Moving Forward with REDD+ in Ghana: Shade Systems, Crown Cover, Carbon Stocks and Socio-Economic Dynamics of Smallholder Cocoa Agroforestry Systems

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SNV

August 2014

Acknowledgement

The researchers would like to acknowledge those who contributed tremendously to the execution of this research. Special gratitude to Dr. Stephen Adu-Bredu, Deputy Director of the Forestry Research Institute of Ghana (FORIG) for his inputs during the sampling design and also for his contributions at the project inception workshop. To our able team of technicians, Messrs Elvis Nkrumah, Yaw Apau, Nana Prempeh Bandoh and Emmanuel Sey, under the able leadership of Seth Kankam, tons of appreciation for the long days spent out on the field identifying trees and collecting data. Time spent by Priscilla Animah-Nuamah to enter the socio-economic data is very much appreciated. We also appreciate the chiefs and people of the 10 research communities, who were our research partners, for their cooperation, support and time taken away from farming activities to provide answers to our numerous questions. We are very grateful to staff of the Climate Change Unit of the Forestry Commission (CCU/FC) for the profound interest in the study and for hosting a validation workshop for this report. Finally, we say a big thank you to SNV for funding the research.

Executive summary

The role of shaded-cocoa systems for climate change mitigation and adaptation has gained considerable importance lately following the realisation of the ability of these systems to capture atmospheric carbon dioxide (CO_2) and store the carbon (C) in shade and cocoa (*Theobroma cacao*) trees and soil compared to other agricultural practices. Cocoa is one of the most widely cultivated tree crops in tropical Africa, extending to over five million ha in West and Central Africa. Many studies have shown that multi-strata cocoa plantations contain higher carbon stocks than other agricultural land uses and offer better opportunities for mitigating climate change. Studies also show that traditional cultivation practices, whereby cocoa farms are established under the forest canopy, offer better opportunity to store carbon. Unfortunately, this approach of cocoa establishment is fading away as a result of perceived incompatibility of hybrid cocoa varieties with shade. Many cocoa farmers, especially in the western cocoa-growing hub of Ghana, appear to be shifting to this new system of cultivation, with possible implications for the productivity and sustainability of the cocoa industry.

To reverse this trend, the traditional practice of growing cocoa under an existing forest canopy, or through deliberate incorporation of trees in the cocoa farm, should be encouraged. The introduction of the REDD+ (Reduced Emissions from Deforestation and Forest Degradation) mechanism is expected to reward practices that achieve mitigation and other co-benefits beyond current unsustainable business-as-usual (BAU) land use practices. The objectives of this study were to quantify the baseline carbon stocks in different smallholder cocoa farming systems, identify land and tree tenure challenges, assess farmers' perceptions of trees in cocoa farms and assess the feasibility of implementing REDD+ interventions in cocoa landscapes in Ghana. Using a replicated transect approach, biophysical data on shade and cocoa trees were collected from 1 ha plots established on 5 km long transects in ten cocoa growing districts across three regions, namely, Ashanti (Nkawie, New Adubiase and Offinso districts), Brong-Ahafo (Asumura, Goaso and Sankore districts) and Western (Sefwi Wiawso, Sefwi Akontombra, Sefwi Asempaneye and Sefwi Adabokrom districts). Socio-economic data were also collected through the administration of semi-structured questionnaires (200 respondents), key informant interviews and focus group discussions involving indigenous and migrant farmers in the research districts.

Considerable variation in the diversity of non-cocoa tree species was observed across the ten districts, which ranged from 27 tree species in Sefwi Akontombra cocoa district to 49 tree species in Goaso cocoa district. *Newbouldia laevis* was the commonest species and constituted as much as 47% of the trees in farms at both Asumura and Sefwi Wiawso cocoa districts. Relative abundance of non-timber tree species was generally higher than for timber species. The dominance of fruit trees (citrus and avocado pear) and *Newbouldia laevis* strongly indicates a deliberate transformation of the landscape by farmers from the naturally occurring pioneer species such as *Terminalia spp* on farmlands to citrus, avocados, N. *laevis* and other non-timber species. This disparity could also be a manifestation of the consequences of off-reserve logging impact, inadequate extension on cocoa agroforestry and a generally weak appreciation of forest governance issues within the cocoa landscape.

The stocking density and other dendrometric parameters of upper canopy trees on farms differed significantly between districts. Stem densities were highest in Offinso district (22.8 ± 1.7 stems ha-1) and lowest in Goaso district (16.2 ±3.00 stems ha-1). Crown cover also ranged from 5.8 ±1.22 to 16.3 ±1.74% in the Asumura and Asempanaye districts, respectively. However, these are nowhere near the recommended shade (30-40%) described as optimal shade using stem numbers (15-18 trees ha-1). The use of stem numbers would classify cocoa farms in only two of the study districts, New Edubiase and Offinso landscapes, as having high shade.

Carbon stocks of shade trees differed significantly between districts; it ranged from 2.91 ± 0.95 Mg C ha-1 at Sefwi Akontombra district to 15.6 ±2.89 Mg C ha-1 at New Edubiase district. Carbon stocks in cocoa trees, on the other hand, were similar across the 10 sites and averaged 7.45±0.41 Mg C ha-1 (range: 5.84 - 10.2 Mg C ha-1). This distribution between cocoa and shade trees resulted in significantly different total aboveground C stocks with New Edubiase district having the highest (23.4 ±3.23 Mg C ha-1) and Sefwi Wiawso district the lowest (10.9±1.56 Mg C ha-1). Across districts, carbon stocks distribution between cocoa and shade trees averaged 48% and 52% respectively. The mean stocks across all study districts was 15.5 ±1.19 Mg C ha-1. These results for total tree carbon stocks are similar to, and fall within, the range reported by earlier studies.

Results from this study indicated a mean cocoa tree height of 6.3 m for all 10 study areas, which represents ninety 1 ha plots. For cocoa to meet the national forest definition threshold, the critical parameter is tree height, based on the fact that the cocoa landscapes in most areas are quite contiguous and easily meet the crown cover and land area parameters. Thus, cocoa is clearly a forest, based on the three parameters for forest definition. This result reiterates the need to consider the potential and implications of monoculture cocoa landscapes as forests in the national REDD+ discussions. Evidence from this study also suggests that multi-strata cocoa agroforestry systems using indigenous timber species can qualify as forests.

Results of the socio-economic study showed that 47% of the respondents were above 50 years old. The mean farm size was 2.5 ha, with the dominant farm size in the landscape was 1.6 ha. Eighty-eight per cent of the farms were 4 ha or below, while 70% were below 20 years and 40.7% were below 10 years. Thus, there are indications that cocoa farmers are ageing and therefore may not be willing to invest in interventions to improve productivity. This has implications for the sustainability of the cocoa industry in Ghana and could manifest in the form of low productivity resulting from factors such as susceptibility to disease and low nutrient uptake. It is therefore critical that measures are put in place to encourage youth participation in cocoa farming. However, the relatively large proportion of young farms may also suggest that farmers are taking steps to rehabilitate cocoa farms or establishing new ones, which both offer opportunities for climate-smart interventions.

The study also revealed that characteristics of the known sharecropping systems (*abunu* and *abusa*) are not always as expected, based on historical understanding. The main issue is the duration of the *abunu* tenancy; in the past, tenants assumed full ownership of the parcel of land after the cocoa farm had been shared, but some are now arguing that this is no longer the case. This underscores the potential conflict issues that could hamper any REDD+ intervention, given that sharecroppers and some migrant farmers are still not unanimous in their understanding of the tenancy arrangements that govern cocoa farming.

There was also a strong indication that although sharecroppers are responsible for the day-to-day management of the farm, the landowners have the main say when it comes to major interventions that affect the farm, hence trainings and other capacity-building programmes should be looked at in the context of these power plays.

Importantly, the study established a clear contrast between farmer understanding of the benefits of cocoa agroforestry and the actual practice on their farms. Although farmers know the benefits of incorporating trees into cocoa farms, they are generally wary of doing so due to pest and disease issues, possible negative impact on yield, challenges with illegal chainsaw and timber concessionaires, inadequate and sometimes total lack of knowledge on the provision of the legal and policy regimes governing off-reserve tree tenure and exploitation and access to seedlings of indigenous timber species.

A major issue related to low upper canopy tree diversity and dominance of non-timber trees is the total lack of extension support to holistically deal with the issues that concern farmers in terms of tree incorporation and the sustenance of their farms. It is important to emphasise that while some of these challenges are purely policy and national forest governance issues, that are beyond projects, many more are pure extension issues. The option available therefore is to promote good cocoa agroforestry interventions that will incorporate desirable timber tree species in an optimal manner. Given the current manifestation of cocoa agroforestry in the landscape, the best opportunity for cocoa REDD+ intervention is the enhancement of carbon stocks and, in some instances, avoided degradation as well as avoided deforestation, depending on the context. Also, given that the recommended number of cocoa trees per hectare is 1,111, any additional benefit in terms of mitigation will be associated with the non-cocoa trees. This will be demonstrated by how the non-cocoa trees meet the national forest definition threshold. The study, for the first time, provided innovative guidance on shade classification as expressed in crown cover using a combination of ground data and visual interpretation on Google Earth. The findings from this study hold clear applications and will serve as major platforms to strategise the design and implementation of Ghana’s Emissions Reductions Programme with the Carbon Fund.

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Abbreviations

A/R	afforestation and reforestation
BAU	business-as-usual
C	carbon
CO_2	carbon dioxide
CDM	Clean Development Mechanism
CCU/FC	Climate Change Unit of the Forestry Commission
CRP	Cocoa Rehabilitation Project
CRIG	Cocoa Research Institute of Ghana
DBH	diameter at breast height
ERP	Economic Recovery Program
FGDs	focus group discussions
FCPF	Forest Carbon Partnership Facility
FC	Forestry Commission
FIP	Forest Investment Program
FORIG	Forestry Research Institute of Ghana
FSD	Forest Services Division
GDP	Gross Domestic Product
GHG	greenhouse gas
HFZ	high forest zone
NRCD	National Redemption Council Decree
NCRC	Nature Conservation Research Centre
PES	payment for environmental services
REDD	Reduced Emissions from Deforestation and Forest Degradation

Section 1
Introduction

1.1 Background

Tropical forests constitute a large and globally significant store of carbon (C), containing more carbon per unit area than any other land cover. The main carbon pools in tropical forest ecosystems are the living biomass of trees and understory vegetation and the dead mass of litter, woody debris and soil organic matter. The carbon stored in the aboveground living biomass of trees is typically the largest pool and the most directly impacted by deforestation and degradation. Cutting down trees in the forest releases carbon to the atmosphere. Although selective logging may only remove a few big trees per area (and damage surrounding ones), it can lead to a substantial decrease in total biomass and carbon stock (Hairiah et al. 2010). The conversion of tropical forest to agriculture and pasture is a major cause of deforestation and forest degradation, which also increases the rate of accumulation of carbon in the atmosphere. Over the last 20 years, the majority of the emission has been attributed to burning of fossil fuel, while 10-30% has been attributed to land use change and deforestation (WRI 2005). The practice of slash and burn agriculture in tropical Africa not only increases carbon accumulation in the atmosphere but also removes the ability of the forest to capture carbon.

If we maintain tree cover after native forest has been destroyed we can still store carbon. Afforestation and reforestation (A/R) actions are important ways of restoring carbon stocks following deforestation and land degradation. In general, activities that tend to retain tree cover on the landscape over a considerably long period should be able to increase carbon stocks within that landscape. Since the carbon stock in an individual tree depends on the size of the tree, trees that are naturally small, as is the case for many cultivated tree crops like citrus, oil palm and cocoa, do not capture an adequate amount of carbon compared to the usually large trees of tropical forests. However, cultivation practices that effectively combine fruit and other tree crops with large timber species in agroforestry settings can be an important way of capturing a considerable amount of carbon in agricultural systems.

There is a general belief that cultivation of cocoa, as it is traditionally practiced in Africa, has the potential to restore carbon stocks to levels comparable to those in the native forest that they replaced. Cocoa is an understory species and so cultivation is traditionally under tree canopy. It is therefore intuitive that carbon stocks in cocoa farms with dense tree canopy cover will be more similar to those in the original native forest than to those in farms with lower or no canopy shade. Indeed, several studies have revealed that a larger proportion of the carbon stocks in most cocoa agroforests are contributed by the non-cocoa trees than by the cocoa tress (Sonwa et al. 2009, Oke and Olatiilu 2011, Norgrove and Hauser 2013, Somarriba et al. 2013). While traditional (older) cocoa farms in most tropical African countries were established under heavy canopy cover, the availability of new cocoa varieties that thrive under low or no canopy shade has increased considerably in recent times. The question is whether carbon stocks in these emerging cocoa plantations will be close enough to that of the original native forests they have replaced. Understanding carbon accumulation dynamics in cocoa agroecosystems is important to the long-term management of cocoa farms that inure to climate change mitigation and the associated socioeconomic effects.

The introduction of monetary incentives to encourage practices that result in reduced carbon emission into the atmosphere or accumulation of carbon stocks have led to a need to determine how much carbon is stored in cocoa agroforests. According to FAO (cited in Seidu 2010), over 5 million hectares of land are currently under cocoa cultivation in Western and Central Africa with a

substantial percentage of these cocoa orchards (with some forest trees) containing higher carbon stock than other agricultural land uses and therefore offering better opportunities for mitigating climate change. Research conducted by Sonwa et al. (2009) in 60 cocoa plantations in southern Cameroon found that an average cocoa farm stores 243 Mg per ha of carbon. This is significant when extrapolated to all cocoa growing regions in Western and Central Africa. Maintaining shade canopy over cocoa farms in a perennial system is an evolving option for diversifying farm income while contributing to long-term carbon sequestration.

In Ghana, the shaded-cocoa system extends over more than 1.25 million ha, employing about 350,000 farmers. The crop is a major cash crop and foreign exchange earner for the Ghanaian economy, contributing about 29% to the gross domestic product (GDP) of the country (GIPC 2002). Though acreages are reported to be increasing, poverty is still pervasive in most cocoa growing areas and the clearing of forests for subsistence agriculture continues, leading to ecosystem degradation and greenhouse gas emissions. The Increased Cocoa Productivity for Improved Ecosystems Services, otherwise known as the Cocoa-Eco Project, was initiated by SNV to introduce an approach that combines supporting local cocoa livelihoods for poverty alleviation and reducing ecosystem degradation in cocoa production systems in Ghana. This is expected to be achieved through actions that improve business development skills, increase cocoa productivity, enhance natural resources management, conserve biodiversity and reduce emissions associated with smallholder cocoa farming systems. It is expected that through this initiative, smallholder cocoa farmers in Ghana can qualify and earn additional income through REDD+ (Reduced Emissions from Deforestation and Forest Degradation) mechanisms and related incentive packages associated with carbon mitigation programmes.

The objectives of this study were:

i. to quantify the baseline carbon stocks and sequestration potentials in different smallholder cocoa farming systems

ii. to identify land and tree tenure challenges, assess farmers’ perceptions of trees in cocoa farms and assess the feasibility of implementing REDD+ interventions in cocoa landscapes in Ghana.

Section 2
Review of Related Literature

2.1 Introduction

This chapter is devoted to a review of literature relating to the dynamics of shade regimes and carbon stocks in smallholder cocoa systems in general, providing a theoretical framework and body of ideas to guide the research process, plan for data analysis and situate the study within on-going dialogues. The review begins with an overview of the smallholder cocoa sector in Ghana and continues to describe shade and shade levels in cocoa systems and how shade trees impact on carbon stocks in cocoa systems. Earlier research on shade trees, shade effects on cocoa production and shade trees and carbon stocks in cocoa agroforestry systems are all extensively reviewed with the aim of identifying existing gaps and collecting relevant information to fill identified gaps. The chapter also provides an overview of land and tree tenure issues, focusing on how existing forest and tree tenure arrangements influence farmers' tree planting and management decisions in cocoa landscapes. Challenges and opportunities related to using cocoa as REDD+ (Reduced Emissions from Deforestation and Forest Degradation) intervention are also reviewed.

2.2 The smallholder cocoa sector in Ghana

The cocoa sector in Ghana plays a significant role in the fight against poverty and the development of the economy of Ghana as a whole. Globally, Ghana is the world's third largest cocoa producer (after Cote d'Ivoire and Indonesia) and maintained its position as the second largest exporter of cocoa beans after Cote d'Ivoire over the period 2005-2011 (Asante-Poku and Angelucci 2013). Cocoa is Ghana's leading cash crop and is considered to be the highest export crop earner, accounting for 8.2% of the country's GDP and 30% of total export earnings in 2010 (GAIN 2012). In terms of employment, the livelihood of about six million people (25-30% of the population) depends on the cocoa sector (Anthonio and Aikins 2009).

Ghana's cocoa production is characterised by small-scale farming with an average productive cocoa area per household of approximately 2-3 hectares (Asante-Poku and Angelucci 2013, Barrientos et al. 2008). Approximately 800,000 families grow cocoa on 1.6 million hectares of land with the Western region having the highest production value (accounting for over 50% of total production) followed by the Ashanti region (accounting for about 16% of total production) and the Eastern and Brong Ahafo regions, which together account for about 19% of total production (COCOBOD 2012, cited in Asante-Poku and Angelucci 2013).

2.3 Trajectory of cocoa productivity increases in Ghana

One feature of cocoa production in Ghana is its historically low productivity. Ghana produced an all-time high of 1,004,194 tons of cocoa in the year 2010/2011 compared to 710,000 MT in 2009 and 904,000 MT in 2010 (Asante-Poku and Angelucci 2013). Given the sharp increase in 2010/2011 production, currently the more commonly used estimates for productivity are 300-400 kg ha-1 (about 30-50% of potential productivity). The midpoint of this range (350 kg ha-1) is 56% and 79% lower than the average yields in Cote d'Ivoire (800 kg ha-1) and Malaysia (1,700 kg ha-1) respectively. Key factors responsible for the lower productivity are declining soil fertility, over-aged cocoa trees (estimated at 23% of total area), high incidence of pest and diseases (25% of total area), poor maintenance, poor agronomic practices, ageing cocoa farmers (estimated to be about 51 years on average), limited credit availability and inadequate infrastructure (UNICEF 2009, Boateng 2003). Cocoa farms which employ more intensive management practices have achieved yields of up to 1,500 kg ha^{-1}, however, the investment costs and training necessary to achieve these results is prohibitive for many smallholder farmers.

2.4 Adoption of improved varieties

Hybrid cocoa varieties developed by the Cocoa Research Institute of Ghana (CRIG) and introduced in 1984 through the government's Cocoa Rehabilitation Project (CRP) have been adopted by approximately one-third of Ghanaian farmers (Padi and Owusu 1998). However, these systems, when not accompanied by fertiliser, can rapidly deplete soil nutrients and tend to have shorter production cycles because of the physiological stresses of higher yields. The hybrid varieties out-perform the older Amazons and Amelonado varieties by producing more pods per tree and coming to bear fruits in three years compared to at least five years for the older varieties. But hybrid cocoa trees perform only under optimal weather conditions and when complementary farming practices such as the application of chemical inputs, the adoption of new planting procedures, pruning and spraying are carried out. Farmers also need to make more harvest rounds at the beginning and at the end of the season, something they are reluctant to do on a regular basis, especially where it conflicts with other farming or trading activities (Bohaene et al. 1999, Bloomfield and Lass 1992).

In the late 1980s, only 10% of cocoa grown in Ghana was of the high yielding type (Nyanteng 1993). By 2002, 57% of farmers from the three main areas of production were growing hybrid varieties (Vigneri 2005). Traditional varieties may have disappeared entirely from all fields planted after 1995, having been replaced with new varieties which yield approximately twice as much cocoa per hectare as similar-aged fields planted with traditional trees (Edwin and Masters 2003).

2.5 Establishment and management of cocoa farms by smallholder farmers

Cocoa farms are generally developed in a similar fashion throughout West Africa: primary or secondary forests are selectively cleared, commonly burned and cocoa is planted, along with understory food crops (Duguma et al. 2001). Cocoa farmers in Ghana continue to rely on the traditional methods such as the hoe and cutlass method for farming (GAIN 2012). Cocoa cultivation in Ghana is also predominantly rain fed and the best conditions for cocoa farming are those in which there is favourable rainfall during the night followed by sunny days as these result in healthy looking trees with fully filled pods. The main cropping season in the country is October-February/March while there is also a smaller/lighter mid-crop cycle, which occurs from around April/May to mid-September (GAIN 2012).

The major management requirements of cocoa agroforests are shade control, weeding, pest and disease control, harvesting of pods and processing of beans (Wessel 1987). According to Wessel (1987), the role of shade in the management of cocoa agroforests is rather complex as it affects or is related to several other growth factors. It reduces light intensity, temperature and air movement and influences relative humidity that indirectly affect gement. Several reports suggest that, all other factors being equal, a level of shade that allows 20 to 30% of full light to reach the cocoa is needed for optimum growth and productivity (Lemée 1955, Okali and Owusu 1975 cited in Wessel 1987). However, depending on the age of the tree and the intensity of light, there could be a significant variation in the level of shade requirement. This may vary from place to place and even from provenance to provenance (Duguma et al. 2001).

2.6 Cocoa high technology programmes

In order to address the low technology and input use in cocoa production in Ghana, government has introduced the Cocoa High-Technology Programme (Hi-Tech). The programme aims to increase cocoa production through soil fertility maintenance at levels that are economically viable, ecologically sound and culturally acceptable using fertiliser and efficient management resources. The Cocoa Hi-Tech is a holistic approach to sustainable cocoa production in which all the recommended technologies by CRIG are contained in a single package. The project began in the 2003/2004 season covering an area of 40,000 hectares and involving 50,000 farmers in 41 cocoa growing districts. During the 2004/2005 cocoa season, the project further expanded to cover an area of 100,000 hectares involving 125,000 farmers (Appiah 2004). Cocoa production areas covered by the programme have increased production from the national average of 300-400 kg/ha to 600-700 kg/ha through fertiliser application (Dormon 2004). Under the programme, farmers are supported to restore lost soil nutrients through the supply and application of subsidised inorganic fertiliser.

2.7 Structure of the cocoa agroforests

Cocoa is traditionally grown in agroforestry systems with permanent shade management resulting from the selective thinning of the original forest canopy and retaining a diversity of trees, planting useful fruit and timber species as well as protecting valuable trees from natural regeneration. These trees, which provide shade to the cocoa, also furnish subsistence and/or market products at different points in time (Amoah et al. 1995, Osei-Bonsu et al. 2003). Cocoa farms are therefore structurally multi-strata systems with horizontal and vertical distribution of tree species components and represent an important factor in sustaining the cocoa farm. In this stratified system, native timber trees and exotic agroforestry tree species occupy the upper canopy (over-storey) with cocoa and other fruit trees occupying the lower canopy. Certain upper-storey canopy trees, e.g. *Terminalia superba* Engl. & Diels, *Newbouldia laevis* (Beauv.) Seem. Ex Bureau or Ceiba pentandra L. are retained, and fruit trees, e.g. orange (*Citrus sinensis* (L.) Osbeck), avocado (*Persea Americana*) and mango (*Mangifera indica* L.) may be planted for shade, food and other purposes. The botanical composition affects the quantity and quality of shade with tall trees casting lighter shadow than short ones (GRO-Cocoa 2007).

2.8 Shade trees and shade effects on cocoa production

The use of shade in cocoa systems in general is an ancient practice that dates back to the period of domestication of the crop and is usually attributed to early cultivators mimicking the natural sub-canopy environment of wild cocoa trees in the forests of the upper Amazon and Orinoco river basins (Anim Kwapong 2006, Simpson and Orgozaly 1986). Cocoa is a natural under-story plant that is usually established by under-planting selectively thinned natural forests, naturally regenerating trees or deliberately incorporating trees into the farm (Greenberg 1998, N'Goran 1998). It is usually planted in association with economically attractive trees such as citrus to provide shade in addition to providing food and cash for the farm household (Gockowski and Sonwa 2008). Removing shade from cocoa has resulted in significant increases in yield with a positive interaction between increased light and applied nutrient (Cunningham and Arnold 1962).

Results from several studies at CRIG, including long running shade/fertiliser trials in which shade and fertiliser levels were varied, led to extension recommendations to reduce or entirely eliminate shade trees and apply fertiliser (e. g. Asomaning et al. 1971, Ahenkorah et al. 1974, Ahenkorah et al. 1987 and Cunningham and Arnold 1962). These studies found that the removal of shade alone doubled yields while shade removal and application of fertilisers tripled on-station yields, giving a strong empirical basis for the development and extension of no shade cocoa systems. While the low shade recommendation was widely followed in the rapid expansion of the sector in the Western Region in the 1980s and 1990s, fertiliser recommendations have largely been ignored due to a combination of underdeveloped fertiliser and credit markets in Ghana (Gockowski and Sonwa 2008). A survey conducted in 2001/2002 showed that in the Western Region of Ghana there are more cocoa systems with light or no shade and less cocoa systems with medium to heavy shade cocoa compared with the national average (Gockowski and Sonwa 2008, Ruf et al. 2006).

Today, cocoa systems in West Africa range from no-shade mono-specific hybrid varieties to complex cocoa-fruit tree-timber-medicinal agroforestry systems with biodiversity values nearly equivalent to secondary forest (Gockowski et al. 2006, Sonwa et al. 2007). Cocoa production in major West African countries is now without shade and has expanded largely at the expense of primary forest. The absence of shade places significant ecological stress on the cocoa trees, which become susceptible to pests attack (Entwistle and Yeodeowei 1964). There is little scientific evidence to quantify the environmental benefits of shaded cocoa, but it is regarded as environmentally preferable to many other forms of agriculture in tropical forest regions (Greenberg 1998, Power and Flecker 1998). Reitsma et al. (2001) and Estrada et al. (1997) have both suggested that shaded cocoa could have positive environmental effect in landscapes already much impoverished by human activities. Murray (1975) has summarised most of the factors attendant with shade effects as reduction in diurnal variations in both soil and air temperatures, reduction in wind movement and improved mineral recycling (Ofori-Frimpong et al. 2007).

Beer et al. (1998) have listed the major physiological benefits that cocoa receives from shade trees and placed them into two main categories, both associated with reduced plant stress. These are: 1) Amelioration of climatic and site conditions through (i) reduction of air and soil temperature extremes (heat at lower elevations and cold at higher elevations), (ii) reduction of wind speeds, (iii) buffering of humidity and soil moisture availability and (iv) improvement or maintenance of soil fertility including erosion reduction; and 2) Reduction in the quantity and quality of transmitted light and hence avoidance of over-bearing (e.g. in coffee) and/or excessive vegetative growth (e.g. flushing in cacao). Shade reduces nutritional imbalances and dieback.

Despite these physiological benefits, there has been a gradual change in recent years with the shade cocoa being replaced with the new sun-tolerant hybrid varieties generally called the sun cocoa. This was mainly in Cote d'Ivoire in the Western region of Ghana. Although research results suggest that the sun cocoa provides higher yield at the early stages driven by initial fertile forest soils, yields decline after 10-15 years when forest soils become depleted of major nutrients suggesting the sun-tolerant system of production is not sustainable over the long-term. It seems that production is almost twice as much in an un-shaded hybrid cocoa system compared to the shaded traditional system. However, Obiri et al. (2006) have emphasised that the cocoa bean yield in unshaded hybrid system begins to drop within 10-15 years while the production of the traditional shaded systems starts decreasing after 25 years. The economic rotation age is only 18 years for an unshaded hybrid cocoa system, while this is 29 years when shaded. It appears however that the short-term economic benefits are the main drivers of the shift from shaded to full sun cocoa cultivation.

2.9 Shade and shade level description in cocoa agroforestry systems

Over the years, cocoa production in Ghana has been carried out under shade regimes that have evolved over several decades. Several reports suggest that, all other factors being equal, a level of shade that allows 20-30% of full light to reach the cocoa is needed for optimum growth and productivity (Lemée 1955, Okali and Owusu 1975, cited in Wessel 1987). While it has been established that the provision of shade is crucial to the sustained production of cocoa, a careful assessment of the literature shows that approaches to quantification and/or classification of shade levels and regimes on cocoa farms have been ambiguous and subjective. More often than not, they have been based on the number of stems of shade trees, thereby making it difficult to compare shade levels between studies and sites.

In Ghana, cocoa agroforests have generally been classified as falling into one or more shade regimes depending on the number of upper canopy trees present. This is the most widely used approach and has been adopted by the Cocoa Research Institute of Ghana (CRIG), the foremost institute with responsibility for cocoa research. Based on the number of trees present, existing cocoa agroforests are the high or heavy shade cocoa farms with about 22–30 forest trees/ha, the medium shade cocoa farms with 15–18 forest trees/ha (Manu and Tetteh 1987, STCP 2002, Ofori-Frimpong et al. 2007, CRIG 2010) and the low shade cocoa farms with 5-6 trees/ha (Ruf 2011). In their studies on the impact of shade and cocoa plant densities on soil carbon sequestration, Ofori-Frimpong et al. (2010) defined two shade regimes: shaded (16-18 trees per hectare) and unshaded. There was no indication of the size, maturity or type of shade trees and it was unclear whether unshaded plots meant the complete absence of shade trees or if the number of trees per hectare was simply less than the minimum 16 defined for the shaded system.

In the Western and Bas Sasandra regions of Ghana and La Côte d'Ivoire respectively, Gockowski and Sonwa (2008) described shade levels as no shade, light shade and medium to heavy shade with no description of the percentage of shade cover. The same authors, Gockowski and Sonwa (2010), defined full sun cocoa (no-shade cocoa) as any farm with fewer than 13 shade trees per hectare, while studying cocoa intensification scenarios across the Guinea Rainforest of West Africa. In a survey of nearly 2000 cocoa farms in each of Ghana and in La Côte d'Ivoire, Simons et al. (2006, cited in Biodiversity and Agricultural Commodities 2010) classified the different shade regimes across the cocoa landscape into four broad classes namely: No shade, shade < 30%, shade 30-60%, and shade > 60%. In Nigeria, Oke and Olatiilu (2011) classified shade in cocoa systems as either sparse or dense cocoa agroforest using the number of shade trees per hectare. Sparse cocoa agroforests were classified as having 40 trees per hectare while dense cocoa agroforests had 76 trees per hectare. Adopting an approach similar to Simons et al. (2006) and Gockowski and Sonwa (2007), Ashley-Asare and Mason (2011) classified cocoa shade as no or low shade, medium shade and high shade. These authors went a step further and defined canopy cover, tree densities and diameter at breast height (dbh) for these shade classes. Canopy cover was defined as 10, 25 and >50% respectively, tree densities were 28, 35 and 51 shade trees per hectare and dbh was 34.3, 61.8 and 50.1 cm.

