Motivations for shade-grown cocoa production in Ghana

A research into the motivations of Ghanaian cocoa farmers in the Nyinahini and Bia projects of the Agro Eco-Louis Bolk Institute whether or not to produce cocoa under shady circumstances and which shade tree species are found most desirable or undesirable.

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Foreword

“A person can do a lot with the right attitude and people on his or her side.”

At the beginning of the research I asked myself the question “How much can I do in five months to help the cocoa farmers in Ghana to improve their livelihoods. Looking back at the research I can say that you can reach a lot when you are really willing to do something to make a change and when you have the right people on your side. I would like to thank Agro Eco – Louis Bolk Institute for providing me the opportunity to carry out my thesis research. Most parts of the research, from accommodation to transport and the interviewing of the farmers, organizations, research institutes and companies, were arranged very well and worked out pretty good. I am very grateful for all the people who were willing to help and share their knowledge during the research. It would have been impossible to bring the research to this end and to do so much work in a relatively short time without them. I also would like to thank all the farmers that were interviewed individually and in focus groups for their time and patience to answer all my questions. Furthermore, I would like to thank the translators Dennis Oppong, Samuel Apana and Seth Bruni and my supervisors Willem – Albert Toose (Agro Eco – Louis Bolk Institute) and Erika van Duijl (University Van Hall Larenstein) for their feedback during and after the research. A special thanks to Denise Dahrs who assisted and supported me during the research wherever she could. Sustainable cocoa production is a very accurate subject at the moment, so hopefully the information in this report could be used as back ground information and as stepping stone for follow up research. I have tried to write the report in such a way that it is also understandable for people who are not familiar with the research or the jargon.

Summary

Large areas of tropical forests have been cleared to support the increasing cocoa production in Ghana, resulting in one of the highest deforestation rates in Africa (Gyampoh, A.B., 2011). Besides, the unsustainable production of cacao beans leads to more vulnerable trees that need more and more chemical fertilizers and pesticides to survive. Most farmers are not able to buy enough fertilizers or pesticides to keep the production of cocoa high, which causes that nearly a third of the crops are destroyed each year due to pest and disease pressure (Beer, J., e.a., 1988). Farmers used to grow cacao in shade tree agroforestry systems in the past by using beneficial trees for the cacao plants as well as for the farmer (Gyampoh, A.B., 2011). This research focused on the motivations of Ghanaian cocoa farmers in the Nyinahini and Bia project of the Agro Eco – Louis Bolk Institute whether or not to grow cocoa under shady circumstances, what elements determine those motivations and which tree species are found most desirable or undesirable to grow as shade trees on a cocoa farm.

Two project areas of the Agro Eco – Louis Bolk Institute were selected to interview cocoa farmers from different communities and social backgrounds. Semi-structured interviews were used to interview farmers individually and in focus groups on their motivations whether or not to grow shade trees on a cocoa farm. Ninety farmers were interviewed individually and another ninety within focus groups of ten farmers. Several organizations, research institutes and companies have also been visited to collect more background information about the advantages and disadvantages of shade trees on cocoa farms and to find out which shade tree species they promote. A list of the most desirable or undesirable tree species was composed by using the answers from the two project areas. Those answers were combined with the lists from three other stakeholders, the Cocoa Research Institute of Ghana (CRIG) and two literature sources (Asare, R., 2006 and Anglaaere, L.C.N., 2005). The final list was used to create a field guide “Shade tree guide for Ghanaian cocoa farmers” that shows the most desirable or undesirable shade tree species on a cocoa farm. The guide contains pictures to identify the different trees and icons to provide information about the different purposes and pre-germination methods of the shade trees.

The conducted research has shown that the farmers seem to be aware of most advantages and disadvantages that shade trees provide. The results indicate that all the farmers who were interviewed individually had shade trees on their farm and that most of them have already planted shade trees. Most farmers are willing to plant the shade trees because of the social, environmental and financial benefits that the trees might give. The most relevant arguments why the farmers would like to have (more) shade trees on their cocoa farm are “improvement of air and water quality” and “the increased lifetime of cocoa trees”. The most important argument not to grow shade trees on a cocoa farm was that chainsaw operators could come to the farm to cut the shade trees (illegally) and destroy the cocoa trees. The main elements that have determined their motivation not to plant (more) shade tree before are “no access to seedlings” and the “lack of knowledge on the positive and negative effects of shade trees on cocoa farms”. Twelve tree species were found most desirable. Another five tree species were found most undesirable. The reasons why those tree species are found most desirable are because of the purposes they could be used for like timber, firewood, medicines or fruits. The other tree species are found most undesirable as they host the Swollen-shoot virus which effects and destroys the cocoa trees, because they give too much shade or acidify the soil.

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1. Introduction

Cocoa (*Theobroma cacao*) originally is an under-story tree crop from the Amazon Forest and tolerates a considerable degree of shade. The tree grows well in combination with other tree species that give shade to the cacao trees and provide other benefits for the farmer, like food, fruit, timber and fuel wood. Shade reduces the stress on cocoa trees by improving climatic conditions and nutritional imbalances in the soil (Beer, J., e.a., 1988). The tree crop is commonly grown by smallholder farmers in the lowland tropics, including parts of Latin America, West Africa and Indonesia. Some smallholder farmers use 'agroforestry' systems for the production of their cocoa (Franzen, M. and Borgerhoff Mulder, M., 2007). Agroforestry is an approach whereby trees, plants and animals are combined in conservative, long-term productive (agricultural) systems (Motis, T. 2007). Sometimes primary or secondary forests are thinned and cocoa is planted underneath the remaining canopy of native tree species. A system whereby (cultivated) shade tree species are planted in between the cocoa trees is also commonly used. Furthermore, there is the full-sun cocoa production system. Cocoa trees are not grown in the shade of other trees anymore, but exposed to more extreme climatic conditions like wind, rain and high temperatures. More and more farmers start to use this method because of lower labor costs and higher short-term yields (Franzen, M. and Borgerhoff Mulder, M., 2007). However, the production of cocoa under full-sun circumstances seems to be unsustainable as it affects the long-term productivity of the cocoa trees and decreases the soil fertility within a few years. The unsustainable production of cacao beans leads to vulnerable trees that need more and more chemical fertilizers and pesticides to survive. Nearly a third of the crops are destroyed each year due to pest and disease pressure, meaning a total loss of $2.4 billion annually (Guyton, B., et al, 2003). Consequences that arise from this production method cause serious problems, such as decreasing soil fertility, ozone layer depletion, freshwater pollution and human toxicity (Afrane, G. and Ntiamoah, A., 2007). Harvesting and maintenances costs increase with the age of cocoa trees and the decline in production of a farm forces farmers to move to 'new' fertile land. Large areas of tropical forests have been cleared to support the existing and increasing cocoa production in Ghana, resulting in one of the highest deforestation rates in Africa (Gyampoh, A.B., 2011). The cocoa sector in the Netherlands has indicated to tend for a 100% sustainable cocoa sector by 2025 (Rijksoverheid, 2010). However, the demand for sustainably produced cocoa is *increasing* while the offer of this product is *decreasing*. Farmers have to change their production methods and start using sustainable production systems to maintain and guarantee a sufficient and high quality supply of cacao beans to meet the demand of its consumers now and in the future (Meyer, M.K., 2004). How could shade trees contribute to the sustainable production of cocoa, what motivates farmers whether or not to grow cocoa under shaded circumstances and which elements determine those motivations?

