throughout the rest of the year. An individual dura will peak in fruit production from about age 15 to 30 years (Hartley, 1988).

The leaf or frond of dura oil palm is simply pinnate and can reach lengths of over 8 meters, although lengths of 2-4 meters are more common in Ghana. One dura can ideally carry 45-50 leaves. The stalk is hard and fibrous. The leaflets are attached laterally to and supported by a stiff midrib. This leaflet carrying section of the plant is referred to as rachis, which in cross sections proves to be asymmetrical, with the abaxial face, (the underside of the leaf) being much more curved than the adaxial. The petiole is shorter and thicker than the rachis, and bears short spines instead of leaflet. The leaflets can number up to 300. They point laterally from the stalk and are supported by a bristle-like spine, to which the leaf material is attached. In early leaf development the leaflets are not separated, but folded at the point where separation will occur (Hartley, 1988). Dura, unlike woody tree species, have one growing point, the apex, where individual leaves emerge. This is located at the center of the crown and consists of soft undeveloped leaves, or ‘cabbage’ (Hartley, 1988). Young, unopened leaves, ‘spears’ emerge from this point. The spear rapidly emerges vertically from the plant, at a rate of 30 to 40 per annum in mature individuals. An individual leaf can remain on the plant for 2 years, through which time the tip slowly bends back to below the horizontal as new leaves emerge from the apex, until it dies and dries on the plant. The dead leaves can remain attached to the stem for some time, snapping at the base of the rachis long before the petiole is shed. Thus, it appears that the stem of the plant is structured from the leaf bases of leaves that had been shed. The dry petioles can remain on the plant for over 12 years. Dura trees which have begun to shed these leaf bases are called ‘smooth-stemmed’ (Zeven, 1964). The width of the stem after the leaf bases are shed can be from 20 – 75 centimeters. This part of the tree is of no economic importance as timber, although the individual leaf bases that make up the stem are used as fuel wood.

2.2 Climatic and Environmental Conditions for Oil Palm

Oil Palm requires rainfall of 1500-2000 mm with no long period of drought of more than 3 months (Nelson *et al.*, 2010). The average relative humidity should preferably be over 75%. The plant also requires a high light intensity with at least 1500 hours of sunshine per year. The optimum temperature ranges from 25 to 30 degree Celsius. Oil palm can be grown on a wide range of soils. The most suitable soil would be one with a deep, well drained and well structured with unrestricted rooting medium of reasonably good water holding capacity. Whenever possible, flat or undulating land should be chosen. Steep land may be utilized and the oil palms are normally planted on terraces as a means of soil conservation measure to prevent soil erosion. Oil Palm grows on a wide range of soil types, provided there is good drainage and a pH between 4 and 7. The plant tolerates periodic flooding or a high water table; many soils are alluvial in nature. Irrigation is generally not practiced (Nelson *et al.*, 2010).

2.3 History of Oil Palm in Ghana

There are various local uses for the different parts of the oil palm. The most important world wide is the palm oil derived from the fruits. Palm oil was the major international trade item from Ghana in the 19th century (Gyasi, 1992). Early trade from modern day Ghana with Europe dates to the 15th century, when the Portuguese established the first European fort in West Africa specifically Ghana at El Mina (Gyasi, 1992). However, it is noted that Ashanti-mined gold was probably reaching Europe during the middle ages in a complex trans-Sahara-Mediterranean trade route (Lynn, 1991). Palm oil trade began to flourish as an alternative to the slave trade after abolition by the British in 1807 (Lynn, 1991). Palm oil trade was a major source of revenue concurrent with slaving (Lynn, 1991). Abolition of the slave trade only served to elevate its importance, making it "far and away the major item traded from West Africa after abolition" (Lynn, 1991).

The demand for palm oils was driven by the European industrial revolution need for oils used in soaps and candle production, as well as lubricants (Lynn, 1991). Initially, these were filled by palm oil. Palm kernels and their oil were virtually neglected both domestically and in markets abroad (Lynam, 1972). Uses for kernel oil were discovered in the new product margarine, and the residue from the oil extraction was discovered to make good livestock feed (Kaniki, 1980). By the middle of the 19th century both palm oil and palm kernels were being exported from West Africa (Lynn, 1991). World palm oil prices rose throughout the first half of the 19th century, and as the kernel market began to emerge, its price rose as well. Around 1850, these oil palm products became the principal agricultural trade items in British West Africa (Lynam, 1972).

The success of the oil palm market was due to the small initial investment necessary for production. Unlike the slave trade, which required large capital investments, palm products could be produced by individual households with limited resources. This allowed for the general population to enter into international markets, giving them purchasing power and access to manufactured goods. The peak of the trade was in 1884, when 20,000 tons of palm oil and 40,000 tons of kernels were exported from Ghana (Lynn, 1991). With slight, gradual decline, the industry remained the most important of Ghana's cash crop through the turn of the century (Gyasi, 1992). The source of this localized industry was dependent on 'natural' (not planted) palm groves.

In the early 1900's, imported cocoa began to flourish and quickly surpassed oil palm as the primary agricultural cash crop (Anyane, 1966). Because more farmers began devoting resources to cocoa, which is less labour intensive and was bringing higher returns than palm oil, natural oil palm groves were often left under harvested. The year 1905 showed a record cocoa crop, as well as an increase in all other agricultural exports except palm oil and kernels, causing the Gold Coast Department of Agriculture to accurately predict that 'it is a matter of time [barring mechanization] before this industry dies out' Anyane, 1966).

Anyane, (1966) explored the decline of the oil palm industry in Ghana. In examining how to boost the industry, he weighed the positive and negative aspects of encouraging large scale plantations or nurturing of the existent peasant industry. Although plantations offer higher production and more efficient oil extraction, initial investment is high. Attempts were made to modernize the oil palm industry in the first half of the 20th century (Kaniki, 1980). These attempts met with little success. Plans for communal palm oil processing factories to be developed in high palm density areas never materialized for lack of enthusiasm. Larger privately financed and/or subsidized factories failed to operate at capacity. The processing factories, with large start-up costs, could not offer a price which would compare to what the farmers could make from processing the oil themselves (Kaniki, 1980).

Exports of palm oil and kernels ceased altogether in 1955, and Ghana became an importer of palm oil (Gyasi, 1992). These problems with low development of production were compounded by the decrease in acreage of wild oil palms. Decrease in palm numbers was largely attributed to the felling of the palms for tapping (Gyasi, 1992). The change in oil palm use was exacerbated by the creation of plantations in other parts of the world, namely Malaysia and Indonesia, which have produced higher palm nut yields and efficiency in extraction (Anyane, 1966). Plantation establishment has also taken place in West Africa, including Ghana, marked by the establishment of the West African Institute of Oil Palm research (WAIFOR), and an Oil Palm Research Station in Kade. Plantations are in areas where rainfall is closer to the ideal moisture demand for the species. Consequently, there is neglect of areas which were historically the main oil palm producers. Today, wild oil palm groves are still the source of the largest portion of palm oil production throughout West Africa (Gyasi, 1992). This produces the palm oil which is consumed locally. Exports of palm oil are rebounding from the stagnation in the 50's and 60's, although this palm oil is almost exclusively the product of plantation palms in the new oil palm belt (Lynam, 1972).

2.4 Oil Palm Selection and Hybrid Seed Production

Oil palm is an introduced crop and its development in India is quite encouraging (Latiff, 2000). Hence, demand for planting materials has increased in recent years due to increase in investment by private entrepreneurs and support extended by the Government. Commercial dura × pisifera (D × P) planting materials were produced by exploring genetic materials introduced from Malaysia and Nigeria. Progenies from Thodupuzha, Kerala after intense selection were used to establish five seed gardens. Commercial dura × pisifera (D × P) were produced from genetically superior parents after extensive selection. During 2004, only about 1 million sprouts were supplied against the demand of 1.9 million in Malaysia. During 2005-06, the demand of 2.182 from indigenous source and 3.155 million of exotic sources has been reported in Malaysia. A demand of 2.205 and 5.680 million from indigenous and exotic sources has been forecast for the year 2006-07 in Malaysia. Import of exotic planting materials in Malaysia is being contemplated to fulfill the requirement (Latiff, 2000)

Plate 2.1 Cross between Dura and Pisifera at Malaysian Oil Palm Research Institute (Teoh, 2002)

Traditionally, breeding of oil palm has focused on yield improvement, in terms of Fresh Fruit Bunch (FFB) and oil content, slow height increment, oil quality and disease tolerance. Currently, the Malaysian oil palm industry has placed emphasis on the production of the following types of planting materials to meet industry and market needs (Rajanaidu *et al.*, 2000). Development of dwarf palms (PSI type) – to reduce the palm height increment and significantly extend the economic cropping cycle. Breeding for high unsaturated oil (High iodine value) (PS2 type) – to produce materials with higher proportions of unsaturated fatty acids by crosses with high iodine value Nigerian *duras* and *E guineensis* x *E. oleifera* hybrids. Breeding for high lauric oil (PS3 type) –

using high yielding Nigerian *dura* palms with high kernel contents. Breeding for high carotenoid content (PS4 type) was done using selected Nigerian *duras* and *pisiferas* as well as hybridization with *E. oleifera*.

As current DxP planting materials derived from seeds have a high level of variation, several companies undertook research on production of clonal palms in the 1980s. This research was based on the premise that yields can be increased by about 30% with clones derived from elite palms in a DxP population (Hardon *et al.*, 1987). However, commercial production of clones was hampered by the discovery of abnormal flowering behaviour and the research effort was diverted to overcoming the occurrence of abnormalities in palm clones (Corley *et al.*, 1986). Their earliest clonal planting had produced a 31% increase in FFB per ha and 54% improvement in oil yield compared to conventional DxP materials during the initial seven years of production (Siburat *et al.*, 2002).

2.5 Characteristics of Palm Oil

The oil palm produces two types of oils, palm oil from the fibrous mesocarp and lauric oil from the palm kernel. In the conventional milling process, the fresh fruit bunches are sterilized and stripped off the fruitlets, which are then digested and pressed to extract the Crude Palm Oil (CPO). The nuts are separated from fibre in the press cake and cracked to obtain palm kernels which are crushed to obtain Crude Palm Kernel Oil (CPKO) and a by-product, palm kernel cake which is used as an animal feed (Ekpa *et al.*, 1994). Fractionation of CPO and CPKO in the refinery produces the liquid stearin fraction and a solid stearin component. The fatty acid compositions of the palm oil products, compared with coconut oil and soy oil showed that palm oil has a balanced ratio of saturated and unsaturated fatty acids while palm kernel oil has mainly saturated fatty acids which is broadly similar to the composition of coconut oil (Ekpa *et al.*, 1994). Compared to tenera oil, dura oil has a higher amount of saturated fatty acids but this makes it more stable and less prone to oxidation at high temperatures (Siburat *et al.*, 2002).

2.6 Food and Non-food Uses of Palm Oil

Palm oil and palm kernel oil have a wide range of applications; about 80% are used of food applications while the rest are feedstock for a number of non-food applications (Salmiah, 2000). Among the food uses, refined, bleached and deodorized (RBD) olein is used mainly as cooking and frying oils, shortenings and margarine while RBD stearin is used for the production of shortenings and margarine. RBD palm oil (i.e. unfractionated palm oil) is used for producing margarine, shortenings, *vanaspati* (vegetable ghee), frying fats and ice cream. Several blends have been developed to produce solid fats with a zero content of *trans*-fatty acids (Berger, 1996). (*Trans*-fatty acids, which may have an adverse effect on health, are produced when unsaturated fats are partially hydrogenated to obtain solid fat products such as margarine). In the production of ice cream, milk fats are replaced by a combination of palm oil and palm kernel oil (Berger, 1996). A blend of palm oil, palm kernel oil and other fats replaces milk fat for the production of non-diary creamers or whiteners (DeMan and DeMan, 1994).