This is perhaps the only and most comprehensive description or definition of shade levels found in the literature on shading regimes in cocoa systems. Through the Sustainable Agriculture Network, the Rainforest Alliance has developed criteria and indicators for cocoa production that advocate for 70 emergent non-cocoa tree species (roughly equivalent to shade tree spacing of 12 m x 12 m) per hectare of cocoa, 12 of which must be native species. This provides a shade density of approximately 40% for cocoa trees underneath the emergent canopy (SAN 2005).

These, and several other studies in which varied descriptions and/or classifications of shade regimes have been proffered, illustrate the difficulty in making generalisations and/or classifications of shade regimes using the number of shade trees on the farm. Depending on the age of the tree, canopy architecture and the intensity of light, there could be a significant variation in the level of shade provided. This may vary from place to place and even from provenance to provenance (Duguma et al. 2001). Thus, *Newbouldia laevis* — a shade tree with a very narrow columnar crown and as a result providing very little shade — would be described as providing heavy shade if more than 22 stems occurred on a hectare on a farm. In actual fact, the shade provided is nowhere near heavy and so this measure is very deceptive. It appears that the nature of shade present on any particular farm or prevalent in a particular system will depend on the type and number of tree species as well as the crown diameter of the species. Since trees differ in canopy size and in the nature of their leaves, there is the need, and it should be possible, to compute an index for shade based on the height and crown diameter of shade trees found on cocoa farms.

Indeed, rigorous and standard empirical descriptions of shade crown cover in shaded-cocoa systems in Ghana and other cocoa producing countries at large are scant and lacking. The contribution of the present paper (which is part of a wider study aimed at quantifying carbon stocks in cocoa systems) amongst others is to build on the existing literature by rigorously investigating shade tree crown cover on cocoa farms and how it affects carbon stocks in shade trees.

2.10 Shade trees and carbon stocks in cocoa agroforestry systems

During the last century, the CO_2 concentration in the atmosphere increased from 280 to 367 ppm (IPCC 2001). The carbon cycle in terrestrial ecosystems has a recognised key role in regulating actual levels and trends in that concentration (Dixon et al. 1994, Houghton et al. 2000). Agroecosystems play a central role in the global carbon cycle and contain approximately 12% of the world's terrestrial carbon. Many observers see agroforestry systems as presenting a promising alternative to common-practice agriculture in the tropics because they can serve as carbon sinks and biodiversity pools and may play a significant role in mitigating or adapting to climate change (Tscharntke et al. 2011, Soto-Pinto et al. 2010, Nair et al. 2009). Given the enhanced carbon (C-) sequestration that occurs with tree planting and the practice of agroforestry farming, cocoa systems have been recognised as viable strategies under the Clean Development Mechanism (CDM) of the Kyoto Protocol (IPCC 2000). Cocoa agroforestry has emerged as a land-use system for reducing or offsetting deforestation (Soto-Pinto et al. 2010, van Noordwijk et al. 2002), while at the same time sequestering carbon and contributing to climate change mitigation.

Several studies have reported on the carbon storage capacity in cocoa agroforests. They have also revealed important variations in carbon stocks that reflect differences between ecological zones, management practices and age of farm. Indeed, cocoa plantations are noted to contain higher carbon stock than other agricultural land uses and offer better opportunities for mitigating climate change. Along a chronosequence of cocoa farm fields aged 2, 15 and 25 years in the cocoa growing zone of Ghana, Isaac et al. (2005) estimated carbon stocks in shade and cocoa trees to be 4.8, 56.1 and 83.7 Mg C ha^{-1}, giving annually up to 15 years aboveground C sequestration rates of 3.95 Mg C ha^{-1}. Still, in Ghana, Asase et al. (2010) differentiated unshaded and shaded cocoa agroforests that contained 39 and 104 Mg C ha^{-1} respectively in aboveground biomass. In a 35 year-old shaded cocoa system in Cameroon, using equations that took account of wood densities of individual species, Norgrove and Hauser (2012) estimated carbon stocks in cacao trees was 14.4 Mg C ha^{-1}, compared with 121.1 Mg C ha^{-1} in the upper canopy shade tree. Leuschner et al. (2013) also calculated total aboveground carbon in a cocoa-Gliricidia system to be 12.1 Mg C ha^{-1}

in Indonesia. In a cocoa agroforestry system with the leguminous tree, Inga, and fruit trees as shade trees in Bolivia, Jacobi et al. (2013) found aboveground carbon to be 34 Mg C ha^{-1}, while in Cameroon, Saj et al. (2013), Norgrove and Hauser (2013), Gockowski and Sonwa (2010) and Sonwa et al. (2009) reported tree carbon stocks of 70, 135.5, 88.7 and 243 Mg C ha^{-1} respectively. Smiley and Kroschel (2008) in Sulawesi, found aboveground carbon of 40 Mg C ha^{-1} in a cocoa-gliricidia system and Dawoe (2009), in the Atwima Nwabiagya district, estimated carbon stocks in trees on plots aged 30 years and above to be 83 Mg C ha^{-1} In all these studies, the greatest proportion of carbon was found in the shade trees. While carbon in soil remained relatively stable over time, stocks of carbon held within aboveground biomass increased more distinctly over time and fluctuated only moderately. Total C stock (above and belowground), especially in the older cocoa systems, was comparable to that in secondary forest reference plots and only a small proportion of the total stock of C was in the cacao per se. These observations point to the fact that cutting shade trees in cocoa systems would significantly reduce carbon stocks. There is the need therefore to put in place policies and mechanisms that would encourage the inclusion of an appropriate number of shade trees in such a manner as to derive both economic and ecological benefits.

2.11 Overview of land ownership in Ghana

The term *land tenure* refers to the set of rights that a person or some private or public entity holds in land. It implies the various laws, rules and obligations governing the holding and/or ownership of rights and interests in land (Bruce 1989:1). Tenure relations in rural communities are often complex. Local tenure systems may incorporate aspects of official legislation as well as traditional or customary tenure systems, which are often highly complex. For example, instead of one person having all the rights to a given plot of land and the resources on it, the bundle of rights may be divided up. It may be divided according to the resource: the land is owned by one person, the trees by another. It may also be divided according to the way the resource is exploited: one person may be considered the owner of a tree and have exclusive rights to chop it down or collect the firewood but many other people may have rights to collect fruits or leaves. Or, the rights to the resource may change over time: one person may hold land for cultivation purposes during the rainy season while it becomes pasture with much less restrictive rules of access during the dry season (Freudenberger 1994: 5). One characteristic of local tenure systems is that they are often adaptive, evolving over time in response to changing ecological and/or socio-economic conditions (Freudenberger 1994).

Land tenure relations in rural communities have a significant effect on agricultural production and how rural people make and sustain their livelihoods as well as the management of natural resources on which rural livelihoods depend. Land tenure influences who could benefit from managing forest resources on a sustainable basis and who would not (Barraclough and Ghimire 1995). In almost all developing countries, forests, woodlands, trees, etc. play important roles in supporting rural livelihoods, especially in remote areas and in times of hardship. However, for all these types of land resources, the rights held by the poor are frequently their most fundamental livelihood asset (DFID 2002). The security and quality of these rights directly affect how these resources are used and managed. Sustaining the forest resource for its own environmental, economic and sociological value can only be ensured within the context of secure land tenure systems that adequately reward and protect the majority of the people on the ground (Kasanga 1994). These are the principal reasons for devoting this section to a discussion of land and tree tenure.

Land ownership in Ghana can broadly be divided into three categories, namely, customary ownership, state ownership and split ownership (a partnership between the state and the customary owners)[1] (Larbi 1998, Larbi et al. 1998). Customary land ownership occurs when the right to use or to dispose of use-rights over land rests neither on the exercise of brute force nor on the evidence of rights guaranteed by government statute, but on the fact that they are recognised as legitimate by the community, the rules governing the acquisition and transmission of these rights being usually explicitly and generally known, though not normally recorded in writing (Bower 1993). As Larbi et al. (1998) note, such ownership may occur in any one or a combination of the following ways:

- Discovery and long uninterrupted settlement
- Conquest through war and subsequent settlement

1. These are the categories of land ownership provided for in the 1992 Constitution of Ghana.

- Gift from another land owning group or traditional overlord
- Purchase from another land owning group.

Customary lands account for 80- 90% of all the undeveloped land in Ghana with varying tenure and management systems (Kasanga and Kotey 2001). Certain distinct schemes of interest exist in customary or communal ownership, including the allodial interest,[2] which is the highest proprietary interest known to exist in customary land. Here, land is acquired absolutely forever and one has the right to pass on the land to inheritors without acknowledgement to a superior. It is equivalent to the concept of freehold in the English system. Other lesser interests that flow out of the allodial interest are the usufructuary interest (right to acquire, use and dispose of land with no restriction on the use of the land), tenancies (sharecropping), licenses and pledges (Kasanga and Kotey 2001, Kasanga 1988).

Customary lands in Ghana are managed by custodians (chiefs or a family heads) who manage the land with the principal elders of the community. Any decisions taken by the custodian that affect rights and interests in the land, especially the disposition of any portion of the communal land to non-members of the land holding community, require the concurrence of the principal elders. Custodians of customary lands therefore hold the land in a fiduciary capacity and they are accountable to the members of the land owning community (Larbi et al. 1998). Individuals and families from the landowning group hold the customary freehold — denoting the near maximal interest in land. This principle is valid for all parts of Ghana where the allodial title is vested in the wider community (Kasanga and Kotey 2001).

Although community-based systems remain the dominant form of land tenure in Ghana, the economic growth surge of the past has fuelled the emergence of land markets and more privatised forms of landholdings. This is particularly evident in the rural southern cocoa-growing regions (characterised by agricultural commercialism and mounting pressures on land) where customary lands are increasingly allocated to private individuals (Knox 1998). Such lands are largely allocated on a leasehold basis rather than alienated outright, as the constitutional provision regulating the land market in Ghana does not allow the allocation of land on a freehold basis. The present provision stipulates that there can be no freehold grants of state, vested and stool/skin[3] (customary) lands. Ghanaians are generally entitled to 99-year leases for residential development and 50-year leases for non-residential development, subject to renewal. Non-Ghanaians are entitled to 50-year leases for all types of land uses (Larbi 1998). Since customary lands are largely allocated to non-members of the land-owning group on a leasehold basis, such lands are still classified as customary lands. Thus, the landholders of customary lands include communities (represented by stools/skins), clans, families and individuals (Kasanga and Kotey 2001).

State lands are those that have been expressly acquired by the state through compulsory acquisition or negotiation. The boundaries of these lands are cadastrally surveyed but are scattered throughout the country. They vary in size depending on the purpose of the acquisition and leases of these lands are granted to statutory institutions and private individuals for development.

Split ownership, on the other hand, occurs when the state takes over the legal incidents of ownership (the right to sell, lease, manage, collect rents, etc.) from the customary landowners and holds the land in trust for the land owning community. The landowners retain the equitable interest in the land — the right to enjoy the benefits from the land. This is generally referred to as vested land and it is managed in the same way as state lands. However, unlike state lands, the boundaries are not cadastrally surveyed, and they are usually larger in size, covering wide areas (Larbi et al. 1998).

Any piece of land in Ghana falls into one of these ownership categories. The universal principle in Ghana is that "there is no land without an owner". Since state and vested lands are acquired expressly through legislation, all other lands outside these categories belong to the class of customary lands — either for stools/skins, clans or families.

2. The "allodial" title is coined on a Latin term "allodium" used in feudal medieval Europe (1241) originally to designate the relationship of Simon de Montfort to some of his lands in France. It describes an absolute power of allocation but not necessarily a title of personal use (cited in Hammer, M. (1998) 'Stool rights and modern land law in Ghana', afrika spectrum 33 (3): 311 - 338).
3. A "stool" refers to a particular land-owning group represented by a 'stool' chief. It also refers to a community governance or administrative structure similar to dynasties (Kasanga et al., 1996).
Note: A skin in Northern Ghana is the equivalent of a stool in Southern Ghana.

2.11.1 Land purchase

Although land purchase is rare in most areas of Ghana these days, several authors maintain that cases of land purchase have occurred in the past and it has been one of the common means by which earlier migrant farmers gained access to land (Amanor and Diderutuah 2001, Kasanga and Kotey 2001, Knox 1998, Hill 1963).

For example, Knox (1998) notes that the introduction of cocoa to Ghana in 1879 invoked radical tenure changes as the profitability of the crop lured farmers to migrate to the Akyem Abuakwa area in the Eastern region and other cocoa-growing areas of southern Ghana. Since their purpose in inhabiting the land was to earn profits rather than for subsistence, the local leaders rationalised that the land ought to be sold to them rather than granted, as had been the traditional means of allocating land to outsiders. Two main forms of tenure took root. In one, groups of unrelated individuals organised to purchase land and received parcel strips in accordance with their contribution to the purchase. These farmers largely originated from patrilineal[4] groups, such as the Krobo. By contrast, the matrilineal[5] Akan purchased land as individuals or among extended families, often in tracts larger than they were capable of cultivating themselves as land became looked upon as an investment (Knox 1998). Hill (1963) also observed that the chiefs were glad to seize the opportunity to sell land outright to enterprising migrant cocoa farmers. It is, however, not clear from the literature whether such past land purchases constitute a final alienation of land from the chiefs' control.

2.11.2 Share tenancy/ sharecropping

Two main systems of share tenancy or sharecropping arrangements exist in Ghana: *abusa* (one-third of cocoa output for tenant) and *abunu* (50:50 sharing arrangement) (Foli and Dumenu 2011, Asenso-Okyere et al. 1993, Benneh 1988). In the *abusa* system, the tenant is admitted onto an already existing cocoa farm so that he primarily maintains and harvests the crop. The tenant receives one third of proceeds or the cocoa output as his wages. In contrast, in the *abunu* system, tenants are requested to plant cocoa trees usually on bushland and manage cocoa trees until the whole field is planted to cocoa, at which time land ownership, rather than output, is usually divided between the tenant and the landowner on a 50:50 basis (see Asenso-Okyere et al. 1993). The major reason for dividing land rather than sharing output in the *abunu* tenancy may be rooted in the difficulty for the landowner to check cocoa output accurately and the suspicion that the tenant may be able to cheat the landowner.

Tenancy arrangements in Ghana differ from one locality to another and in most places these systems have undergone transformations over the years. Amanor (1994:45) provides evidence of how the *abusa* system has been transformed over the years into the *abunu* system in Ghana. He notes that in the period 1920-40 the landowner appropriated a third share of the proceeds of the cocoa harvest or received a third portion of the cocoa farm which was created under the *abusa* tenancy. However, in the post-war period, as land became increasingly scarce and expensive, this arrangement was increasingly transformed into a half share (*abunu* tenancy). The dominant system in most cocoa growing areas in Ghana presently is for tenants to be admitted onto an existing cocoa farm in return for a third share of the cocoa output. Sharecropping or share tenancy is more important among migrant farmers as a mode of gaining access to land in cocoa growing areas of Ghana. As uncultivated forestland outside reserve forests has largely disappeared in these areas, renting land under share tenancy arrangements has become the major means for migrants to gain access to land (Boadu 1992).

2.11.3 Land acquisition and transfer

Differences in the history and inheritance laws of the patrilineal and matrilineal societies in Ghana have created different land ownership and transfer systems. However, the mode of acquisition of land is similar in both societies (Agyeman 1993). In general, a Ghanaian man follows a sequential decision-making process with respect to land acquisition over his life cycle: if forest land is available, he acquires it through clearance when he is young; he acquires family land through inheritance, allocation and gift when he gets married; and later he acquires additional land through renting and private purchase (usually leasehold) (Quisumbing et al. 1999). No customary law in Ghana prevents women from owning land or trees. However, in most places, their right to inherit land is relatively weak and insecure but once they have

4. Patrilineal societies in Ghana follow the patrilineal system of inheritance. That is, the individual who succeeds is traced from the male ancestor in the direct male line. Land is passed by patrilineal succession from father to sons (Agyeman, 1993:15).
5. Matrilineal societies follow the matrilineal system of inheritance. The succession to property is through the matrilineal line according to primogeniture (Agyeman, 1993: 23).

acquired land its use is not restricted (Agyeman 1993). For example, in patrilineal societies, if a man dies and his land is divided among his children, the daughters receive a much smaller portion than the sons. In most cases, the daughters' claim to land is regarded as a privilege and not a right to be enforced in a court of law (Nukunya 1972, cited in Agyeman 1993). Similarly, women are relatively disadvantaged in acquiring land through forest clearance since forest clearance is a male activity.

When virgin forests were abundant, forests were appropriated primarily by young males before marriage mainly for the production of food crops. Relatively strong land rights were granted in return for the substantial labour input required to clear forest. Traditionally, in the Akan matrilineal system, this type of land was either bequeathed to nephews or allocated to other male members of the extended family, in accordance with the decision of the family head (Quisumbing et al. 1999: 8). Wives and children were left with no rights to a man's property if he were to die intestate. Uncultivated fallow land was often allocated temporarily to members of the extended family, who otherwise possessed small land areas (Brydon 1987, cited in Quisumbing et al. 1999).

In the context of rural areas, land, apart from being used as a basis for providing shelter, is also the basis of livelihood for the rural population. Where agriculture is the predominant occupation, the means of livelihood will be dependent not only on the fertility and ease of putting land into productive use, but also on the allocation of rights in land (Acquaye 1986). Land tenure and land availability partly shape and influence the way rural people use and depend on natural resources for their livelihoods and thus have a significant effect on the management of these resources on which rural livelihoods depend. Many studies have indicated that, where people have limited land for agricultural production, forest foods and income from forest products often play important role in rural livelihoods. Thus, dependence on income from non-timber forest products has been shown to be inversely related to size of landholdings in Orissa, India (Fernandes and Menon 1987, cited in Arnold 1996) and in Brazil (Hecht et al. 1988, cited in Arnold 1996).

The potential for the poor to generate forest product supplies and income from land they farm, rather than from forests, is usually affected by land rights. Because of the relatively long production period of tree products, if there is not sufficient security of tenure to ensure that planters will be able to reap the harvest from the trees they establish, tree growing is likely to be inhibited (Arnold and Bird 1999). In some situations, tenurial conditions may need to be clarified or modified before tree management can succeed. Tenurial rights that enable, or appear to enable, the state to expropriate land that has trees on it may inhibit tree growing. More widely, insecurity of tenure generated by the threat or possibility of tenurial change, such as land titling, can inhibit investment in tree growing. Sharecropping and some other forms of short-term tenancy can also prevent or discourage tree growing (Warner 1993, cited in Arnold and Bird 1999).

2.12 Forest and tree tenure and use rights

Security of tenure of natural resources is an important issue if local communities are to use the natural resources in their localities sustainably. Natural resources tenure simply refers to the terms and conditions on which natural resources are held and used. Thus, forest and tree tenure refers to the terms and conditions by which forests and trees are held and used (Bruce 1986, cited in Birgegard 1993). It includes questions of both ownership and access or use rights. The set of rights that a person or some private entity holds to forests or trees may include the right to own, to inherit, to plant, to dispose of and to prevent others from using trees and tree products (Fortmann 1985).

Tenure is not a matter of man's relationship with natural resources such as forests and trees. It is a matter of relationships between individuals and groups of individuals in which rights and obligations with respect to control and use of natural resources are defined. It is thus a social institution (Birgegard 1993). Access to, and use of, natural resources is the key to survival for the majority of people in the developing world. The control and use of land and other natural resources has been the way to sustain the family or the household (Birgegard 1993). One of the factors that affects the level and type of consumptive utilisation of forests in many settings is the security of tenure that local residents possess in relation to forests. Individuals who lack secure rights are strongly tempted to use up these resources before they are lost to the harvesting efforts of others (Banana and Gomya-Ssembajjwe 1998). Similarly, where forest habitats have little economic value to local people because of restrictive access rules, sustainable local management institutions are unlikely to emerge (Lawry 1990). Tenure therefore determines, in large part, whether local people are willing to participate in the management and protection of forest and tree resources.

2.13 Existing forest and tree tenure arrangements in Ghana

Forest and tree tenure arrangements and timber logging rights in Ghana, especially in the off-reserve areas of the high forest zone (HFZ), are highly complex. Depending on whether trees are planted or are naturally occurring and whether they occur on family, communal or rented land, several usufruct rights exist. Thus, tree tenure systems operating in forest reserves are different from those outside reserves. In off-reserve areas, tree tenures are also different for planted trees compared to those growing naturally, and for timber trees compared with non-timber species (Marfo 2006, Acheampong 2003, Agyeman 1993, Asare 1986). These differences are considered below.

2.13.1 Rights to planted trees outside reserves

In a study of indigenous tenures relating to trees and forests, Asare (1986) observed that, in most parts of the HFZ, any individual (man or woman) who has the right to use a piece of land in perpetuity also has the right to plant any species of tree, and such trees are vested in the planter/cultivator. In a study of the extent and manner in which forest-based resources form part of livelihood structures of forest fringe communities in the Asankrangwa forest district, Acheampong (2003) also noted that people generally have more secure rights to planted trees than those occurring naturally. The planter can will trees planted on privately acquired land to anyone he likes. However, trees that are planted on family or lineage lands can only be inherited by members of the lineage group.

Strangers who have acquired long-term title or right to the use of land through some form of agreement (such as granting on a leasehold basis) also have the right to plant and use any species of tree. However, strangers with temporary use of land do not have the right to plant permanent trees on those lands (Asare 1986). Although customary laws do not prevent tenants from planting trees, landowners do not encourage this because most people believe that the long production period and the lack of appropriate documentation of land ownership increases the security of the tenant to land rights when trees are planted. Thus, an attempt by a tenant to plant trees is regarded as an attempt to acquire permanent ownership of land. This appears to be a common practice throughout much of Africa (Arnold and Bird 1999, Warner 1993, Agyeman 1993).

2.13.2 Rights to naturally-occurring trees outside reserves

Rights to naturally-occurring trees outside reserves vary between timber and non-timber species. In the case of non-timber trees (such as kola, oil palm, raphia palm, bamboo, etc.), the rights also depend on whether the tree has some commercial value or it is for subsistence use only (Acheampong 2003, Asare 1986). Rights to naturally-occurring non-timber trees that have some commercial value, such as kola, oil palm and raphia palm, are restricted and are vested in the landowner. For example, only landowners or people who have perpetual use of land on which kola or oil palm trees occur can harvest the fruits. The right to naturally-occurring non-timber trees that are only of subsistence value is very much more relaxed. For example, bamboo and fruit trees (such as pawpaw, *Dacryodes klaineana, Chrysophyllum albidum, Spondias monbin*, etc.) can be collected from anywhere without permission from the landowner provided crops are not damaged (Asare 1986).

All naturally-occurring timber trees — whether on private or on communal land, or even on private farms —, however, belong to the government. The use of such trees is controlled by legislation and it is an offence for an individual or community to cut or sell timber or merchantable tree species without permission from the appropriate government institution. The right to control and manage tree resources, including allocation of logging rights, is vested in the state (cf. Matose 2002). Farmers have no legal rights either to harvest timber trees they maintain on their farms or to any of the revenue accruing to timber extraction, though they continue to exercise judgement over which trees to maintain on their farms during clearing for cultivation (Amanor 1999, cited in Marfo 2006). This is a strong disincentive to farmer tree management and protection (Ardayfio-Schandorf et al. 2007).

2.13.3 Rights to trees and other products in forest reserves

In pre-colonial Ghana (then called the Gold Coast), forests were owned in common by communities (families, clans and stools). However, the country's Forest Ordinance of 1927 gave authority to the colonial government to reserve parts of the country's forests. Although the bill did not alter ownership of the forest reserves, it vested control of them in the government of Ghana and prescribed that they should be held in trust for the communities. Thus, all forest products within forest reserves, including both timber and non-timber tree species and even NTFPs are vested in the government (Owubah et al. 2001). Although, in theory, the ownership of land and forests did not alter at the time of reservation, in practice, the traditional owners have no right of access to the trees or land in the reserve, except on permit from the competent government authority, the Forest Services Division (FSD). The management of trees and the right to own, plant, use and dispose of trees within the forest reserves is controlled by the state, through the Forest Protection Decree of 1974 (or National Redemption Council Decree (NRCD) 243). This decree has, from the beginning, created a feeling of animosity between local communities and the FD (Agyeman 1993).

2.14 Challenges and opportunities in using cocoa in REDD+ intervention

Reducing emissions from deforestation and forest degradation (REDD) has emerged as a central policy instrument to halt land-use related emissions from developing countries. REDD+ goes beyond deforestation and forest degradation and includes the role of conservation, sustainable management and enhancement of forest carbon stocks (UN-REDD Programme 2009). It is a form of payment for environmental services (PES) that seeks to reduce climate change and provide incentives for developing countries. The mechanism could help fight poverty while conserving biodiversity and sustaining vital ecosystem services.

The idea of REDD was first brought to the table during the Kyoto protocol negotiations in 1997, which recognised the important role that forests could play in reducing carbon emissions from deforestation. However, formal recognition of REDD was not achieved until 2007 at the UNFCCC 13th Conference of the Parties (COP 13) under the Bali Action Plan. The plan cemented the international community's commitment to reducing deforestation through REDD. As discussions gained momentum, COP 14, held in Pozna in 2008, saw the expansion of REDD into REDD+. It was agreed that funds from REDD+ could support new pro-poor development, help conserve biodiversity and secure vital ecosystem services. Successive conferences in Copenhagen (COP 15) in 2009 and Cancun (COP 16) in 2010 saw an international agreement on the REDD+ framework as well commitments from several developing countries to reduce overall emissions.

2.14.1 Status of REDD+ in Ghana

Ghana joined the international REDD+ readiness process through the World Bank's Forest Carbon Partnership Facility (FCPF) (FIP 2012). The readiness process aims to create capacity to fully engage in and utilise the REDD+ mechanism to address climate change adaptation and mitigation. Ghana was also included as one of the pilot countries for the Forest Investment Program (FIP), which aims to pilot and provide up-front investments for the pilot countries to test and initiate the REDD+ activities. In 2012, Ghana was also included in the UN-REDD programme. The FIP funding came to align with and build on the REDD+ readiness process to provide transformational and additional investments to directly address some of the key drivers, and to facilitate and test approaches, which support decision-making and policy along the national REDD+ strategy. Funding was received from the FCPF in support of its R-PP and REDD+ activities for capacity building and supporting key steps in the process, including the preparation of the national REDD+ strategy. Also, funding for the pilots has been provided by the governments of Japan and Germany to assist with the development of national reference levels and a national monitoring, reporting and verification (MRV) system. In effect, Ghana is serious about and on course for implementing the REDD+ mechanism.

2.14.2 Challenges of using cocoa as REDD+ intervention

The evolution of the full-sun cocoa system, which is now widely adopted, has resulted in the widespread removal of shade trees from cocoa farms and accelerated the pace of deforestation. According to a UNDP (2012) report, Ghana has experienced significant forest loss through the activities of the timber sector and expansion of the cocoa industry by promotion of zero shade cocoa production systems (UNDP 2012). Most new cocoa planting has been in the Western region where approximately 80% has been established without shade, or less than 10% canopy cover. In comparison, 50% of cocoa in the Eastern region is grown with 30-40% canopy cover (Katoomba 2009).

The increase in cocoa production in recent decades has been due to expansion of the land area rather than improved productivity (Katoomba 2009). Deforestation and habitat conversion, climate change, unsustainable land management practices and resource use and the intensification of cocoa production system are the major threats to sustainable cocoa landscape. Much of the cocoa is grown with low shade cover, resulting in a low biodiversity and carbon stock, and is more vulnerable to changes in climate. With respect to these challenges, cocoa farms in Ghana are established on fragmented pieces of land. Based on this Katoomba (2009) stated that the smallholder basis of cocoa raises challenges to cost-effective carbon monitoring and verification.

2.14.3 Ghana's forest definition and its implication for cocoa REDD+ intervention

A critical question regarding the practicability or otherwise of implementing REDD+ intervention in the cocoa landscape has to do with how a forest may be defined. A particular definition may influence, one way or another, whether the cocoa landscape can be suitable or otherwise. In line with requirements under the CDM (IPCC 2000, UNFCCC 2006) and REDD readiness efforts, Ghana has defined its forests as being a minimum of 1 hectare, having at least 15% canopy cover and containing trees that are at least 5 m tall (ERP 2014). Cocoa is not a native forest species and according to research conducted by Forest Trends and Nature Conservation Research Centre (NCRC) (2013) it also fails to achieve the 5 m height requirement. Under those conditions, a monoculture cocoa plantation cannot be considered a forest. The shade trees in the cocoa agroforest, however, could constitute a forest if they offer enough canopy cover and are taller than 5 m. Thus, the forest definition and type of cocoa system (monoculture vs. shade) have serious implications for the type of REDD+ that is viable. If the forest definition should change, then the technical opportunities would also shift. For example, if Ghana had set the forest definition at only 2.5 m high, then other tree crops, like oil palm, which are native forest species, would constitute a forest and therefore conversion of tropical high forest to oil palm plantations would not qualify for REDD+.