This research, carried out on request of the Agro Eco - Louis Bolk Institute, attempts to answer the questions mentioned above and focuses on the shade tree species that are found most desirable or undesirable to grow on a cocoa farm. This report contains information on how shade trees contribute to the sustainable production of cocoa beans and which advantages and disadvantages come along with the introduction of shade trees on cocoa farms. A description of the methodology that was used during the research and the results that came up are included and a conclusion and recommendations for follow-up researches are attached.

1.1. Problem analysis

Farmers used to grow cacao in shade tree agroforestry systems in the past by using beneficial trees for the cacao plants as well as for the farmer (Gyampoh, A.B., 2011). However, traditional shade grown cocoa agroforestry systems have undergone a transition after the promotion of non-shaded and more intensively managed cocoa plantations. More and more farmers start to transform their cocoa production methods from the original sustainable production systems into full-sun grown systems. Farmers are interested in this methodology because of lower labor costs and higher short-term yields (Franzen, M. and Borgerhoff Mulder, M., 2007). However, the production of cocoa under full-sun circumstances has been found unsustainable as it affects the long-term productivity of the cocoa trees and decreases the soil fertility within a few years. Besides, the unsustainable production of cacao beans leads to more vulnerable trees that need more and more chemical fertilizers and pesticides to survive. Most farmers are not able to buy enough fertilizers or pesticides to keep the production of cocoa high. This problem causes that nearly a third of the crops is destroyed each year due to pest and disease pressure, meaning a total loss of $2.4 billion annually (Beer, J., e.a., 1988). Large areas of tropical forests have been cleared over the last few years to support the existing and increasing cocoa production in Ghana. This process has resulted in one of the highest deforestation rates in Africa (Gyampoh, A.B., 2011). Farmers have to start using sustainable production systems to maintain and guarantee a sufficient and high quality supply of cocoa beans. It will not be possible to meet the demand of cocoa consumers now and in the future when the farmers keep using unsustainable production methods (Meyer, M.K., 2004). Different certification bodies have set up programs for sustainable cocoa production to help and train farmers to use good agricultural practices, efficient farm management and responsible production of their cocoa. Besides, the different programs help to enable farmers to improve their working conditions and take better care of their children and the environment. Each certification body has set standards which farmer have to meet to guarantee a responsible and sustainable production of their cocoa (UTZ Certified, 2009).

1.2. Research objective

The main objective of this research is to better understand farmers' motivations whether or not to produce cocoa under shady circumstances with environmental and financial benefits.

Research questions that have been addressed during the research:

What motivates a Ghanaian cocoa farmer in the Nyinahini or Bia projects of the Agro Eco-Louis Bolk Institute whether or not to produce cocoa under shady circumstances with environmental, social and financial benefits?

- What are the advantages and disadvantages of shade trees on cocoa farms?
- What influences farmers' motivation for producing cocoa under shady circumstances?
- Which tree species are found most desirable and undesirable to plant as shade tree on a cocoa field?
- Is a field guide that shows the desirable and undesirable shade tree species and their purposes found useful by the farmers?
- What else can be done to assist and stimulate farmers to produce cocoa under shady circumstances with environmental and financial benefits?

Several aspects have been investigated to answer the different research questions. The first aspect was to see if there is a difference in cocoa production between shaded and non-shaded cocoa farms. The research looked into the motivations of cocoa farmers whether or not they see shade trees on a cocoa farm as an advantage and which arguments are most relevant for them. Secondly, it was examined how many of the interviewed farmers have naturally regenerated or planted shade trees on their cocoa farms already. Furthermore, it was studied if the farmers would like to have more shade trees on their farms and which tree species they have found most desirable or undesirable to intercrop with. Following on this, a survey was conducted why farmers have not planted (more) shade trees before. At the end, the research looked at the shade tree species that are promoted by different stakeholders and if a field guide of the most desirable and undesirable shade tree species for cocoa farms, including their characteristics, should be created.

2. Methodology and research area

The research was sub-divided into four different parts to collect and process all the data. The main part of the research was the semi-structured interview. The questionnaire was used to understand the motivations of farmers whether or not to produce cocoa under shady circumstances. Two project areas of the Agro Eco – Louis Bolk Institute were selected to interview farmers individually and in focus groups. The first project area is Nyinahini, the second Bia.