2.6 Oil Palm and the Environment

Oil palm plantations have been heavily criticized for being main cause of the high rate of deforestation in South Asia. Increasingly, there is recognition worldwide of the necessity to reconcile agriculture practices with the need for environmental conservation. It has to ensure that agricultural operations do not damage the environment and, in the long-term, contribute to the sustainability of cropping systems (Nelson *et al.*, 2010). In several areas, environmental considerations are already well catered for. These include the minimum use of chemicals, the adoption of integrated pest management, judicious use of inorganic fertilizer, recycling of palm biomass within the plantation and between mill and plantation, zero-burning practice on clearance, and soil conservation measures. Examples of the latter including terracing of hilly areas, construction of drains and preservation of natural watercourses, use of silt pits and of cut fronds across slopes to minimize erosion and runoff.

The use of beneficial plants, such as *Cassia cobanensis* and *Euphorbia heterophylla*, as sources of nectar for parasitoids, is being widely adopted by plantations to keep populations of oil palm insect pests in balance with nature (Nelson *et al.*, 2010). This has led to a reduction in the use of insecticides for bagworm and nettle caterpillar control. Several features of an oil palm plantation resemble those of the natural forest cover that it often replaces. As a perennial tree crop, oil palm, at least from the seventh or eighth year onward, provides a continuous and dense canopy cover and also recycles nutrients and organic matter within the ecosystem. Unlike most other oil crops, little or no tillage is involved in its cultivation which minimizes the oxidation and loss of organic matter which may otherwise occur. The canopy not only provides protection to the soil from the worst impacts of heavy rainfall, it also increases humidity while reducing air and soil surface temperatures, and factors which go towards providing a favorable microclimate for many co-existing species (*Hardter* and Fairhurst, 2003). Environmental considerations are equally important in the processing sector of the industry. Legislation imposes limits to the nature and amounts of discharges to the atmosphere and waterways by mills and refineries (Henson, 1990). However, mill 'waste' products, which were once viewed as embarrassing liabilities are now viewed as co-products of increasing potential value. In addition to Excess Fibre Bunch (EFB) and Palm Oil Mill Effluent (POME) as nutrient sources in the plantation, the use of excess fibers in manufacturing, the recovery of POME solid for animal protein, the generation of biogas from the effluent ponds and use of surplus boiler energy to generate electricity, are further examples, all of which serve to promote a 'zero-waste' concept (Henson, 1990).

2.7 Field Establishment

Field establishment activities for oil palm are lining, holing and planting of polybag oil palm seedlings at density of 136 to 148 palms per ha, depending on the soil type. It is important that effort is made to obtain full ground coverage by leguminous cover crops such as *Pueraria javanicaand Calopogonium caeruleum* to minimize soil loss through runoff as well as to improve the soil properties through nitrogen fixation (GHPB, 1997). Field Maintenance operations for immature oil palm with full cover of leguminous cover crops include: weeding, water management, pruning, pest and disease management and manuring. Integrated pest management involving a mix of cultural, physical, chemical and biological control approaches to minimize crop losses to pests is commonly adopted in plantations (GHPB, 1997). Examples of biological control measures applied include the use of baculovirus and *Metarhizium anisopliae* to control the rhinoceros beetle (*Oryctesrhinoceros*), control of leaf-eating bagworms and nettle caterpillars by their natural predators and parasitoids and the use of barn owls as the biological agent to control rats (GHPB, 1997).

2.8 Oil Palm Propagation

Oil palm seeds have a peculiar dormancy and as such require special treatment in order to induce germination: seeds of oil palm require a heat treatment of 39–40°C for 60–80 days, followed by cooling and rehydration this will break the dormancy and allow germination of the seeds. Excised embryo propagation can also be done in vitro in which case the embryo starts to enlarge in 24 hours for optimum performance; the seedlings must be nursed for about 10-14 months before transplanting. During the nursery period shading must be provided, usually, black polyethenes are used as the nursery bags. The planting density for maximum productivity is 140-160 plants per ha. Oil palm is commonly planted 9 m apart in a triangular pattern giving 143 plants per hectare (Stone, 2007).

2.9 Management of Oil Palm Plantation

Some of the managements practices that can be undertaken under palm plantations include, weeding, irrigation in areas of low rainfall, fertilizer application, pruning of branches, bushfire control, felling of older ones to make way for young ones to grow and control of diseases as they occur (Daniel, 2000). Harvesting can be done when a plant is 3-3.5 years old when the plants have started fruiting. The indication for ripe fruits is loose detached at the base of the plant. Harvesting is done with cutlasses, chisels or Malayan knives. The latter consists of a sickle on a long bamboo or aluminum pole. The process is done by cutting the bunch from the stalk. In Africa, some trees can grow very tall and smooth stemmed in which case ropes are used to climb the plant and cutting done with a cutlass (Daniel, 2000).

2.10 Prospects of Oil Palm Production

World demand for vegetable oils is rising sharply, from 100 million tonnes in 2005 to an estimated 150 million tonnes in 2020, as the world population continues to grow and the standards of living increase in many developing countries (Breure, 2003). The role of oil palm as a supply of relatively inexpensive and versatile edible oil is, therefore, expected to become ever more prominent (Poku, 2002). With best practices for cultivation and processing, it can produce 4–6 times more oil/ha than any of the other oil crops, in an economically and environmentally sustainable manner. Extrapolations from crop-growth models suggest that the physiological potential for oil yield of oil palm may well be 12–14 tonnes per hectare against present maximum yields of 7 tonnes per hectare. The new possibility of clonal propagation is an important factor in this respect. The main drawback of oil palm is the difficulty of cost-effective mechanization of harvesting. Hence, availability and cost of labour may well become limiting factors in producing countries with improving standards of living.

Well-established oil palm plantations provide an ecosystem that has some of the characteristics of humid tropical forests. Recent studies have shown that the net carbon sequestration by a mature oil palm ecosystem is higher than that of humid tropical forests (Bada, *et al., 1981*). The negative publicity on palm oil as being an 'unhealthy tropical vegetable oil' has been repeatedly proved unjustified by scientific evidence. On the other hand, much needs to be done at national and regional levels, particularly in South-East Asia, to restore the reputation of the oil palm as an ecologically sustainable plantation crop, as this has been severely tarnished in the past decade by poorly controlled expansion, causing air pollution and unnecessary destruction of tropical forests (Caliman *et al.*, 2005). In West Africa the smallholder sector of palm oil producers, processors and traders are increasingly overtaking the privatized formal plantation sector in becoming the main supplier for the ever-growing domestic markets. Sustainable palm oil production needs to be redefined here, as the best management practices applied in the estate sector may be incompatible with the socio-economic priorities of the smallholders and their families (Schaelemann *et al.*, 2008).

2.11 Management of Oil Palm By-products

Oil palm by-products include empty fruit bunches, mill effluent, sterilizer condensate, palm fibre and palm kernel shell. The first two are widely used as mulch and soil improvers in palm plantations, and fibre and shell are increasingly used as fuels in the oil mills (Yusoff, 2006). Ash can be mixed with concrete (Tangchirapat *et al.*, 2007) and shells to surface plantation roads (Yusoff, 2006), while methane from mill effluent fermentation can also provide energy for mills (Yacob *et al.*, 2006). Other experimental items made from by-products include paper (Wanrosli *et al.*, 2007), fibre board and fillers (Wahid *et al.*, 2005), activated carbon, compost for growing mushrooms, and enzymes, vitamins and antibiotics (Ramachandran *et al.*, 2007). Commercial research goes on: for example, vanilla flavouring can be generated from empty fruit bunches (Ibrahim *et al.*, 2008), while fibre is being proposed as a means to filter heavy metal pollutants from other industrial processes (Isa *et al.*, 2008). Even the pests may find commercial use: for example, the *Oryctes rhinoceros* beetles caught in pheromone traps in oil palm plantations are used in a nutritional supplement for ornamental fish feed (Kamarudin *et al.*, 2007). The use of byproducts can increase the financial viability of oil palm and reduces waste. Uptake in Malaysia is in advance of that in Indonesia and varies from company to company (Kamarudin *et al.*, 2007).

2.12 Importance of Genetic Resources Conservation

Genetic resources are sometimes called the "first resource" of the natural resources on this planet - the others being land, air, and water (Davis *et al.*, 1986). Genes are the link from generation to generation of all living matter. Therefore, attention to genetic resources means attention to the vast diversity among and between species of animals, plants, and microorganisms. Within this diversity there is a hierarchy of organization and the term genetic resource has meaning at each level. At one level, genetic resources include all the individuals of a species, particularly if it is threatened with extinction. Genetic resources also include populations, gene pools, or races of a species which possess important attributes not found uniformly throughout the species. Breeding lines and research materials, such as mutant, genetic, or chromosomal stocks, are also genetic resources and are important in animal and plant breeding and in all phases of biologic research (Davis *et al.,* 1986).

Genetic resources also refer to genes themselves, maintained in selected individuals or cloned and maintained in plasmids. These are the substance of agriculture and food production and major economic enterprises (McGuire and Qualset, 1984). This high level of productivity has resulted from the development of new crops and new uses for old crops, the protection of annual productivity by means of pest-resistant varieties and pest-management schemes, and continuing research into the genetic systems that give rise to critical characteristics of crop species. These developments are totally dependent on the availability of genetic resources. There is an analogous situation with regard to animals (McGuire and Qualset, 1984).

Genetic improvement has profoundly increased productivity of livestock, dairy, and poultry operations. However, financial constraints for research have begun to limit researchers' abilities to maintain the large populations of animals that are necessary to maintain potentially useful genetic diversity (McGuire and Qualset, 1990). Research funding has typically not taken into account maintenance costs of genetic resource collections, yet research continuously needs and produces more genetic resources (Davis *et al.,* 1986). Beyond the easily recognized plants and animals used directly for human sustenance are lesser known useful genetic resources, such as yeast, microorganisms used in fermentation for bread, beer, and winemaking. Plants and animals in their natural habitats are valuable for their aesthetic values, their potential uses by humans, and for maintaining functioning ecosystems.

2.13 Constraints to Oil Palm Conservation

Ravigadevi *et al.,* (2002) stated that lack of deliberate extension efforts and other fundamental constraints such as; tenure rights, which are mostly tenancy-right through leasing and rent, are the major constraint to oil palm conservation (Ravigadevi *et al.,*2002). This does not allow tenant to conserve new oil palm plantations in their farms for longer periods. Since in Ghana land in the community is communally owned and also shared among community or family members, land acquisition through inheritance is mostly the order of the day and as such prevents the members from using the land for oil palm cultivation. In this situation, farm size become very small, thus prevent oil palm conservation. Tenant in this area commonly grow food/annual crops (Oke, 2002)

Attitude of land owners to farming is negative because of the drudgery involved (Oke, 2002). Most of them inherited the oil wild groves from their parent which now serves as source of quick and regular income. Long period of maturity of oil palm trees, since land or wild palm groves had been fragmented due to inheritance; it becomes very difficult to open up new land which is unavailable for oil palm conservation (Ravigadevi *et al.,* 2002). Regular communal crises in most of the rural folks in Nigeria that always bring about wanton destruction of houses, farm for instance, setting of cocoa plantation, oil palm groves and houses on fire did not encourage farmers to contribute to oil palm conservation (Akintibubo, 2002). Oke (2002) discovered that persistent crises in dura oil palm conservation included; land shortage, lack of funds, low oil content, marketing and processing techniques, climate as well as frequent bushfires. Akintibubo, (2002) revealed that constant demand for palm trees for palm wine and 'akpeteshie' has contributed to the decline of the wild grove oil palm (dura).