2.14.4 Opportunities for using cocoa planted with shade trees as REDD+ intervention

It is estimated that there are about 1.5 million hectares of cocoa in Ghana, some 30% of the population are dependent on cocoa for part or all of their livelihoods and cocoa exports account for about 40% of total exports (Katoomba 2009). Cocoa cultivation practices that maintain higher proportions of shade trees (cocoa agroforestry) are increasingly being viewed as sustainable and environmentally preferable to other forms of agricultural activities in tropical forest regions (UNDP 2012). A higher shade (from 30% canopy cover) cocoa farm with improved management practices can be viewed as a sustainable agroforestry system that stores significant quantities of carbon on the farm (Katoomba 2009). Carbon benefits therefore have the potential to enhance the profitability of sustainable cocoa production in Ghana. A key REDD action, including existing cocoa farms in the more degraded high forest reserves, would be to increase productivity of cocoa farms so that these farmers have less need to extend their farms or abandon them for new forest areas (Katoomba 2009). Therefore, cocoa carbon also has the potential to generate significant poverty reduction benefits. REDD+ payments will also provide incentives for local people to keep native trees standing, plant trees in areas that have been degraded and invest in best management practices.

2.15 Challenges and opportunities of land and tree tenure for cocoa REDD+ intervention

In Ghana, land rights and tenure are administered through a complex legal environment with customary laws and norms operating alongside statutes. The customary owners (stools, clans, families and Tendanas), who hold the allodial title, own about 78% of the total land area in Ghana (FIP 2012). Of the remaining 22% the state is the principal owner of (about 20%), while 2% is held in dual ownership (i.e. the legal estate in the government and the beneficiary/equitable interest in the community). Customary owners hold land in custody for communities and various arrangements on land use for community members prevail. The situation has been further complicated by internal migration related primarily to expanding cocoa; in many areas more than 50% of the population are from other parts of Ghana engaged through various arrangements (lease, sharecropping, etc.) in cocoa and other farming activities.

The separation of land from the resources on land, such as naturally growing trees, is complicating tenure and benefit sharing as well as reducing incentives for maintaining trees on off-reserve lands. The complication associated with tree tenure is considered as major constraint for REDD cocoa carbon since it acts as a disincentive to farmers to keep trees, especially timber trees. The state owns all naturally-occurring trees, while planted trees belong to the person who plants them. Farmers have the right to fell naturally-occurring trees for household use or agriculture, but not for economic purposes. The tenure system appears generally unfriendly, especially in the case of naturally-occurring trees. However, the aspect of the policy that gives right of ownership to the one who planted the tree provides hope for REDD+ implementation in cocoa farms, whereby farmers can integrate trees into their farms through planting.

Section 3
Methodology

3.1 Introduction

This chapter presents the methodologies used to collect relevant information to achieve the objectives of the study. The chapter begins with a description of the study area. Subsequent sections provide a detailed description of the sampling design and field assessment, the layout of transects, data collection and processing procedures, the approach adopted for the collection of socio-economic data, which is primarily aimed at documenting land and tree tenure and share-cropping arrangements in the study area, and the procedures for data analyses.

3.2 Study area

The study was conducted in the mid-western cocoa growing areas of Ghana covering three of the ten administrative regions:A shanti, Brong Ahafo and Western. The landscape lies within the dry and moist semi-deciduous forest zones. The forest zone lies within the wet semi-equatorial zone marked by double maximum rainfall ranging between 1700 mm and 1850 mm per annum. The major rainfall season is from mid-March to July and the minor season is between September and mid-November. The regions together constitute over 85% of Ghana's cocoa production, with the Western region alone producing over 50% (Asante-Poku and Angelucci 2013, cited in COCOBOD 2012).

3.3 Reconnaissance survey

Selection of sites for the study was preceded by a reconnaissance survey of the proposed project landscape. The goal of the reconnaissance survey was, among other things, to conduct a quick assessment of the extent of coverage of cocoa plantations in the area, to determine accessibility of the landscape and to identify communities and individuals who could assist in facilitating subsequent field activities. Key cocoa growing areas visited in the Ashanti region included Nkawie, Offinso, Kyekyewere, Agona, New Edubiase and Fumsu. Areas visited in the Brong Ahafo region included Kukuom, Goaso, Abuom and Sankore. In the Western region, the team visited the Sefwi cocoa landscape, starting from Wiawso, through Akontombra, Juaboso and Asempanye.

In each area visited, the team drove through the landscape, stopping intermittently in communities to meet with chief cocoa farmers, elders, assemblymen and opinion leaders. The meetings were short and informal, as the main objectives were to introduce the project, establish rapport and solicit the cooperation of farmers during the fieldwork. During the meetings, discussions centred on the extent of cultivation of cocoa in the area, the general characteristics and accessibility of the landscape and whether the farmers and communities would allow access to their farms for the study. Names of potential contact persons and their phone numbers and GPS coordinates of the villages were obtained.

3.4 Site selection

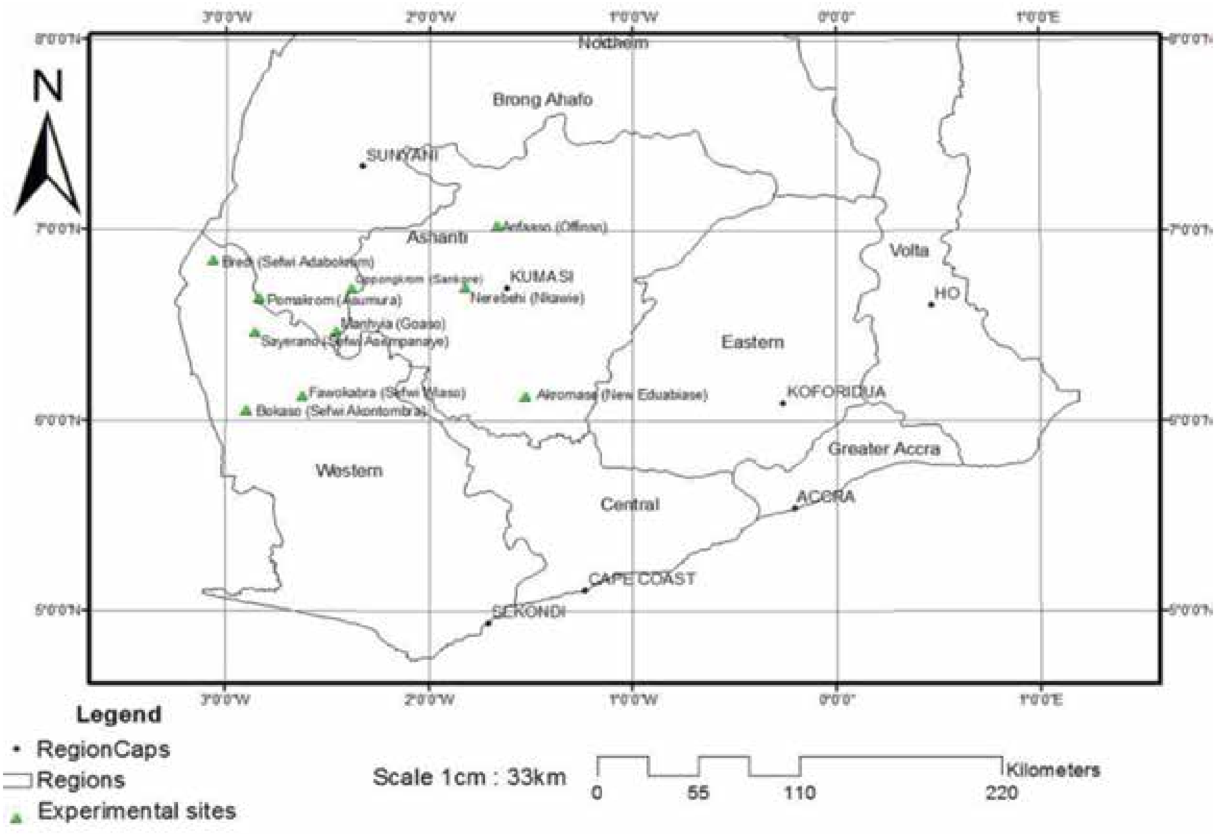
Selection of areas for the study was informed by the information obtained during the reconnaissance survey. Considering the biophysical and socioeconomic diversity of the cocoa landscape surveyed, 10 cocoa districts were selected, three each in the Ashanti and Brong Ahafo regions and four in the Western region (Table 3.1 and Appendix 2). In each district, one of several communities with a contiguous cocoa plantation was randomly selected as a focal or reference community (Figure 3.1). Each reference community automatically became the location for the socioeconomic study (questionnaire administration, focus group discussions and key informant interviews). In addition, field plots were established with the community as the reference point.

Table 3.1 List of cocoa growing communities/sites selected for the study

Region	Cocoa district*	Site/Community
Ashanti	Offinso	Amfaaso
	Nkawie	Nerebehi
	New Edubiase	Akromaso
Brong Ahafo	Asumura	Pomaakrom
	Goaso	Manhyia
	Sankore	Oppongkrom
Western	Sefwi Wiawso	Fawokabra
	Sefwi Akontombra	Bokaso
	Sefwi Asempaneye	Seyerano
	Sefwi Adabokrom	Bredi

*COCOBOD classification

Figure 3.1 Map of study sites/communities



3.5 Data collection

3.5.1 Sampling design and field assessment

The three administrative regions, Ashanti, Brong Ahafo and Western, were purposively selected from among the six regions in Ghana known for cocoa cultivation. Three each of the COCOBOD designated districts were randomly selected from Ashanti and Brong Ahafo regions and four from the Western region. Thus, field plots were established and assessed in cocoa agroforestry systems in 10 cocoa districts, each represented by a community. In each community, three transects were established in a contiguous cocoa landscape in a Y-shaped fashion with transects roughly aligned at 120 degrees from each other (see Figure 3.2). Each transect was at least 5 km long. Three plots, each measuring 100 m x 100 m, were established along each transect at intervals of at least 500 m. Thus, there were nine plots per site and a total of ninety plots across all sites. There were, however, instances where the transect exceeded 5 km, when contiguous cocoa were interspersed with patches of other land use types. In instances where the recording plot fell within a non-cocoa land use, the transect continued until the next cocoa establishment. Within the 100 m x 100 m plots, subplots measuring 25 m x 25 m were demarcated. The subplots were placed at alternate points along the main transect line (see Figures 3.2 and 3.3).

Plot level assessments included measurements of cocoa and non-cocoa canopy trees. All non-cocoa trees with diameter at breast height (dbh=1.3 cm) 5 cm and above were identified and measured. Tree dbh was measured by calipers while heights were measured using laser hypsometers (Nikon Laser Hypsometer). To obtain an estimate of the shade provided by the upper canopy trees to cocoa, and the contribution of these upper canopy trees to canopy cover, relative to the national forest definition, the crown area of each upper canopy non-cocoa tree within the 1 ha sample plot of cocoa farms was estimated by measuring the diameter of the crown in eight different directions, following the cardinal points and a subdivision within the cardinal points, i.e. north, south, east and west and then north-west, north-east, south-west and south-east. The diameter measurements were taken from one tip of the crown to the other. This approach ensured that the variation of the pattern of the crown was captured. The total crown cover for all the upper canopy trees was expressed as a percentage of 1 hectare to ensure easy comparison with the parameters of the national forest definition at the plot level. The study also assessed the possibility of using Landsat imagery derived from Google Earth to differentiate contiguous cocoa from shade cocoa, mostly occurring in patches, using the different colour regimes that are presented for the crowns of upper canopy trees and that of cocoa. The height and dbh of cocoa trees were measured only within a 25 m x 25 m subplot. Thereafter, 10 cocoa trees were randomly selected and their heights measured to establish the mean height of the cocoa plantation. This was also done to ensure that data could be generated to inform the decision on how cocoa parameters are comparable to the national forest definition.

Figure 3.2 Layout of transects, main plots (100m × 100m) and subplots (25m × 25m) in each study district. Lower arm of Y-shape (Transect 3) shows dimensions of main and subplots and parameters measured (for both cocoa and shade trees) within each transect. Each transect is 5km long and minimum distance between plots is 500m.

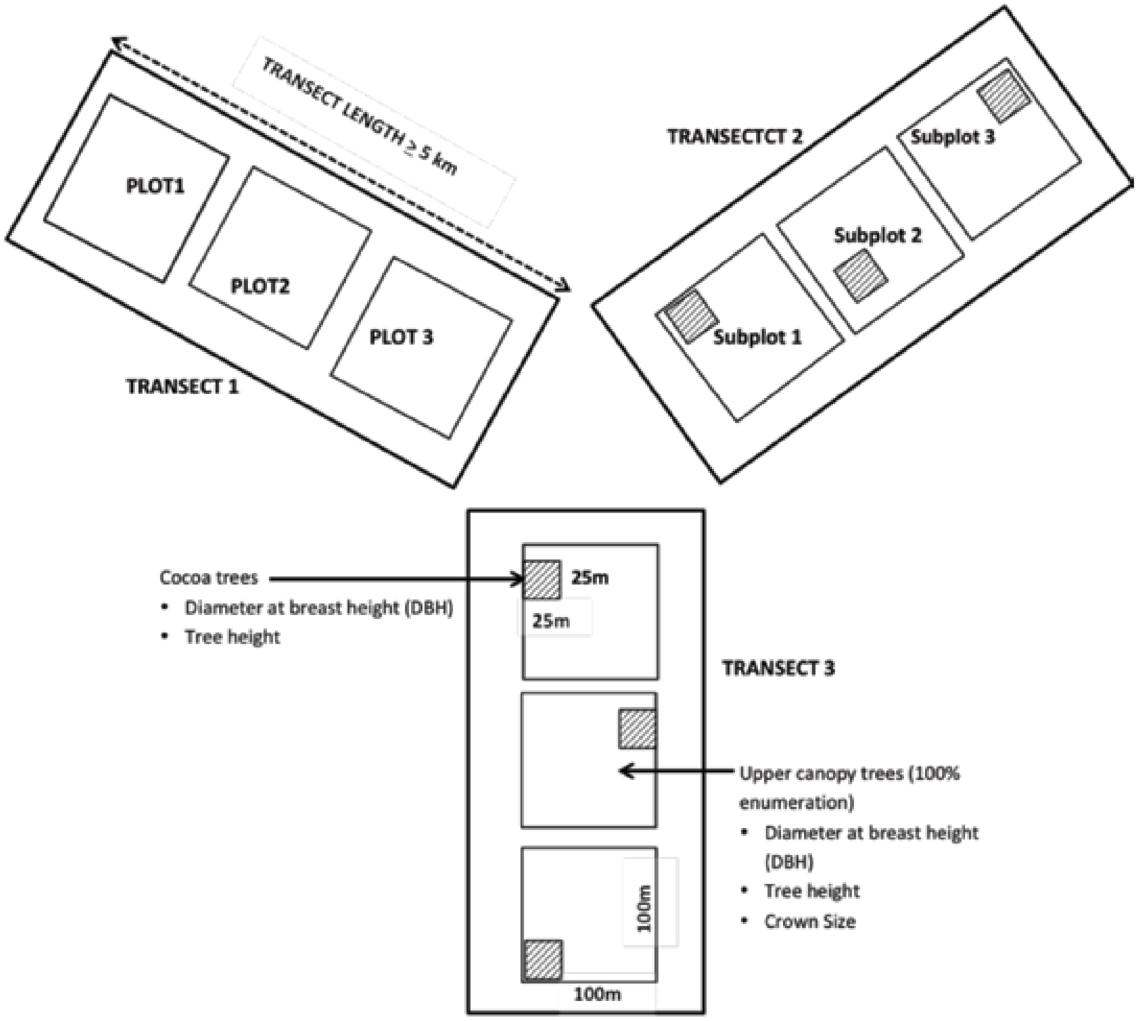
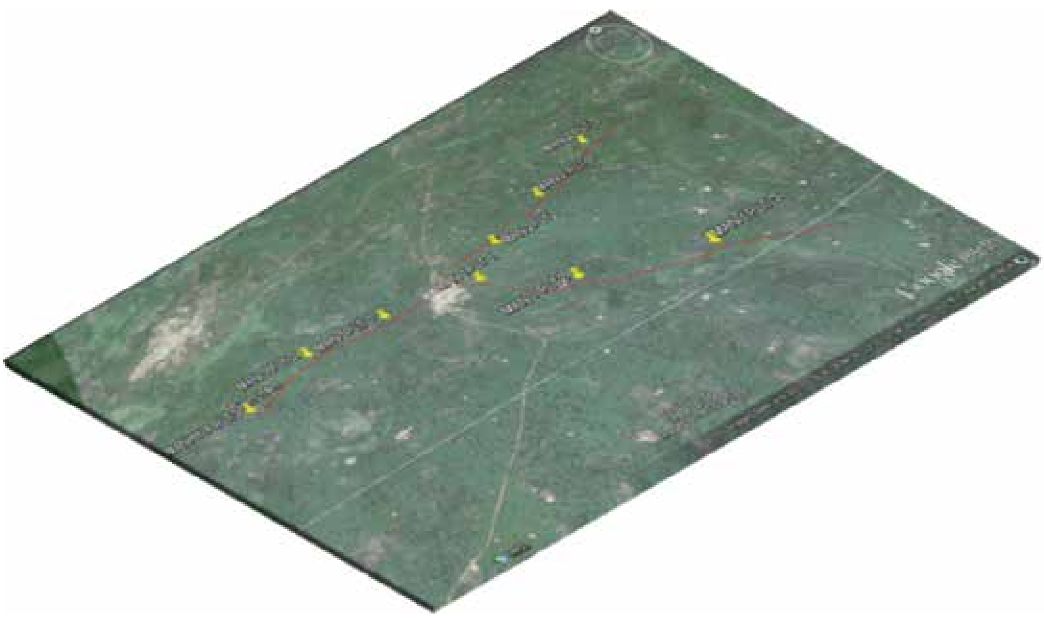


Figure 3.3 Google Earth image of plots along three transect lines near the village of Manhyia in the Goaso district, Brong Ahafo region.



3.5.2 Socioeconomic study

A combination of semi-structured questionnaire, focus group discussions and key informant interviews were used to collect the socioeconomic data. In each of the communities, 20 cocoa farmers were randomly selected and interviewed using a semi-structured questionnaire (see Plate 2). In all, 200 cocoa farmers were surveyed across the 10 cocoa districts. The settlement types in cocoa landscape are such that several satellite villages and/or hamlets can be found scattered around a larger or main village. In most cases, respondents were identified in the main village as well as the satellite communities. However, for the purposes of reporting, only the main village or reference community is indicated. The survey was used to gather information on the farmers' perceptions of trees in cocoa farms and their willingness to engage in active tree planting in cocoa farms as well as their view on land tenure and sharecropping arrangements in their communities. The key informant interviews and focus group discussions were held with selected individuals or groups in each of the communities. The focus group discussions were organised separately for cocoa farm owners (landowners) and caretakers of cocoa farms (who were not the owners of the farms they managed). The objectives were the same: to document the land tenure and share-cropping arrangements existing in the study area and to identify changes in tenure and sharecropping arrangements that might have occurred over the years. In addition, forest and tree tenure and use rights, access to planted trees, barriers to shade tree incorporation in cocoa systems, factors that encourage or motivate farmers to incorporate trees in their cocoa farms and the types of trees preferred in cocoa farms were all discussed.

3.6 Data analysis

The non-cocoa or canopy trees recorded at the 1 ha plot level were identified to species. However, for the purposes of analyses, data at the plot level were pooled to the transect level, which comprised of nine 1 ha plots (a total of 9 ha per transect). Thus, there were nine replicates for each of the ten sites, forming a total of ninety 1 ha plots. The Shannon-Weiner diversity indices were calculated using Biodiversity pro software. Similarly, the height and dbh data of the cocoa trees were also pooled to the transect level and converted to a per hectare basis. Aboveground biomass of cocoa and upper canopy trees were estimated using the allometric equation developed by Chave et al. (2005) for moist forests:

$$\text{Biomass (kg)} = \exp{-2.977} + \ln(X*Z^2*W),$$

where X = species specific density; Z = diameter at breast height (DBH); and W = height.

Carbon stock per site was compared by one-way analysis of variance using the pooled data at the transect level as replicates for each site. For each variable (crown cover, cocoa carbon, shade tree carbon and stem diameter) normal distribution was tested using the Shapiro-Wilks W-test for homogeneity of variances. Variables that conformed to normal distribution were analysed using one-way analysis of variance while those that did not meet the assumptions for an ANOVA were analysed using Kruskal-Wallis parametric ANOVA on the mean ranks using the software package Statistix 7.0 (Analytical Software 2000). Separation of means was done at 5% probability level. Regressions and correlations were also employed as tools for statistical tests and to establish trends and relationships between parameters.

The land and tree tenure data obtained through the questionnaire administration were assigned numerical codes and analysed using SPSS. Simple descriptive statistics and frequencies were also generated. Cross tabulations of relevant variables was done where necessary to reveal patterns and relationships while the information from the key informant interviews and focus group discussions were content analysed.

Section 4

Findings of the Study

4.1 Introduction

This chapter presents the results of both the biophysical and socioeconomic studies. Results of the biophysical study include species diversity, relative abundance of timber and non-timber tree species, canopy cover and shade levels in cocoa plantations and carbon stock levels of cocoa and non-cocoa canopy trees. The relationship between crown cover, stem diameter and carbon stocks are also presented. For the socioeconomic study, results are presented on the characteristics of the respondents and of their farms. Results on existing land and tree tenure as well as sharecropping arrangements in the cocoa landscape are also presented. The final sections focus on farmers' perceptions on cocoa agroforestry and farmer tree planting and management.

4.2 Species diversity and distribution on the smallholder cocoa farms

A total of 109 tree species were recorded during the field inventory across all 10 study sites. Out of the 109 species, 35 species occurred at Adabokrom, 27 occurred at Akontombra, 45 occurred at Asempaneye, 37 occurred at Asumura, 49 occurred at Goaso, 43 occurred at New Edubiase, 40 occurred at Nkawie, 46 occurred at Offinso, 35 occurred at Sankore and 34 occurred at Sewfi Wiawso (Table 4.1).

Table 4.1 Species diversity indices for the different study sites with associated number of individual species

Site	Total Individuals	Total Species	Shannon H'	Shannon Hmax	Shannon J'
Adabokrom	97	35	1.42	1.54	0.92
Akontombra	84	27	1.22	1.43	0.85
Asempaneye	128	45	1.51	1.65	0.92
Asumura	147	37	1.04	1.57	0.66
Goaso	146	49	1.52	1.69	0.90
New Edubiase	184	43	1.34	1.63	0.82
Nkawie	136	40	1.40	1.60	0.88
Offinso	204	46	1.29	1.66	0.77
Sankore	108	35	1.39	1.54	0.90
Wiawso	165	34	0.99	1.53	0.65

With respect to species dominance in the study districts, *Ficus exasperata* was the most dominant species at Adabokrom (10%), with *Persea americana* being the most dominant species at Akontombra (16.7%) and T*riplochiton scleroxylon* (10.2%) dominating at Asempaneye (Table 4.2). *Newbouldia laevis* dominated among the species at Asumura (47.6%) while *Milicia excelsa* dominated at Goaso (9.5%). Similarly, *Newbouldia laevis* dominated among the species at New Edubiase (24.3%), and *Morinda lucida* dominated among the species at Nkawie (13.2%), with *Citrus sinensis* being dominant at Offinso (24%). Again, at Sankore and Sefwi Wiawso, the dominant species recorded were *Newbouldia laevis* (11.1% and 47.3% respectively). *Newbouldia laevis* was the most dominant species in the study (Table 4.2).

Table 4.2 Dominant species (shade trees) recorded in each cocoa district (Percentages are proportions of total individuals recorded in each district).

Community	Most dominant species	Total number of individual shade trees	Percentage of total individual shade trees
Adabokrom	Ficus exasperata	97	10
Akontombra	Persea americana	84	16.7
Asempaneye	Triplochiton scleroxylon	128	10.2
Asumura	Newbouldia laevis	147	47.6
Goaso	Milicia excelsa	146	9.5
New Edubiase	Newbouldia laevis	185	24.3
Nkawie	Morinda lucida	136	13.2
Offinso	Citrus sinensis	205	24.0
Sankore	Newbouldia laevis	108	11.1
Wiawso	Newbouldia laevis	165	47.3

The Shannon-Weiner diversity index (H’) ranked the areas as Goaso > Asempaneye > Adabokrom > Nkawie > Sankore > New Edubiase > Offinso > Akontombra > Asumura > Wiawso (Table 4.1). However, results of Shannon evenness or species equitability (J’) revealed that the species at Adabokrom and Asempaneye were more evenly distributed. This was followed by Goaso, Sankore, Nkawie, Akontombra, New Edubiase, Offinso, Asumura and Sefwi Wiawso.

4.3 Similarities between species

The Spearman’s rank correlation test of species similarity between the 10 sites showed that Adabokrom – Goaso, Adabokrom – New Edubiase, Wiawso – Akontombra, Asumura – Goaso and Goaso – New Edubiase recorded the highest species similarity in the study area. While the following sites recorded the least species similarity: Akontombra – Asempaneye and Offinso – Asempaneye (Table 4.3).

4.4 Relative abundance of timber and non-timber tree species

All non-cocoa upper canopy trees identified in the plots were grouped into timber and non-timber species. Generally, the relative abundance of non-timber species in all the cocoa districts was higher than timber species, except Asempaneye where the abundance of timber and non-timber species was equal (Table 4.4; Appendix 1). Most of the sites recorded very wide disparities in the abundance of timber and non-timber species, a strong indication that farmers are shifting the composition of species in cocoa agroforestry systems in favour of non-timber species. This disparity could also be a manifestation of logging impact or exploitation of timber species within the cocoa landscape.

Table 4.3 The Spearman's rank correlation test of species similarity between the ten sites

	Adabokrom	Akontombra	Asempaneye	Asumura	Goaso	New Edubiase	Nkawie	Offinso	Sankore	Wiawso
Adabokrom	1	*	*	*	*	*	*	*	*	*
Akontombra	0.6	1	*	*	*	*	*	*	*	*
Asempaneye	0.6	0.4	1	*	*	*	*	*	*	*
Asumura	0.6	0.6	0.5	1	*	*	*	*	*	*
Goaso	0.7	0.5	0.5	0.7	1	*	*	*	*	*
New Edubiase	0.7	0.6	0.5	0.6	0.7	1	*	*	*	*
Nkawie	0.6	0.5	0.5	0.6	0.6	0.6	1	*	*	*
Offinso	0.5	0.5	0.4	0.5	0.5	0.5	0.5	1	*	*
Sankore	0.6	0.6	0.5	0.6	0.6	0.6	0.5	0.6	1	*
Wiawso	0.5	0.7	0.4	0.5	0.5	0.5	0.5	0.5	0.5	1

Table 4.4 Relative abundance of timber and non-timber species within smallholder cocoa systems

	Adabokrom	Akontombra	Asempaneye	Asumura	Goaso	New Edubiase	Nkawie	Offinso	Sankore	Wiawso
Timber species	45	19	64	39	67	85	48	44	31	44
Relative abundance (%)	45	22.6	50.0	26.5	45.9	45.9	35.3	21.6	28.7	26.7
Non-timber species	55	65	64	108	79	100	88	160	77	121
Relative abundance (%)	55	77.4	50.0	73.5	54.1	54.1	64.7	78.4	71.3	73.3

It is very obvious from the data that there is a shift in the species composition of the off-reserve landscape in the HFZ, with a general decline in species diversity. The dominance of fruit trees (citrus and avocados) and *Newbouldia laevis* strongly indicates a deliberate transformation of the landscape by farmers from the naturally occurring pioneer species such as *Terminalia spp*. and other timber species that have been traditionally grown in tandem with cocoa, and also provide timber benefits, to non-timber species such as fruits, *Gliricidia sepium* and *Newbouldia laevis*.

A prime factor that drove the transformation of the species composition of the landscape was logging. But general governance issues such as tree tenure and ownership and inconsistent understanding and weak implementation of forest policy and legal regime have also contributed to a strong negative perception about tree incorporation in the cocoa systems. Farmers consistently complained about the indiscriminate logging and continued award of concessions in the cocoa landscape as well as the lack of proper compensation for cocoa trees destroyed.

For a long time, the governance issues associated with off-reserve trees have bedevilled efforts at improving cocoa agroforestry systems involving the incorporation of timber trees that could have multiple benefits for farmers in Ghana.

The very minimal occurrence and low dominance of the indigenous timber species such as *Terminalia* spp., *Melicia excelsa*, etc. within the cocoa landscape have serious implications for the implementation of climate-smart cocoa models and REDD+ strategies. Most of these models are posited on indigenous timber species that present better opportunities to contribute to climate change mitigation projects in cocoa systems and also serve as preferred species in terms of shade and moderation of climatic parameters for optimal cocoa productivity. In order to reverse the current trend in terms of dominant species within the landscape, it is important to overcome the governance issues associated with off-reserve trees at all levels, from the national to the community level. Once farmers' confidence has been gained, then mechanisms can be rolled out to introduce tree diversification strategies.

It is also possible that the dominance of fruit trees is an indication that farmers want to diversify the sources of income as was indicated by respondents at Offinso, who incorporated citrus and pear to ensure that they could generate revenue in the off season period of cocoa harvesting.

4.5 Upper canopy trees stand characteristics and stem number as a proxy for shade cover

Shade tree stand characteristics (mean number of stems/ha, mean diameter and mean stem diameter) in each of the study districts are given in Table 4.5. The number of upper canopy trees per hectare on farms differed significantly between districts (F=3.65; p=0.0007). Stem densities in Offinso (22.8 ± 1.7), New Edubiase (20.6± 3.3), Sefwi Wiawso (18.3 ±3.57), Asumura 16.3 ±2.5 and Goaso (16.2 ±3.00 stems ha-1) were similar but statistically higher than densities recorded at Sankore (12 ±2.71), Adabokrom (10.8 ±1.27) and Akontombra (9.33±1.22 stems ha-1). Stem diameter similarly differed between locations (F=3.70, p=0.0006) and ranged between 31.2 ±4.71 and 51.6±3.67 cm across districts. Adabokrom (51.6 ±3.67), Sankore (49.6 ±3.64), Asempenaye (44.7 ±3.19) and Goaso (43.0 ±3.55 cm) were the locations with large-stemmed shade trees, while Akontombra (31.2 ±4.71) and Sefwi Wiawso (33.1 ±3.72 cm) had shade trees with significantly smaller (F=4.89; P=0.0000) stem diameters.