2.1. Study area:

Both project areas are located in the South-West of Ghana, West-Africa. The Nyinahani project (6°28'25.16" N and 2°20'34.11" W) is situated in the South-West of the Atwima Mponua district in the Ashanti region. The Bia project (6°18'02.06" N and 2°55'17.66" W) is located close to Juabeso and part of the Western region. The distance between the two project areas is about 65 kilometers. Both areas lie in the wet semi-equatorial forest zone in Ghana and are marked by two rainy seasons. The major rainfall period, with an average annual rainfall of 1700 to 1850 millimeter, starts in March to July and peaks in May. The second rainfall period is less intense and begins in August to November with an average rainfall of 1000 to 1250 millimeter per year. December to February is hot, dry and dusty. Average temperatures of 27°C in August and 31°C in March are recorded in the area. The vegetation in both areas consists basically of semi-deciduous forests. However, the vegetation in Ghana has been extremely disturbed by human activities. Valuable tree species and other forest products have become rare. The forests that are left, mainly occur along major rivers and water streams (Agro Eco – Louis Bolk Institute, 2011). A Population and Housing Census was conducted in Ghana, in 2010. The results show a population density of 97 people per square kilometer in the Western Region (Bia project) while a population density of 194 people per square kilometer was recorded in the Ashanti Region (Nyinahini project) (Bediako, G., 2011). The majority of the farmers in Ghana are small-scale farmers. The most common farming system in the western part of Ghana is the Cash tree cropping system, which is based on the cultivation of tree crops as cocoa, oil palm, rubber and kola to sell on the market (Benneh, G., 1971). Cocoa is the main cash crop for the majority of the farmers and is commonly intercropped with food crop like plantain, cassava, yam or cocoyam. Some farmers even grow rice when they have agricultural fields along rivers or wet areas. Cocoa fields are 1.2 hectares in general and farmers grow a total of 2.8 hectares of cocoa on average. An average yield is 4.25 bags per hectare while five to eight bags could be expected. A bag of cocoa weights 64 kg and farmers received and average price of 140 Ghana Cedi (GHS) in 2010 per bag. This is €1.25 per kilogram, meaning an average income of €340.00 from cocoa (Vos , I., 2010). A map that indicates the location of both project areas is attached in Appendix I.

2.2. Methods

As mentioned above, two project areas were visited to interview farmers about their motivations whether or not to grow shade trees on cocoa farms. Furthermore, several organizations, research institutes and companies were visited to collect more background information about the advantages and disadvantages of shade trees on cocoa farms and to find out which shade tree species they promote to grow on cocoa farms. A list of the most desirable or undesirable tree species was composed by using the answers provided by the farmers from the two project areas. Those answers were combined with the lists from three other stakeholders: the Cocoa Research Institute of Ghana (CRIG) and two literature sources (Asare, R., 2006 and Anglaaere, L.C.N., 2005). The final list was used to create a field guide "Shade tree guide for Ghanaian cocoa farmers" that shows the most desirable or undesirable shade tree species on a cocoa farm. Furthermore it contains pictures to identify the different trees and icons which provide information about the different purposes and pre-germination methods of the shade trees.

As stated before, the research was sub-divided into four different parts to collect and process all the data. The methodology that was used for each part of the research is described below:

Part 1: Literature study

A literature study was conducted on the reasons for using shade in cocoa farms and on the advantages and disadvantages of shade trees for farmers. Online databases for scientific research documents and documents provided by Agro Eco – Louis Bolk Institute, were used to collect the preferred information.

Part 2: Individual interviews and focus groups:

The second step of the research was to understand the motivations of Ghanaian cocoa farmers to produce cocoa under shaded or non-shaded circumstances, which elements determine those motivations and which shade tree species are found most desirable or undesirable to grow on a cocoa plantation. Two project areas of the Agro Eco – Louis Bolk Institute were selected (see chapter 2.1.). Those areas were selected because of the contact persons and employees of Agro Eco – Louis Bolk Institute that live and work in the different communities and who were able to assist and translate during the interviews. Communities were selected on accessibility as some are very remote and hard to reach. There was no information available on the differences between the communities (e.g. distance to the forest, water resources or culture), so (accessible) communities were selected randomly. The research was conducted in four communities of the Nyinahini project and five communities of the Bia project to interview farmers individually and in focus groups. General information about the farmers and their farms can be found in appendix IV. Transportation to the different communities was arranged by motorcycles in the Nyinahini project and a four-wheel drive pick-up was used in the Bia project.

Individual interviews:

The individual interviews were carried out by two persons (Tijmen Hoogendijk and Denise Dahrs) to increase the efficiency and reduce the time that the farmers had to wait to be interviewed. Translators helped during the interviews as most of the farmers do not speak English. Field officers in the different communities were asked to select farmers randomly to create a broad target group with different ages, education levels and social and environmental backgrounds. A semi-structured interview, that took about 15 – 20 minutes, was used to interview a total of ninety firmest individually and collect data on several subjects. The topics that were addressed in the interviews are: general information about the farmer, general information about the farm, cocoa production, crop production, other tree species on the farm, opinion about shade trees and opinion about a field guide that shows the most desirable and undesirable shade tree species including their purposes. An example of the individual interview forms is attached in appendix II.

Focus group interviews:

Ten random farmers in each community were asked to join a focus group. The goal of the focus groups was to let the farmers discuss several topics related to shade trees on a cocoa farm. The first assignment was to give positive and negative arguments regarding shade trees on a cocoa farm. After that the farmers who joined the focus group were asked to indicate the relevance of each argument by dividing twenty-five stones over fifteen different arguments. The list of arguments that was given by the first focus group and which this group used to indicate the relevance of each argument, was also used during the rest of focus to make the results comparable. The third assignment was to do this for a list of eight (possible) negative arguments. Furthermore, the farmers were asked to discuss and mention all the tree species they have found desirable or undesirable on a cocoa farm, how many of them had shade trees on their farm already,

how many of them have planted shade trees and why they did not plant (more) shade trees on their cocoa farm before. A focus group was conducted in each visited community (nine in total) and took about thirty to forty minutes. An example of the focus group form is attached in appendix III.

The data collected from the individual interviews and focus groups was entered into Microsoft Access. Two databases were created, one for the individual interviews and one for the focus groups, to separate the data.

Part 3: Visiting different organizations

The third part of the research was to visit several organizations, research institutes and companies to find out which tree species they promote to plant as shade trees on a cocoa farm and which tree species they mention as undesirable and should not be grown on a cocoa farm. The second goal of the visits was to see if a certain mix of shade tree species is recommended to plant over the years, if they provide seeds or seedlings to farmers and where they get them from. Finally they were asked for their opinion about a field guide that shows the most desirable and undesirable shade tree species, if it would be useful and what information should be included. The list below shows the different organizations, research institutes and companies that have been visited including the person that was interviewed.

Organizations
- Rebecca Ashley Asare, Katoomba Incubator / Forest Trends
- Christian Mensah, Rainforest Alliance

Research institutes
- Richard Asare, International Institute for Tropical Agriculture (IITA)
- Dr. Anim Kwapong, Cocoa Research Institute Ghana (CRIG)
- Dr. Luke C.N. Anglaaere Forest Research Institute Ghana (FORIG)

Companies
- Crispin Suglo, Samartex Timber and Plywood Company Ltd
- Ian Patterson, Takoradi Renewable Energy Ltd
- Vince McAleer, Armajaro

A summary of each interview was written to give a good overview of all the information and answers that were provided by the different organizations, research institutes and companies.