2.14 Impact of Oil Palm Conservation on Biodiversity

The expansion of oil palm that involves conversion of forested areas will impact biodiversity richness and some of the habitats that shelter endangered species Fitzherbert *et al.,* (2008).The destruction of habitat for orang-utans, elephants and tigers has been highlighted in many forums and has provoked major international criticism of the oil palm industry (Koh and Gan, 2007). Oil palm is often criticized for being a 'mono-crop' containing a narrow range of associated species. According to Fitzherbert *et al.,* (2008) about 15% of the species found in primary tropical forests persist in oil palm plantations, indicating severe depletion of biodiversity. The number of bird and butterfly species is reported to decrease by 77% and 83% respectively after forest land is converted to oil palm plantations (Koh and Gan, 2008) and in a biodiversity study carried out in tropical regions, remnant species after oil palm establishment included 26 butterfly, 35 bird, and 7 mammal species (Koh and Gan, 2007). By contrast, a quantitative study on mature oil palm plantations located in the tropics identified a wide diversity of 298 plant species including 186 dicotyledonae, 77 monocotyledonae and 35 pteridophyta (ferns and allies) representing 81 families (Germer, 2003). Biodiversity richness within a plantation may vary depending on the ground cover and pest control techniques used by the plantation. Over the past twenty years, approaches to pest management in oil palm plantations have evolved from control methods based solely on pesticide use to integrated pest control methods (Caudwell, 2000; Golden Hope Plantations, 1997; Philipe, 1993; Teh and Ho, 1997; Wood, 2002). Plantations can increase biodiversity within oil palm plantings with management practices that encourage the retention of a variety of ground cover species within the plantation that can attract insects that predate upon pests such as bag worms and leaf eating caterpillars. It is now common practice to plant white alder (*Turnera subulata),* coral vine *(Antigonon leptopus*), *Sennacobanensis* (formerly *Cassia cobanensis*) to provide nectar for insect predators of leaf eating pests. These practices also reduce the amount of pesticide required to maintain adequate pest control. Further research is needed to evaluate different ground cover management practices and their impact on local biodiversity (Koh and Gan, 2007). . Whilst quantitative studies are required to characterize species diversity in anthropogenic grassland (vegetative land cover dominated by *Imperata cylindrica* with associated species) and degraded forest across a range of soil and climatic conditions, it is likely that species diversity may actually increase when grassland containing narrow species diversity is converted into oil palm (Koh and Gan, 2007). Since the demand for oil palm is expected to increase, the threat to endangered species habitat and biodiversity will be significant if expansion is permitted on land presently covered with forest (Koh and Gan, 2007). In this context, yield improvements provide benefits to the environment since by increasing yield, less land is required for crop production and more forest land is spared for conservation. It should be noted that gallery forest fragments found within grassland landscapes provide a refuge for some species, whilst maintaining forested buffer zones along streams and riparian areas, or on slopes too steep to plant will also help to conserve biodiversity (Fitzherbert *et al.*, 2008) and is already the practice recommended by the Roundtable for Sustainable Palm Oil (RSPO, 2007).

2.15 Agroforestry systems and biodiversity conservation

Land use changes associated to agriculture and livestock have modified natural ecosystems of arid zones, creating complex landscapes with patches of transformed and untransformed areas (Shachak *et al.,* 2005). Processes determining such transformations continue to be operating and, therefore, conservation of dry zones needs urgent policies to protect the remaining natural ecosystems and to restore transformed areas. Developing appropriate strategies for biodiversity conservation, restoration, and sustainability requires the research faculty to understand the structure and functioning of the natural ecosystems and their interactions with the transformed environments and social systems surrounding them. Ecological studies have established important bases for understanding the natural history and functioning principles of natural arid ecosystems (Huenneke and Noble 1996; Callaway and Walker 1997; Hacker and Gaines, 1997; Valiente-Banuet *et al.*, 2002; Shachak *et al.*, 2005). In contrast, few studies have analyzed the transformed areas which are, however, crucial for not only designing restoration strategies, but because some of them may also potentially contribute to biodiversity conservation and maintenance of ecosystem services (Darkoh, 2003). Among the transformed areas, agroforestry systems have particularly attracted the attention of a number of researchers and decision makers due to their promising capacity to achieve these goals (Perfecto and Vandermeer, 2008). In tropical regions such as Ghana, the areas traditionally transformed as crop fields commonly retain abundant tree cover (Harvey *et al.,* 2004). Peasants not only manage forest relicts as sources of useful plants (Schroth *et al.*, 2004), but also transfer and promote growing of wild plants and oil palms into cultivated farms (Casas *et al.,* 2007), or simulate the forest structure in artificial systems using crop plants (Wilken, 1977). Such practices constitute traditional agroforestry systems (Schroth *et al.*, 2004), which are effective in maintaining biological diversity (Vandermeer *et al.,* 1998), sheltering native species not tolerated in agro industrial-type systems as well as species not occurring in natural systems (Vandermeer *et al.,* 1998; Tscharntke *et al.,* 2005). Traditional agroforestry systems are often small areas plant species composition of which may greatly vary according to both management and environment types (Bhagwat *et al.*, 2008), and in some cases, these systems and the surrounding wild areas constitute landscapes with higher diversity than unmanaged landscapes (Swift *et al.*, 1996, 2004; Tscharntke *et al.*, 2005). Although, for the above reason, the role of agroforestry systems for conservation has been investigated throughout the world, it has primarily been studied in most tropical regions such as Ghana and Nigeria (Harvey *et al.*, 2004). Also, still further limited is our understanding on how farmers decide whether to retain or eliminate plants in agroforestry systems, how they manage densities and arrangements of the plants (Harvey *et al.*, 2004), and which factors influence the loss of traditional management systems. Research on these topics is therefore, relevant for increasing the potential for use, conservation, and restoration of these systems. A study was conducted in some reserved areas in Ghana and Nigeria which are among the main reservoirs of biological diversity of tropical zones of Africa (Da´vila *et al.*, 2002). These regions have been the scenario of human cultural history for nearly 12,000 years (MacNeish, 1967), which makes these areas as among the richest in Africa, with regard to traditional ecological knowledge and management techniques of forests and agricultural systems. For instance, Casas *et al.*, (2001) and Lira *et al.*, (2009) documented information on nearly 1,600 useful plant species of these regions, among which 120 native species were managed in agroforestry systems (Casas *et al.*, 2008). In the drier zones of these regions, the more extensive agroforestry systems are those that were derived from the columnar cacti forests described by Valiente-Banuet *et al.*, (2000). These systems described occur in areas with soils derived from volcanic rocks or alluvial systems, which are more conducive for agriculture than the area with the predominating calcareous soils. Agroforestry systems of tropical areas are generally dedicated to rainfed cultivation of maize (*Zea mays)*, plantain (*Musa spp)*, cocoyam (*Colocasia antiquarum*) and oil palm (*Elaes guineensis)* in small parcels (1–4 ha), usually managed with low inputs. These systems may have vegetation cover composed of strips or clusters of perennial plants, living fences, and isolated plants that are relicts of the original forest and left standing when the areas are cleared (Casas *et al.*, 2008). Also, these systems may maintain plants, although considered as bad weeds in other contexts, which the local people consider as valuable edible plants (Casas *et al.*, 2001; Blanckaert *et al.*, 2007). People also resort to planting inside agricultural plots, vegetative propagules and trees like *Leucaena esculenta, Sideroxylon palmeri,* and *Prosopis laevigata* (Casas *et al.*, 2001). Some studies have documented that these systems may maintain high levels of species richness and genetic diversity of dominant species (Casas *et al.,* 2006; and Parra *et al.,* 2008). In addition, the study by Hacker and Gaines, (1997) found that populations of *Polaskia chichipe* have high regeneration capacity in agroforestry systems. However, previous studies (Casas *et al.*, 2006, 2008) have recognized that changes in management practices, apparently associated to cultural, social, and economic phenomena, are causing decrease of vegetation cover within agricultural fields, and this process could be affecting plant species diversity, genetic variation, and functioning of the agroforestry systems.

The agroforestry systems (AFS) main characteristic is the inclusion, through the consortium, of a greater variety of plants or animals. Thus there is in the same production system, plants having an annual cycle and perennial plants not associated with the creation of animals (Haddad, 2006). The AFS also feature low or no use of chemical inputs, high species diversity, structural complexity, and the shrub and tree component responsible for the conservation of soil and maintaining productivity, and especially the structural simplicity and high economic value of intercrop components (Nair and Dagar, 1991).

The leaf analyses of wild and green manure species identified the macro and micro nutrients incorporated into the system through the management (pruning) of the AFS oil palm Silva (2002). As a source of nutrient, the following species are particularly notable: *Inga edulis, and Manihot esculenta* supplied nitrogen; *Tithonia diversifolia* and *Cajanus cajan* supplied phosphorus, *Tithonia diversifolia* supplied potassium, and *Crotalaria spectabilis* served as a source of boron. Among the wild species stood out *Solanum paniculatum*, *Jatropha gossypiifolia* and *Alternanthera dentate* and these demonstrate the benefit of green manure (Bertalot *et al.*, 2003).

Agroforestry systems show good prospects for meeting the sustainable production of oil palm, combining the production of oil and the conservation of biodiversity (Bertalot *et al.*, 2003). The diversification of production systems involving the other palm species (green manure oil and timber) can be a strategy to reduce phytosanitary risks, increase income for the area considering the many commercial products provided throughout the year, less use of external inputs, in addition to social and environmental benefits that include the recovery of degraded areas and the maintenance of environmental services (Bertalot *et al.*, 2003).

2.16 Conservation Strategies for Tree Crops on Farms

Harvey *et al.*, (2004) propose six strategies and an action plan to conserve tree crops on farms and sustain rural livelihoods. The strategies are:

Identify and prioritize rural hotspots where conservation of tree crops and rural livelihoods can be achieved jointly. This strategy seeks to identify, with stakeholders' participation, “priority landscapes where action for conservation and agricultural sustainability will bring the greatest results” and “rural hotspots, where traditional smallholder livelihoods are most vulnerable.” Here, rural hotspots are landscapes that have high tree crops, high levels of human pressure, and high levels of biodiversity conservation.

Identify and mitigate key threats to tree crop conservation within priority agricultural landscapes. A number of studies have significantly improved the understanding of landscape dynamics and identified the threats they pose to tree crop conservation (Ramakrishnan *et al.,* 2000, Bhagwat *et al.*, 2008 and Garcia *et al.,* 2007). But understanding threats does not reverse trends. Threats to tree crop conservation pose "wicked" problems (Rittel and Webber, 1973), and their mitigation requires involvement of government, NGOs, landowners, and most importantly sections of the local communities that depend most heavily on wild natural resources and lack livelihood alternatives and political leverage (Allen and Gould, 1986 and Ghazoul, 2007).