The Cocoa Research Institute of Ghana (CRIG) recommends farmers maintain 16-18 well-spaced mature forest trees per hectare (≥ 12m height), roughly at 24 m x 24 m spacing, providing permanent shade cover corresponding to approximately 30-40% crown cover. Cocoa agroforests have consequently been classified as falling into one or more shade regimes depending on the number of upper canopy trees present. Based on these criteria, existing cocoa agroforests are the high shade cocoa farms with about 22–30 forest trees ha-1, the medium shade cocoa farms with 15–18 forest trees ha-1 (Anim-Kwapong 2006, Manu and Tetteh 1987, STCP 2002, Ofori-Frimpong et al. 2007, CRIG 2011) and the low shade cocoa farms with 5-6 trees ha-1 (Ruf 2011). Going by this classification, 60% of cocoa farms in the study districts can be classified as having medium or high shade (15-23 stems/ha) as number of stems per hectare ranged from 9.33 at Akontombra to 22.3 at Offinso. However, an empirical assessment taking actual measurements of crown/canopy cover indicated that none of the farms approached the 30-40% crown cover associated with plots having the CRIG-recommended 15-18 forest trees per hectare. Using the number of trees per hectare as they exist on cocoa farms as a proxy to make generalisations to define or quantify crown cover therefore clearly presents difficulties.

Depending on the tree species present, age of the tree and the intensity of light, there could be significant variations in the level of shade provided and this may vary from place to place (Duguma et al. 2011). The nature and quality of shade present on any particular farm or prevalent in a particular area or system will depend on the type and number of tree species as well as the crown diameter of the species. Using an approach that quantifies the amount of shade cast by upper canopy trees or the extent of crown cover on the cocoa canopy as opposed to the number of trees present on the farm is more realistic. This brings to the fore the need to adopt a more pragmatic way of describing or quantifying shade in cocoa agroforestry systems. Crown cover has been defined by IPCC (2003) as the percentage of ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage plants. Defining shade cover based on this definition clearly is the better option.

Measured crown cover in this study ranged from 5.8 ±1.22 % to 16.3 ±1.74 % in the Asumura and Asempanaye cocoa districts respectively. These are nowhere near the 30-40% prescribed and described by CRIG as high shade using stem numbers (15-18 trees ha^{-1}).

The use of stem numbers would classify cocoa farms in two of the study districts, New Edubiase and Offinso, as having high shade with the rest falling into the medium shade class. From the point of view of existing crown cover on the farms, this could be deceptive. It is perhaps time to shift shade definition on farms from number of trees to crown cover.

Table 4.5 Shade tree characteristics on cocoa farms in study districts in the Western, Ashanti and Brong Ahafo Regions

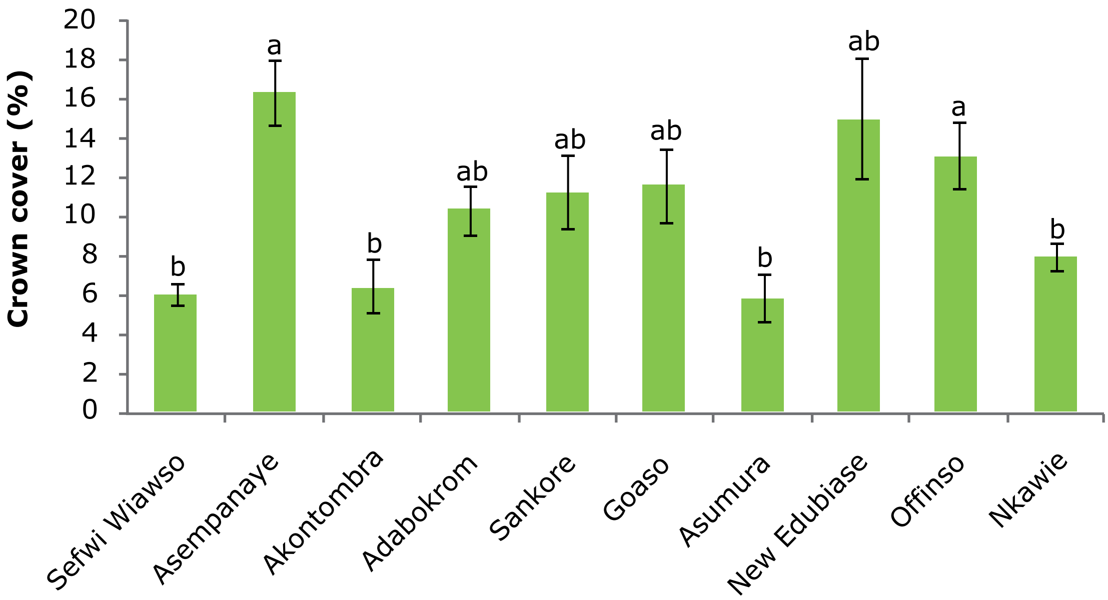
Cocoa District	Mean Crown cover (%)	Mean number of stems (ha-1)	Mean shade tree height (m)	Mean shade tree stem diameter (cm)	Classification of Shade based on stem number
Sefwi Wiawso	5.95b (0.57)	18.3ab (3.57)	13.7abc (1.42)	33.1 bc (3.72)	Medium
Asempanaye	16.3a (1.74)	14.2ab (1.11)	19.1a (1.41)	47.7abc (3.91)	Moderate*
Akontombra	6.31b (1.44)	9.33b (1.22)	11.9c (1.05)	31.2c (4.71)	Moderate*
Adabokrom	10.3ab (1.26)	10.8b (1.27)	15.1abc (0.74)	51.6a (3.67)	Moderate*
Sankore	11.2ab (1.92)	12.0b (2.71)	18.2abc (1.58)	49.6 ab (3.64)	Moderate*
Goaso	11.6ab (1.94)	16.2ab (3.00)	15.3abc (1.24)	43.0abc (3.55)	Medium
Asumura	5.80b (1.22)	16.3ab (2.58)	13.8abc (1.19)	35.0abc (3.97)	Medium
New Edubiase	15.0ab (3.12)	20.6ab (3.25)	18.2ab (0.99)	44.9abc (2.85)	High
Offinso	13.1ab (1.74)	22.8a (1.71)	13.5abc (0.82)	40.2abc (3.68)	High
Nkawie	7.97ab (0.66)	15.1ab (2.47)	12.8bc (0.64)	36.6 abc (3.31)	Medium

Figures in the same column followed by similar alphabets do not differ significantly ($P \leq 0.05$) based on the Kruskal-Wallis parametric ANOVA applied to mean ranks.
*Stem numbers between 7 and 14 trees per hectare were not captured in the original classification of high shade (22 – 30 trees/ha), medium shade (15-18 trees/ha) (STCP 2002, Ofori-Frimpong et al. 2007, Manu and Tetteh 1987, Anim-Kwapong 2006) and low shade (5-6 trees/ha) (Ruf, 2011). This study classifies 7-14 trees ha-1 as moderate shade.

4.6 Assessing crown cover in relation to the national definition of forest

Crown cover provided by shade trees on sampled farms ranged from 5.8 ±1.22 % for Asumura to 16.3 ±1.74 % in the Asempanaye cocoa districts (Figure 4.1). Differences were significant (F=5.34; P=0.000). The highest percentages of crown cover were recorded in the Asempanaye (16.3±1.74%), New Edubiase (15.0±3.12%) and Offinso (13.1 ± 1.74%) cocoa districts with values at Adabokrom, Sankore and Goaso being intermediate (range 7.7-9.17%). The lowest values were recorded at Sefwi Wiawso (5.95±0.57 %), Akontombra (6.3 ±1.44 %) and Asumura (5.8 ±1.22%) cocoa districts.

Figure 4.1 Crown cover (%) on cocoa farms in different cocoa growing districts. (Bars correspond to the standard errors of means. Bars with the same letters are not significantly different).



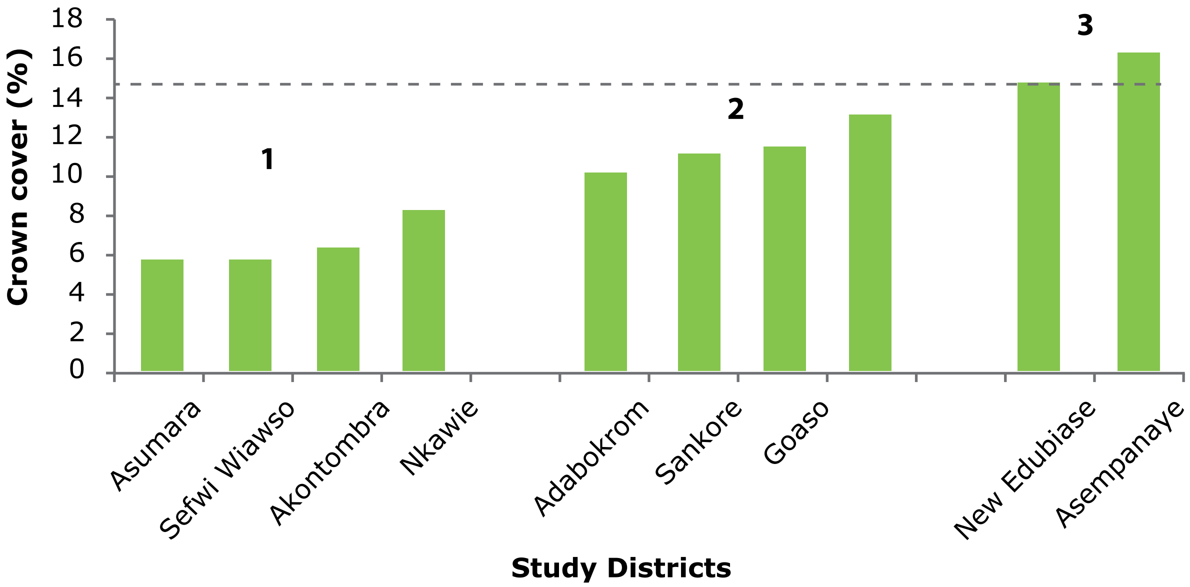
A close look at the measured percentage crown cover in the different cocoa districts reveals that they can broadly be grouped into three classes, namely crown cover ≤ 8.0% (for Asumura, Sefwi Wiaso, Akontombra and Nkawie districts); crown cover 8.1-14.9% (Adabokrom, Sankore, Goaso and Offinso districts); and crown cover ≥15.0% (New Edubiase and Asempanaye districts).

Juxtaposed against the national definition of forest (15% crown cover), crown cover in 8 (80%) of the 10 study districts does not qualify to be described as forests as it falls below the 15% minimum threshold (Figure 4.2). Assuming this picture is representative for cocoa landscapes nationwide, what are the implications for Ghana in the light of the country's REDD+ readiness efforts? Since Ghana has opted for REDD+, these findings are a pointer to steps that need to be taken and issues that need to be addressed (ecological and governance) as attempts are made to shift cocoa farming onto a more sustainable pathway through the implementation of potential REDD+ activities. With reported increases in the number of farmers removing shade trees from their farms in anticipation of short-term yield increase, it is crucial that cocoa farmers are encouraged to adopt practices that minimise forest degradation by preventing encroachment into forested areas to establish new farms. There is also the need to encourage them not to cut down mature forest trees on cocoa farms, but instead focus on carbon stock enhancement through the planting of shade trees and enabled natural regeneration in new or young farms.

4.7 Carbon stocks in cocoa and shade trees

Carbon stocks in shade trees ranged from 2.91 ± 0.95 Mg C ha^{-1} at Akontombra to 15.6 ±2.89 Mg C ha^{-1} at New Edubiase and differed significantly (F=4.51; p = 0.0001) between districts (Table 4.6). Carbon in cocoa trees on the other hand was similar across the 10 sites (F=1.73; p = 0.095) and averaged 7.45±0.41 Mg C ha^{-1} (range 5.84 -10.2 Mg C ha^{-1}). This distribution

Figure 4.2 Study districts grouped into districts with similar crown cover.



Group 1: ≤ 8.0 %; Group 2: 8.1 -14.9 % and Group 3: ≥ 15.0 %. Broken lines represent the 15% crown cover threshold as defined for forests in Ghana. Cocoa farms in 90% of study districts fall below broken lines i.e. do not qualify as forests.

between cocoa and shade trees resulted in significantly different ($F=3.82$; $p = 0.0005$) total aboveground C stocks with New Edubiase having the highest 23.4 ±3.23 Mg C ha^{-1} and Sefwi Wiawso the lowest 10.9±1.56 Mg C ha^{-1}. Across the study district, carbon distribution between cocoa and shade trees averaged 48% and 52% respectively. Mean stocks across all study districts stood at 15.5 ±1.19 Mg C ha^{-1}. Agroforestry ecosystems are known to store higher carbon than other cropping systems thereby contributing to climate change mitigation (Paustian et al. 2000, Albrecht and Kandji 2003, Montagnini and Nair 2004). Thus, the conversion of agricultural lands to cocoa agroforests could be a management strategy for storing large quantities of carbon to maximise benefits from the lands.

Our results for total tree carbon stocks are similar to, and fall within, the range reported by Isaac et al. (2005) in the high forest cocoa zone in the Western region in Ghana. They recorded aboveground carbon stocks of 16.8 and 15.9 Mg C ha-1 respectively in 15 and 25 year old shaded cocoa stands. Our values are also similar to Leuschner et al. (2013) who calculated total aboveground carbon in a cocoa-Gliricidia system to be 12.1 Mg C ha-1 in Indonesia. Results of this study, however, fall in the lower range compared to studies by Jacobi et al. (2013) in Bolivia; Saj et al. (2013), Norgrove and Hauser (2013), Gowkwowski and Sonwa (2010) and Kotto-Same et al. (1997) in Cameroon; Dawoe et al. (2009) in Ghana; and Smiley and Kroschel (2008) in Sulawesi, in which stocks of tree carbon ranged from 34.4-135.5 Mg C ha^{-1} in cocoa agroforestry systems.

Explanations for the lower carbon stocks found in this study include the relatively young age of most of the plots (40.7% of all farms were 10 years' old or less) as well as the non-planting and removal of shade trees due to the perception that shade trees are a major cause of pests, diseases and low yields. It also needs to be pointed out that aboveground carbon depends on a number of factors including the canopy species, tree density, environment and the approach used in estimating total carbon. Norgrove and Hauser (2013) have pointed out that using equations like Brown et al. (1989), which do not incorporate wood density, would overestimate the biomass and thus carbon stocks of a low wood density species such as cocoa. Using allometric equations that integrate wood densities of separate species, as done in the current study, or developing location and species-specific allometric equations is likely to lead to a more accurate assessment of biomass and thus carbon stocks. This study used the equation developed by Chave et al. (2005). Hence, comparison of the carbon stocks figures generated in this study should also be placed in the context of the allometric equations used in the estimation of biomass.

Table 4.6 Mean values ±SEM for % crown cover, shade tree carbon, cocoa tree carbon, total carbon and their carbon dioxide equivalents in ten cocoa growing districts in the Ashanti, Brong-Ahafo and Western regions of Ghana (Numbers in parenthesis are standard errors of the means).

District	Crown cover (%)	Shade tree carbon (Mg C ha-1)	Cocoa tree carbon (Mg C ha-1)	Total Carbon (Mg C ha-1)	CO2 equivalent of total carbon (Mg CO2-eq. ha-1)
Sefwi Wiawso	5.95b (0.57)	5.05ab (1.40)	5.84a (0.91)	10.9b (1.56)	40.0
Asempanaye	16.3a (1.74)	11.8a (1.99)	6.77a (0.68)	18.5ab (2.12)	67.9
Akontombra	6.31b (1.44)	2.91b (0.95)	10.2a (1.31)	13.2ab (2.07)	48.4
Adabokrom	10.3ab (1.26)	7.70ab (1.29)	8.02a (0.87)	15.7ab (0.87)	57.6
Sankore	11.2ab (1.92)	8.60ab (1.92)	7.00a (0.87)	15.6ab (2.40)	57.2
Goaso	11.6ab (1.94)	9.17ab (2.33)	7.79a (0.74)	15.4ab (2.58)	56.5
Asumura	5.80b (1.22)	5.04ab (1.35)	7.58a (0.47)	12.6ab (1.68)	46.2
New Edubiase	15.0ab (3.12)	15.6a (2.89)	6.28a (0.82)	23.4a (3.23)	85.9
Offinso	13.1ab (1.74)	9.29a (1.41)	8.65a (0.70)	17.9ab (1.45)	65.7
Nkawie	7.97ab (0.66)	8.02ab (0.65)	6.40a (0.61)	11.5b (1.19)	42.2

Figures in the same column followed by similar alphabets do not differ significantly ($P \leq 0.05$) based on the Kruskal-Wallis parametric ANOVA applied to mean ranks. Total carbon stock was converted to tons of CO_2 equivalent by multiplying by 44/12 or 3.67 (Pearson et al. 2007).

Several authors have emphasised that the main drivers of C storage in cocoa systems are shade trees, which usually have the highest amount of carbon. The near-even distribution of carbon between cocoa (48%) and shade trees (52%) in this study is possibly a reflection of the extent to which shade trees have been progressively removed from farms. This could be the result of the widely held perception by farmers in some districts that presence of shade trees on farms is a major cause of disease incidence and low yields.

4.8 Relationships between crown cover, stem diameter and carbon stocks

Significant linear relationships (R^2=0.8014; p=0.0005) were found to exist between crown cover and shade tree carbon stocks (Table 4.7 and Figure 4.3). The predictive ability of the equation is moderately high and demonstrates the association between the two parameters. Similarly, the relationship between shade tree stem diameter and shade tree carbon was significant (R^2 = 0.4016; P=0.0491) but with relatively low predictive ability (Table 4.7 and

Figure 4.4), just as that between shade tree diameter and total aboveground carbon stocks (R2 = 0.0351; p=0.6042) (Table 4.7 and Figure 4.5). Although the predictive abilities of the two equations relating stem diameter and total and shade tree carbon are low, they (the equations) nevertheless demonstrate the relationship between the size of the shade tree and the amount of carbon stored. The bigger the stem diameter, the more the amount of carbon stored. It has been widely recognised that shade trees in cocoa systems are the driving force behind carbon storage in cocoa systems and most of the carbon is in the shade trees though they are often assumed to negatively affect growth and yield of cocoa plants through competitive water use (Tscharnkte et al. 2013). Besides playing a significant role in C sequestration, empirical studies have also shown the positive effects of plant species-specific, complementary resource use in agroforestry systems (Ong et al. 2004).

Table 4.7 Linear regressions (y = ax2 + c) showing the relationship between (i) crown cover and shade tree carbon, (ii) shade tree stem diameter and shade tree carbon, and (iii) shade tree stem diameter and total carbon stocks in ten cocoa districts in Ghana

	Total tree C-stock ($Mg\ ha^{-1}$)	a	c	P	R^2
(i)	Shade tree C	0.8566	0.5507	0.0005	0.8014
(ii)	Shade tree C	0.3196	4.8802	0.0491	0.4016
(iii)	Shade tree C	0.3141	2.5012	0.0491	0.3574

Figure 4.3 Relationship between shade tree crown cover and carbon stocks in shade trees

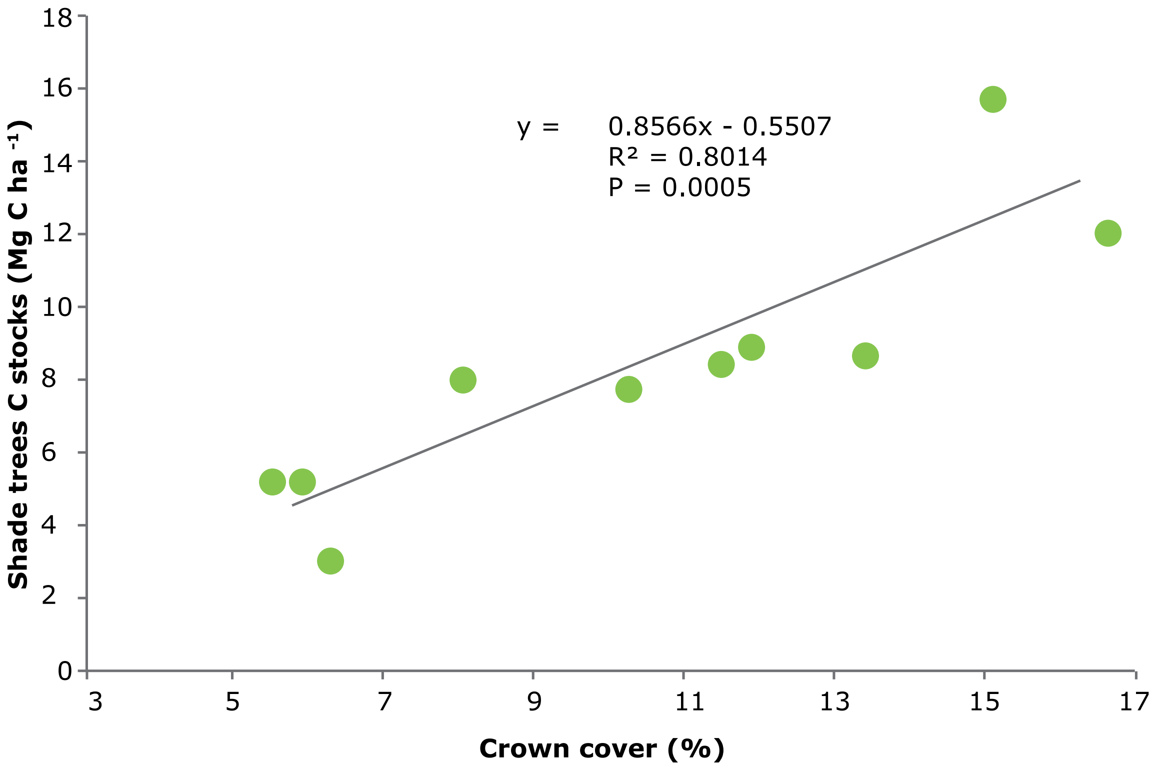


Figure 4.4 Relationship between shade tree diameter and shade tree carbon stocks

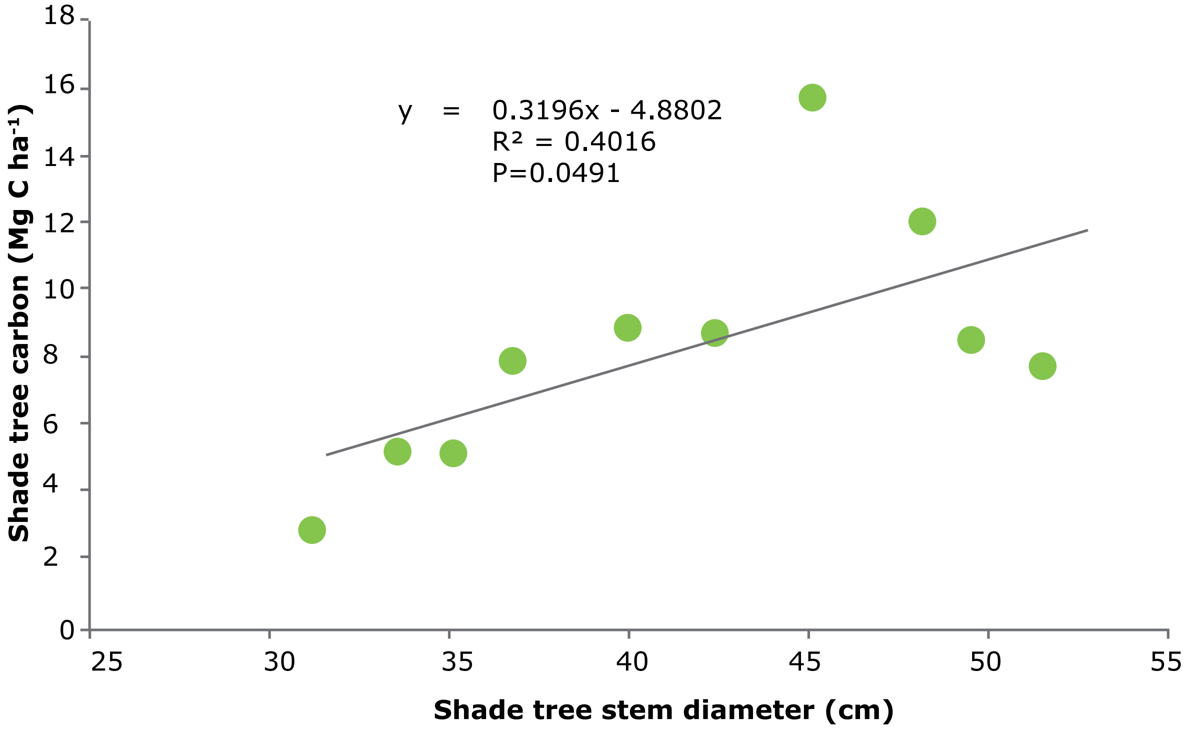
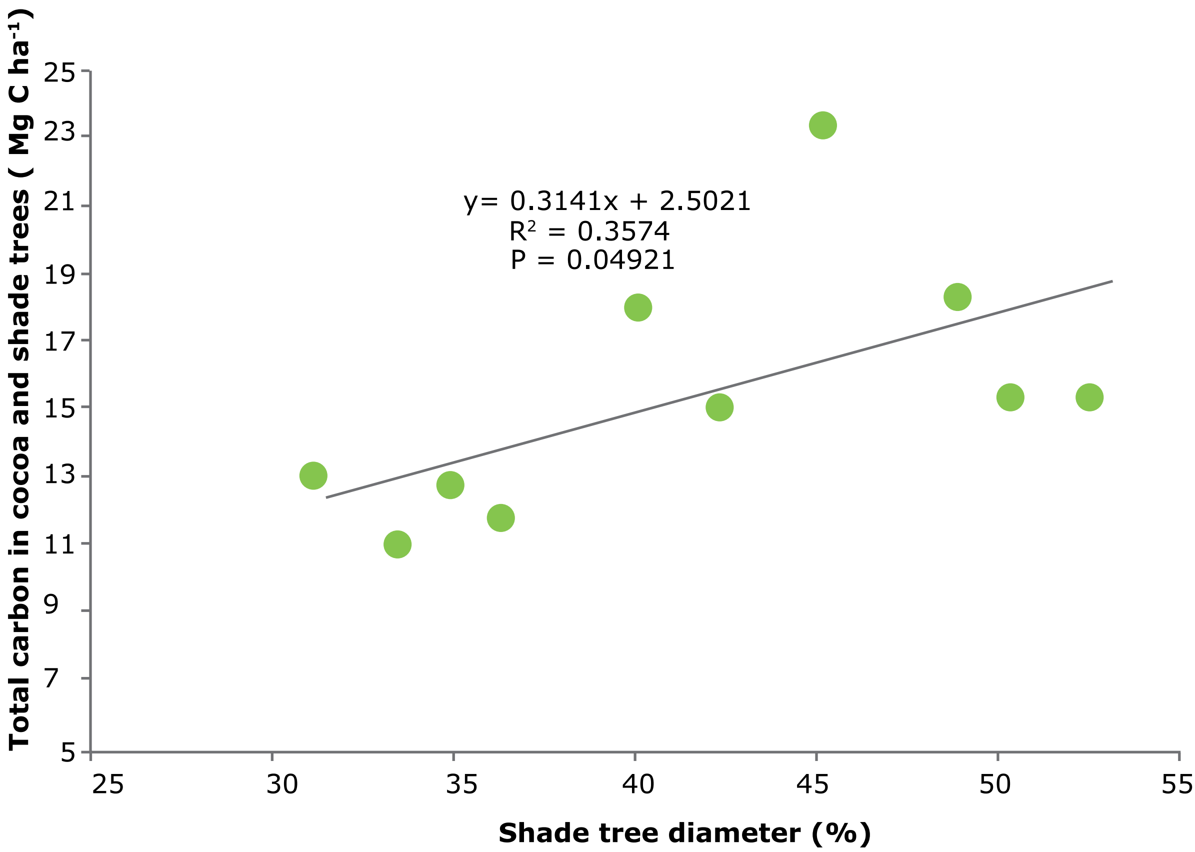


Figure 4.5 Relationship between shade tree diameter and total carbon stocks



4.9 Carbon stocks and associated shade tree parameters in the cocoa agroforestry system in ten cocoa districts in Ghana

Shade tree characteristics (mean number of stems ha^{-1}, average height (m), average stem diameter (cm) and associated total carbon stocks (Mg C ha^{-1})) grouped according to districts with similar crown cover are given in Table 4.8. As would be expected, there was a progressive increase in total tree carbon stocks with increasing mean stem numbers per hectare and stem diameter. Group 3 districts (New Edubiase and Asempanaye), with the highest number of stems ha^{-1} and stem diameter, recorded the highest mean carbon stocks of 21.0 ± 2.45 Mg C ha^{-1} by virtue of the fact that the tallest and biggest trees were found on these landscapes. Group 1 districts, that had fewer and smaller trees, consequently had the lowest total carbon storage. Progressively also, total tree carbon increased with increasing crown cover. This is to be expected as increasing tree size (tree height and diameter) is generally associated with increasing crown cover. Group 3 districts with crown cover equal to or more than the 15% (the national threshold for forests) compared to the other sites translated to high total tree carbon stocks.