Part 4: Shade tree field guide

After the data from the farmer focus groups had been processed into Microsoft Access, it was possible to create a list of shade tree species. A distinction was made between the farmers from the Nyinahini and Bia project of Agro Eco-Louis Bolk Institute. Those two lists are combined with the desirable and undesirable shade tree species list from the Cocoa Research Institute Ghana (CRIG) and two different literature sources (Asare, R., 2006 and Anglaaere, L.C.N., 2005). The tree species are ranked by the number of times they are mentioned as desirable or undesirable. The final list that is included in the field guide consists of the tree species that were mentioned two or more times by the five different stakeholders as desirable or undesirable. Icons are used to provide information about the different tree species. The information about the shade trees is commonly provided by the online database of Plant Resources of Tropical Africa (PROTA), (*database.prota.org*). Figure one shows what kind of information is included in the field guide per tree species. The green or red frame indicates whether a tree species was found desirable or undesirable. A manual how the field guide should be introduced and explained to cocoa farmers is also written and available. The figures four, five and six show the layout of the field guide (cover and desirable and undesirable tree species).

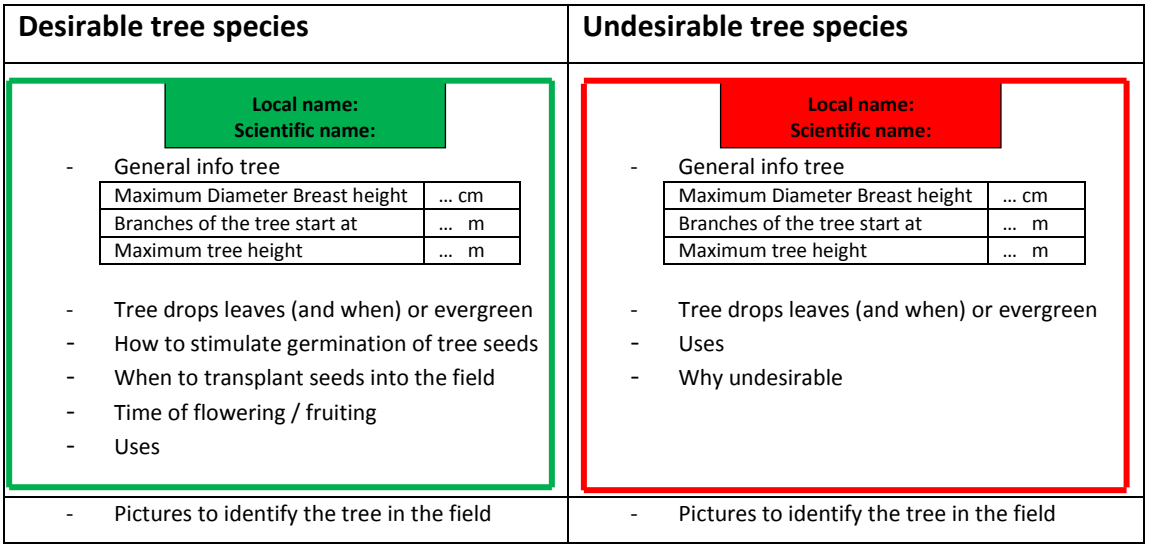

Fig. 1: List of information that is included per desirable and undesirable tree species

3. Results

A literature study was conducted on the reasons for using shade in cocoa farms and on the advantages and disadvantages of shade trees for farmers. This first part of this chapter describes how shade trees contribute to the sustainable production of cocoa and provides a clear overview of the advantages and disadvantages that shade trees might give. The second part of this chapter (Results of field work) gives an overview of the collected data and answers most of the research questions.

3.1. Literature study 'Why shade tree management?'

Cacao originally is an under-story tree crop (a tree that grows in the shade of larger trees) from the Amazon Forest and tolerates a considerable degree of shade (Beer, J., e.a., 1988). Sustainable cacao production is necessary to maintain and guarantee a sufficient and high quality supply of cacao beans to meet the demand of its consumers now and in the future (Meyer, M.K., 2004). Figure two provides an overview of the productivity of cocoa in shade- and full-sun grown farms over a period of eighty years. It seems that production is almost twice as much in an un-shaded hybrid cocoa system compared to the shaded traditional system. However, according to the research of Obiri, B.D., e.a., (2006), production of the un-shaded hybrid system starts to decline within 10 to 15 years while the production of the traditional systems starts decreasing after 25 years. The economic rotation age is only eighteen years for an un-shaded hybrid cocoa system, while this is twenty-nine years when shaded.

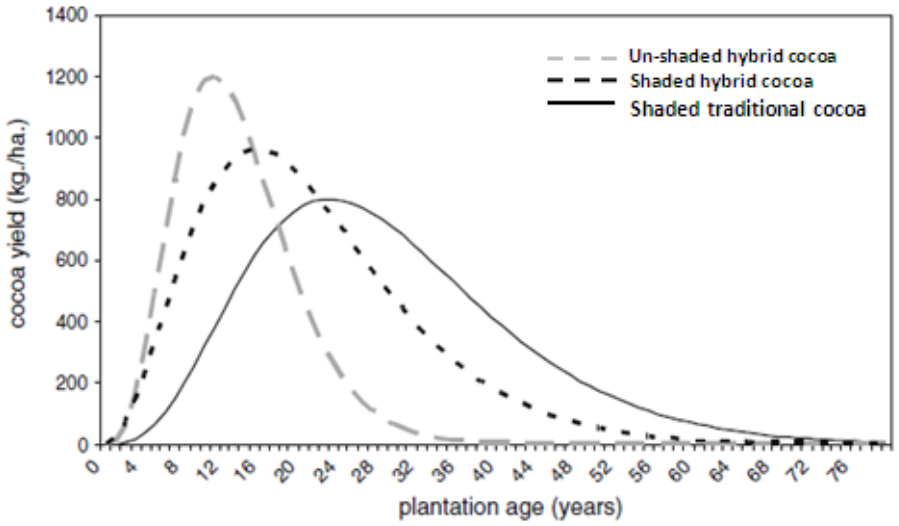

Fig. 2: Cocoa yield patterns in hybrid, shaded hybrid and traditional systems. (Obiri, B.D., et al, 2006).