Conserve remaining native habitat within the agricultural matrix. Maintaining them obviously makes good sense in terms of tree crop conservation because their role in increasing landscape connectivity is well established in some rural communities in Africa. The conservation of some trees crops and their permanence in the landscape entails opportunity costs. The benefits that can be obtained from coffee and pepper alone explain why the private forest patches are converted into plantations as soon as capital is available Nigeria (Garcia and Pascal, 2006). At present, only wealthy individuals who are not dependent on the income generated by these tree crops can afford to keep them forested. Sacred forests are themselves subject to a lot of pressure, and few maintain spatial integrity (Garcia and Pascal, 2006). Some of the tree crops on farms also serve as host for pests and diseases, as reported from some West African countries such as Ghana (Blanche *et al.,* 2002). A cursory examination could therefore conclude that the less wealthy households maintain more tree crops cover and hence more biodiversity in their estates, but this is so only because of the lack of capital and not because of a specific management decision. Despite the existence of mechanisms that make payment conditional on preservation of forests, any economic reward granted to these households for their role in conserving tree crops could actually provide them the needed leverage to become a "credible threat" to biodiversity (Schroth, 2007). Farmers need to be given the choice to join incentive schemes for conserving tree crops within the agricultural matrix so that they will receive financial rewards (Garcia and Pascal, 2006).

Protect, diversify, and sustainably manage tree cover within the agricultural matrix (Garnett, *et al.*, 2007).Two main factors shape the decisions to retain or fell trees: tree rights and shade management. Farmers need to obtain permits to fell, transport, and sell trees, but rights vary from estate to estate. Owners of estates with "redeemed" land tenures have the right to manage their tree crops for their full commercial value.

Promote and conserve indigenous, traditional, and ecologically based agricultural practices (Bobo*et al., 2006*). The implicit assumption behind this strategy is that smallholders will welcome the preservation of their traditional livelihood systems. Traditional livelihood systems do not exist in isolation, and their practitioners respond to changing socioeconomic circumstances to maximize their economic and social welfare. Thus, traditional livelihoods may be threatened by their practitioners as they pursue more economically rewarding livelihood options. Farmers are conscious of the role tree crops cover play in providing suitable microclimate, preventing soil erosion, increasing soil fertility, and controlling pests and diseases (Ghazoul, 2007.)

Restore degraded unproductive lands through reforestation by the use of tree crops, natural regeneration, and enrichment planting (Lindenmayer *et al.*, 2006). Reforestation, enrichment planting, and fostering natural regeneration are activities that have already been in existence (Lindenmayer and Franklin, 2002).Resolving competing claims over rights, access, and control of the land and natural resources will determine the success of any measure promoted (Garcia and Pascal, 2006).

CHAPTER THREE

METHODOLOGY

3.1 Study Area

The study was carried out in the Sunyani West District (Fig. 3.1) of the Brong Ahafo Region of the Republic of Ghana. The district was established in November 2007 through LI 1881, 2007. The Administrative capital of the District is Odomase. The District lies between latitude 7º 19´N and 7º 35´N and longitudes 2º 08´ W and 2º 31´ W. The District shares boundaries with Wenchi Municipality to the North East, Tain District to the North, Berekum and Dormaa East to the West, Sunyani Municipal to the South East and to the Eastern boundaries of the District are Tano North and Ofinso North District. Sunyani West District has a total land area of 1658.7 square kilometers (Sunyani West District Annual Report, 2011).

Soils in the district fall into the Ochrosols group which is generally fertile and therefore support the cultivation of oil palm (*Elaes guineensis*), cocoyam (*Colocasia antiquarum*), maize (*Zea mays*), cassava (*Manihot utilissima)*, cocoa (*Theobroma cacao*), plantain (*Musa spp*) and yam (*Dioscorea spp*). Some popular timber species in the district are Odum (*Milicia excels*), Mahogany (*Khaya senegalensis*), Wawa (*Ricinodendron heudelotii*), Ofram (*Terminalia superba*), Teak (*Tectona grandis*), Emire (*Terminalia ivorensis*), and Onyina (*Ceiba pentandra*) among others (Sunyani West District Annual Report, 2011).

The topography of the District can be described generally as undulating. The drainage is best described as dendritic with several streams and rivers being seasonal ones. The climatic zone of Sunyani West district falls within the Wet Semi-Equatorial region and therefore has two rainy seasons in a year. The major rains begin in April and end in July and the minor rainy season is from September to October. Average annual rainfall is about 170mm. The dry season often lasts for five months (between November and mid-March) each year (Sunyani West District Annual Report, 2011).

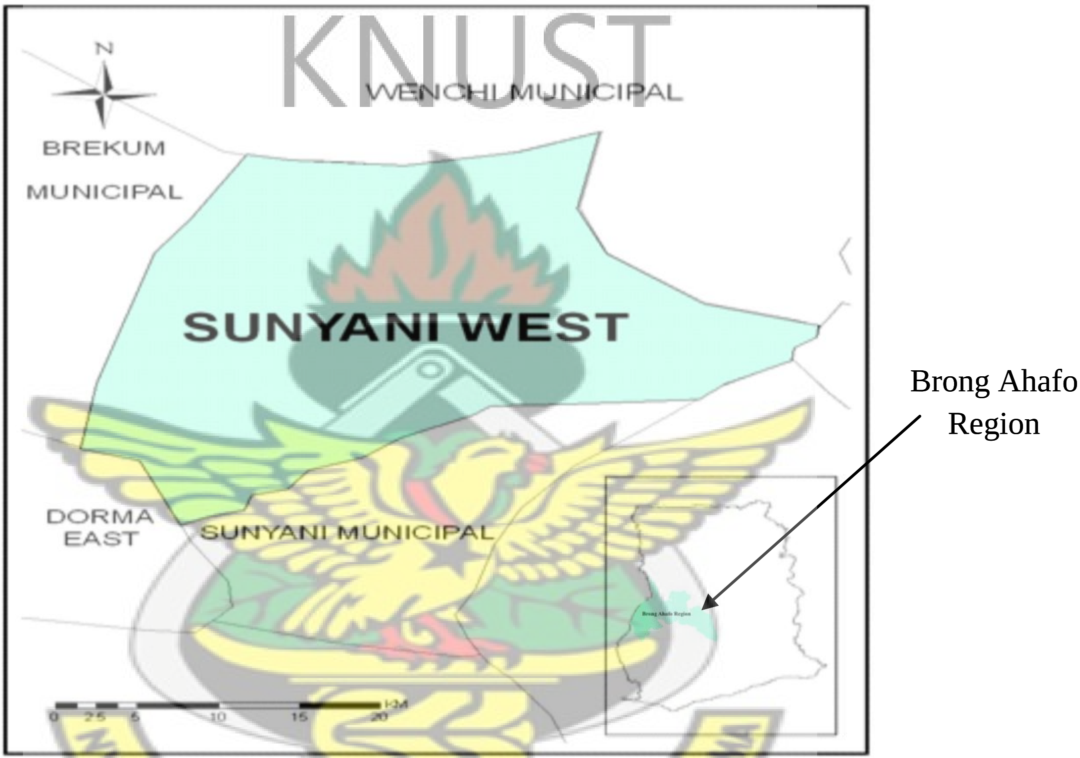

Fig 3.1: Map of Brong Ahafo Region Showing Sunyani West District

Source: www.ghanadistricts.com

3.2 Selection of Research Sites

Eight communities in the district were selected for the study. They are; Addae Boreso, Koduakrom, Nkranketewa, Kwabenakumakrom, Amanfoso, Nsoatre, Mantukwa and

Dumasua (Fig 3.2). These communities were purposively selected due to accessibility and availability of data of interest which was best to answer the research questions.

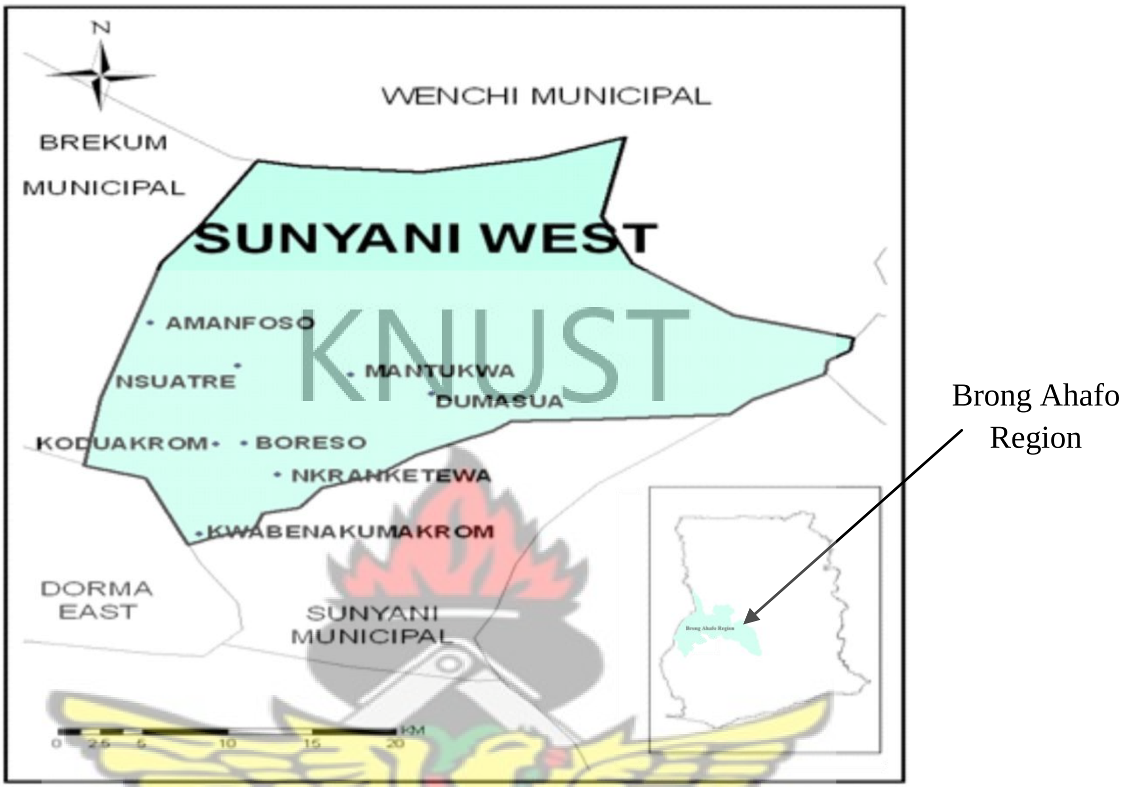

Fig.3.2. Sunyani West District with Communities Selected as Research Sites.

Source: www.ghanadistricts.com

3.3 Research Design

Familiarization visit, reconnaissance survey, and socio-economic survey were employed in this study. Familiarization visit helped to familiarize with the farmers and solicit for their views on their farm operations and perceptions on dura conservation. Also, a reconnaissance survey was conducted 2 weeks (17^{th} to 31st October, 2011) before the actual data collection. The reconnaissance survey helped to establish contact with farmers in the communities where the actual survey took place. It also helped to rapidly appraise some of the main biophysical and socio-economic factors in these selected communities. Lastly Socio-economic survey was conducted 2 weeks after the reconnaissance survey. A semi-structured questionnaire was used to obtain data on the socio-economic characteristics of the farmers. Data were taken from farmers who have access to cocoa farms, arable crop farms and fallow lands in areas such as demographic characteristics, management, constraints and agroforestry technologies that are capable of promoting conservation of the dura oil palm by farmers.