Table 4.8 Shade tree dendrometric parameters and associated carbon stocks in the study districts

Group	District	Crown cover %	Mean shade trees stem number (ha-1)	Mean shade tree height (m)	Mean stem diameter (cm)	Total shade and cocoa tree-sC-Stocks (Mg C ha-1)
1	Asumura	5.80	16.3	13.9	35.0	12.6
	Sefwi Wiawso	5.95	18.3	13.7	33.1	10.9
	Akontombra	6.31	9.3	11.9	31.2	13.2
	Nkawie	7.97	15.1	12.8	36.6	11.5
	Group mean ± SE Range	6.51±0.49 ≤ 8.0	14.7±1.93 9.3-18.3	13.1 ±0.46 11.9-13.9	34.0 ±1.17 31.2-36.6	12.1 ± 0.52 10.9 -13.2
2	Adabokrom	10.3	10.8	15.1	51.6	15.7
	Sankore	11.2	12.0	18.2	49.6	15.6
	Goaso	11.6	16.2	15.3	43.0	15.4
	Offinso	13.1	22.8	13.5	40.2	17.9
	Group mean ± SE Range	11.6 ±0.58 8.1 -14.9	15.4 ±2.7 10.8-22.8	15.5 ±0.98 13.5 -18.2	46.1 ±2.69 40.2-51.6	16.2 ±0.587 15.4-17.9
3	New Edubiase	15.0	20.6	18.2	44.9	18.5
	Asempanaye	16.3	14.2	19.1	47.7	23.4
	Group mean ± SE Range	15.5 ≥ 15.0	17.4 ±3.20 14.2 – 20.6	18.7 ±0.45 18.2 –19.1	46.3 ±1.40 44.9-47.7	21.0 ±2.45 18.5-23.5

4.10 Characteristics of respondents to the tenure study

Seventy-two per cent of the 200 respondents to the questionnaire survey were males and 28% were females. Getting women to respond to the questionnaire was particularly difficult, as cocoa farming is a male-dominated activity. Eighty-one per cent of the respondents were married with 9% being single, 2% divorced and 8% widowed.

The ages of the respondents ranged between 22 and 82 years with a mean of 48 years. The age with the highest frequency was 70 years (5.5% of the respondents) (Table 4.9). However, the majority (24%) of the respondents were between 40 and 49 years while 71% were above 40 years of age. Thus, the respondents were relatively mature (Table 4.10).

The majority (64%) of the respondents were migrant cocoa farmers while 36% were indigenes. Twenty eight per cent (28%) of the respondents had no formal education at all, 62% had basic education (primary, JHS, middle school)[6] and 5.5% were educated to secondary level. Only 4% of the respondents had tertiary education (teacher training college, polytechnic or university) (Figure 4.6).

Table 4.9 Descriptive statistics of age of respondents

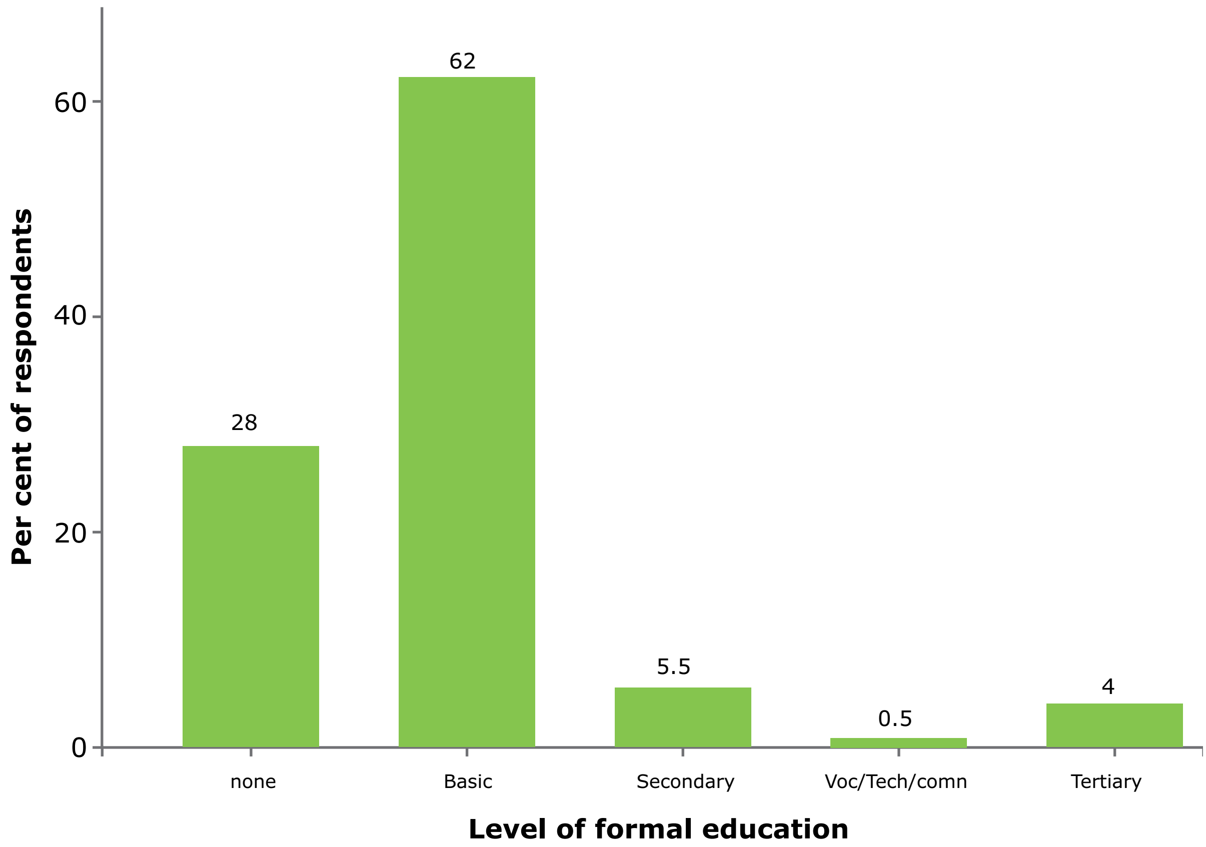
Parameter	Value
Number of respondents (N)	200
Mean age (years)	48.4
Mode (age with the highest frequency - 5.5% of the respondents) (years)	70
Std. deviation	14.4
Minimum age (years)	22
Maximum age (years)	82

Table 4.10 Age distribution of respondents

Age (years)	Number of respondents	Per cent of respondents
20 – 29	22	11.0
30 – 39	36	18.0
40 – 49	48	24.0
50 – 59	45	22.5
60 – 69	27	13.5
70 – 79	20	10.0
80 – 89	2	1.0
Total	200	100

6. Middle School was the level of education between Primary School and Secondary School that existed in Ghana until the 1980s when it was replaced by the Junior Secondary School and Senior Secondary School scheme.

Figure 4.6 Educational attainment of respondents (N=200)



4.11 Characteristics of farms

4.11.1 Size and age of cocoa farms

In order to have an idea of cocoa farm sizes and ages in the study districts, the respondents were asked for the number of cocoa farms they owned and to indicate the sizes and ages of their first three farms. A total of 449 cocoa farm plots were reported by the 200 cocoa farmers interviewed. The majority (34%) reported that they owned only one cocoa farm, 30.5% said that they owned two, while 24.5% claimed that they owned three farms. One person each reported that they owned 8 and 10 different cocoa farms (Table 4.11). Cocoa farmers in the study communities that own land often have different cocoa farms through *abunu* sharecropping arrangements with tenant farmers.

Table 4.11 Number of cocoa farms owned by farmers

Number of cocoa farms	Number of respondents	Per cent of respondents
1	68	34.0
2	61	30.5
3	49	24.5
4	11	5.5
5	6	3.0
6	1	0.5
7	2	1.0
8	1	0.5
10	1	0.5
Total	**200**	**100**

It is always difficult to obtain reliable information on land holdings through interviews. Respondents are often uncertain about the actual acreage or how to measure or estimate it, or they may withhold the correct information. The data presented on farm sizes should therefore be regarded as indicative rather than definitive or conclusive. The respondents provided the sizes of 397 farms out of the total 449 farms reported to be owned by the 200 farmers. Cocoa farm sizes in the study area ranged from 1 to 60 acres (0.4 to 24.3 ha)[7] with an average farm size of 6.3 acres (2.5 ha). However, the majority (14.9%) of the 397 farms were 4 acres (1.6 ha) (Table 4.12). As indicated by the difference between the minimum and maximum values, there is a large variation in farm sizes in the study area. As much as 88.2% of the farms were between 1 and 10 acres, 7.8% were between 11 and 20 acres and only 0.6 % (two farms) were more than 40 acres (Table 4.13 and Figure 4.7). These results compare positively with Ghana COCOBOD's figures. According to COCOBOD, cocoa farm sizes in Ghana are relatively small ranging from 0.4 to 4.0 ha with an estimated total cultivation area of about 1.45 million hectares (COCOBOD, in Anim-Kwapong and Frimpong 2005). This observation clearly indicates that the cocoa landscape in Ghana is dominated by smallholders which has implications for adoption of cocoa agroforestry and, ultimately, for REDD+ intervention.

Table 4.12 Descriptive statistics of farm sizes in the study area

Parameter	Value
Number of farms (N)	397
Mean farm size (acres)	6.3
Mode (farm size with the highest frequency – 14.9% of the farms) (acres)	4.0
Std. Deviation (acres)	7.0
Minimum farm size (acres)	1.0
Maximum farm size (acres)	60.0
Sum (Total area of cocoa farms studied) (acres)	2,490.5

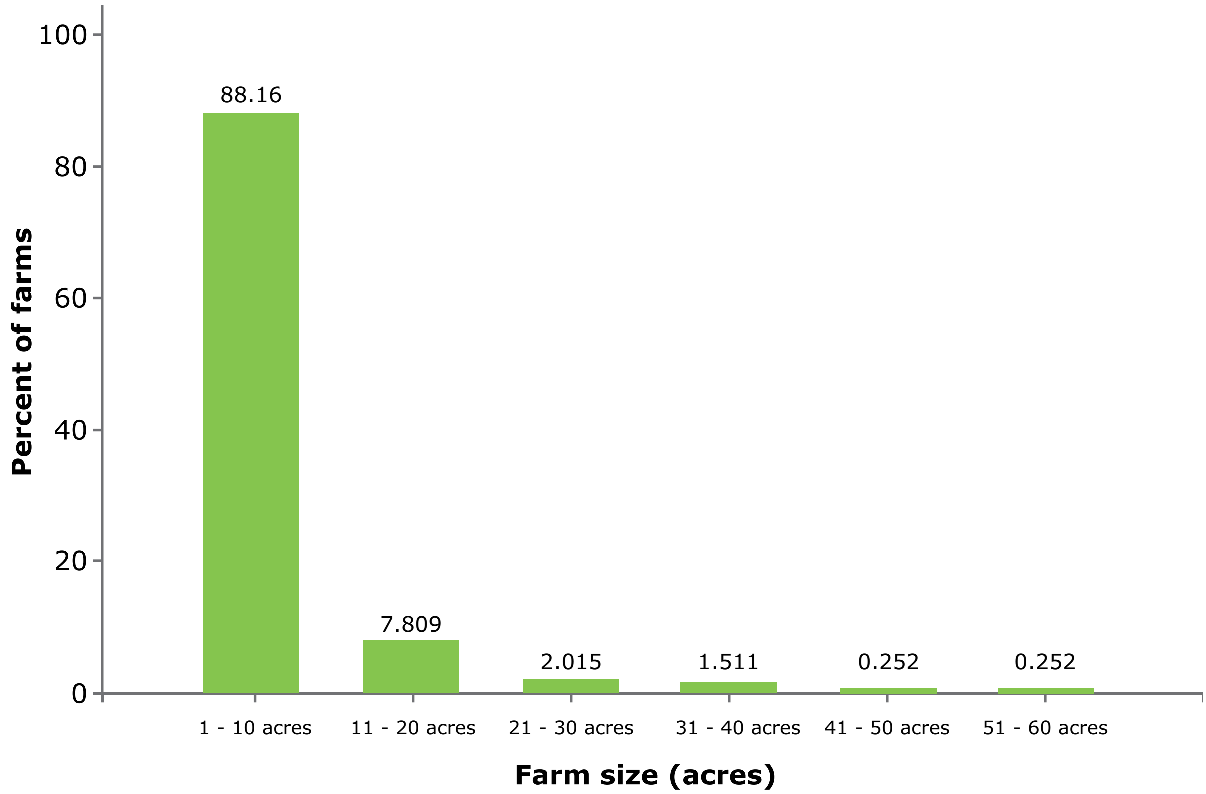
Note: 1 hectare is equivalent to 2.47 acres

Table 4.13 Farm sizes in the study area

Farm size	Number of farms	Percent of farms
1 - 10 acres	350	88.2
11 - 20 acres	31	7.8
21 - 30 acres	8	2.0
31 - 40 acres	6	1.5
41 - 50 acres	1	0.3
51 - 60 acres	1	0.3
Total	397	100.0

7. 1 hectare is equivalent to 2.47 acres

Figure 4.7 Farms sizes in the study area and their proportions (N = 397)



The majority (12.6%) of the 350 farms of 1 to 10 acres were in the New Edubiase cocoa district, 12% were in the Sefwi Wiawso cocoa district and 11.7% were in the Nkawie cocoa district. As much as 29% of the 31 farms that ranged in size from 11 to 20 acres were in the Sefwi Akontombra cocoa district while 12.9% each were found in the Sefwi Wiawso, Sefwi Adabokrom and Goaso cocoa districts. The majority (37.5%) of the eight farms from 21 to 30 acres were in the Sankore cocoa districts. Similarly, the majority (50%) of the six farms of 31 to 40 acres were also in the Sankore district. The only 50-acre farm was in the Goaso district while the only 60-acre farm was in the Sefwi Akontombra district (Table 4.14).

Table 4.14 The study cocoa districts and cocoa farm sizes

Farm size (acres)	Cocoa districts (% of farms)										Total no. of farms
	Sefwi Wiawso	Sefwi Akonom-bra	Sefwi Asepan-eye	Sankore	New Edubi-ase	Offinso	Nkawie	Goaso	Asu-mura	Sefwi Ada-bokrom	
1 – 10	12.0	10.9	11.4	9.1	12.6	7.4	11.7	7.7	10.0	7.1	**350**
11 - 20	12.9	29.0	0	9.7	0.0	6.5	6.5	2.9	9.7	12.9	**31**
21 - 30	0	12.5	0	37.5	0	0	12.5	0	12.5	25.0	**8**
31 - 40	0	0	0	50.0	0	0	0	16.7	16.7	16.7	**6**
41 - 50	0	0	0	0	0	0	0	100.0	0	0	**1**
51 - 60	0	100.0	0	0	0	0	0	0	0	0	**1**
Total no. of farms	**46**	**49**	**40**	**41**	**44**	**28**	**44**	**33**	**40**	**32**	**397**

The farmers provided the ages of 396 out of the total 449 farm plots reported. The ages of cocoa farms in the study area ranged from 1 to 70 years with an average age of 17.69 years. The modal age (the age with the highest frequency) was 10 years: the majority (11.1%) of the 396 farms were 10 years old (Table 4.15).

The majority (40.7%) of the cocoa farms were between 1 and 10 years of age, 29.3% were between 11 and 20 years and 16.7% were between 21 and 30 years. Only one cocoa farm was reported to be 70 years of age (Table 4.16 and Figure 4.8). These observations show that farmers may be taking steps to rehabilitate their cocoa farms or establish new farms.

Table 4.15 Descriptive statistics of ages of cocoa farms in the study area

Parameter	Value
Number of cocoa farms (N)	396
Mean age (years)	17.7
Mode (age with the highest frequency – 11.1% of the farms) (years)	10
Std. Deviation (acres)	12.2
Minimum age (years)	1
Maximum age (years)	70

Table 4.16 Ages of cocoa farms in the study area

Age of farms (years)	Number of farms	Per cent of farms
1 - 10	161	40.7
11 - 20	116	29.3
21 - 30	66	16.7
31 - 40	35	8.8
41 - 50	13	3.3
51 - 60	4	1.0
61 - 70	1	0.3
Total	396	100.0

Table 4.17 provides further details of the ages of cocoa farms in the study area. The majority (18%) of the farms with ages ranging from 1 to 10 years were in the Nkawie cocoa district, 16.1% were in Sefwi Aknotombra cocoa district and 14.9% were in Sefwi Asempaneye cocoa district. Similarly, 16.4% of the farms aged between 11 and 20 years were in the Sefwi Akontombra district, while 12.9% each were in the New Edubiase and Asumura districts. Farms of 51 to 60 years old were in the Sankore district (50%), Offinso district (25%) and Goaso district (25%). The only farm that was reported to be 70 years old was in the Nkawie district (Table 4.17). Even though the Nkawie cocoa district is an old cocoa frontier, it is possible that farmers are rehabilitating their farms or planting new farms. This may explain why the majority of the farms aged between 1 and 10 years are found in this district.

Figure 4.8 Ages of cocoa farms in the study area (N = 396)

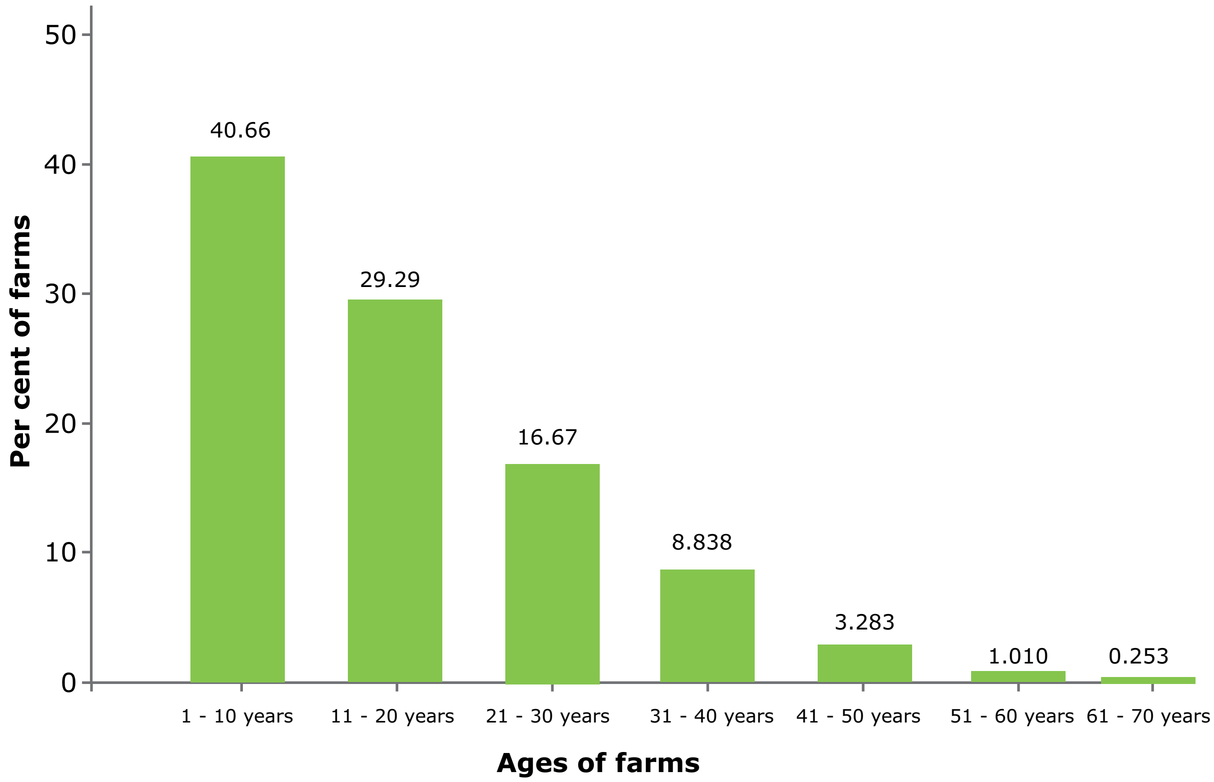


Table 4.17 The study cocoa districts and ages of cocoa farms

Age of farms (years)	Cocoa districts (% of farms)										Total no. of farms
	Sefwi Wiaw-so	Sefwi Akon-tom-bra	Sefwi Asem-paneye	Sanko-re	New Edu-biase	Of-finso	Nka-wie	Goa-so	Asu-mura	Sefwi Ada-bokrom	
1 - 10	10.6	16.1	14.9	5.6	10.6	0.6	18.0	8.1	9.9	5.6	**161**
11 - 20	12.1	16.4	12.1	7.8	12.9	6.0	6.0	6.9	12.9	6.9	**116**
21 - 30	21.2	3.0	6.1	16.7	10.6	10.6	4.5	7.6	6.1	13.6	**66**
31 - 40	2.9	2.9	2.9	20.0	8.6	25.7	11.4	5.7	5.7	14.3	**35**
41 - 50	0	7.7	0	15.4	0	38.5	0	30.8	7.7	0	**13**
51 - 60	0	0	0	50.0	0	25.0	0	25.0	0.0	0.0	**4**
61 - 70	0	0	0	0	0	0	100.0	0	0	0	**1**
Total no. of farms	**46**	**49**	**43**	**40**	**42**	**30**	**44**	**33**	**38**	**31**	**396**

4.11.2 Cocoa varieties grown by farmers

The majority (75.3%) of the 198 farmers who were able to provide information on cocoa varieties indicated that they grow the hybrid cocoa (locally known as agric cocoa). Other than that, 5.6% reported that they grow the local cocoa (Tetteh Quashie cocoa) while 19.2% said that they grow both the local and hybrid cocoa (Figure 4.9).

4.11.3 Land tenure arrangements on cocoa farms

Four main land tenure arrangements existed in the study areas: own land, family land, rented land and sharecropping land. Out of the 401 cocoa farms whose tenure status was revealed, 44.1% were lands owned by the cocoa farmers themselves, 21.9% were family lands and 33.2% were lands under sharecropping arrangements (Figure 4.10).

Figure 4.9 Cocoa varieties grown by farmers (N = 198)

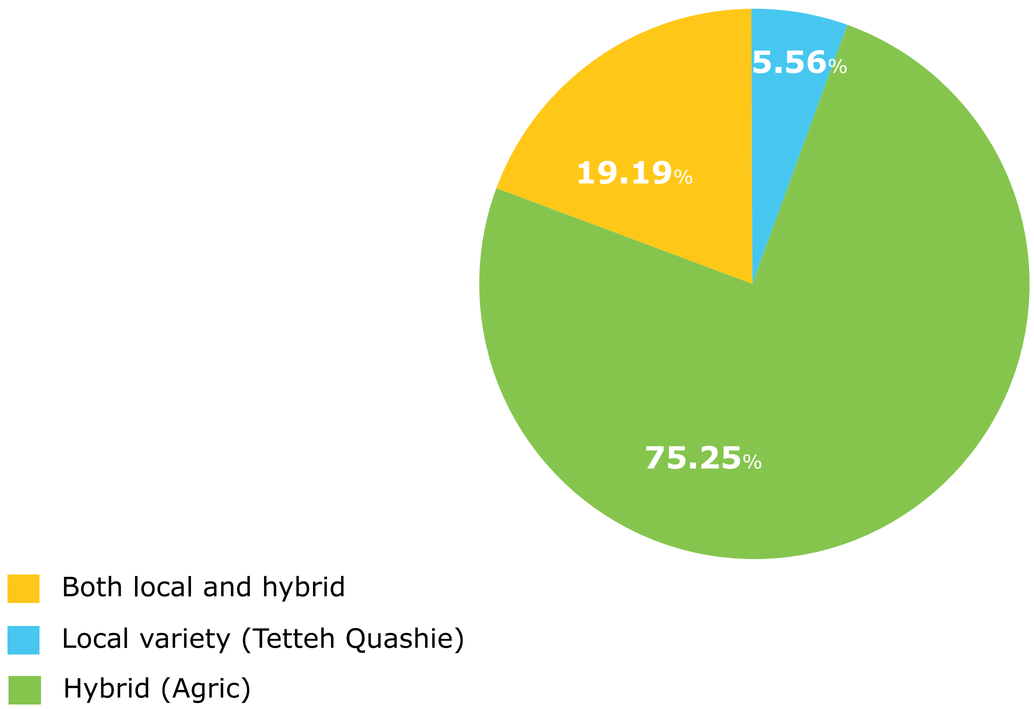
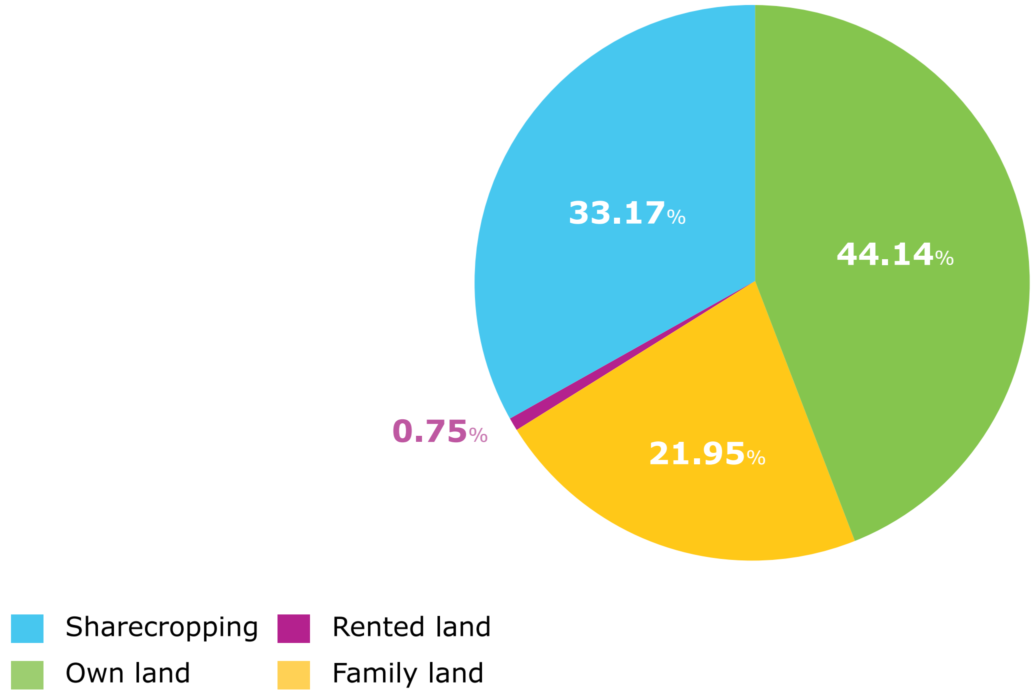


Figure 4.10 Land tenure arrangements on cocoa farms (N = 401)



4.12 Sharecropping arrangements

Two main sharecropping arrangements exist in the cocoa landscape where the study was undertaken: *abunu* and *abusa* systems. The *abusa* was, however, more prevalent than the *abunu*. The majority (53.4%) of the 133 farms identified to be under sharecropping arrangements were *abunu* farms while 46.6% were under the *abusa* system. At the farmer level, 86 of the 200 farmers were found to be engaged in sharecropping. Out of the 86 sharecroppers, 55.8% were *abunu* farmers, 41.9% were *abusa* tenants and 2.3% were engaged in both the *abunu* and *abusa* systems.

4.12.1 The abunu system

Key informant interviews and focus group discussions (FGDs) revealed that, in the *abunu* system, a migrant or tenant farmer approaches a landowner (usually an indigene) with the request for a piece of land for the cultivation of cocoa. When the request is granted, the tenant pays *drink money* to the landowner and commences work on the land. There is no prescribed or fixed amount for the drink money. The amount of drink money paid depends on the size of land requested and also on the landowner. For example, in Sayerano in the Asempaneye cocoa district, the drink money was reported to range between Gh¢ 500 and Gh¢ 1000 while in Fawokabra in the Sefwi Wiawso cocoa district, it ranged from Gh¢ 200 to Gh¢ 400. In Sayerano, farmers reported that the drink money could be paid after the farm is established and shared as an expression of gratitude to the landlord. The tenant bears all the cost of the establishment of the cocoa farm including cost of inputs till the cocoa starts fruiting. The farm land or plot is then divided into two: one-half to the landlord and the other half to the tenant. So long as the farm is not shared, any cocoa proceeds from the farm are divided into three parts: two-thirds to the tenant, since the tenant bears all input costs, and one-third to the landlord. Food crops on the land or farm, while still under preparation and before the farm is shared, belong to the tenant and he reserves the right to decide whether to give any to the landlord. The sharing of the cocoa farm is usually done by the tenant while the landlord is the first to select his portion. Once the farm is shared, the understanding is that the land that goes to the tenant now belongs to the tenant. The right to such plots can be transferred to his children or next of kin.

The tenancy agreement is documented just before or after the farm is shared. Usually, the landowner meets with the tenant in the presence of witnesses to discuss and agree all the arrangements and terms of the agreement before appending their thumbprints or signatures to the agreement. Documentation of lands acquired through *abunu* is now a prevalent practice in the study area mainly as a result of the lack of trust, especially from the side of the tenant. However, it must be stressed here that the tenancy agreements are not always put on paper — sometimes they are verbal agreements.

Abunu tenants are permitted to plant trees on their cocoa farms once the farm is shared. The main challenge militating against this is the perception or fear of farmers that timber concessionaires would in the future come to harvest trees and destroy their farms with little or no compensation. Tenants under *abunu* arrangements are permitted to replant the cocoa when the cocoa farm becomes too old and less productive. The tenant continues to own the land/farm so long as he continues to manage it. However, if the tenant is absent and leaves the land uncultivated for a long period without informing the landlord, the landlord has the right to take back or re-possess the land. In situations when a tenant would want to dispose of his farm, the first right of purchase is usually given to the original landlord. If the tenant gives out or sublets his farm to another person, actions of the new tenant are regulated by the original tenant and not the landlord.

Duration of tenancy of abunu sharecropping

An enquiry into the duration of the *abunu* tenancy sparked some controversy among the cocoa farmers. Most of the farmers claimed that the *abunu* system grants an indefinite ownership of land to tenants who can bequeath such lands to children or relatives. However, others had contrary views. Some landowners disagreed with the indefinite transfer of the *abunu* land to the tenant and asserted that this was so in the past but now the landowner has the right to reclaim the land if (1) the cocoa farm is no more or the cocoa trees overage and die out; (2) the land is used to grow any crop other than cocoa; (3) the land is left uncultivated for a long period; or (4) the tenant dies. Others reported categorically that the duration of the *abunu* tenancy is 50 years and gave examples of landowners who have applied this duration in their *abunu* agreements. They believed that landowners have the right to negotiate with tenants regarding the duration of *abunu* tenancy. They cited land scarcity as the cause of these changes. These developments have implications for farmer tree planting and therefore the adoption of cocoa agroforestry and ultimately for REDD+. This is because farmers who lack secure and long-term rights to land are unlikely to invest in tree planting.