Sun grown monocultures need irrigation, chemical fertilizers and pesticides to survive (Beer, J., e.a., 1998). These practices are very labor intensive and costly in comparison to shade grown tree crop system. Chemical fertilizers cause at least three major problems in the soil. The acidic chemical fertilizers change the pH of the soil in the first place and kills beneficial organisms that live in the soil. Secondly, the chemicals break down the soil particles, which create a cement-like hardpan. The soil ability to trap and hold water decreases. Applied chemicals seep into surface and underground water supplies and poison the drinking water in rural areas. Finally, fertilizers can damage plants' health as a plants ability to defend itself from bacteria and fungi is directly related to nutrient amount in the soil. Large amounts of nitrogen or phosphorus can kill beneficial microorganisms that live in the roots of plants (Trees for the Future, 2008).

3.1.1. Advantages of shade trees on a cocoa farm

Cocoa prefers to grow under shady circumstances rather than in the full sun. In many areas shade trees are planted in between these crops. The amount of shade that is provided depends on the space between trees, the form of the leaves, density of the crown and the height of trees 3(Schöll, L. van and Nieuwenhuis, R., 2004). This chapter describes the advantages that shade trees might provide to cocoa trees or the farmer.

More products from the same piece of land:

Research conducted by Belsky , M. and Siebert, S. (2002) indicates that households who use technical monoculture systems are generally more affected by market price fluctuations than farmers who cultivate shade grown trees. Agroforestry, when well designed, can provide a productive system with a wide range of diverse products like fuel wood, timber, food, medicines and animal fodder. It spreads the need for labor inputs over different seasons as not all trees bear fruit at the same time for example. This might help farmers to become less dependent on one product for income and reduces the risk of a complete failed yield. It is actually a form of risk management. The extra products could be used for home consumption or to sell on the market to generate more income (Arnold, J.E.M., 1983).

Increased lifetime of cocoa trees:

Extreme climatic conditions (e.g. high difference in temperature, wind velocity, soil moisture or temperature and light availability) causes stress to the cocoa tree. Too much light may cause overbearing of fruits and excessive vegetative growth which in turn creates nutritional imbalances and dieback of cocoa trees (Beer, J., et al, 1998). Moisture stress due to higher evapo-transpiration and the lower nutrient concentrations in the soils due to overbearing of fruits make the cocoa trees more susceptible to incidence of pest and diseases (Ofori-Frimpong, K., et al). Shade trees are able to reduce plant stress by improving the climatic conditions (e.g. reduction of air and soil temperature extremes, reduction of wind speeds and buffering of soil moisture and fertility). It seems that shade promotes the long-term production of older cocoa plants with low levels of fertilization. Cocoa trees that grow under less than optimum shade have a shorter life cycle where shaded cocoa trees may produce for 60 – 100 years under certain soil and rainfall conditions (Ruf, F. and Zadi, H., 1998).

Reduced incidence of diseases and weeds:

Annual crop rotation was one of the main practices to control pest and diseases before chemical pesticides became available. Perennial cropping systems, like cocoa plantations, do not offer the possibility of annual crop rotation. However, the different species develop a certain equilibrium between pests or diseases and their natural enemies. This balance is an important aspect of biological and integrated pest management. A more diverse system reduces the risk for weeds and diseases as it might attract more natural enemies and wherein certain species can function as barrier against the spread of pests. Insects or pests that damage a particular crop can be driven away by substances that other crops produce or by the other crop's attraction of insects that eat the damaging organisms. However, the advantage of the shade trees is only to a certain extent as some weeds and diseases might increase under shady circumstances while others might be promoted. Some tree species (see table 13 for example) might even function as host for pests, which makes it very hard and important to select the right species to intercrop with. (Schroth, G., e.a., 2000 and Schöll, L. van and Nieuwenhuis, R., 2004).

Improved environmental services

Natural ecosystems could supply beneficial resources and processes. The environmental services that are provided by cocoa agroforestry could be classified in four categories (biodiversity conservation, carbon storage, soil enrichment and air and water quality improvement/ protection). Each category is described individually below.

1. *Biodiversity conservation*

Cocoa is a shade tolerant tree species and can therefore grow under a canopy of trees from the traditional tropical forests. The shade system can range from remnant forest trees to planted commercial shade trees (Greenberg, R., 2006). However, most traditional forest species are not the best producers of useful products like fruit or timber and harder to fell and dismantle without damaging the cocoa trees, especially compared to cultivated species. This makes that forest trees are often cut down and replaced by smaller, more manageable and valuable trees. The resulting habitat at canopy level looks like a degraded tropical forest in its floral and faunal composition where epiphytes, mistletoes and lianas support many organisms like birds, ants and small primates (Bentley, W., e.a., 2004 and Asare, R., 2006). Cocoa agro-forest do not equate with primary forests as they support lower species richness. Climax species occur only rarely while pioneer and early secondary species become dominant. This is the effect of ground clearing once or twice a year to eliminate undergrowth. Cocoa plantations which are established along forests, receive many seeds from different individuals of the same species in the surrounding forest and can therefore function as belt between exploited areas and forests to contribute to the genetic variation of forest resources and the acceleration of seedling settlement (Asare, R., 2006 ; Donald, P.F., 2004 and Sonwa, D., e.a., 2001). In fact, agro-forestry plays four major roles in conserving biodiversity: (1) agro-forestry provides habitat for species that can tolerate a certain level of disturbance, (2) agro-forestry helps preserve genetic resources of sensitive species, (3) agro-forestry provides corridors between interrupted areas and (4) agro-forestry helps to conserve biological diversity by providing other ecosystem services such as erosion control and water recharge (Jose, S., 2009).

2. *Carbon storage*

Carbon storage involves the removal and storage of carbon from the atmosphere into carbon sinks as oceans, soils and vegetation. The presence of trees or shrubs in an agro-forestry system increases the amount of carbon that can be stored in comparison to monoculture crop fields or pastures (Sharrow, S.H. and Ismail, S., 2004). The amount of carbon stored, depends upon the type of system, species composition, age, geographic location, environmental factors and management practices. An additional factor that makes carbon storage more interesting for farmers is the carbon credit market, which compensates the farmer with money in exchange for storing carbon (Jose, S., 2009).