Information gathered through observation have been presented descriptively whiles data collected using semi-structured questionnaires have been analyzed using Statistical Package for Social sciences (SPSS), version 16 and Microsoft Excel 2007.

3.4 Sampling and Selection of Respondents

Agroforestry systems for this study were selected purposively as well as the farmers. During the reconnaissance survey some of the farmers did not meet the desired criteria for inclusion in the research; (1) Farmers who have cocoa farms, arable crop farms and fallow lands. (2) Had managed dura in them for the past 10 years. Therefore, the most appropriate method of identifying farmers who met the criteria for the study was to apply purposive sampling. Based on the pre-established criteria a total of 410 farmers were purposively selected from the eight communities and a sample size of 80 farmers was selected from the above population using the formula below:

$$\mathbf{n = N / 1+N (e)^2}$$

Where,
n =sample size
N = Population size
e = Margin of Error
Source: (Israel, 1992).

Table 3.1: Sample Size of Population and Communities Selected

Confidence level=90%   Margin of error=10%

COMMUNITIES SELECTED	POPULATION CONSIDERED (N)	SAMPLE SIZE (n)
Addae Boreso	33	7
Koduakrom	31	6
Nkranketewa	32	6
Kwabenakumakrom	38	8
Amanfoso	37	8
Nsoatre	104	21
Mantukwa	57	10
Dumasu	78	15
Total	**410**	**80**

The farmers were selected at random for the study. Simple random sampling (SRS) is a method of selection of a sample comprising of *n* number of sampling units out of the population having *N* number of sampling units such that every sampling unit has an equal chance of being chosen. It tends to yield representative samples, and allows the use of inferential statistics in analyzing the data collected. This sampling technique was chosen because each selection is independent of other selections, and every possible combination of sampling units has an equal and independent chance of being selected.

3.5 Designing Data Collection Instruments

With regard to this study a semi-structured questionnaire was designed as an instrument to collect data from the study area. The semi-structured questionnaire included both open-ended and closed-ended questions. This design was selected because it facilitates the collection of a wide range of information and allows respondents to answer in their own words than a structured questionnaire.

Pre-testing of questionnaire was conducted to ensure its feasibility and applicability of the designed questionnaire on the field. This was undertaken four weeks before the actual data collection. It was carried in two communities (Kwatire and Adentia) outside the communities selected as research sites in the district. In all 20 farmers were randomly selected for the pretesting. Pre-testing of a questionnaire generally means administering a questionnaire to respondents selected from the target population using the procedures that are planned for the main study. Questionnaires were pre-tested to ensure its reliability and feasibility during its administration to the target group. After the pre-testing the total number of questionnaires were reduce from 55 to 49. This was done because after the pre-testing it was realize that some the questions were given the same answers and hence the need for reduction.

3.6 Methods of Data Collection

The data for the study was collected from two main sources; these are primary and secondary sources. Data collection lasted for four months; thus from November, 2011 to February, 2012.

The primary data was obtained from questionnaires, field observations and focus group discussions. The questionnaire consisted of a set of questions presented to the farmers for answers. The few literate among the farmers questionnaires were given to them to read, interpret what is expected of and wrote down the answers themselves. On the other hand those who could not read and write the questionnaires were translated into the local dialect of the respondents and the answers were written down by the researcher. A total of eighty questionnaires were administered.

Secondary data were also collected for this study. The secondary data were obtained from review of existing literatures and journals. Other information was obtained from Ministry of Food and Agriculture (MoFA). The secondary data were used to supplement and validate the information obtained from the primary sources.

3.7 Methods of Data Analysis

The data that were gathered from the survey were analyzed using Statistical Package for Social Sciences (SPSS) and Microsoft Excel (Professional plus edition). The survey data were encoded, entered into a spreadsheet and checked prior to analysis. Cross-tabulation with selected variables, percentages and frequencies were undertaken using tables. Percentages were based on either the total number of respondents or total responses, details of which are provided in figures and tables. These were done in order to facilitate statistical and mathematical operations taking into account the objectives of the study. Chi-square test was used to test variables such as age, education and gender.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results obtained from the data analysis. It presents a detailed discussion of the results and compares it to the work done by other researchers. The discussion is centered on the management practices, constraints and agroforestry technologies that promote conservation of dura oil palm. The key statistical tests conducted revealed that some of the variables were significant whiles others were not significant. The cross tabulation was on the practice of agroforestry technologies and the key variables that could influence farmer's decision on conserving the dura oil palm in the study area. Pearson chi-square was used to test the results of the variables at 5% level of significance.

4.1 Age Distribution of Farmers in the Sunyani West

The results from the study showed that 13.8% of the farmers fall within the age class of 18-30, 40% of the farmers interviewed fall within the age class of 31-45 years,36.2% of the farmers also fall within the age class of 46-60 and only 10% fall within the age above 60 years (Fig 4.1).However, chi-square test found age to be not significant ($P<0.400$) and therefore we cannot say that age affects the conservation of dura oil palm in the study area. This could imply that conservation of dura oil palm does not take into consideration the age of the individual farmer. Corley (2005) and Hashim *et al.,* (2005) also found that age does not influence the sustainability of oil palm. Also based on the test it could mean that conservation of dura oil palm does not depend on the individual farmers age and as such no matter your age there is possibility for you to conserve genetic material such as the dura oil palm. Schroth *et al.,* (2004) who conducted a study on biodiversity conservation in agroforestry systems also found age not to influence the conservation of biodiversity in agroforestry systems.

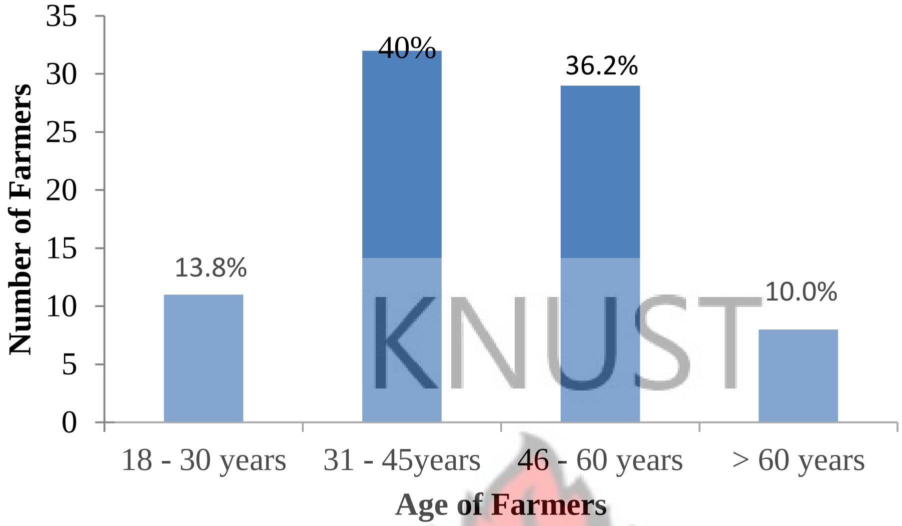

Fig.4. 1 Age Distribution of Farmers Interviewed in the Sunyani West District

4.2 Gender of Farmers in the Sunyani West

Majority of the respondents interviewed were males representing 69% and 31% females (Fig.4.2). One of the reasons that accounted for more males being interviewed is that, the study area is a cocoa growing area and cocoa cultivation involves tedious work which is mostly done by men. Moreover what accounted for fewer females was that most of them offer support to their husbands during farming activities. Although the female farmers constituted a smaller percentage of the total farmers, a lot of them showed interest in adopting agroforestry technologies that could contribute to dura conservation, but added that their decision depends on the availability of farm lands. This is so because due to population increase and urbanization there fragmentation of farm lands and as such the demand for land for cultivation of arable crops to feed the family is their priority. The chi-square test for gender was not significant (P<0.362) and therefore we cannot say that gender influences the conservation of dura oil palm in the study area. Also we can say that conservation of genetic material does not take into consideration the gender of the individual farmer. Hashim *et al.,* (2005) who conducted a study on the role of plantation industry in the conservation and enhancement of biodiversity in the oil palm ecosystem also found that gender does not influence the conservation of genetic material.

4.3 Educational Background of Farmers in the Sunyani West

The study revealed that most of the farmers have low levels of education (Fig. 4.3). Majority of them ended their formal education at the basic level or did not attend school at all. This in line with Daniel, (2000) that, management of *Elaes guineensis* does not take into consideration the educational level of the farmer and argue that farmers learn different management strategies through their farming activities.

There was a cross-tabulation of the practice of agroforestry technologies and the key variables that could influence farmer's decision in the conservation of dura oil palm in the study area. Chi-square test found that the level of education on decision of farmers in the study area to conserve dura was not significant ($P<0.425$).This low level of education could however, affect the management practices that will contribute to the conservation of the dura oil palm.

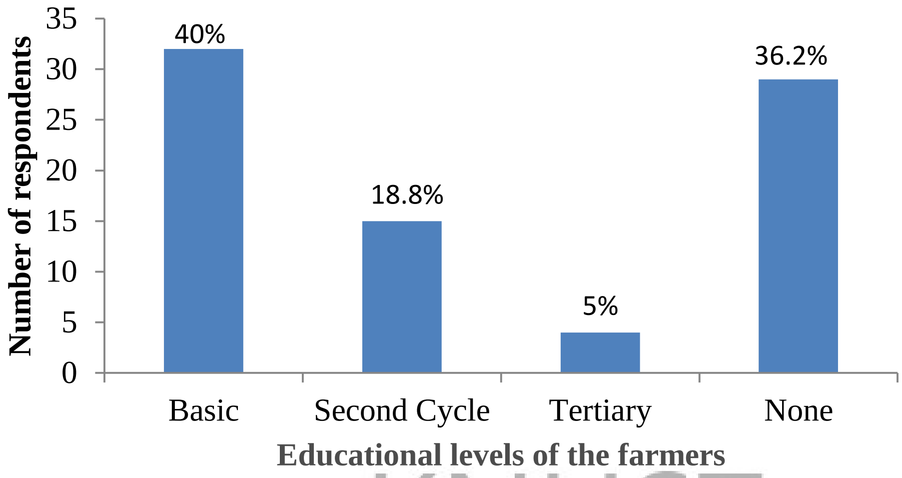

Fig. 4.3 Educational Background of Farmers Interviewed in the Sunyani West District

4.4 Household Size of Farmers in the Sunyani West

Household is a social organization in which members normally live and sleep in the same place and shared their meals (Shaner *et al*, 1982). The study conducted revealed that out of the 80 farmers selected for this study, 46.2% fell within the household size of 1-5 and 15% above 10 (Fig.4.4). Chi-square found the household size not significant and that could have no influence on dura conservation ($P<0.412$). This disagrees with Bada *et al.*, (1981) who found that household size has influence on the farm sizes of farmers in Oyo state, Nigeria.