Variants of the abunu system

Even though the classical meaning of the *abunu* tenancy in relation to cocoa is for tenant farmers to establish new cocoa farms on bushland in return for a 50% share of the farm, other variants of the system were reported in the various study sites. One variant reported at Nerebehi in the Nkawie cocoa district involves giving a neglected cocoa farm (farm left in the bush) or an old and unproductive farm to a caretaker or tenant who harvests the cocoa and uses the proceeds to rehabilitate the farm. When the farm is rehabilitated it is then divided between the tenant and the land/farm owner on a 50:50 basis. Once the farm is shared, the general understanding is that the portion given to the tenant now belongs to him. The farmers reported that the tenant usually pays a fee or drink money (ranging between Gh¢ 1,000 and 1,200 depending on the farm size) to the landowner when the farm is shared. They claimed that, for some landlords, the cocoa output rather than land is shared.

Another variant reported at Pomaakrom in the Asumura district and Akromaso in the New Edubiase district involves the tenant, as usual, acquiring land from the landlord and establishing the cocoa farm. After the farm is established, the cocoa output or proceeds rather than land are shared each year after harvesting the cocoa in a proportion of half to the tenant and the other half to the landlord. The tenant maintains the farm but the landlord contributes to the buying of fertiliser and chemicals. The farmers claimed that the arrangement could eventually metamorphose into *abusa*.

Conflicts in the abunu system

Both the landlords and tenant farmers agreed that conflicts do exist and occur between landlords and tenants. The following are the common causes of conflicts between landlords and tenants reported by the respondents:

- Dishonesty on the part of tenants, e.g. not declaring the correct cocoa yields and incomes
- *Abunu* landlords harvesting food from the yet to be shared *abunu* farm without permission from the tenant. Landowners may have access to food crops planted by the tenant but with permission from the tenant
- Poor management of farms by tenants when the farm is not shared. This is usually a problem when tenants have multiple farms to manage
- Landlords asking tenants to perform extra assignments not previously agreed upon
- Failure of tenants to complete the cultivation of land allocated to them by landlords within a specified period agreed upon by both tenants and landlords. Under such circumstances, the uncultivated land is taken away from the tenant and this usually brings dissatisfaction and therefore conflict
- Disagreements related to cost of maintenance, inputs and harvesting when the farm has not been shared
- Non-disclosure of conditions governing tenancy arrangements to tenants right from the beginning of the agreement. Upon realising the full implication of some agreements the sharecropper may decide to discontinue leading to conflicts
- Tenants asking landlords to bear the cost (surveyor’s cost) of dividing the farm
- Tenants selling cocoa and not giving landlords part of the proceeds when the farm has not yet been shared
- Tenants cultivating more food crops and not concentrating on the cocoa, which is the target or primary crop. In such cases, landlords see them as delaying in the planting of the cocoa
- Landlords reducing the initially agreed plot size and giving it to another tenant farmer after receiving payment of drink money from the first tenant. This amounts to selling or giving the same plot to two tenants
- Tenants taking care of multiple plots and devoting more time to one at the expense of others
- Tenants subletting farms to other tenants (i.e. tenant becoming a landlord).

A potential source of conflict acknowledged by both landlords and tenants is the disagreement or controversy surrounding the duration of the *abunu* tenancy and whether the *abunu* system grants permanent ownership of land to the tenant. Both the landlords and tenants see this as a potential source of conflict in the future as cocoa farmlands continue to get scarce. Furthermore, when the two parties in a tenancy agreement (landlord and tenant) pass on and children of the tenant want to lay claim on ownership of the land relatives of the landlord mostly challenge such claims. They indicated that a possible way to avoid such future conflicts is by documentation of the tenancy agreement and specifying the duration of the tenancy. They maintained that recent discussions point to a renegotiation of the *abunu* agreement after a 50-year period, however, this has not yet been operationalised.

4.12.2 The abusa system

Under the *abusa* system, a tenant, usually a migrant, is entrusted with the care of an already established cocoa farm. The tenant maintains and harvests the cocoa and the proceeds or cocoa output from the farm each year is shared in the ratio of 2:1 with the tenant taking one-third and the landlord or farm owner taking two-thirds. Input costs are similarly shared: the landowner bears two-thirds of the cost while the tenant bears one-third. The key informants revealed that purchase of chemicals depends on the landlord and that good or kind landlords usually bear all the costs of chemical inputs.

Variants of the abusa system

Other types of *abusa* system were reported in the study area. In Opponkrom in the Sankore district, farmers revealed a type of *abusa* in which the tenant acquires land from a landowner, establishes the cocoa farm and takes care of the farm until it begins to fruit, then continues to maintain the farm and harvest the cocoa every year. Proceeds from the sale of cocoa are shared in a ratio of 1:2 — the landlord takes one-third while the tenant gets two-thirds. This is a reverse of the usual *abusa* system in which the tenant takes one-third and landlord takes two-thirds. The farmers maintained that this arrangement is special and usually happens when a "good landlord" has a "good tenant". That is, when the tenant's behaviour and performance is pleasing and acceptable to the landowner. In this system, the tenant bears all input costs. The question remains as to whether the tenant ever gets to own a piece of the farm or land, as is the common practices in the *abunu* system in many places.

Another type of *abusa* mentioned by farmers as operated in the past involved a tenant establishing a cocoa farm in return for two-thirds of the cocoa farm land. Here, land, rather than cocoa proceeds, was shared. The cost of establishment of the farm and inputs were borne by the tenant. The farmers reported that in a situation where the landlord bore input costs, the landlord expropriated two-thirds of the farm while the tenant received one-third. These kinds of *abusa* systems were reported to have faded out and given way to the *abunu.*

Abusa conflicts

Just like the *abunu* system, the *abusa* system also has conflicts. Causes of conflicts between tenants or caretakers and landlords reported by key informants and focus group discussants included the following:

- Some *abusa* landlords make new rules or regulations not originally discussed with tenants, e.g. deducting incidental costs after the sale of cocoa. This usually leads to conflicts
- Poor management of farms by tenants. Such a situation may arise when the caretaker is taking care of farms belonging to other people and may not have the time to concentrate on a particular farm. Such tenants neglect the required routine maintenance practices and only come to harvest when the cocoa season is due
- Dishonesty on the part of tenants, e.g. cheating at crop harvest. Sometimes landlords find out that tenants harvested more than they declared. This is a major source of conflict
- Landlords trying to reduce the initial acreage of farm agreed upon with tenant
- Landlords giving tenant additional work outside the primary activity of taking care of the cocoa farm. Some landowners desire to use tenants as labourers at their homes and on other farms belonging to the landowner. This is popularly referred to as *nnahoo* (extra work) in the study communities and is a major source of conflict between landlords and *abusa* tenants
- Difficult to please landlords; some landlords complain about everything and are never satisfied with the tenant
- Tenants perceived by landlord to be stealing his cocoa.

4.12.3 Changes in sharecropping arrangements

Several changes were reported to have taken place in both the *abunu* and *abusa* share tenancy arrangements in the study area. These changes were attributed to reduced availability of suitable land for cocoa cultivation. Most respondents reported that the prevalence of the *abunu* tenancy is declining as land is getting scarcer. They revealed that land acquisition for *abunu* is now more difficult compared to the past. Most landowners now prefer to establish their own cocoa farms before entering into an *abusa* tenancy with a caretaker.

Another change reported in all the study communities is the payment of drink money by *abunu* tenants in order to get access to land. Farmers reported that, in the past, the drink money was minimal, usually involving the purchase of some drinks and a token sum. However, in recent times payment of the drink money has involved paying huge sums of money. Some said that some landlords did not even collect any money for lands given out in the past.

In Seyarano in the Asempaneye district farmers reported that, in the past, tenancy agreements were mostly verbal in the presence of witnesses. In recent times, however, more and more people are turning to written agreements where tenants and landowners append their thumbprints or signatures to agreements in the presence of witnesses. Such agreements are usually also countersigned by the chief.

In most of the study districts it was reported that, in the olden times when cocoa farms were established by clearing virgin or natural forests, a type of *abusa* system operated in which cocoa farms were divided into three and the tenant took two-thirds of the farm while the landlord took one-third. The understanding was that the tenant had to be assisted because of the amount of work and this came in the form of the extra one-third share. Some good landlords even bore part of the cost of land preparation, provided seedlings and even gave tenants food. The farmers claimed that this type of *abusa* tenancy has gradually changed to the *abunu* tenancy because of land scarcity.

In Opponkrom in the Sankore district and Bredi in the Sefwi Adabokrom district, farmers reported that input costs under the *abusa* tenancy arrangements were all borne in the past by the landlord. However, in recent times, because of rising cost of inputs the caretaker or tenant bears one-third of the input cost while the farm owner or landlord bears the remaining two-thirds. They explained that, depending on the landlord, this arrangement could be applied to all input costs, including labour, while in other cases it could be applied to only fertiliser costs.

A significant change that is taking place is in relation to the duration of the *abunu* tenancy and whether *abunu* grants tenants permanent ownership of land. Key informant interviews in Seyerano revealed that, in the past, the general understanding among parties in the *abunu* tenancy was that once the *abunu* farm is shared the portion given to the tenant becomes his property forever and he has the right to plant anything, including trees, and even bequeath the land to his next of kin. However, with decreasing land availability, landlords have started discussing and moving towards arrangements involving fixed duration of occupancy. The farmers said that most landlords are in favour of a 50-year agreement. Similarly, in Akromaso in the New Edubiase district farmers maintained that while in the past it was generally agreed that *abunu* tenants could farm the land indefinitely once it was shared, some landowners are now beginning to place a time limit on *abunu* land. They said there is the possibility that landlords would, in the near future, give farmers a specific period or duration (e.g. 50 years) after which land would revert to the landlord unless the terms are renegotiated. Also, in Nerebehi in the Nkawie district, farmers reported that, increasingly, tenants are now being given specific durations within which they can farm on the *abunu* lands. They claimed that this is a new development and has arisen because of land scarcity and land fragmentation. This observation has implications for the planting of trees on cocoa farms since farmers would not be willing to undertake long-term investments such as tree planting when there is lack of long-term security.

Another change observed in both the *abunu* and *abusa* systems which was absent in the past is the issue of *nnahoo*. This refers to additional work or responsibilities given to tenants by landlords outside the primary activity of taking care of the cocoa farm. Some landowners may decide to use tenants as labourers at their homes and on other farms belonging to the landowner. This is usually made very clear to the tenant right from the very beginning to avoid confusion and misunderstandings at a future date. However, in some cases, especially in the *abusa* system, tenants are not made fully aware of the extent of the *nnahoo* before the tenancy begins. As indicated already, the *nnahoo* is a major source of conflict between tenants and landlords.

A system of sharecropping discovered in Nerebehi in the Nkawie district is the system of *do fa wo aduane na dua me cocoa ma me* which literally means cultivate your food crops and plant my cocoa for me. Under this system, land is given to the tenant to clear and plant food crops. The landlord then brings his cocoa seedlings to be planted and cared for by the tenant on the food crop farm. The tenant remains on the land until the cocoa canopy closes. The tenant takes all the food crops

Table 4.18 Benefits of cocoa agroforestry that farmers are aware of (N = 200)

Benefits of cocoa agroforestry	Number of farmers	Per cent of farmers
Sustainable yield of cocoa	143	71.5
Multiple revenue	96	48.0
Soil fertility improvement	142	71.0
Erosion control	35	17.5
Weed suppression	86	43.0
Biodiversity enrichment	53	26.5

Note: Number of respondents will not add up to 200 due to multiple responses

but has no future share in the cocoa farm or cocoa harvest. This was reported to be a rather uncommon practice that may occur as a result of acute land scarcity and in situations when a tenant may be in desperate need of land. This system is just for the establishment of the cocoa farm. The maintenance of the cocoa could be through a separate arrangement which is unclear.

4.13 Cocoa agroforestry

4.13.1 Awareness of benefits from cocoa agroforestry

Ninety-five per cent of the 200 farmers maintained that they were aware of benefits to farmers from cocoa agroforestry. The farmers mentioned several benefits of cocoa agroforestry with most mentioning more than one benefit. The majority (71.5%) of the farmers reported that trees in cocoa farms or cocoa agroforestry offer sustainable cocoa yield, 71% said that cocoa agroforestry improves soil fertility, 48% claimed that cocoa agroforestry provides multiple revenue, while 43% maintained that cocoa agroforestry leads to weeds suppression (Table 4.18).

Other benefits from cocoa agroforestry mentioned by the farmers include provision of shade for cocoa, increase of soil moisture, provision of timber for future use, improvement in the yield of cocoa, reduction of the effect of the sun on the cocoa, enhancement of micro-climate and protection of cocoa against storms (trees serve as windbreaks).

4.13.2 Perceptions of farmers of cocoa agroforestry systems

To understand the perception of farmers of cocoa agroforestry systems, the respondents were asked to either agree or disagree with some perception statements. The majority (90.5%) agreed that shade trees on cocoa farms increase the moisture content of the soil, 7.5% disagreed and 2% were not sure and therefore neither agreed nor disagreed. Similarly, 89.5% agreed that soils under cocoa agroforests are more fertile than soils with no shade in cocoa farms, 7.5% disagreed and 3.5% neither agreed nor disagreed. The majority (74%) of the farmers disagreed with the statement that cocoa trees under agroforestry technology have lower incidence of pests (such as capsid or *akate* and mistletoe) than no shade cocoa technology. Another 81% disagreed with the statement that cocoa trees under agroforestry technology have lower incidence of diseases (such as swollen shoot and blackpod or *anonom*) than no shade cocoa technology (Table 4.19). Most farmers maintained that cocoa agroforestry (especially when there are many trees on the farm) increase the incidence of pests and diseases and therefore increase maintenance cost. This perception can influence farmers' decisions on the planting of trees on cocoa farms. Farmers therefore need education on cocoa agroforestry systems, especially the type and number of trees per unit area to incorporate in cocoa farms.

Table 4.19 Perception of cocoa farmers on cocoa agroforestry systems (N = 200)

Perception statement	% of farmers		
	Agree	Disagree	Not sure
Shade trees increase the moisture content of the soil	90.5	7.5	2.0
Soils under cocoa agroforests are more fertile than soils with no shade in cocoa farms	89.5	7.5	3.5
Cocoa trees under cocoa agroforestry systems require less fertiliser	46.5	47.5	6.0
Cocoa trees under agroforestry technology have lower incidence of pest (such as capsid or akate, mistletoe) than no shade cocoa technology	20.5	74.0	5.5
Cocoa trees under agroforestry technology have lower incidence of diseases (such as swollen shoot and black pod or anonom) than no shade cocoa technology	13.5	81.0	5.5
Cocoa agroforestry systems give more sustainable yield than no shade cocoa technology	78.5	14.5	7.0
Low shade tree density increases cocoa yield	84.5	14.0	1.5
High shade tree density increases cocoa yield	10.5	87.0	2.5
Higher cocoa tree density increases cocoa yield	9.5	88.0	2.5

4.13.3 Adoption of cocoa agroforestry

The majority (89.5%) of the 200 farmers reported that they have adopted cocoa agroforestry in one way or another. They gave several reasons to explain why they have adopted cocoa agroforestry. These include the following:

- Agricultural extension officers educated them on the importance of trees on cocoa farms
- Trees improve the growth and yield of cocoa; for a sustainable yield of the cocoa; to improve the lifespan of the cocoa
- To provide alternative livelihoods
- To obtain timber for building in the future (roofing); because of shortage of timber trees for roofing
- Because of climate change and the sunshine, there is the need to leave trees on the land to protect the cocoa
- To provide shade and increase the yield of the cocoa
- Trees in cocoa farms are a source of organic manure (fertiliser) through litter decomposition; trees improve soil fertility
- Trees retain water in the cocoa farm which is absorbed by the cocoa trees
- Trees in cocoa farms control erosion
- To diversify income sources, e.g. avocado pear provides income when the fruits are sold
- Trees serve as windbreaks to protect the cocoa during rainstorms
- It is customary to leave a few trees on cocoa farms
- For weed suppression
- Timber trees on cocoa farms can be sold to chainsaw operators for money

The farmers also mentioned certain challenges associated with the adoption of cocoa agroforestry systems. These included the following:

- Too many trees in cocoa farms increase the incidence of mistletoes
- Branches falling from trees sometimes destroy cocoa
- There is high incidence of pests and diseases such as black pod when there are many trees in the cocoa farm; Trees like Ceiba in the cocoa farm harbour capsids (*akate*)

- Illegal chainsaw operators harvest trees and destroy cocoa farms when trees are left on the farms
- Timber concessionaires harvest trees in cocoa farms and destroy the cocoa; timber contractors harvest without informing farmers
- Cocoa yield reduces when there is too much shade in the cocoa farm
- Undesirable trees compete with the cocoa for nutrients and water
- Too much shade causes cocoa pod to rot
- Too much shade retards the growth of cocoa
- Trees in cocoa make pest control difficult: the capsids hide in the trees when applying pesticides
- Restrictions imposed by the Forestry Commission (FC) on harvesting trees maintained on farms: the Commission will not allow farmers to harvest the timber trees they plant
- Seedlings of desirable trees are difficult to get
- Trees serve as habitat for pests which increases cost of maintaining the cocoa farm.

4.13.4 Shade trees cocoa farmers prefer to incorporate in their farms

Generally, farmers prefer shade trees that offer additional benefits. Most of the respondents reported that they prefer trees that give them extra income such as timber trees and fruit trees. They also prefer trees that do not provide too much shade and those that improve the fertility of the soil and soil moisture. The farmers are very knowledgeable about desirable and undesirable trees in cocoa farms. They maintained that trees such as odoma (*Ficus capensis*), sesemasa (*Newbouldia laevis*), kakapenpen (*Rauvolfia vomitoria*) and kookoonisuo (*Spathodea campanulata*) are good for cocoa because, in addition to other benefits, they improve soil moisture content. Others such as ofram (*Terminalia superba*), esa (*Celtis mildbraedii*), odum (*Milicia excelsa*), emire (*Terminalia ivorensis*), mahogany (*Khaya ivorensis*), asanfena (*Pouteria altissima*), wawa (*Triplochiton scleroxylon*), konkroma (*Morinda lucida*) and dahoma (*Pipterdeniastrum africanum*) are preferred partly because of their timber benefits.

Undesirable trees reported by the farmers include onyina (*Ceiba pentandra*), nyankyerene (*Ficus exasperata*), cola (*Cola nitida*), oil palm (*Elaeis guineensis*) and avocado pear (*Persea americana*). They reported that these trees harbour pests that attack cocoa. Onyina was reported to promote *akate* (Capsids) in cocoa farms and also often shed its branches, which can destroy the cocoa. However, some farmers said that they prefer it because, according to them, its deep tap roots draw ground water, which benefits cocoa. Farmers also reported that avocado pear is not good for cocoa since it harbours and promotes mistletoes. However, because of the extra income it provides when the fruits are sold, most farmers leave it on their cocoa farms. Table 4.20 provides a list of trees that farmers prefer on their cocoa farms and the reasons for their preference.

Table 4.20 Shade trees farmers prefer on their cocoa farms and reasons for their preference

Scientific name	Local/ common name	Reasons for preferring tree
Ficus capensis	Odoma (Domene)	Provides moderate shade which is good for cocoa; improves soil moisture; the litter and the seeds fertilise the soil; promotes soil fertility
Bombax buonopo-sense	Akata (Akonkodie)	Provides support for creeping plants; improves soil moisture
Newbouldia laevis	Sesemasa (Tronsuo)	Provides moderate shade which is good for cocoa; retains water in the farm; used as stake for yam; has straight bole and smaller crown so does not overshadow the trees; mistletoes do not grow on them; recommended by extension officers; used as stakes for yam; improves moisture content of soil; used for medicinal purpose
Rauvolfia vomitoria	Kakapenpen	Good for nursing cocoa; evergreen and good in dry season; improves soil moisture; helps the cocoa to yield for a long time
Citrus senensis, Persea americana, Mangifera indica	Fruits trees (citrus; pear, mango, etc.)	Provides cash income and shade
Gliricidia sepium	Gliricidia	Helps to improve the fertility of the soil; keeps away termites; helps the cocoa to grow well because it is a multipurpose tree
Solanum erianthum	Pepediawuo	Improves soil fertility; improves cocoa yield
Sterculia tragacantha	Sofo	Improves soil moisture content
Spathodea campan-ulata	Kookoonisuo	Improves soil moisture
Alstonia boonei	Nyamedua (Sinuro)	For timber; improves soil moisture; recommended by agricultural extension agents; improves yield of cocoa; it is evergreen; improves soil moisture; cools the soil
Ricinodendron heu-delotti	Wama	Litter improves soil fertility and soil moisture; cocoa under this tree has high yield and yields for a long time
Nesogordonia papa-verifera	Danta	Protects the cocoa against harsh weather
Terminalia superba	Ofram	Provides timber; provides moderate shade which is good for cocoa – does not provide too much shade; does not deplete the soil of water; grows fast; recommended by agricultural extension officers; good for cocoa through experience; leaves decompose quickly which improves soil fertility; medicinal purposes
Entandrophragma angolense	Edinam	Provides timber; the leaves provide litter to enrich the cocoa soil; grows tall so the canopy is above the cocoa and so does not overshadow the cocoa
Celtis mildbraedii	Esa	Provides timber; litter improves soil fertility; provides multiple revenue – can be used for pestle
Milicia excelsa	Odum	Provides timber; improves fertility of soil – the seeds fertilise the soil when rotten; draws water for the soil and cocoa

Terminalia ivorensis	Emire	Provides timber; has broader leaves for providing shade; does not deplete the soil of water; grows fast; improves fertility of soil; does not provide too much shade; retains water; increases soil moisture content; tall and does not provide too much shade; branches do not break easily to destroy cocoa
Khaya ivorensis	Mahogany	Provision of timber; improves fertility of soil; provision of medicine; grows tall so the canopy is above the cocoa and so does not overshadow the cocoa; branches are strong and do not break easily
Pouteria altissima	Asanfena	Provides timber
Triplochiton scleroxylon	Wawa	Provides timber for domestic use
Morinda lucida	Konkroma	Provides timber for frames; the branches cannot fall and destroy cocoa because they are not heavy; provides less shade and for domestic use; used as medicine; improves yield of cocoa
Cedrella odorata	Cedrella	Provides timber; litter from the tree serves as fertiliser for the cocoa
Pipterdeniastrum africanum	Dahoma	Provides timber
Pycnanthus angolensis	Otie	Provides timber; improves soil moisture; improves soil fertility
Daniellia ogea	Hyedua	For timber; for medicinal purposes
Antiaris toxicaria	Kyenkyen	For future timber revenue
Amphimas pterocarpoides	Yaya	Provides timber; branches do not break easily to destroy cocoa
Ceiba pentandra	Onyina	Provides timber; draws groundwater for cocoa

4.14 Farmer tree planting and management

In order to understand farmers' views on on-farm tree planting, they were asked whether they planted the shade trees on their cocoa farms themselves. Planting of trees on cocoa farms is not a normal practice in the study area. Trees on farms are usually those that have been selectively left and nurtured to maturity. These are left mainly because of shade provision and possible future exploitation for timber. Trees that are planted are usually fruit trees. Most (78%) of the 200 farmers said that they did not plant the trees themselves but left them on the farms during land preparation. Others said that they nurtured the trees after the cocoa had been planted. Only 22% of the farmers claimed that they planted some or all of the shade trees on their cocoa farms themselves. This finding is interesting because even though farmers understand the importance of trees in cocoa farms and are knowledgeable about desirable tree species, they prefer not to plant them. This may be due to governance arrangements relating to tree tenure and harvesting rights (see below).

4.14.1 Destruction of trees on cocoa farms

The majority (80.5%) of the farmers confirmed that they sometimes destroy trees on their cocoa farms. They cited several reasons to explain why they do that. These reasons have been placed under three main broad headings: ecological challenges, pest and disease challenges and forest and tree governance challenges. Some of the ecological challenges that force farmers to destroy trees in cocoa farms are: wrong location of trees in relation to cocoa, destruction of cocoa by fallen tree branches, competition of trees with cocoa for water and nutrients and retardation of cocoa growth and yield with too much shade. The pest and disease challenges include increased incidence of mistletoes, *akate* (capsids) and black pod disease, rotting of cocoa pods when there is too much shade and creation of conditions for transmission of pests and diseases. The forest and tree tenure challenges mentioned by the farmers include timber contractors harvesting trees and destroying the cocoa in the process, inadequate knowledge about the importance of trees to the cocoa, generation of cash income by selling timber trees that are removed from the cocoa farm and preventing chainsaw operators from harvesting timber trees and destroying cocoa farms (Table 4.21).

Table 4.21 Reasons farmers gave for destroying trees on cocoa farms

Ecological challenges	Pest and disease challenges	Forest and tree governance challenges
• *Albizia,* for instance, competes with cocoa and kills the cocoa trees • Increase in the number of shade trees • Branches of larger diameter trees destroy some of the cocoa trees, e.g. Onyina • Trees compete with the cocoa trees for resources such as space, nutrients and water • Too many trees makes the farm too shady • Wrong placement of trees • For maximum absorption of sunlight by the cocoa • I destroy the trees that are not good for the cocoa • I kill the trees with too many branches • I kill them to prevent too much shade on the farm • I remove the trees that retard the growth of the cocoa or reduce the cocoa yield • If there are too many trees it will reduce the yield of cocoa • Ceiba is removed because it gets too big and destroys cocoa trees • If trees are undesirable and can disturb cocoa trees I kill them • The trees in the cocoa farm make the cocoa trees grow too tall • To avoid competition between the cocoa; to improve the yield of cocoa • Trees very close to the cocoa tree have the tendency to destroy the cocoa tree • When there are too many trees I remove some of them • Wrong location of the shade trees on the farm kills the cocoa trees	• Too many trees (too much shade) promote the growth of mistletoes • Too many trees increase the incidence of black pod disease • Trees create conditions for mistletoe growth • Excessive shade creates conditions for pests and diseases • The trees with too many leaves/ shade harbour *akate* (capsids) so I remove some of them from the farm • If there are pests and diseases we remove some of the trees because too much shade breeds pests and diseases • Some of the shade trees such as Nwama increase disease incidence, e.g. black pod. Such trees are destroyed • When there is too much shade the pods get rotten • Trees increase shade and cause rot of cocoa pods	• Because the timber contractors harvest them and destroy the cocoa. So I destroy the timber trees • I have little knowledge about the importance of trees to the cocoa • To get timber to sell for income and for roofing of buildings • To prevent chainsaw operators from harvesting the trees and destroying my farm • I was told that trees are not good for cocoa • Concessionaires coming to harvest timber

4.14.2 Factors that discourage farmers from planting trees on cocoa farms

The farmers mentioned several factors that discourage them from planting trees on their cocoa farms. These include inadequate access to quality seeds and seedlings (46% of the respondents), destruction of farms by timber concessionaires (37%), unfavourable tree tenure (or tree ownership rights problems) (26.5%), lack of support from agricultural extension officers (21%) and lack of training in the management of agroforestry trees (17.5%) (Table 4.22).

Table 4.22 Factors discouraging farmers from planting trees on cocoa farms (N=200 in all cases)

Factor	Number of respondents	Per cent of respondents
Land tenure (land ownership problems)	17	8.5
Tree tenure (tree ownership right problems)	53	26.5
Lack of training in management of agroforestry trees	35	17.5
Difficulty in managing the shade tree by cocoa farmers	28	14.0
Inadequate access to quality seeds and seedlings	92	46.0
Seedlings are not affordable	33	16.5
Benefits of the technology to farmers are not well communicated	54	27.0
High labour demand for tree pruning	16	8.0
Lack of agricultural extension support	42	21.0
Destruction of farms by concessionaires	74	37.0

Note: Numbers of respondents will not add up to 200 due to multiple responses

Farmers that mentioned unfavourable tree tenure as a factor discouraging them from tree planting reported that restrictions on the harvesting of planted trees, especially, the fact that farmers need to ask permission from the FSD of the FC in order to harvest trees they have planted themselves, along with damage caused by timber contractors to cocoa during tree harvesting and the lack of adequate compensation for damaging cocoa trees are critical challenges that must be addressed. Thus, any intervention that seeks to improve tree cover or the incorporation of trees in the cocoa landscape must address the governance issues surrounding timber tree tenure and access rights, crop damage compensation payments and timber tree benefit sharing in order to succeed.

Other factors mentioned by the farmers as discouraging them from planting trees relate to the challenges posed by trees themselves in cocoa farms. These include falling branches of trees damaging cocoa trees, cocoa yield reduction due to too much shade, increased pests and disease incidence in shady cocoa farms and suppression of food crop production in the open spaces in the cocoa farm because of shade trees. For some farmers, the long maturity or production period of trees is an important factor that serves as a disincentive to tree planting in cocoa farms, especially timber trees.

4.14.3 Conditions that can encourage farmers to incorporate or plant trees on cocoa farms

After disclosing the factors that discourage them from planting trees on their cocoa farms, the farmers were asked to mention the conditions that can encourage them to incorporate or plant trees on their cocoa farms. They mentioned several critical conditions which when put in place will motivate them to incorporate or plant trees on their cocoa farms. These conditions can be grouped into three main broad conditions: addressing the current forest and tree governance challenges, provision of incentives and provision of extension support (Table 4.23). These conditions were supported by key informant interviews and focus group discussions.

Other farmers claimed that nothing will encourage them to plant trees on their cocoa farms because farmers who have trees on their farms are not doing well. They maintained that they will only plant trees on their farms when they have an example of someone whose cocoa is doing well because of trees. They claimed that increasing cocoa productivity is about provision of agrochemicals such as fertiliser and pesticides and not about planting trees. This shows that, even though most farmers are knowledgeable about the importance of trees in cocoa farms others are still not sure about the value of trees to cocoa. This reinforces the importance of providing extension support for cocoa farmers.