3. *Improved soil conservation*

Loss of soil and nutrients is an important problem that occurs all over the world and increases linearly with the decrease in canopy and surface litter (mulch) cover. The surface litter protects the soil from raindrop impacts, improves the stability and infiltration capacity of the soil and conserves soil moisture by reducing evaporation (Blanco, H. and Lal, R., 2008). Beneficial micro-organisms in the soil are protected by shade trees as they reduce soil temperature (Beer, J., e.a., 1998). Nitrogen and non-nitrogen fixing trees and crops can be used to improve physical, chemical and biological properties of the soil by adding significant amounts of organic matter above and belowground. Nutrients are stored, released and recycled in an agroforestry system. This makes that the fertile lifetime of the soil is increased. This system is more sustainable than a slash and burn systems for example where the leaching away of nutrients is very common (Jose, S., 2009). Research conducted by Isaac, M.E., e.a. (2007) notes that nutrient uptake by

cocoa trees is increased under shady circumstances (Nitrogen (N) 43-80%, Phosphorus (P) 22-45% and Potassium (K) 96-140%) and that the cocoa standing biomass also increases under shade in comparison to non-shaded monocultures.

4. *Improved air and water quality*

Windbreaks and shelterbelts provided by agroforestry have several benefits. These benefits include windbreaks to limit wind erosion and to protect crops from heavy winds. Vegetative buffers are able to filter airstreams by removing dust, gasses, microbial particles, to remove atmospheric carbon dioxide and to produce oxygen (Tyndall, J. and Colletti, J., 2007). Another important benefit of shade trees is to provide and protect clean water supplies. The surface runoff can result in the leaching away of nutrients and pesticide and end up in water bodies. Finally the systems become polluted and unusable. Vegetative buffers reduce runoff velocity of water and promote infiltration, sediment deposition and nutrient retention. Trees with deep rooting systems improve ground water quality by serving as a safety net, whereby excess nutrients that have been leached below the rooting zone of the cocoa trees are taken up by tree roots. These nutrients are then recycled back into the system through root turnover and litter fall (van Noordwijk, M., e.a., 1996). The multiple crops, with each its own rooting pattern utilize the different resources more efficiently than when only one crop is grown (Schöll, L. van and Nieuwenhuis, R., 2004).

3.1.2. Disadvantages of shade trees on cocoa farms

Shade trees might bring some disadvantages to a cocoa farm and have to be taken into account. The main disadvantages that a shade tree could give are described below.

Hindering of cocoa production:

Natural fall of branches and trees or the harvest of mature trees could damage the understory crop or could bring injury to the farmer. Some tree species are self-pruning which might increase this risk. Some tree species might suddenly drop their leaves when they are attacked by insects or diseases, which could cause a severe shock or die back of the shade adapted crop (Beer, J., 1987).

Competition for soil moisture, air, light and nutrients:

Woody species have large root systems, which could lead to competition for soil moisture during the dry season and oxygen during the wet season. Shade trees might also compete for nutrients with cocoa trees, which lead to reduced production (Beer, J., 1987 and Vernon, A. J., 1966).

Increased incidence by pest and diseases:

Humidity increases when there is less light or wind available, which may favor fungal diseases or attract insects (Beer, J., 1987). Shade trees could act as alternative host for pest and diseases, meaning that cocoa trees will not be affected. However, it is also possible that a shade tree species attracts certain pests and diseases, like the Swollen-shoot virus, which in turn could infect and destroy the cocoa trees (Schroth, G., e.a., 2000).

Increased labor input:

Cocoa trees will grow taller when there is a higher competition for sunlight, which makes it harder to harvest the pods that grow in the top of the tree (Schöll, L. van and Nieuwenhuis, R., 2004 and Beer, J., 1987). Pruning of the cocoa trees is a good solution to overcome this problem.

Damaged cocoa trees by chainsaw operators:

Chainsaw operators are very common in Ghana, especially on cocoa farms. Their operations mainly supply the needs of the local and domestic timber market. The Timber Resource Management Act provides rights to timber resources in the form of a Timber Utilization Contract (TUC) and a Timber Utilization Permit

(TUP). However, chainsaw operators normally don't have such permits, which means that there operations are illegal. None of the official fees and taxes are paid on the harvested timber. Farmers are sometimes intimidated by chainsaw operators who fell their timber trees, sometimes at night, without permission or compensation for the damaged cocoa trees (Asare, R., 2006). This problem frustrates many farmers and makes that many of them remove valuable tree species from their farm before chainsaw operators come to harvest the trees and destroy the cocoa trees (Owubah, C.E., et al, 2000).

3.1.3. Certification standards

Different certification bodies have set up programs for sustainable cocoa production to help and train farmers to use good agricultural practices, efficient farm management and responsible production of their cocoa. Besides, the different programs help to enable farmers to improve their working conditions and take better care of their children and the environment. Each certification body has set standards and indicators which farmer have to meet to guarantee a responsible and sustainable production of their cocoa (UTZ Certified, 2009). This chapter focuses on the indicators that are set according to shade trees in cocoa farms to promote biodiversity and sustainable production. Table one gives a short overview of the different indicators for cocoa production in Ghana that are set by the certification bodies Rainforest Alliance (RA) and UTZ. The indicators show that farmers should maintain or plant enough trees to eventually have eighteen shade trees per hectare dispersed on their farm. Rainforest Alliance even states that the eighteen shade trees should consist of twelve different native tree species per hectare. The field guide "Shade tree guide for Ghanaian cocoa farmers", which was created on occasion of this research, will help farmers to select the most desirable shade tree species to plant on their farm in order to meet the standards.

Table 1: Indicators that are required to become certified by Rainforest Alliance or UTZ

Indicator	RA	UTZ
Shade cover (%)	30 - 40	
Min Nr of permanent (mature) shade trees / ha in cocoa farms	18	18
Nr of different native tree species /ha	12	

(Source: Sustainable agriculture Network, 2009 and UTZ Certified, 2009).

3.1.4. Conclusion

Shade trees may provide many advantages (e.g. extra products from the same piece of land, increased lifetime of cocoa trees and several environmental services) to the farmer and the cocoa trees on his or her farm. However, shade trees might also bring some disadvantages (e.g. competition for moisture and nutrients and some tree species attract pest and diseases which in turn may affect the cocoa trees).