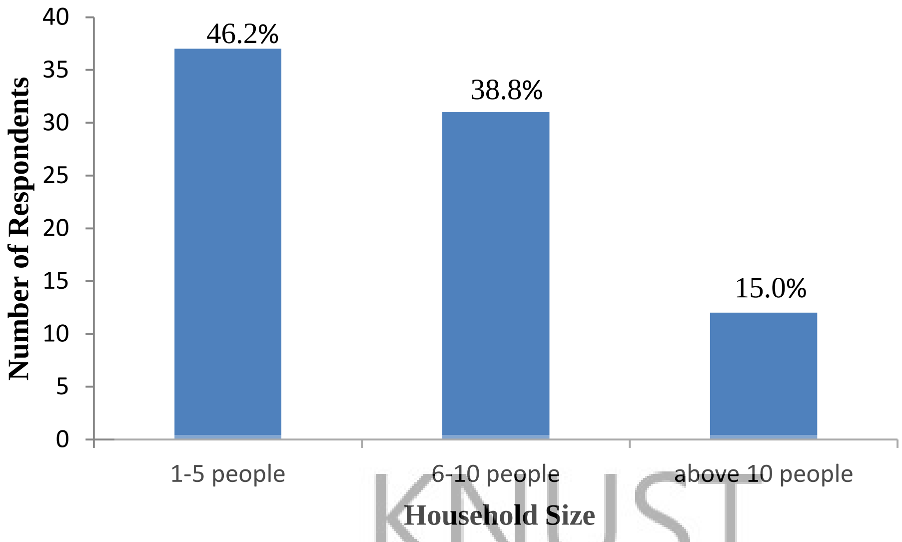

Fig. 4.4 Household of Farmers Interviewed in the Sunyani West District

4.5 Farm Size of Farmers in the Sunyani West

Farm sizes of respondents in the study area were found to be generally small. Majority (68.8%) of the respondents had farm sizes below a hectare whilst few respondents (2.5%) had above 10 hectares (Fig 4.5). The small farm sizes in the study area could be a factor which discouraged farmers from leaving dura oil palm in their farms. This is because farmers may not risk leaving the dura oil palm which will compete with their crops for nutrients, water, light and space. David *et al*., (1996) found that farmers with large farm sizes could invest resources in new technologies and get better returns, which encourage adoption of conservation technologies. The effect of farm size on dura conservation in the study area was found to be significant (P>0.002) according to the chi-square test and therefore can influence conservation of dura oil palm in the study area. Farmers with large farm sizes are willing to leave dura oil palm on their land as suggested by David *et al*., (1996) that farmers who have large farm sizes are more likely to adopt improved soil conservation technologies.

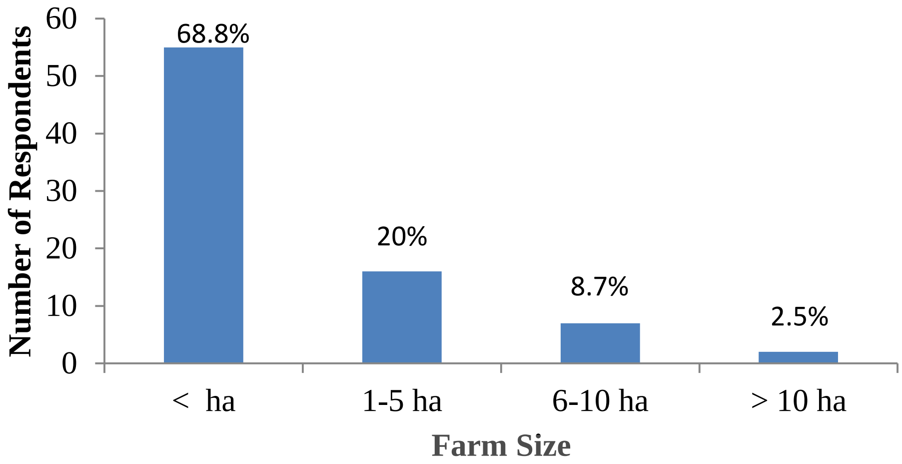

Fig.4. 5 Farm size of Farmers Interviewed in the Sunyani West District

4.6 Oil Palm Variety Cultivated by Farmers in the Sunyani West

The largest group of the respondent farmers interviewed revealed that they cultivate tenera. This constitutes 96.3% of the 80 farmers. Several reasons were assigned to the cultivation of the tenera variety. Notable among them are that, the tenera variety is early maturing, high yielding, and provides high production of palm wine and ‘akpeteshie’. The remaining 2.4% grow the dura adjacent to their tenera plantations. The reason being that most consumers who buy palm oil from the palm oil processors were interested in palm oil produced from the combination of dura and tenera. Chi-square test found the preferred variety significant and that has influence on dura conservation in the study area ($P>0.012$). Schaelemann *et al.*, (2008) reported that, in West Africa the smallholder sector of palm oil producers, processors and traders is increasingly overtaking the privatized tenera oil palm plantation sector in becoming the main supplier to meet the ever-growing domestic markets.

4.7 Farmers Preferred Variety for Meal Preparation in the Study Area.

Out of the 80 farmers interviewed, 76.2% of them preferred to use the dura oil palm to prepare their dishes and 23.8% prefer to prepare their meals using the tenera. The farmers gave some reasons that the oil obtain from dura is less fatty and when used to prepare meal can be kept for a long period of time. The study also revealed that the dura oil portrays the deep red colour of oil palm and also when the dura is used to prepare soup it tastes better than the dura. Another important fact mentioned during the study is that those who will even use the tenera to prepare their soup prefer to add some quantity of dura to help boost the taste of the soup. The survey also revealed that most of the farmers cultivate tenera because it is high yielding and early maturing and profitable for commercial purposes but allow the dura to grow in their tenera plantations for the preparation of their household dishes. The effect of preferred variety on conservation of dura oil palm in the study area was not significant ($P<0.488$) according to the chi-square test.

4.8 Duration of Dura on Farmers' Land in the Sunyani West

The study looked at the number of years respondents' kept the dura on their land. It was found that out of the 80 farmers interviewed 58.8% kept the dura on their land for a period of 1-5 years, 28.7% kept it on the land for 6-10 years and only 12.5% left it on the land for more than ten years (Fig. 4.8). Majority of the dura after germination are left on the land for 1-5 years because of the population increase which puts pressure on land for farming. As a result of this, most farmers prefer to cut down the dura and burn for cultivation of crops such as maize, cassava and plantain. Some of the farmers also sell the mature dura trees which could be nuisance to farming activities on the land to palm wine tappers to get money to support their farming activities. The dura trees which are left on the land for more than 10 years are found on marginal and waterlog areas which do not support most agricultural crops. When dura is allowed to grow on a piece of land for some time, within a few years, it will multiply to occupy the whole land and thus making agricultural activities unpleasant (Alhaji personal communication). The dura also takes a lot of nutrients and water from the soil and as such most farmers do not want to allow them in their crop farms. This confirms Kwarteng (2005) that dura is a heavy feeder as it takes much water and nutrients from the soil. Chi-square found the period dura is left on the respondents land in the study area not significant (P>0.112) and that could have no influence on dura conservation in the study area.

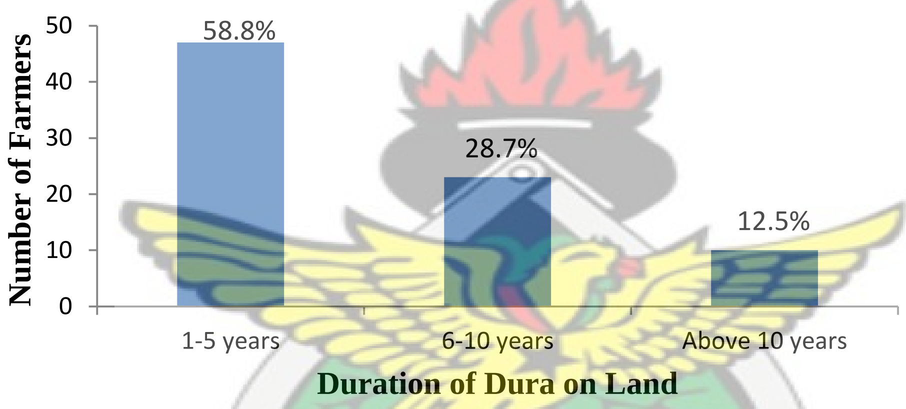

Fig. 4.8 Duration of Dura on Farmers Land in the Sunyani West District

4.9 Farmers Propagation of Dura in the Sunyani West

Propagation of dura oil palm by farmers in the Sunyani West showed that dura can be propagated naturally or artificially. Out of the 80 farmers interviewed, 98% indicated that the dura oil palm germinates naturally and only 2% propagate the dura artificially. Anyane, (1996) states that, the wild groves of oil palm trees are managed by farmers for palm fruits and wine tapping in Benin. The effect of dura propagation on conservation of dura oil palm in the study area was not significant (P<0.075) according to the chi-square test.

4.10 Reasons for Dura Conservation in the Sunyani West

The study carried out on the conservation of the dura oil palm revealed some reasons why farmers conserve the dura. These were to prevent dura extinction, food, income, and biodiversity enrichment. The study also indicated that 46% of the farmers conserve the dura oil palm in their farms for food and only 3% conserve it for biodiversity (Fig.4.11). During the survey it was revealed that most of the farmers conserve the dura for food because they say the oil produced from dura is less fatty, deep red in colour, and its soup taste better than the cultivated tenera. Compared to tenera oil, dura oil has a higher amount of saturated fatty acids but this makes it more stable and less prone to oxidation at high temperatures (Siburat *et al*., 2002). The oil produced from dura can be kept for a long period of time as compared to that of tenera (Aboagye, personal communication).

Thirty-six percent also conserve the dura for income. This is because the dura germinates naturally so when they leave them in their farms, they sell to palm wine tapers. The money obtained from this is used to supplement their farming activities. When farmers have a lot of dura palm trees, they fell and tap the wine themselves during off seasons which also help to boost their income levels. This confirms Anyane (1966) that with the introduction of *akpeteshie* into the palm market, it has become more profitable for farmers to manage palm for its final value as a tapping tree. Palm wine and *akpeteshie* are valued as a cheap local alternative to bottled recreational beverages, as well as for cultural and ceremonial use (Wadwha, 1971). Biodiversity enrichment accounted for only 3% and the reason being that most of the farmers found it as not too necessary when they are thinking about food and income to sustain a living. Using Chi-square, the reasons for dura conservation was not significant ($P<0.375$) and therefore we cannot say that it influences dura conservation in the study area.

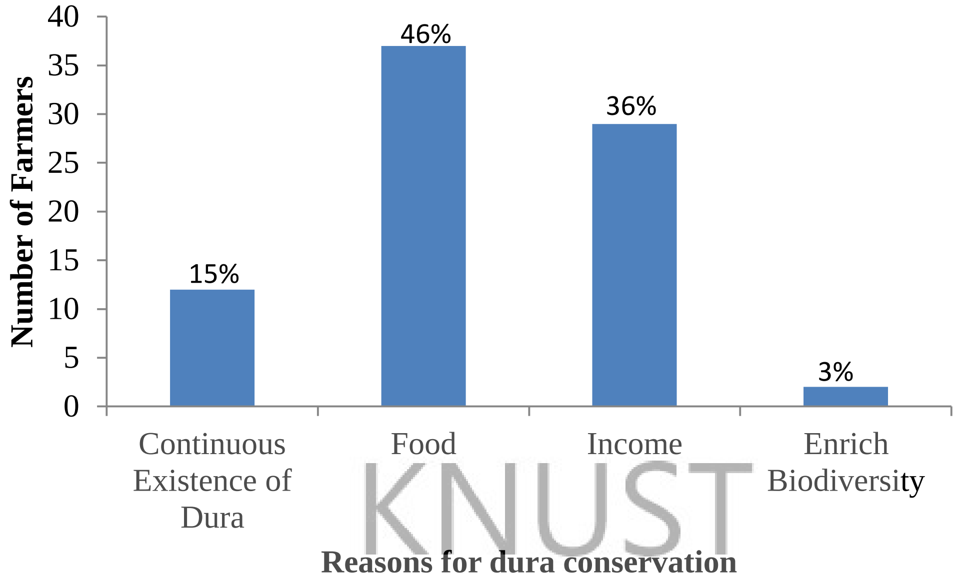

Fig. 4.10 Farmers' Reasons for Dura Conservation in the Sunyani West District

4.11 Potential Agroforestry Systems for Dura Conservation

An agroforestry system is defined as "the set of interdependent agroforestry components (trees with crops and/or animals) representing a current type of land-use in a given region" (Nair, 1989). In fact, according to Ashley *et al.*,(2006) the policy terrain of conservation landscapes has a major effect on agroforestry's potential to contribute to conservation. The study revealed two main agroforestry systems that can contribute to dura conservation (Table 4.1). These included apiculture and agrisilvicultural system. Chi square test was significant on agroforestry systems used for dura conservation (P>0.016).