Table 4.23 Conditions that can encourage farmers to incorporate or plant trees on cocoa farms

Address current forest and tree governance challenges	Provision of incentives	Provision of extension support
• Allow me to reap the benefits of tree planting • Assure us of ownership rights of planted trees • Government should stop concessionaires from harvesting trees in cocoa farms • Grant us timber rights — farmers should have ownership rights over trees in their own farms • Clarify tree ownership rights to encourage farmers to grow and maintain trees on their farms • The FC should allow farmers to harvest trees on their farms for their own use or for sale • Timber contractors should compensate farmers after destruction of cocoa farms • Royalties should be paid to cocoa farmers who have shade trees on their farms when the trees are harvested • Giving me ownership of the trees I plant; I do not need to get permit from the FSD in order to harvest trees I plant • Giving me ownership of the trees I preserve on my land • I will plant trees if timber concessionaires will not harvest the trees and destroy my cocoa • Protect farms against illegal chainsaw operators • Government should stop concessionaires from logging trees in cocoa farms • Clear and well spelt out procedures for benefit sharing	• Provide us with quality seeds and seedlings • Farmers to be provided with seedlings free of charge • Provision of agrochemicals for our cocoa • Provide us with access to seedlings • Better cocoa prices — government should increase the price of cocoa • Provision of Inputs — e.g. pesticides, fertiliser and spraying machines for our cocoa farm • Government should provide farmers with tools and equipment • Government should subsidise fertiliser • Provision of financial support — provide me with money to support the planting of trees • Prices of agrochemicals and other inputs should be reduced • Government should reward farmers who plant trees in their farms • Establishment of a nursery in the various communities so that farmers can have easy access to tree seedlings • If there is an assured market for the trees I plant • Provision of loans to farmers to plant trees • Government should pay our cocoa bonus • Seedlings should be supplied to farmers when farms are young	• Regular visits by extension officers and training on tree management • Assurance about the importance of trees to the cocoa • Training in cocoa agroforestry and the types of trees to leave on the farm • Education on the benefits from cocoa agroforestry — education about the benefits of shade trees • Educating farmers on the benefits of trees to farmers • Assurance that I will get a market for the trees grown • Training in tree planting and management • Provide us with information about climate change • Government should provide improved extension services to farmers • Provide extension services and farmer field training

Section 5
Synthesis of findings and discussions

5.1 Introduction

This chapter provides a synthesis of the findings of the study and discusses their implications for the sustainability of cocoa, biodiversity conservation, Ghana's forest definition and REDD+ implementation in the cocoa landscape of Ghana. The findings are discussed within the context of existing literature.

5.2 Upper canopy tree diversity, shade cover and carbon stocks: implications for biodiversity conservation and REDD+ implementation in the cocoa landscape of Ghana

Tree diversity in cocoa farms offers farmers a range of agronomic, economic, cultural and ecological benefits (Sonwa et al. 2001, Gockowski et al. 2006). A diversified farm enables farmers to exploit the different components in the system, as well as their interactions, so as to meet subsistence needs, maximise incomes and reduce risks of fluctuations in world market prices of cocoa beans (Rice and Greenberg 2000, Duguma et al. 2001, DiFalco and Perrings 2003). In addition, multi-strata cocoa can help to protect forest patches, regenerate and conserve particular forest tree species and provide agroforestry habitats for key animal species (Greenberg et al. 2000, Siebert 2002, Schroth et al. 2004) that play vital roles in maintaining and conserving forests.

In West Africa, the diversity of non-cocoa trees on cocoa farms primarily results from farmers harnessing the natural processes of regeneration within forest-fallow systems by preserving some mature trees and selecting certain seedlings and coppice sprouts to grow in tandem with the cocoa. Farmers also plant forest trees, although it is more common for farmers to plant fruit trees. This practice of integrating food crops, native trees and fruit trees into cocoa farms embodies a process of tree diversification — a characteristic of cocoa agroforests. However, the probability that this diversification practice will achieve its potential, in terms of significant increases in household incomes and conservation of biodiversity on farm and in the managed cocoa landscape in general, is limited by a number of institutional, technical, marketing and legal factors. For example, there appears to be a lack of emphasis or encouragement for tree diversity and diversification amongst national extension systems and cocoa projects (Asare and Asare 2008). In Ghana, priority has instead been given to increasing cocoa bean production and pest and disease control. Technology has also contributed to an overall reduction in shade cover for cocoa over time through the promotion of hybrid varieties which favour lower densities of shade (Padi and Owusu 1998, Asare 2005) and the widespread availability of chainsaws which facilitate removal of mature forest trees (Ruf and Konan 2001). There is neither a strong focus on understanding interactions between native species and cocoa, nor on simplifying and sharing the information between stakeholders on the importance of biodiversity conservation on farms (Asare 2005).

It is important to highlight that results from this study showed that upper canopy tree diversity was generally low and that non-timber species dominated the cocoa agroforestry systems, relative to timber species and generally low biomass carbon stocks, compared to forests. A key question that has always been on the national agenda is the extent to which the cocoa landscape can be linked to existing forests and national parks as a form of corridor that will support biodiversity (trees and animals). Another critical issue that has dominated the national discussions is the possibility of reversing the current expansionist approach in cocoa cultivation, which would lead to reductions in greenhouse gas (GHG) emissions and the improvement of off-reserve tree stocking. This will provide multiple benefits to smallholder farmers and relieve pressure off the forest reserves and national parks.

The current manifestation of low upper canopy tree diversity and dominance of non-timber trees is a clear indication of a shift and a transformation that has evolved over time based on farmer perception and off-reserve forest governance complexities. Cocoa, though not native to Ghana, has traditionally been grown in tandem with timber trees. This obviously supported ecosystem functioning that could be comparable to natural forests in several ways because of its multi strata nature, the incorporation of indigenous timber species and a generally positive attitude of farmers towards long-term cocoa sustainability relative to short-term gains. The tree diversity indices (Shannon) of this study indicated a relatively lower diversity when compared to the study by Anglaare et al. (2011) at Bontomuruso and Gogoikrom in the Atwima district of the Ashanti Region of Ghana; the Shannon index for matured cocoa was 4.69. The Anglaare et al. (2011) study area falls within the same district as the study site for Nkawie in this study, which recorded a relatively lower tree diversity of 0.88. It is also important to emphasise that contrary to the current low biodiversity, as indicated by the biodiversity indices and relatively high dominance of non-cocoa trees, a very high percentage of farmers interviewed (95%) maintained that they were aware of the benefits of cocoa agroforestry to farmers. The farmers mentioned several benefits of cocoa agroforestry with most mentioning more than one benefit. The majority (71.5%) of the farmers reported that trees in cocoa farms or cocoa agroforestry offers sustainable cocoa yield, 71% said that cocoa agroforestry improves soil fertility, 48% claimed that cocoa agroforestry provides multiple revenue and 43% maintained that cocoa agroforestry leads to weeds suppression. This shows a clear contrast of farmer understanding of the benefits of cocoa agroforestry and actual practice on their farms. Furthermore, though farmers knew the benefits of incorporating trees in cocoa, they also intimated strong challenges which inhibit their adoption of cocoa agroforestry through the incorporation of indigenous timber trees. These could broadly be classified into pest and disease issues and impact on yield, challenges with illegal chainsaw and timber concessionaires, inadequate and sometimes total lack of knowledge on the provision of the legal and policy regimes governing off-reserve tree tenure and exploitation and access to seedlings of indigenous timber species.

A major gap that is running through the issue of low upper canopy tree diversity and dominance of non-timber trees is the total lack of extension support to holistically deal with the issues that bother farmers in terms of tree incorporation and the sustenance of their farms. It is important to underscore that while some of these challenges are purely policy and national forest governance issues that are beyond projects, many more are extension issues which can be addressed or managed if the stakeholders are engaged. This can be done through sensitisation, farmer awareness creation and education, which is supported by demonstration activities at the community level to cement farmer confidence in mitigating the identified challenges.

Shade cover in this study was indicated as the crown area of upper canopy trees expressed as a percentage of 1 ha. It is very instructive to differentiate shade trees from shade cover. For instance, CRIG recommends 16–18 shade trees per hectare, providing between 30 and 40% shade cover. Thus, shade trees basically refer to the non-cocoa trees that are either incorporated by the farmer or selectively left on the plot during land preparation. However, data from this study indicated that not all non-cocoa trees within the cocoa landscape are necessarily shade trees. There are many fruit trees such as citrus and avocados that offer no shade services to the cocoa system, because their structure is the same as the cocoa and forms part of the cocoa canopy. Thus, even though one can have several shade trees within a cocoa farm per the number of stems, their contribution to shade for the cocoa could be very low. For instance, this study observed a rather high incorporation of Newbouldia laevis in Sefwi Wiawso as well as Asumura cocoa districts, with mean number of stems of non-cocoa trees being 18 and 16 respectively. Per the existing recommendation of shading for cocoa, this should be very appropriate and in line with the best agronomic or agroforestry practice. However, the contribution to shade provision by these numbers of non-cocoa tree stems to shade cover at Sefwi Wiawso and Asumura was approximately 6% of a hectare of cocoa farm. Ironically, although the number of stems perfectly falls in line with the recommended level, the same cannot be said of the shade cover to the cocoa. Clearly, the use of the number of stems of non-cocoa trees should always be considered in the context of the recommended tree species, which are indigenous timber trees, that grow very tall and relatively very big. Based on the non-cocoa tree occurrence within the cocoa landscape, it is not enough to do shade classification in a vacuum, without situating it within the context of the recommended species.

It is also possible to view the incorporation of non-cocoa trees in another context. It is known that the incorporation of multi-purpose trees in a given farming system is a classical agroforestry definition. Hence, a farmer's decision to incorporate trees could be based on the need for several services of these multi-purpose trees. For instance, in the study by Asare and Asare (2008) on desirable trees for cocoa, they rightly identified attributes of desirable non-cocoa trees beyond their shade qualities. Farmers identified moisture, soil fertility, weed suppression, mechanical damage, wind break, good aeration, good timber value, shade quality and good non-timber value as key attributes of desirable non-cocoa trees for incorporation within cocoa systems. The attributes are not ranked in order of desirability and the same scoring regime was applied in a decision support matrix for the selection of desirable trees, as indicated in Table 5.1. Hence, the reference to non-cocoa trees as shade trees could, in some instances, be misleading, and even confusing when attempts are made to classify or sub-divide these shade regimes into low, medium and high shade, based on number of stems. Shade is provided by the crown cover, so reference should be made to the percentage of crown cover. Hence, instead of referring to the recommended non-cocoa trees as shade trees, we could say upper canopy trees, bearing in mind the attributes identified by Asare and Asare (2008). However, it is understood that stem number, in the context of the recommended tree species by Manu and Tetteh (1987), could provide an indication of shade in terms of crown cover, but given the current manifestation of tree species in the cocoa landscape, the context for the stem number as an indication of shade has been lost. This necessitates the need for a closer look at a more holistic and unambiguous definition.

It is also well known that the recommended number of cocoa trees per hectare is 1,111 trees. This is irrespective of the variety. Hence, in terms of REDD+ implementation in cocoa landscapes, the real opportunity for additionality comes with the incorporation of non-cocoa trees in an optimal agroforestry system. However, in some instances, marginal gains in carbon stocks could be achieved through best practices, soil fertility management and others, for improved cocoa tree growth. Based on the aforementioned, the following discussions in this section of the report will focus on non-cocoa trees and their contribution to carbon stocks, with its associated implications for REDD+ strategies and implementation.

Results of carbon stock dynamics associated with different non-cocoa tree stem counts and shade in terms of crown cover presented interesting outcomes that further throw light on the fact that a high stem number does not necessarily translate into better mitigation potential for the cocoa landscape, unless the species component is taken into consideration. For instance, the total number of stems for the non-cocoa trees at Sefwi Wiawso cocoa district was approximately 18/ha, with mean tree height and diameter being 13.7 m and 33.1 cm respectively, but the carbon stocks was 10.9 MgC/ha. Given that 18 trees per hectare is the recommended number of non-cocoa trees, one would have expected the carbon stocks to be much higher, but for the dominance of *Newbouldia laevis.* Overall, the mean total carbon stocks of non-cocoa trees in all the study areas was 17.8 MgC/ha, an indication of the obvious implication of having more non-timber species than timber species and relatively few non-cocoa tree species. The wide incorporation of the species could give an impression that the non-cocoa trees were young, but a knowledge of the silvics of the species shows that it is not a typical big diameter species that grows very tall. We also observed the dominance of smaller diameter non-cocoa trees in most of the study sites, an indication that these species are not remnants of previous land use, such as secondary forest or fallow areas, but they were either nurtured or enhanced by the farmer to naturally grow. However, some farmers intimated that they cut the trees down after some time to prevent loggers from destroying their farms. Thus, in terms of climate change mitigation in cocoa landscapes, it is also important to consider the sequestration potential of the species as an additional attribute for the selection of desirable species. This is very relevant in current discussions on climate-smart cocoa farming and the implementation of Ghana's Economic Recovery Program (ERP) and FIP.

Table 5.1 Decision support matrix with attributes of species for species selection in cocoa agroforestry systems. (Source: Asare and Asare 2008).

Attributes	Species Ratings				
	Me	Ti	Ts	Ni	Sc
Shade Quality	7	5	5	1	5
Moisture	7	5	3	5	9
Soil fertility	9	5	7	7	9
Weed suppression	9	7	9	5	7
Mechanical damage	9	1	1	9	7
Wind Break	9	5	7	5	9
Allows good aeration	9	7	7	7	7
Good Timber Value	9	9	7	1	1
Good NTFP value	9	9	7	5	5

Attributes	Species Ratings				
	Me	Ts	Ab	Fe	Sc
Shade Quality	7	7	9	5	5
Moisture	9	7	7	5	9
Soil fertility	9	7	7	7	7
Weed suppression	7	5	9	5	3
Mechanical damage	9	5	3	3	7
Wind Break	7	3	3	5	5
Allows good aeration	9	7	5	7	7
Good Timber Value	9	7	5	3	3
Good NTFP value	9	7	7	7	5

Attributes	Species Ratings				
	Me	Ti	Ts	Ki	Sc
Shade Quality	9	7	9	9	7
Moisture	9	5	7	9	9
Soil fertility	7	5	9	7	9
Weed suppression	7	5	7	7	7
Mechanical damage	9	5	5	9	5
Wind Break	7	5	5	7	5
Allows good aeration	9	5	7	9	7
Good Timber Value	9	7	3	9	3
Good NTFP value	9	7	7	9	7

Attributes	Species Ratings				
	Tsc	Ti	Ts	Cp	Ar
Shade Quality	5	7	7	9	9
Moisture	1	9	9	7	9
Soil fertility	1	9	9	5	9
Weed suppression	3	7	7	9	9
Mechanical damage	5	5	5	1	5
Wind Break	5	7	9	5	7
Allows good aeration	7	7	9	3	9
Good Timber Value	9	9	7	7	9
Good NTFP value	7	9	7	5	5

Attributes	Species Ratings				
	Me	Ti	Ts	Fc	Sc
Shade Quality	9	7	7	7	7
Moisture	9	9	5	7	7
Soil fertility	7	7	7	5	7
Weed suppression	7	7	7	5	5
Mechanical damage	7	5	3	3	3
Wind Break	7	7	7	7	7
Allows good aeration	7	9	9	5	5
Good Timber Value	9	9	7	1	3
Good NTFP value	9	7	7	5	7

Attributes	Species Ratings				
	Fc	Ti	Cp	Ki	Sc
Shade Quality	9	7	5	5	7
Moisture	9	5	7	5	9
Soil fertility	7	5	7	3	9
Weed suppression	9	7	5	3	9
Mechanical damage	7	7	5	7	7
Wind Break	7	7	5	3	7
Allows good aeration	5	5	7	7	7
Good Timber Value	1	7	7	9	1
Good NTFP value	5	7	5	9	5

Note

Me=Milicia excelsa, Ti=Terminalia ivorensis, Ts=Terminalia superba, Nl=Newbouldia laevis, Sc=Spathodea campanulata, Ki=Khaya ivorensis, Ab=Alstonia boonei, Fc= Ficus capensis, Fe=Funtumia elastica, Cp=Ceiba pentandra, Tsc=Triplochiton scleroxylon, Ar=Aningeria robusta.

5.3 Crown cover variation of upper canopy trees in smallholder cocoa landscapes: implications for forest definition and REDD+ implementation

According to Ghana's forest definition, an area can be classified as forest if the crown area is at least 15%, the minimum mean tree height is 5 m and the land area is 1 hectare or more. A look at the cocoa landscape shows different land use types, including croplands, natural forests, fallow areas and settlements. The cropland areas also include food crop farms and cocoa farms under various agroforestry systems and shade regimes. Using the national forest definition, once a land use has parameters that meet the national threshold, that land use could qualify as a forest. Results from this study indicated a mean cocoa tree height of 6.3 m for all ten study areas, which represents ninety 1 ha plots. It was obvious that for cocoa to meet the national forest definition threshold, the critical parameter was the tree height, based on the fact that the cocoa landscapes in most areas are quite contiguous and easily meet the crown cover and land area parameters. Thus, cocoa is clearly a forest, based on the three parameters for forest definition. This result reiterates the need to consider the potential and implications of monoculture cocoa landscapes as forests in the national REDD+ discussions. However, it is also very clear in Ghana's RPP that cocoa is considered as a crop. As a matter of fact, cocoa is considered a major driver of deforestation in the HFZ of Ghana (Ghana RPP 2010). The contradiction is obvious: cocoa, per its structural parameters, qualifies as a forest, but it is also known that cocoa is not indigenous to Ghana, and its cultivation replaces naturally growing forests. The decision to classify cocoa as forest, in view of the fact that it meets the national forest definition, or to classify it as a crop, based on the fact that its cultivation was as a result of natural forest conversion, is a national one and can only be dealt with by the government of Ghana, through the appropriate institutions.

Since cocoa is a major crop in Ghana that employs many farmers and also serves as a major foreign exchange earner, its cultivation cannot be stopped. The option available therefore is to promote good cocoa agroforestry interventions that will incorporate desirable timber tree species in an optimal manner as recommended by Asare and Asare (2008). Given the current manifestation of cocoa agroforestry in the landscape, the best opportunity for cocoa REDD+ intervention is enhanced carbon stocks and in some instances avoided degradation as well as avoided deforestation, depending on the context. Given that the number of cocoa trees is constant, 1,111 tress per hectare, any additional benefit in terms of mitigation will be associated with the non-cocoa trees. This will be demonstrated by how the non-cocoa trees meet the national forest definition threshold.[8]

Figure 4.2 shows the mean crown cover of non-cocoa trees for all the study areas. The results indicated that with the exception of New Edubiase and Asempaneye cocoa districts, all the sites had crown cover that was below the national threshold. Obviously, once the crown area qualifies, the land area will automatically pass, with results of this study showing that all the non-cocoa trees in the sample areas had mean heights greater than 5 m. This means that the agroforestry system being practiced at these two areas qualifies those landscapes to be classified as a forest. Given this, all the REDD+ interventions are possible at New Edubiase and Asempaneye. However, the other sites can only implement forest carbon stocks enhancement. This also means that there is a huge opportunity to implement forest carbon stocks enhancement within the cocoa landscape of Ghana, with Asumura, Akontombra, Sefwi Wiawso and Nkawie forest districts being the areas with the highest potential for forest carbon stocks enhancement.

Data on crown cover in this study, combined with Landsat satellite imagery from Google Earth, also has application for visual interpretation and segregation of upper canopy trees from contiguous cocoa, which are mostly below the canopy of the non-cocoa trees. This study explored the possibility of providing some crude guidance on shade classification based on crown cover. Knowing the crown cover of 90 sample areas on the ground, and the representation of these crowns from the visual interpretation of Google Earth imagery, it is possible to have a fairly good knowledge of what each shade regime means. Given that CRIG's recommendation is to have shade cover of 30–40 % of the area, we assume this to be a high shade regime. Hence, through visual interpretation, one can know the areas within the landscape that qualify as

8. As of the time of writing this paper (August, 2014), Ghana's national forest definition at the UNFCCC website is Crown cover = 10%; height = 2m; land area = 0.5 ha. However, we are aware of the fact that the country has initiated steps to replace this forest definition with a revised version, Crown area = 15%; height = 5m; land area 1ha. Though the revised version has not yet reflected on the UNFCCC website, recent documents such as the Ghana ERP (https://www.forestcarbonpartnership.org/sites/fcp/files/2014/MArch/Ghana%20Summary.pdf) have utilised the revised version. Hence the authors have proceeded to make use of the revised version in this report, in line with the general knowledge on the discussions on forest definition in Ghana.

high shade. In this study, none of the sites met the CRIG recommendation for shade, which means there is still a potential to improve the shading system through the incorporation and replacement of timber species with the current prevalent non-timber species.

Figure 5.1 is a Landsat imagery of the landscape at Oppongkrom at Sankare cocoa district. The crown measurements of the upper canopy trees was 9.4% of the 1 ha. This is far below the shade level recommended by CRIG and also falls below the national forest definition threshold. However, a major limitation of visual interpretation using Google Earth is the blurred appearance of most landscapes which hinders better interpretation.

5.4 Implications of socio-economic issues for cocoa sustainability and REDD+ implementation

Results of the study showed that 47% of the respondents were above 50 years of age. The mean farm size was 6.3 acres (2.5 ha), with the most dominant farm size in the landscape being 4 acres (1.6 ha). Eighty eight per cent of the farms were 10 acres (4 ha) or below, and 70% of the farms were below 20 years, of which 40.7% were below 10 years. There are indications that cocoa farmers are ageing, for which reason farmers are not willing to invest in interventions to improve productivity. With results of this study indicating that 47% of the farmers were over 50 years of age and with over 50% of farmers in the landscape having farms that are above 10 years old, it is possible that cocoa sustainability could be a huge problem. This could manifest in the form of low productivity resulting from susceptibility to disease, low nutrient uptake, etc. It is therefore critical that measures are put in place to rehabilitate these ageing cocoa farms, with a commensurate effort to encourage youth participation in cocoa farming. However, there was also a good representation of young cocoa farms. This clearly indicates farmers are also initiating new plantations which offer opportunities for climate-smart interventions.

Sharecropping is a critical issue that could even have implications for conflict within the cocoa landscape. The study revealed that the known sharecropping systems (*abunu* and *abusa*) do not always imply the classical understanding that have often been associated with them. The observations made in this study on sharecropping dovetail into the bigger tree and land tenure issues within the cocoa landscape. For instance, the issue of expiration of tenancy agreement upon the ageing and replanting of old cocoa farms has implications for cocoa farm rehabilitation. If a farmer will lose his or her farm when he replants, then he would rather keep an over-aged farm and gain little productivity than lose his farm completely. This also underscores the potential conflict issues that could hamper any REDD+ intervention, given that sharecroppers are still not unanimous in their understanding of the tenancy arrangements that govern cocoa farming.

Figure 5.1 A sample plot at Oppongkrom, Sankore cocoa district, showing the crown cover of trees within the landscape.

Section 6
Conclusions and Recommendations

6.1 Conclusions

The objectives of this study were to quantify the baseline carbon stocks and sequestration potentials in different smallholder cocoa farming systems, identify land and tree tenure challenges, assess farmers' perceptions of trees in cocoa farms and assess the feasibility of implementing REDD+ interventions in cocoa landscapes in Ghana. Using a replicated transect approach, biophysical data on shade and cocoa trees were collected from 1 hectare plots established on 5 km long transects in ten cocoa growing districts in the Ashanti, Western and Brong-Ahafo regions of Ghana. In addition, socioeconomic data was collected through the administration of semi-structured questionnaires (200 respondents), key informant interviews and focus group discussions involving indigenous and migrant farmers in the research districts.

6.1.1 Number and diversity of shade trees species at the plot level for each shade regime

A total of 109 different species of shade trees were recorded during the field inventory across the ten cocoa sites in the HFZ of Ghana. The lowest number of species (27) was recorded at Akontombra, while the highest number of species (49) was recorded at Goaso. Based on the total number of species, the sites can be ranked in the following order: Goaso > Offinso > Asempanaye > New Edubiase > Nkawie > Asumura > Adabokrom = Sankore > Sewfi Wiawso > Akontombra. Shade tree species dominance varied between communities. The most dominant species across the study districts was *Newbouldia laevis*. It was dominant at Asunura (48% of total individuals), Sefwi Wiaeso (47%), New Edubiase (24%) and Sankore (11%).

The Shannon-Weiner diversity index (H') ranked the sites as follows: Goaso > Asempaneye > Adabokrom > Nkawie > Sankore > New Edubiase > Offinso > Akontombra > Asumura > Wiawso while the Shannon evenness or species equitability (J'), on the other hand, showed that the species at Adabokrom and Asempaneye were more evenly distributed. This was followed by Goaso, Sankore, Nkawie, Akontombra, New Edubiase, Offinso, Asumura and Sefwi Wiawso. There were similarities between sites in shade tree species composition. Adabokrom – Goaso, Adabokrom – New Edubiase, Wiawso – Akontombra, Asumura – Goaso and Goaso – New Edubiase recorded the highest species similarity with rank correlations of 0.7. Akontombra – Asempaneye and Offinso – Asempaneye. with rank correlations of 0.4. recorded the least species similarity.

6.1.2 Existing shade / crown cover regimes on smallholder cocoa agroforestry systems in the project area

Crown cover / shading regimes (expressed as a percentage of one hectare) ranged from 5.8 ±1.22 % to 16.3 ±1.74 % in the study districts. On the basis of the similarity in crown cover, districts can be grouped into three classes namely those with crown cover ≤ 8.0% (Asumura, Sefwi Wiawso, Akontombra and Nkawie districts); those with crown cover within 8.1-14.9% range (Adabokrom, Sankore, Goaso and Offinso districts) and those with crown cover ≥15.0% (New Edubiase and Asempanaye districts). Eighty per cent of existing crown cover / shade regimes in the study district fell below the 15% minimum threshold defined for forests in Ghana.

6.1.3 Baseline carbon stocks associated with each shade regime in the different smallholder cocoa systems

Average carbon stocks in shade trees was 8.32 ±1.15 Mg C ha-1 and ranged from 5.04 ±1.35 Mg C ha-1 (Asumura) to 15.6± 2.89 Mg C ha-1 (New Edubiase), while average stocks in cocoa trees was 7.45 ±0.41 Mg C ha-1 (range 5.84 ± 0.91 to 8.65 Mg C ha-1). Carbon stocks in cocoa trees were similar across the study districts. Total carbon stock was lowest in Sefwi Wiawso (10.9 ±1.56 Mg C ha-1) and Nkawie (11.5 ±1.19 Mg C ha-1) and highest in New Edubiase (23.4 ±3.23). Shade trees stored more carbon than cocoa trees. Carbon distribution between shade and cocoa trees averaged 52% and 48% respectively across the landscape.

6.1.4 Carbon stocks and dendrometric parameters associated with the shade trees in the cocoa agroforestry system

There were significant relationships between crown cover (%) and shade tree carbon stocks (Mg C ha^{-1}), shade tree stem diameter (cm) and shade tree carbon (Mg C ha^{-1}) and shade tree diameter (cm) and total aboveground carbon stocks (Mg C ha^{-1}). Although the predictive abilities of two equations relating stem diameter and shade tree carbon, and stem diameter and total carbon, in cocoa and shade trees were low, they nevertheless demonstrated the relationship between the size of the shade tree and the amount of carbon stored. There was a progressive increase in total tree carbon stocks with increasing mean stem numbers per hectare and stem diameter. Generally, the bigger the stem diameter, the higher the amount of carbon stored. Study districts with the highest number of shade tree stem numbers per hectare (average of 17 stems/hectare), had the tallest trees (mean height of 18.7 m), the highest mean shade tree stem diameter (46.3 cm) and consequently the highest total tree carbon storage (21.0 Mg C ha^{-1}). Similarly, study districts with the lowest number of shade tree stem numbers per hectare (average of 15 stems/ hectare), had the shortest trees (mean height of 13.0 m) and a much lower mean shade tree stem diameter (12 cm) and consequently the lowest total tree carbon storage (12.1 Mg C ha^{-1}).

6.1.5 The dynamics of plot level shade regimes and associated carbon stocks (Mg C ha^{-1} and tons C ha-1 and CO_2 equivalent) in the cocoa systems in the project area

Average crown cover in the study districts ranged from 5.8 ±1.22 % in Asumura district to 16.3 ±1.74 % in the Asempanaye cocoa district. The percentage of crown cover differed significantly between the districts. Crown cover across the districts can be grouped into three crown cover classes namely crown cover ≤ 8.0% (for Asumura, Sefwi Wiawso, Akontombra and Nkawie districts); 8.1 -14.9% (Adabokrom, Sankore, Goaso and Offinso districts); and crown cover ≥15.0% (New Edubiase and Asempanaye districts). This means that only 20% of cocoa in the sampled districts (two districts out of ten) is grown under shade regimes of 15% crown cover and above, while 40% of cocoa (four districts out of ten) is grown under shade regimes of up to 8% crown cover, and between 8.1 and 14.9% crown cover. Carbon stocks associated with each of these classes of shade/crown cover increased with increasing crown cover. For the different crown cover classes, i.e. crown cover ≤ 8.0%, 8.1 -14.9% and crown cover ≥15.0%, average total carbon stocks were 12.1 ± 0.52, 16.2 ±0.587 and 21.0 ±2.45 Mg C ha-1. The carbon dioxide equivalent of total carbon (Mg CO2- ha-1) ranged from 40.0 to 85.9 Mg CO2- ha-1 with the average across districts being 56.8 ±4.38 Mg CO2- ha-1.

6.1.6 Feasibility of implementing REDD+ interventions in studied cocoa landscapes

Significant opportunities exist to develop cocoa-carbon projects in Ghana. However, the extent to which cocoa landscapes would contribute to the realisation of REDD+ objectives hinges very much on Ghana's definition of forest. In line with requirements under the REDD+ readiness efforts, Ghana defined its forests as being a minimum of 1 hectare, having at least 15% canopy cover and containing trees that are at least 5 m tall. The shade trees in the cocoa system, however, could constitute a forest if they offer enough canopy cover beyond the 15% and are taller than 5 m. Thus, the forest definition and type of cocoa system (monoculture vs. shade) have serious implications for the viability of REDD+ interventions. Two out of the ten study districts, New Edubiase and Asempanaye, had crown cover of 15% and 16.3% respectively and technically qualify to be defined as forests and inclusion for REDD+ intervention activities. By judiciously selecting shade trees and integrating them into cocoa systems by planting them in a manner designed to offer optimal ecological and socio-economic benefits, cocoa landscapes in the other study districts have the potential of contributing positively to the country's REDD+ efforts. Full-sun plantations with cocoa trees up to the defined 5-metre height would constitute a forest and therefore would qualify for REDD+.