Farmers have to compare the advantages and disadvantages that a certain tree species might give, to see if it is possible and profitable to overcome the undesirable characteristics with extra inputs like fertilizers or pesticides. Certification bodies have prepared standards for sustainable production of cocoa which states that farmers should grow eighteen shade trees per hectare or more.

3.2. Results field work

General information about the farmers:

As indicated in the methodology, ninety farmers were selected randomly to collect the desired data. The result, which are attached in table two, show that sixty-seven percent of the people that were interviewed are men (thirty in both project areas). Thirty-three percent of the interviewed people are females (twenty in the Bia project and ten in the Nyinahini project). People from different age categories joined the interviews. The average age of the interviewed farmers that live in the Bia project is forty-nine. The average age of the interviewed farmers within the Nyinahini projects is forty-seven years. Around a third of the farmer (33%) have never been to school. Less than half of the interviewed farmers indicated to be able to read and write. The majority of the farmers (90 %) is married. Farmers have six children on average. A minority of the farmers have other occupations besides farming.

In Bia, all farmers indicated to be the owner of their land, while this is only the case for eighty-three percent (33 farmers) of the interviewed farmers that live in the villages of the Nyinahini project. Six farmers (15%) of the Nyinahini project hire land. There is a difference in farm size between the two areas: the average size of farms within the Bia project is six acres (2.4 ha), while the average size of farms within the Nyinahini project is about sixteen acres (6.4 ha). Farmers estimated to have to walk forty-five minutes to their farms on average.

Table 2: General information of the farmers that were interviewed individually.

	Bia % (n=50)	Nyinahini % (n=40)	Total % (n=90)
Male	60 (30)	75(30)	67(60)
Female	40 (20)	25(10)	33(30)
Age			
Age 21 - 30	6 (3)	15(6)	10(9)
Age 31 - 40	22(11)	18(7)	20(18)
Age 41 - 50	30(15)	23(9)	27(24)
Age 51 - 60	22 (11)	28(11)	24(22)
Age >60	20(10)	18(7)	19(17)
Avg age	***49***	***47***	
Education level			
Never been to school	36(18)	30(12)	33(30)
Primary School drop out	8(4)	5(2)	7(6)
Primary School completed	10(5)	23(9)	16(14)
Junior High school	36(18)	20(8)	29(26)
Senior High school	10(5)	23(9)	16(14)
University	0(0)	0(0)	0(0)
Able to read	38(19)	55(22)	46(41)
Able to write	34(17)	55(22)	43(39)
Marietal status			
Married	88(44)	93(37)	90(81)
Divorced	0(0)	0(0)	0(0)
Widow(er)	8(4)	3(1)	6(5)
Avg nr of children	6	6	
Other occupations	18(9)	30(12)	23(21)
Land tenure			
Landowner	100 (50)	83(33)	92(83)
Hire land	0(0)	15(6)	7(6)
Employee	0(0)	3(1)	1(89)
Avg farm size(acres)	6	16	

Motivations for intercropping:

The farmers that were interviewed individually were asked if they grow crops in combination with cocoa trees and if they do so, for what reason. Eighty-seven percent of the farmers mentioned to intercrop cocoa trees in combination with other crops (see table three). A vast majority of this group indicated to do this because it provides extra products which could be used for home consumption (96%) or to sell on the market to generate more income (77%). Additionally, fifty-nine percent of the farmers use the crops to provide shade for the cocoa trees. About a third of the farmers (35%) mentioned to intercrop with vegetables because of their N-fixing nature. The main crops that are grown by the majority of the farmers for intercropping are Plantain (79%), Cassave (64%), Yam (60%) and Cocoyam (60%). The rest of the crops were grown by eleven percent or less of the farmers.

Table 3: Farmers' motivations for intercropping and main crops intercropped with cocoa (n=78).

Motivations for intercropping	**Farmers who intercrop: (%)**
Homeconsumption	96(75)
extra income	77(60)
temporary shade	59(46)
N-fixing nature	35(27)
Crops intercropped with cocoa	**Percentage of farmers (%)**
Plantain	79(62)
Cassave	64(50)
Yam	60(47)
Cocoyam	60(47)
Maize	13(10)

Cocoa production within the Nyianhini and Bia project:

Almost all interviewed farmers, indicated that they grow cocoa as their main crop. The vast majority (89%) of this group grows the hybrid cocoa tree species on their farm. Other cocoa varieties that are used to produce cocoa are Amazonia (7%), Tetteh Quarsie (3%) and Amelando (1%). Thirty-six (40%) of the interviewed farmers has only one agricultural field where they produce cocoa. A third of the farmers indicated that they have two cocoa fields. Eighteen percent of the farmers appeared to use three agricultural fields to produce cocoa, whereas a minority of the farmers (11% in total) indicated to have more than three fields with cocoa trees. In regard to the cocoa fields, most of the farmers (77%) indicated to have cocoa trees more than ten years old. Fifty-one farmers (57%) have agricultural fields where they have planted cocoa trees less than ten years ago. Most farmers did not know the exact size of their land, which made it impossible to calculate the average yield per hectare. However, farmers were asked to mention the number of bags with cocoa beans (64 kg) that they sold last year. Thirty-nine percent (35) of the farmers sold one to ten bags. Twenty-six percent (23) of the farmers sold between ten and twenty-one bags of cocoa last year and only twenty-five percent of the farmers sold more than 20 bags with cocoa. Each farmer sold and average of 17.6 bags of cocoa beans last year. Table four gives an overview of the results mentioned above.