Table 4.1 Potential agroforestry systems for dura conservation

Agroforestry System	Number of Farmers (n)	Percentage (%)
Agrisilvicultural	50	62.5
Apiculture	30	37.5
Total	**80**	**100**

Several scientist [Dobson *et al.*, (1997), Huang, (1998), Leaky, 1999; Rice and Greenberg, 2000)] have all elaborated the importance of agroforestry systems as an integrated approach for biodiversity conservation on farm.

Out of the 80 respondents interviewed 62.5% of this number indicated that arisilvicultural system can help contribute to dura oil palm conservation (Table 4.1). In this system the oil palm serves as shade in the initial stages of the cocoa trees. The oil palm is felled as the cocoa matures. This is because the oil palm begins to compete with the cocoa for space, nutrients and light. Tall trees such as *Terminalia superba* and *Khaya senegalensis* can also be found in this system. In Ghana, cocoa farmers actively nurture and manage some oil palm species in their farms for their ecological, economic, or cultural value (Amanor, 1996).

4.12 (a) Potential Agroforestry Technologies under Agrisilvicultural System for Dura Conservation

An agroforestry technology is a set of specifications for the roles, arrangement and management of multipurpose trees and associated components (Von Carlowitz, 1989). These specifications must include the technology related to tree characteristics, referred to as the ideotype of the tree (Huxley, 1984). The study conducted revealed that some agroforestry technologies can contribute to dura conservation. The survey indicated three technologies that could contribute to dura conservation (Table 4.2). Chi-square for agroforestry technologies for dura conservation was significant (P<0.020) and that has influence on dura conservation.

Table 4.2: Potential Agroforestry Technologies under Agrisilvicultural System for Dura Conservation

Agroforestry Technologies	**Number of Farmers**	**Percentage**
Cocoa Agroforest	40	50
Plantation crop combination	25	31
Improved tree fallow	10	12.5
Trees on cropland	5	6.5
Total	**80**	**100**

4.12.1 Cocoa Agroforests

Cocoa agroforest was considered as an agroforestry system that could contribute to dura oil palm conservation. This system accounted for 50% of the various agroforestry technologies considered under the agrisilvicultural system (Table 4.2). The major components found in this system during the survey were cocoa (*Theobroma cacao),* oil palm (*Elaes guineensis)* and plantain (*Musa spp)*.Growing cocoa under diversified native tree shade is increasingly being viewed as a means of contributing to biodiversity conservation within an agricultural landscape (Rice and Greenberg,2000 and Schroth *et* *al.*, 2004), complementing conservation in landscapes. Cocoa agroforest can play a role in conservation strategies in fragmented landscapes by providing habitat and resources for plant and animal species and by maintaining connectivity between forest areas (Schroth *et al.,* 2004).Cocoa agroforest is progressively being viewed as a sustainable land-use practice that complements the conservation of biodiversity (Alger, 1998; Duguma *et al.*, 1998; Parrish *et al.,* 1998;Power and Flecker, 1998; Rice and Greenberg, 2000; Leakey, 2001; Schroth *et al.*, 2004).

4.12.2 Plantation crop combinations

This agroforestry technology combines plantation crops grown with other plants; these may be timber trees or herbaceous crops. Two or more trees and shrub crops grown in combination e.g. oil palm with cocoa can be considered as an agroforestry technology (Nair, 1983). During the field observation, it was realized that the most common place where dura can be found is cocoa with dura oil palm and some timber species such as *Terminalia superba, Ceiba pentandra, Cola nitida, Millicia excelsa, Triplochiton scleroxylon, Khaya ivorensis* and *Terminalia ivorensis.* This was confirmed during interview with the farmers and about 31% of them mentioned that plantation crop combination is the best technology for dura conservation (Table 4.2). As indicated by Johnson (1980) that plantation owners, typically, have seldom been concerned with annual crops except in the case of intercropping during the early stages of plantation establishment. Oil palm and other plantation crops such as rubber have been successfully combined in association with other varieties of crops in most West African countries (Watson, 1983).

4.12.3 Improved tree fallow

Improved tree fallows are a rotation of planted trees with crops such as oil palm. After a period of cropping, trees are planted and remain for 1-5 years, possibly more (Huxley, 1986). Tree fallow amid rice was a traditional practice in North Vietnam (Tran van Nao, 1983). The study revealed that during this period of fallow the dura oil palm germinates and grows until the next cropping season. During this resting time the dura takes advantage to establish itself. Atypical example during field observation was where *Tectona grandis* and *Senna seamia* have been planted and the dura has taken advantage to grow under it.

Out of the 80 farmers interviewed 12.5% mentioned improved tree fallow as one of the major ways that can contribute to dura conservation (table 4.1). As the dura regenerate naturally most of the farmers take advantage to manage them in this technology for household consumption and the surplus is sold to enable them purchase basic needs of the farmers. Anyane, (1966) states that, farmers weed around wild oil palm groves to increase yields and easy harvesting. Inspite of this, Daniel, (2000) mentioned that due to land scarcity and fragmentation, the life span of oil palm on fallow lands are always shorten due to the clearance of the land for cultivation of arable crops.

4.12.4 Trees on cropland

This system consists of trees grown on cropped land, in an open, mixed spatial system. These trees may be natural, left when the land was cleared, or planted. In the transitional area between the croplands in the forest and the Savannah of Cameroon, Zapfack *et al.*, (2002) mentioned the existence of oil palm and other fruit tree species such as *Mangifera indica, Persea americana, Dacyrodes edulis, Citrus reticula, Citrus sinensis, Cola* *nitida,* and *Irvingia gabonensis.* In this system the dura oil palm grows in these scattered trees and remained on the land for a long period of time. Out of the total number of farmers interacted with, 6.5% of them listed this technology as one that can contribute to dura conservation. One unique thing that arose during the study about this system is that, when the trees are planted, the farmer manages the trees as well as the dura oil palm.

Another important point is that the dura oil palm is left on the land during preparation for cultivation of arable crops such as plantain (*Musa spp),* maize (*Zea mays),* cassava (*Manihot utilissima) and* cocoyam *(Colocasia antiquarum).* The farmers manage the dura as well as the associated crops. Parrish *et al.,* (1998) suggest that it is about time that conservationists looked beyond protected areas to the agricultural landscapes in order to obtain alternative strategies to protect biological diversity that are compatible with human needs. After 4 to 5 years the dura is felled for palm wine tapping to give way for the young dura trees to get enough space and light for development. This has been quantified by Meikle *et al.,* (1996) in a study conducted which modeled decision making of the time when farmers will sacrifice potential annual yield of palm fruit to fell the tree for extraction of palm wine.

4.12 (b) Apiculture as a Potential Agroforestry System for Dura Conservation

On the other hand, agrosilvopastoral system came out as another system that could contribute to dura oil palm conservation during the study. Out of the 80 farmers interviewed 27.5 percent of mentioned that this system is potential for dura conservation (Table 4.1). The major components in this system indigenous trees (such as *Terminalia superba), Elaes guineensis* and honey bee

Given that agricultural activities diminish biodiversity by displacing or replacing natural environments, the major challenge for conservationists and agriculturists in biodiversity hotspots is how to balance the economically driven agricultural expansion with strategies necessary for conserving natural resources, and maintaining ecosystem integrity and species viability (Pimentel *et al*., 1992; Perfecto *et al*, 1997 and Parish *et al*., 1998).

One of such system that is considered is apiculture which consists of bee keeping and trees. Under this system hives are set up under some tall trees and oil palm where the bees gather nectar. The study revealed that the dura oil palms grow in clusters at favourable places. This creates conducive atmosphere for the honey bee. Most of these bees suck nectar from young developing fruits of the dura oil palm for honey production. This makes the farmer take proper care of the palm trees and in so doing it enhances the life span of the dura oil palm trees. This technology was ranked as the least method (Table 4.1) of conserving dura because the education on apiculture was very low in the study area. Huang *et al*., (1998) recommends the use of agroforestry technologies amongst others as a conservation tool to buffer biodiversity loss.

4.13 Management Practices that Help Dura Conservation

Rolim and Chiarello (2004) indicated that, in the interest of long-term conservation of biodiversity, management practices like the eradication of non-native species and the promotion of permanent saplings of native species should be encouraged to ultimately replace mature or over-mature canopy species in the cocoa agroforestry. During the survey the farmers listed a number of management practices they undertake to ensure conservation of the dura oil palm (Table 4.3).

Table 4.3: Management Practices that help Dura Conservation in Sunyani West

Management Practices	Number of Farmers	Percentage
Dura left during land preparation	50	46.3
Weeding around those on fallow lands	30	27.8
Protection against bushfire	16	6.8
Pruning of branches	7	6.5
Dura left in tenera plantations	5	4.6
Total	***108**	**100**

NB: 1. *some farmers gave more than one management practices

2. Sample size (n) =80

Out of the total of 80 farmers interviewed 50 of them representing 62.5% revealed that they manage the dura by leaving them on the land during land preparation. This is because the area is used by most of the farmers for cocoa cultivation. The dura germinate naturally and as such when left in the cocoa farms provide shade for the young cocoa trees. In addition, 27.8% of the farmers revealed that they manage the dura for conservation by weeding around those in fallow lands. This is done in order to avoid competition of weeds around the dura for space, nutrients and water. Another important reason is that, farmers weed around the dura tree in order to ensure high yields and easy harvesting. Weeding around those in fallow lands also deters thieves as they realize that those palm trees have owners and as such are not common pull resource. In doing this, the dura is in one way or the other conserved. Anyane (1966) states that, farmers weed around wild oil palm groves to increase yields and easy harvesting.

Moreover, 14.8% of the respondents also manage dura for conservation by protecting them from bushfires. The study revealed that most of the dura can be found at one particular area and form clusters. Because of this the farmers sometimes create fire belts around this cluster of dura oil palm. Daniel, (2000) reported that, farmers manage their wild groove oil palms through bushfire control, weeding and pruning of branches. Gyasi, (1992) also reported that, the low development of production in acreage of wild oil palms was attributed to bushfires. The survey also showed that 6.5% of respondents manage the dura for conservation by pruning the branches. The dura oil palm easily forms a canopy and as such creates shade on most of the light loving crops. The farmers prefer to prune the branches to reduce the excessive shade instead of felling it. In doing this, the lifespan of the dura is prolonged. This confirms Gyasi, (1992) that farmers prefer to prune the branches of their oil palms for roofing, fuel wood and brooms instead of felling the whole palm tree. Also 4.6% of the farmers' mentioned that they mange the dura for conservation by leaving them to grow in their tenera plantations. The study revealed that most of the tenera farmers leave an average of 10 trees of dura per hectare. The reason is that the oil produced from the combination of tenera and the dura are mostly preferred by consumers. This is because it is said that oil produced from this combination is tasty, red in colour and has a long shelf life. Chi-square test indicated that the management practices of dura in the study area were significant ($P>0.038$) and this suggests that these management practices influence dura conservation.