6.1.7 Land and tree tenure challenges and barriers hindering shade tree incorporation in the cocoa systems in the project area

Various land and tree tenure challenges exist in the study area. With respect to land tenure, the challenge has to do with the apparent confusion over the duration of the *abunu* tenancy. The general understanding has been that, once the farm is shared, the portion given to the tenant now belongs to him. While most of the farmers have this understanding and claimed that the *abunu* system grants an indefinite ownership of land to tenants who can bequeath such lands to children or relatives, others, especially landowners, had contrary views. In practice this gives the landowner the right to reclaim the land if (1) the cocoa farm is no more or the cocoa trees overage and die out; (2) the land is used to grow any crop other than cocoa; (3) the land is left uncultivated for a long period; or (4) the tenant dies. They believed that landowners have the right to negotiate with tenants regarding the duration of *abunu* tenancy. With the current pervasive land scarcity, landowners are increasingly maintaining the right and claim to negotiate with tenants regarding the duration of *abunu* tenancy under terms which are usually to the detriment of tenants. In some of the study districts, landlords have intimated that recent discussions at the traditional council levels point to support for the renegotiation of the *abunu* agreement after a 50-year period, however, this has not yet been operationalised.

There are also several conflicts arising from both the *abusa* and *abunu* sharecropping systems and these have been acknowledged by both the landlords and tenant farmers. Some of the more common causes of conflicts between landlords and tenants reported by the respondents include, but are not limited to, the following:

- Dishonesty on the part of tenants, e.g. not declaring the correct cocoa yields and incomes
- *Abunu* landlords harvesting food from the yet to be shared *abunu* farm without permission from the tenant
- Poor management of farms by tenants when the farm is not shared. This is usually a problem when tenants manage multiple farms
- Landlords giving tenants additional work outside the primary activity of taking care of the cocoa farm. Some landowners desire to use tenants as labourers at their homes and on other farms belonging to the landowner
- Disagreements related to cost of maintenance, inputs and harvesting when the farm has not been shared
- Non-disclosure of conditions governing tenancy arrangements to tenants right from the beginning of the agreement. Upon realising the full implication of some agreements the sharecropper may decide to end the agreement leading to conflicts
- Naturally difficult-to-please landlords who complain about everything and want to take advantage of tenants.

These developments have implications for farmer tree planting and therefore the adoption of cocoa agroforestry and ultimately for REDD+. This is because farmers who lack secure and long-term rights to land are unlikely to invest in tree planting.

A major challenge still remaining, and which could serve as a barrier to the incorporation of shade trees, is the tenure over naturally growing economic trees in cocoa and other cash crop plantations. When combined with a preference for full-sun cocoa over shade production systems, the current tree tenure system where state owns all naturally-occurring trees and farmers have no ownership right over naturally growing economic trees in their cocoa farms, creates a disincentive for farmers to keep naturally economic trees in cocoa farms. This has implications for farmers' contribution to REDD+ targets as farmers are encouraged to replace natural economic trees with cocoa. However, the aspect of the policy which gives right of ownership to the one who planted the tree provides hope for REDD+ implementation in cocoa farms, whereby farmers can integrate trees into their farms through planting.

While several *abunu* farmers intimated that they are permitted to plant trees on their cocoa farms once the farm is shared, the majority of them admitted they had never planted any trees on their farms. The main challenge militating against farmers planting trees on their farms is the perception or fear that timber concessionaires would in the future come to harvest trees and destroy their farms with little or no compensation.

6.2 Recommendations

In the light of these conclusions, the following recommendations are made:

i. There is already a high mixture of shade trees on the cocoa systems investigated in this study. Any efforts at sustaining or improving this trend should also aim at maintaining the diversity of tree species. There is a need to educate farmers that the presence of trees on cocoa farms per se is not the cause of low yields being recorded on several farms. Consequently, there is the need for a concerted effort on the part of both NGOs and governmental bodies to strongly dissuade farmers from cutting down large stemmed trees on their farms where these are not adversely affecting cocoa production. This calls for intensive education. Where ecological benefits are targeted, efforts need to be intensified to improve local knowledge on the number of shade trees per unit area required for optimum benefits of shade tree presence of cocoa farms.

ii. There is also the need to educate farmers on the potential of monetary benefits from REDD+ activities. Though the study did not specifically target farmers' knowledge of carbon benefits, it appears there is pervasive lack of knowledge among the broad generality of farmers about the potential of REDD+ strategies for managing cocoa farms. Broad stakeholder participation and access to credit and information are essential for the equitable and sustainable implementation of REDD+ policies. Increased participation is particularly important in terms of maximising local knowledge and capacity to support the implementation of REDD+.

iii. Yields on cocoa farms in the study districts were generally low. Strategies to improve the productivity of the smallholder cocoa farmers must include the promotion of improved cocoa technologies as it evidently enhances productivity of the smallholders. These must not come alone but with appropriate training on their use including approaches to the integration of shade trees on already existing cocoa farms.

iv. This study also recommends that a national effort is made to bring together information on the locations, sizes and number of cocoa farms. While different groups are making efforts to map out farms in the cocoa landscape, comprehensive data and information such as those suggested above is needed to develop a well-planned national REDD+ strategy.

v. The way out of the unending land tenure challenges and conflicts is by documentating the tenancy agreements and specifying the duration of the tenancy for the benefit of both tenants and landlords.

vi. In order to provide incentives to farmers and tree planters to participate in afforestation and reforestation programmes, as well as integrate trees into farming systems including cocoa systems, the government of Ghana has reviewed the tree tenure system in Ghana. Until the introduction of the Timber Resources Management (Amendment) Act of 2002, all timber species were vested in the government. The Timber Resources Management (Amendment) Act of 2002 presently assigns rights of tenure to planters. The majority of farmers still do not know this, and it also appears some officials who are supposed to make this known to the farmers are also not informed. There is the need to educate both farmers and forestry and agricultural officials on this new status of tree tenure.

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Appendix 1

Relative abundance of non-cocoa tree species on smallholder cocoa agroforestry systems in 10 cocoa growing districts

1A. Sefwi Adabokrom and Sefwi Akontombra

Adabokrom	No. of species	Species relative abun-dance (%)	Akontombra	No. of species	Species relative abundance (%)
Ficus exasperata	10	10	*Persea americana*	14	16.7
Citrus sinensis	9	9	*Gliricidia sepium*	11	13.1
Bombax buonopozense	7	7	*Citrus sinensis*	9	10.7
Sterculia tragacantha	7	7	*Spathodea campanulata*	9	10.7
Mangifera indica	6	6	*Morinda lucida*	7	8.3
Milicia excelsa	4	4	*Rauvolfia vomitoria*	5	6.0
Terminalia superba	4	4	*Lannea welwitschii*	3	3.6
Albizia ferruginea	3	3	*Albizia adianthifolia*	2	2.4
Alstonia boonei	3	3	*Celtis mildbraedii*	2	2.4
Amphimas pterocarpoides	3	3	*Newbouldia laevis*	2	2.4
Antiaris toxicaria	3	3	*Pycnanthus angolensis*	2	2.4
Distermonanthus benthami-anus	3	3	*Ricinodendron heudelotii*	2	2.4
Ficus sur	3	3	*Sterculia rhinopetala*	2	2.4
Ficus vogelii	3	3	*Albizia zygia*	1	1.2
Holarrhaena floribunda	3	3	*Alstonia boonei*	1	1.2
Albizia adianthifolia	2	2	*Antiaris toxicaria*	1	1.2
Anacardia occidentalis	2	2	*Aukuobaka aubrevillei*	1	1.2
Ceiba pentandra	2	2	*Cocus nucifera*	1	1.2
Cordia millenii	2	2	*Dialium guineensis*	1	1.2
Discoglypremna caloneura	2	2	*Distermonanthus benth-amianus*	1	1.2
Ficus carpensis	2	2	*Entandrophragma ango-lense*	1	1.2
Morinda lucida	2	2	*Ficus sur*	1	1.2
pouteria altissima	2	2	*Harungana madagascar-iense*	1	1.2
Afzelia bella	1	1	*Milicia excelsa*	1	1.2
Albizia zygia	1	1	*Nesogordonia papaverifera*	1	1.2
Funtumia elastica	1	1	*Piptadeniastrum africanum*	1	1.2
Lannea welwitschii	1	1	*Spondias mombin*	1	1.2
Nesogordonia papaverifera	1	1			
Newbouldia laevis	1	1			
Persea americana	1	1			
Pycnanthus angolensis	1	1			
Rauvolfia vomitoria	1	1			
Ricinodendron heudelotii	1	1			
Spathodea campanulata	1	1			
Trema orientalis	1	1			
Vitex ferruginea	1	1			

1B. Sefwi Asempaneye and Asumura

Asempaneye	No. of spe-cies	Species relativea-bundance (%)	Asumura	N0.of spe-cies	Species relative abundance (%)
Triplochiton scleroxylon	13	10.2	*Newbouldia laevis*	70	47.6
Persea americana	11	8.6	*Citrus sinensis*	12	8.2
Ficus exasperata	9	7.0	*Morinda lucida*	7	4.8
Terminalia superba	8	6.3	*Antiaris toxicaria*	6	4.1
Bombax buonopozense	5	3.9	*Entandrophragma ango-lense*	4	2.7
Ficus carpensis	5	3.9	*Alstonia boonei*	3	2.0
Lecaniodiscus cupanoides	5	3.9	*Milicia excelsa*	3	2.0
Amphimas pterocarpoides	4	3.1	*Persea americana*	3	2.0
Ceiba pentandra	4	3.1	*Albizia ferruginea*	2	1.4
Entandrophragma ango-lense	4	3.1	*Albizia zygia*	2	1.4
Spathodea campanulata	4	3.1	*Amphimas pterocarpoides*	2	1.4
Alstonia boonei	3	2.3	*Bombax buonopozense*	2	1.4
Blighia sapida	3	2.3	*Ceiba pentandra*	2	1.4
Discoglypremna caloneura	3	2.3	*Celtis mildbraedii*	2	1.4
Mangifera indica	3	2.3	*Lannea welwitschii*	2	1.4
Albizia ferruginea	2	1.6	*Myrianthus arboreus*	2	1.4
Albizia zygia	2	1.6	*Rauvolfia vomitoria*	2	1.4
Cola gigantea	2	1.6	*Strombosia glaucescens*	2	1.4
Cordia millenii	2	1.6	*Baphia pubescens*	1	0.7
Khaya ivorensis	2	1.6	*Carapa procera*	1	0.7
Lannea welwitschii	2	1.6	*Cocus nucifera*	1	0.7
Macaranga heterophyla	2	1.6	*Ficus carpensis*	1	0.7
Milicia excelsa	2	1.6	*Ficus vogelii*	1	0.7
Morinda lucida	2	1.6	*Guibortia leonensis*	1	0.7
Newbouldia laevis	2	1.6	*Hannoa klaineana*	1	0.7
Pycnanthus angolensis	2	1.6	*Holarrhaena floribunda*	1	0.7
Ricinodendron heudelotii	2	1.6	*Khaya anthotheca*	1	0.7
Terminalia ivorensis	2	1.6	*Mangifera indica*	1	0.7
Trichilia tessmannii	2	1.6	*Mansonia altissima*	1	0.7
Antiaris toxicaria	1	0.8	*Ricinodendron heudelotii*	1	0.7
Beilschmiedia mannii	1	0.8	*Spathodea campanulata*	1	0.7
Celtis zenkeri	1	0.8	*Sterculia oblonga*	1	0.7
Chrysophyllum perpul-chrum	1	0.8	*Sterculia tragacantha*	1	0.7
Erythrina vogelii	1	0.8	*Terminalia ivorensis*	1	0.7
Ficus sur	1	0.8	*Terminalia superba*	1	0.7

Funtumia elastica	1	0.8	*Trichilia tessmannii*	1	0.7
Hannoa klaineana	1	0.8	*Zanthoxylum gillettii*	1	0.7
Macaranga barteri	1	0.8			
Monodora myristica	1	0.8			
Morus mesozygia	1	0.8			
Pierreodendron kerstingii	1	0.8			
Pterygota macrocarpa	1	0.8			
Scottellia klaineana	1	0.8			
Sterculia tragacantha	1	0.8			
Trichilia monadelpha	1	0.8			

1C. Goaso and New Edubiase

Goaso	No. of species	Species relative abundance (%)	New Edubiase	No. of species	Species relative abundance (%)
Milicia excelsa	14	9.5	*Newbouldia laevis*	45	24.3
Sterculia tragacantha	13	8.8	*Persea americana*	18	9.7
Persea americana	12	8.2	*Celtis mildbraedii*	11	5.9
Morinda lucida	8	5.4	*Amphimas pterocarpoides*	10	5.4
Celtis mildbraedii	7	4.8	*Ceiba pentandra*	8	4.3
Citrus sinensis	7	4.8	*Ficus exasperata*	8	4.3
Ficus exasperata	6	4.1	*Terminalia superba*	7	3.8
Albizia zygia	5	3.4	*Milicia excelsa*	6	3.2
Amphimas pterocarpoides	4	2.7	*Spathodea campanulata*	6	3.2
Ceiba pentandra	4	2.7	*Petersianthus marcrocarpus*	5	2.7
Ricinodendron heudelotii	4	2.7	*Antiaris toxicaria*	4	2.2
Ficus carpensis	3	2.0	*Alstonia boonei*	3	1.6
Ficus vogelii	3	2.0	*Bombax buonopozense*	3	1.6
Nauclea diderrichii	3	2.0	*Citrus sinensis*	3	1.6
Newbouldia laevis	3	2.0	*Cola nitida*	3	1.6
Spathodea campanulata	3	2.0	*Ficus capensis*	3	1.6
Terminalia superba	3	2.0	*Hannoa klaineana*	3	1.6
Albizia adianthifolia	2	1.4	*Holarrhaena floribunda*	3	1.6
Antiaris toxicaria	2	1.4	*Nesogordonia papaverifera*	3	1.6
Bombax buonopozense	2	1.4	*Albizia zygia*	2	1.1

Daniellia ogea	2	1.4	*Antrocaryon micraster*	2	1.1
Entandrophragma angolense	2	1.4	*Entandrophragma angolense*	2	1.1
Ficus trichopoda	2	1.4	*Ficus sur*	2	1.1
Holarrhaena floribunda	2	1.4	*Lannea welwitschii*	2	1.1
Lannea welwitschii	2	1.4	*Pterygota macrocarpa*	2	1.1
Margaritaria discoidea	2	1.4	*Sterculia rhinopetala*	2	1.1
Nesogordonia papaverifera	2	1.4	*Sterculia tragacantha*	2	1.1
Rauvolfia vomitoria	2	1.4	*Albizia adianthifolia*	1	0.5
Trichilia tessmannii	2	1.4	*Albizia ferruginea*	1	0.5
Albizia ferruginea	1	0.7	*Anacardia occidentalis*	1	0.5
Albizia glaberima	1	0.7	*Blighia unijugata*	1	0.5
Anacardia occidentalis	1	0.7	*Carapa procera*	1	0.5
Blighia unijugata	1	0.7	*Cola gigantea*	1	0.5
Canarium schweinfurthii	1	0.7	*Dialium guineensis*	1	0.5
Carapa procera	1	0.7	*Distermonanthus benthamianus*	1	0.5
Celtis zenkeri	1	0.7	*Ficus vogelii*	1	0.5
Erythrina vogelii	1	0.7	*Margaritaria discoidea*	1	0.5
Ficus sur	1	0.7	*Morinda lucida*	1	0.5
Hannoa klaineana	1	0.7	*Nauclea diderrichii*	1	0.5
Khaya anthotheca	1	0.7	*Ricinodendron heudelotii*	1	0.5
Khaya ivorensis	1	0.7	*Trema orientalis*	1	0.5
Lecaniodiscus cupanoides	1	0.7	*Trichilia tessmannii*	1	0.5
Mangifera indica	1	0.7	*Turraeanthus africanus*	1	0.5
Morus mesozygia	1	0.7	*Zanthoxylum gilletii*	1	0.5
Nauclea latifolia	1	0.7			
Pycnanthus angolensis	1	0.7			
Strombosia glaucescens	1	0.7			
Terminalia ivorensis	1	0.7			
Vitex ferruginea	1	0.7			
Zanthoxylum gilletii	1	0.7			

1D. Nkawie and Offinso

Nkawie	No. of species	Species relative abundance (%)	Offinso	No. of species	Species relative abundance (%)
Morinda lucida	18	13.2	*Citrus sinensis*	49	24.0
Terminalia ivorensis	14	10.3	*Cola nitida*	30	14.7
Persea americana	12	8.8	*Persea americana*	21	10.3
Citrus sinensis	8	5.9	*Ficus exasperata*	12	5.9
Newbouldia laevis	8	5.9	*Milicia excelsa*	8	3.9
Sterculia tragacantha	7	5.1	*Celtis mildbraedii*	7	3.4
Antiaris toxicaria	5	3.7	*Dracaena mannii*	7	3.4
Ficus sur	5	3.7	*Morinda lucida*	5	2.5
Holarrhaena floribunda	5	3.7	*Okoubaka aubrevillei*	4	2.0
Ficus carpensis	4	2.9	*Ricinodendron heudelotii*	4	2.0
Funtumia elastica	4	2.9	*Chrysophyllum subnidum*	3	1.5
Milicia excelsa	4	2.9	*Citrus reticulata*	3	1.5
Voacanga africana	4	2.9	*Distermonanthus benthamianus*	3	1.5
Ficus vogelii	3	2.2	*Sterculia tragacantha*	3	1.5
Mangifera indica	3	2.2	*Terminalia superba*	3	1.5
Ricinodendron heudelotii	3	2.2	*Alstonia boonei*	2	1.0
Albizia zygia	2	1.5	*Calpocalyx brevibracteatus*	2	1.0
Cedrella odorata	2	1.5	*Ceiba pentandra*	2	1.0
Ficus exasperata	2	1.5	*Erythrina vogelii*	2	1.0
Lannea welwitschii	2	1.5	*Ficus sur*	2	1.0
Psidium guajava	2	1.5	*Holarrhaena floribunda*	2	1.0
Afzelia bella	1	0.7	*Pierreodendron kerstingii*	2	1.0
Albizia adianthifolia	1	0.7	*Pycnanthus angolensis*	2	1.0
Albizia ferruginea	1	0.7	*Terminalia ivorensis*	2	1.0
Albizia glaberrima	1	0.7	*Trichilia tessmannii*	2	1.0
Antrocaryon micraster	1	0.7	*Vernonia amygdalina*	2	1.0
Bombax buonopozense	1	0.7	*Amphimas pterocarpoides*	1	0.5
Citrus reticulata	1	0.7	*Bombax buonopozense*	1	0.5
Cola gigantea	1	0.7	*Cedrella odorata*	1	0.5

Cola nitida	1	0.7	*Chrysophyllum perpulchrum*	1	0.5
Dialium dinklagei	1	0.7	*Cola gigantea*	1	0.5
Entandrophragma angolense	1	0.7	*Daniellia ogea*	1	0.5
Hannoa klaineana	1	0.7	*Discoglypremna caloneura*	1	0.5
Monodora myristica	1	0.7	*Entandrophragma angolense*	1	0.5
Nesogordonia papaverifera	1	0.7	*Ficus carpensis*	1	0.5
Rauvolfia vomitoria	1	0.7	*Hannoa klaineana*	1	0.5
Scottellia klaineana	1	0.7	*Lonchocarpus santalinoides*	1	0.5
Spathodea campanulata	1	0.7	*Mangifera indica*	1	0.5
Trichilia tessmannii	1	0.7	*Millettia rhodantha*	1	0.5
Trilepisium madagascariense	1	0.7	*Myrianthus arboreus*	1	0.5
			Nesogordonia papaverifera	1	0.5
			Newbouldia laevis	1	0.5
			Rauvolfia vomitoria	1	0.5
			Spathodea campanulata	1	0.5
			Tetrapleura tetraptera	1	0.5
			Vitex ferruginea	1	0.5

1E. Sankore and Sefwi Wiawso

Sankore	Number of species	Species relative abundance (%)	Wiawso	Number of species	Species relative abundance (%)
Newbouldia laevis	12	11.1	*Newbouldia laevis*	78	47.3
Ficus capensis	10	9.3	*Persea americana*	18	10.9
Ficus exasperata	7	6.5	*Milicia excelsa*	10	6.1
Persea americana	7	6.5	*Terminalia superba*	8	4.8
Celtis mildbraedii	6	5.6	*Albizia zygia*	4	2.4
Citrus sinensis	6	5.6	*Cola gigantea*	4	2.4
Gmelina arborea	6	5.6	*Gliricidia sepium*	4	2.4
Sterculia tragacantha	6	5.6	*Morinda lucida*	4	2.4
Morinda lucida	5	4.6	*Albizia adianthifolia*	2	1.2
Ricinodendron heudelotii	5	4.6	*Citrus sinensis*	2	1.2
Entandrophragma angolense	4	3.7	*Distermonanthus benthamianus*	2	1.2

Daniellia ogea	3	2.8	*Entandrophragma angolense*	2	1.2
Myrianthus arboreus	3	2.8	*Ficus exasperata*	2	1.2
Pycnanthus angolensis	3	2.8	*Nesogordonia papaverifera*	2	1.2
Antiaris toxicaria	2	1.9	*Spathodea campanulata*	2	1.2
Aubrevillea kerstingii	2	1.9	*Terminalia ivorensis*	2	1.2
Milicia excelsa	2	1.9	*Tetrapleura tetraptera*	2	1.2
Spathodea campanulata	2	1.9	*Alstonia boonei*	1	0.6
Afzelia bella	1	0.9	*Canarium schweinfurthii*	1	0.6
Amphimas pterocarpoides	1	0.9	*Cecropia peltata*	1	0.6
Bombax buonopozense	1	0.9	*Celtis mildbraedii*	1	0.6
Ceiba pentandra	1	0.9	*Cola caricifolia*	1	0.6
Cola caricifolia	1	0.9	*Entandrophragma candollei*	1	0.6
Cola nitida	1	0.9	*Lannea welwitschii*	1	0.6
Distermonanthus benthamianus	1	0.9	*Mangifera indica*	1	0.6
Ficus sur	1	0.9	*Rhodognaphalon brevicuspe*	1	0.6
Hannoa klaineana	1	0.9	*Rauvolfia vomitoria*	1	0.6
Mangifera indica	1	0.9	*Ricinodendron heudelotii*	1	0.6
Margaritaria discoidea	1	0.9	*Scottellia klaineana*	1	0.6
Nesogordonia papaverifera	1	0.9	*Spondias mombin*	1	0.6
Sterculia rhinopetala	1	0.9	*Sterculia rhinopetala*	1	0.6
Terminalia superba	1	0.9	*Treculia africana*	1	0.6
Trichilia monadelpha	1	0.9	*Trema orientalis*	1	0.6
Trilepisium madagascariense	1	0.9	*Triplochiton scleroxylon*	1	0.6
Vernonia amygdalina	1	0.9			

Appendix 2

List of cocoa districts and communities or sites selected for the study and associated field plots and their coordinates

Cocoa District*	Community/site	Plot	Coordinate
Offinso	Amfaaso	1	N7.02591 W1.67365
		2	N7.02564 W1.68072
		3	N7.02667 W1.66850
		4	N7.02812 W1.66400
		5	N7.03169 W1.66038
		6	N7.03600 W1.65504
		7	N7.02643 W1.66471
		8	N7.02165 W1.66239
		9	N7.01743 W1.65635
New Edubiase	Akromaso	1	N6.12878 W1.52733
		2	N6.13193 W1.53090
		3	N6.13505 W1.53458
		4	N6.12369 W1.52695
		5	N6.12014 W1.52898
		6	N6.11787 W1.53505
		7	N6.12520 W1.52215
		8	N6.12527 W1.51711
		9	N6.12619 W1.51190
Goaso	Manhyia	1	N6.69358 W2.38096
		2	N6.69018 W2.37789
		3	N6.68781 W2.37242
		4	N6.69566 W2.37828
		5	N6.69765 W2.37372
		6	N6.70003 W2.36836
		7	N6.69488 W2.38630
		8	N6.69545 W2.39115
		9	N6.69364 W2.39580
Sankore	Opongkrom	1	N6.47100 W2.45658
		2	N6.46782 W2.45843
		3	N6.46325 W2.46091
		4	N6.47386 W2.45399
		5	N6.47081 W2.44852
		6	N6.47170 W2.44406
		7	N6.48097 W2.45716
		8	N6.48533 W2.45529
		9	N6.48972 W2.45311
Asumura	Pomaakrom	1	N6.64472 W2.83697
		2	N6.64151 W2.83344
		3	N6.63743 W2.82986
		4	N6.64496 W2.84104
		5	N6.64061 W2.84246
		6	N6.63500 W2.84400
		7	N6.64818 W2.83962
		8	N6.65282 W2.84063
		9	N6.65921 W2.83970

Nkawie	Nerebehi	1	N6.70509 W1.81791
		2	N6.70729 W1.81031
		3	N6.70760 W1.80471
		4	N6.70090 W1.82471
		5	N6.69790 W1.82646
		6	N6.69350 W1.82872
		7	N6.70480 W1.82613
		8	N6.70947 W1.82945
		9	N6.71052 W1.83607
Akontombra Wiaso	Bokaso	1	N6.05481 W2.89571
		2	N6.05333 W2.88891
		3	N6.05553 W2.88200
		4	N6.05086 W2.90240
		5	N6.04776 W2.90837
		6	N6.04291 W2.91391
		7	N6.05457 W2.90173
		8	N6.05552 W2.90711
		9	N6.05818 W2.91115
Sefwi Sefwi	Fawokabra	1	N6.13108 W2.62504
		2	N6.12670 W2.62171
		3	N6.12367 W2.61831
		4	N6.13921 W2.62682
		5	N6.14381 W2.62506
		6	N6.14864 W2.62679
		7	N6.13790 W2.63085
		8	N6.14103 W2.63721
		9	N6.14462 W2.64270
Sefwi Adabokrom	Bredi	1	N6.84473 W3.06380
		2	N6.84918 W3.06701
		3	N6.85309 W3.06893
		4	N6.84348 W3.05938
		5	N6.84438 W3.05391
		6	N6.84339 W3.04854
		7	N6.83913 W3.06580
		8	N6.83462 W3.06476
		9	N6.83021 W3.06758
Sefwi Asempanaye	Sayerano	1	N6.46497 W2.85617
		2	N6.46021 W2.85419
		3	N6.45736 W2.84913
		4	N6.47860 W2.84688
		5	N6.48363 W2.84456
		6	N6.48795 W2.84281
		7	N6.47144 W2.86222
		8	N6.47115 W2.86819
		9	N6.46964 W2.87372

*COCOBOD classification

Appendix 3

Photos of fieldwork and other activities



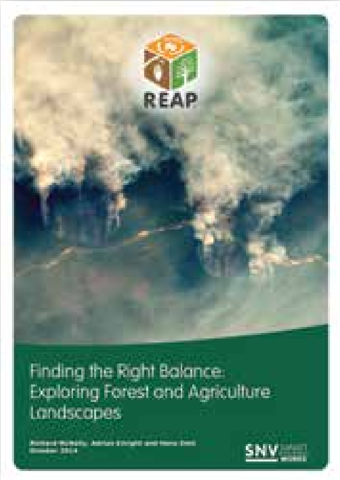


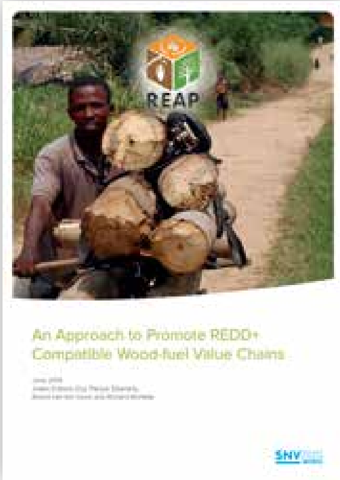

23.05.2014

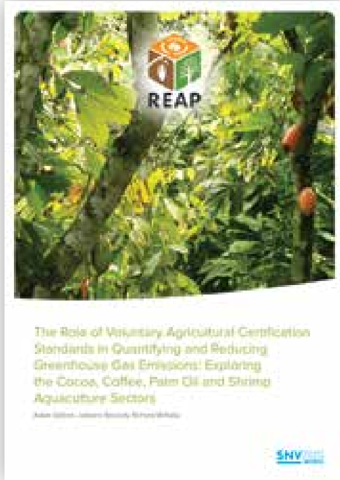


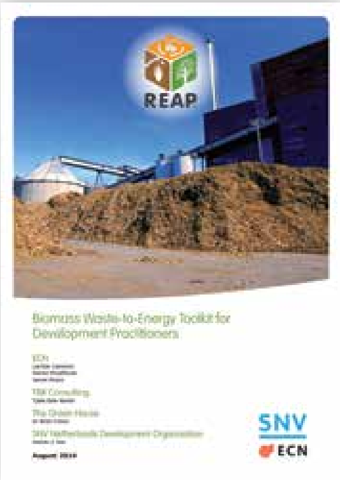


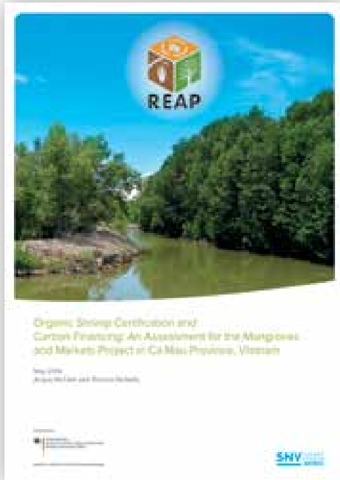












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