4.14 Constraints to Dura Conservation

Parrish *et al.*, (1998) suggest that it is about time that conservationists looked beyond protected areas to the agricultural landscapes in order to obtain alternative strategies to protect biological diversity that are compatible with human needs. Conservation of dura oil palm is hindered by quite a number of constraints listed in (Table 4.4).

Table 4.4: Constraints to Dura Conservation

Constraints	Number of Farmers	Percentage
Palm trees demand for palm wine	55	35.3
Land scarcity/Fragmentation	40	25.6
Inadequate knowledge/Information about conservation	25	16
Bushfires	16	10.3
Lower yield	10	6.4
Long maturity period	8	5.1
Lack of financial support	2	1.3
Total	***156**	**100**

NB: 1 *some farmers gave more than one constraints

2. Sample Size (n) = 80

This is in accordance with Ravigadevi, (2002) that focus group discussions and key informant interview revealed fundamental constraints such as; bushfires, lack of financial support, inadequate knowledge and information about conservation and land fragmentation.

Prominent among the constraints identified during this survey is the demand for palm trees for palm wine tapping. The survey revealed that 35.3% of the farmers in an attempt to conserve dura oil palm face problems with the demand for wine tapping. The study also shows that due to the high cost of "*akpeteshie"*(drink produced from distillation of palm wine) the demands for palm trees have increased to the extent that, immature dura palm trees are often fell for wine tapping. This has caused a reduction in the numbers of dura oil palm trees. Farmers with tenera plantations are more reluctant to sell their tenera oil palm trees for palm wine and this has increased the demand for dura trees. This confirms Gyasi (1992) that, indiscriminate felling of palm trees for palm wine tapping was the main reason given for the decrease in the wild groves of oil palm populations. Akintibubo (2002) revealed that constant demand for palm trees for palm wine and "*akpeteshie"* has contributed to the decline of the wild grove oil palm.

Land scarcity and fragmentation are constraints that hinder conservation of the dura oil palm. About 25.6% of the famers interviewed mentioned this as one of the major constraints limiting dura populations. The farmers mentioned that due to high population growth the demand for land has also increased and size of land allocated to individual farmers keeps on decreasing and as such individual farmers do not allow the dura to grow on their land. During land preparation most of these farmers prefer to cut down the young dura trees to make way for their arable crops.

Another problem that affects conservation of the dura oil palm is the inadequate knowledge and information about dura conservation of which 16% of the farmers interviewed confirmed this. The study revealed that most of the farmers do not have access to extension services and because of that information on species conservation is not given attention.

Bushfires were also enumerated by the farmers as a constraint. Out of the total number of famers' interviewed 10.3% of them mentioned it as a problem hindering conservation of the dura. However, productivity of land and labour is low due to the use of extensive traditional farming methods such as slash and burn and burning (Quansah *et al.*, 2001), which sometimes result in widespread forest fire which destroys most biological species

(Benhin and Barbier, 2004). The low yield of dura has resulted in most farmers losing interest in growing dura. The study revealed that the oil yield of tenera is ten times that of the dura and as such farmers prefer to cultivate tenera instead of the dura. Moreover long maturity period of dura has caused most of the farmers to shift from tending and managing dura on farms to cultivation of tenera. The reason has been that the tenera is early maturing and normally referred by the farmers as '*akokora bedi'* (literally means it will grow to meet the old man before he dies). Lack of financial support was mentioned as the least constraint representing 1.3% as indicated in Table 4.3. This was because most of the farmers think dura grows wild and does not need to be tended and managed. Ravigadevi *et al.*, (2002) state that, there is lack of deliberate extension efforts towards oil palm conservation except documentary programmes on oil palm relayed on radio and television occasionally by the Nigerian Television Authority.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusions

5.1.1 Management Practices that Help Dura Conservation

The survey conducted revealed that farmers undertake some management practices that help to conserve the dura oil palm. These practices included; dura left during land preparation, weeding around those on fallow lands, protection against bushfires, pruning of branches, and dura left in tenera plantations. Out of these management practices, dura left during land preparation for farming was ranked first and dura left in tenera plantations ranked least.

5.1.2 Agroforestry Systems for Dura oil palm Conservation in the

The survey also revealed two main agroforestry systems for dura conservation. These were agrisilvicultural system of which cocoa agroforest, plantation crop combination, improved tree fallow and trees on cropland were considered as the technologies and apiculture was also discussed as another agroforestry system.

5.1.3 Agroforestry Technologies that Promote Dura Oil Palm Conservation

Farmers listed some agroforestry technologies that can contribute to dura conservation. Four main technologies were identified during the study. Out of these three, plantation crop combination was ranked as highest by most farmers; followed by improved tree fallow system, and trees on cropland.

5.1.4 Constraints to Dura Oil Palm Conservation

Dura oil palm which is the native of tropical rainforest regions of Africa faces a lot of constraints which are gradually causing decline in numbers. These constraints have made conservation very difficult. The major constraints identified during the survey included; Demand of palm trees for palm wine, land scarcity and fragmentation, inadequate knowledge and information about conservation, bushfires, low yield, long maturity period and lack of financial support.

5.2 Recommendations

To ensure effective and efficient conservation of the dura, the following are recommended:

- The study showed that consumers prefer to use the dura oil palm for their domestic food preparation than the cultivated tenera (perceived as for industrial purposes). It is therefore recommended that research institutions should establish research sites of dura oil palm so that farmers would know that there is value chain for dura oil palm. Also to carry the research information to food scientist to enable them determine the relevance of dura for domestic consumption and how their interest could be drawn to its establishment.
- As revealed from the study, several factors such as bushfires, felling dura for palm wine tapping, long maturity period, lower yields and land scarcity and fragmentation militate against dura conservation on agricultural land. It is recommended to consider important methods such as fire management and oil palm improvement programmes. These programmme would include the modification of the oil palm germplasm under the genetic resource improvement programme, to help increase its yields and reduce the long maturity period.

- From the study, farmers conserve the dura oil palm on their farms through practices such as pruning of branches and weeding around those on fallow lands. Dura left during land preparation should be protected against bushfires. Other recommended practices would include the identification and prioritization of available land areas which are suitable for dura growing. Also restoration of degraded lands by the use of dura could also be considered.

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APPENDIX

QUESTIONNAIRES FOR AGROFORESTRY FARMERS WHO MANAGE DURA OIL PALM IN THEIR FARMS

Town: ……………………………….

District: ……………………………..

Date: ………………………………..

DEMOGRAPHIC CHARACTERISTICS

1. Name of farmer:……………………………………………………………………
2. Age: 18-30 years [ ] 31-45 years [ ] 46-60 years [ ] Above 60 years [ ]
3. Sex: Male [ ] Female [ ]
4. Marital status: single [ ] Married [ ] others (specify)…………………
5. Number of people in the household: Male [ ] Female [ ]
6. Educational status: Basic [ ] Second cycle [ ] Tertiary level [ ] None [ ]
7. Are you a native or a settler? Native [ ] Settler [ ]
8. How long have you been leaving in this area?

   Less than a year [ ]

   1-5 years [ ]

   5-10 years [ ]

   More than 10 years [ ]
9. What is your major occupation? Farming [ ] Trading [ ] others (specify)……
10. Land ownership. Tenant [ ] Landlord [ ]

AGROFORESTRY LAND USE SYSTEMS

11. Do you have knowledge about agroforestry? Yes [ ] No [ ]
12. If yes, what is it about? ………………………………………………………

13. Which of the following agroforestry systems can help conserve dura oil palm? (a) cocoa system (b) fallow land system (c) arable crop farm system

14. Give reason to your answer in Q 13 above……………………………………

15. What benefits can you derive from practicing agroforestry? …………………

16. Do you have knowledge about agroforestry technologies? Yes [ ] No [ ]

17. If yes, mention some of the agroforestry technologies that can promote conservation of dura oil palm…………………………………………………

18. What are the major components in your farm? Tree species………………. Crops…………………………………………………………………………

19. What is the size of your farm?

    Less than a hectare [ ] 1-5 hectares [ ] 5-10 hectares [ ] above 5 hectares [ ]

20. Do you cultivate cocoa? Yes [ ] No [ ]

21. If yes, how long have you been cultivating it? 1-5 years [ ] 6-10 years [ ] 11-15 years [ ] Above 15 years [ ]

22. During land preparation for cocoa what do you do to dura oil palm on the land? Leave them [ ] Cut them[ ]

23. Is the dura oil palm compatible with the cocoa? Yes [ ] No [ ]. Give reason to your answer……………………………………………………………..

24. What practices do you put in place to ensure that the dura oil palm is maintained on the land? ……………………………………………………………

25. Is the dura oil palm beneficial? Yes [ ] No [ ]

26. If yes, what are the benefits you derive from leaving dura oil palm in your cocoa farm?..

ARABLE CROP FARMS WITH DURA OIL PALM

27. The dura oil palm on your farm do you cultivate or they grow naturally?

    Natural regeneration [ ]

    Artificial regeneration [ ]

28. Do you encounter problems when you leave the dura oil palm in your arable crop farms? Yes [ ] No [ ]

29. If yes, mention them…………………………………………………………….

30. How long does the dura oil palm stay on your land? 1-5 years [ ] 6-10 years [ ] Above 10 years [ ]

31. Do you see any changes on your land after the oil palm is felled? Yes [ ] No [ ]

32. If yes, what are they? …………………………………………………………

TENERA PLANTATIONS

33. What type of oil palm variety do you cultivate? Dura [ ] Tenera [ ]

    Give reason to your answer…………………………………………………

34. If you cultivate tenera do you leave dura in your tenera plantation? Yes [ ] No [ ]

35. If yes, what is the quantity per hectare? 1-5 per hectare [ ] 6-10 per hectare [ ] 10-15 hectare [ ] Above 15 per hectare [ ]

36. What do you do to ensure that the dura is maintained in the tenera plantation?

37. Why do you prefer to cultivate tenera but not dura? …………………………

38. Do you observe any interaction between the dura and the tenera? Yes [ ] No [ ]

39. If yes, mention them…………………………………………………………….

DURA OIL PALM ON FALLOW LANDS

40. Do you have fallow land(s)? Yes [ ] No [ ]

41. If yes, do you find dura species there? Yes [ ] No [ ]

42. If yes, how do you manage them? ……………………………………..

43. Do you harvest? Yes [ ] No [ ]

44. If yes, after harvesting what did you do to the dura? Sell [ ] Household consumption [ ] Both [ ]

GENERAL INFORMATION ABOUT DURA

45. What type of variety will you prefer to use to prepare your meal? Dura [ ] Tenera [ ] Give reason to your answer……………………………………

46. Are you aware that dura oil palm is reducing in numbers? Yes [ ] No [ ]

47. If yes, what can you do to conserve it? ………………………………………

48. What problems do you encounter in an attempt to conserve the dura oil palm?

49. What perceptions do have about dura oil palm? ………………………………