Table 4: Overview of cocoa production

	Total % (n=90)
Cocoa as main crop	94(85)
Hybrid cocoa variety	89(80)
Amazonia cocoa variety	7(6)
Tetteh Quarsie cocoa variety	3(3)
Amelando cocoa variety	1(1)
Nr of cocoa fields per farmer	
1	40(36)
2	31(28)
3	18(16)
4	8(7)
5	2(2)
> 5	1(1)
farmers that have fields with cocoa trees that are:	
>=10 years old	77(69)
< 10 years old	57(51)
Nr of bags of cocoa sold last year	
1 - 10	39(35)
11-20	26(23)
21-30	10(9)
31-40	4(4)
41-50	10(9)
> 50	1(1)
Avg nr of bags sold last year	***17.6***

Reasons for the decline and increase of cocoa production:

The cocoa yield has increased for the majority of the farmers (56%) over the last few years. The main reasons that were mentioned by the farmers who increased their yield are: input of organic fertilizers (mentioned by 54%), spraying organic pesticides (50%), young cocoa trees (50%) and the training of farmers to increase knowledge on good management practices (21%). Other methods that farmers used to produce more cocoa are good weeding (26%), the use of chemical pesticides (14%), use of chemical fertilizers (10%) and pruning (10%). The yield of one farmer increased because he started using more land to produce cocoa. Another farmers yield increased after he created more space between his cocoa trees. Less than the half (42%) of the interviewed farmers faced a decrease in production over the last few years. No input of fertilizers and pesticides was mentioned by fifty percent of the farmers who faced a decline in production. Forty-five percent of those farmers stated that their production has declined because of diseases that have affected the cocoa trees on their farm. Other reasons for the decline are lack of maintenance (18%) and old cocoa trees (18%), too much shade (5%), gravels on land (5%), land water locked and too wet (5%), too much sunlight (5%) and high competition with shade trees for nutrients and water (3%). Table five gives an overview reasons given by farmers.

Table 5: Factors that cause an increase or decrease in cocoa yield.

	Bia % (n=50)	Nyinahini % (n=40)	Total % (n=90)
Yield has increased	52(26)	60(24)	56(50
Yield has decreased	48(24)	35(14)	42(38
Reasons causing increase in yield			
Applying organic fertilizer	38(10)	71(17)	54(27
Young cocoa trees	50(13)	50(12)	50(25
Spraying organic pesticides	35(9)	67(16)	50(25
Training on better management	19(5)	58(14)	38(19
Good weeding	50(13)	0(0)	26(13
Spraying chemical pesticides	27(7)	0(0)	14(7
Pruning	0(0)	0(0)	10(5
Applying chemical fertilizer	19(5)	0(0)	10(5
Reasons causing decrease in yield			
No input of fertilizers / pesticides	71(17)	14(2)	50(19
Farm infected by diseases	50(12)	36(5)	45(17
Lack of maintenance	21(5)	14(2)	18(7
Old trees	8(2)	36(5)	18(7

The occurrence of shade trees on cocoa farms:

Almost all the farmers (98%) that have been interviewed individually (90 in total) seem to see shade trees on a cocoa farm as an advantage. All the interviewed farmers have shade trees on their farm, and the majority of them (60%) have planted shade trees already. Even more of the farmers (73%) would like to grow more shade trees on their farm. The main reason why the rest of the farmers do not want to have more shade trees on their farm is because the farmers think they have enough shade trees already. Table six provides an overview of the results mentioned above.

Table 6: Overview of farmers that (would like to) have (more) shade trees on their farm

	Bia	Nyinahini	Total
Number of farmers interviewed individually	40	50	90
Farmers seeing shade trees as an advantage (%)	98 (49)	98 (39)	98 (88)
Farmers having shade trees on their farm (%)	100 (50)	100 (40)	100 (90)
Farmers having planted shade trees on their farm (%)	74 (37)	43 (17)	60 (54)
Farmers who would like to have (more) shade trees on their farm (%)	68 (34)	80 (32)	73 (66)

The farmers interviewed individually were asked to estimate the number of shade trees that are on their farm. Figure three is the result of the estimation. It seems that most farmers have between six to twenty shade trees on their farm. Seventeen of the ninety farmers estimated to grow thirty-one to forty shade trees on their land. Only a few farmers (6) indicated to grow forty-one shade trees on their farm.

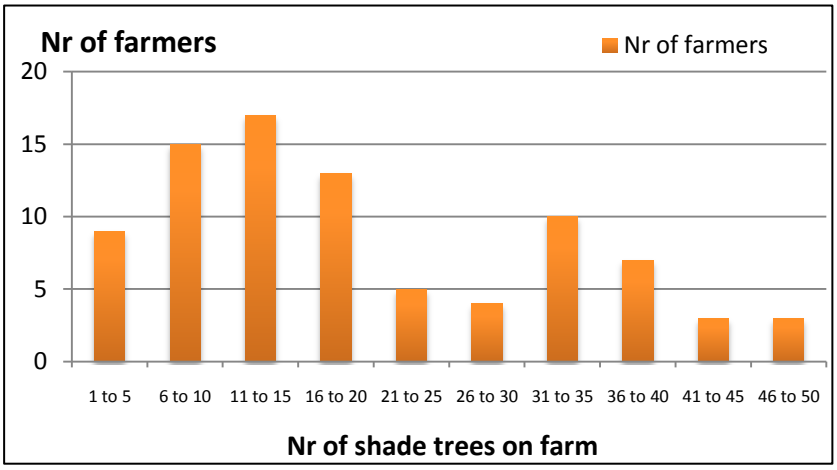

Fig. 3: Estimated number of shade trees that farmers grow on their cocoa farm.

All farmers mentioned to grow shade trees on their cocoa farm already. The top ten of the most common shade tree species on cocoa farms is presented in table seven. The majority of the farmers (70%) indicated to grow *Terminalia superba* (Ofram) on his or her farm. Other tree species that commonly occur on cocoa farms are *Khaya sp.* (Mahogany) (40%), *Milicia exelsa* (Odum) (22%) and *Terminalia ivorensis* (Emire) (22%). Ten to seventeen percent of the farmers also seem to grow *Newbouldia leavis* (Sesemasa), *Ceiba pantandra* (Onyina), *Alstonia boonei* (Nyamedua), *Triplochiton scleroxylon* (Wawa), *Citrus sinensis* (Orange) and Eliue.

Table 7: Top ten of the most common tree species on cocoa farms.

Scientific name	Local name	% of farmers that grow this tree
Terminalia superba	Ofram	70(63)
Khaya sp.	Mahogany	40(36)
Milicia exelsa	Odum	22(20)
Terminalia ivoriensis	Emire	22(20)
Newbouldia leavis	Sesemasa	17(15)
Ceiba pantandra	Onyina	16(14)
Alstonia boonei	Nyamedua	13(12)
Triplochiton scleroxylon	Wawa	12(11)
Citrus sinensis	Orange	11(10)
	Eliue	10(9)

More than one fifth of the interviewed farmers indicated to grow between two and four different shade tree species on their cocoa farm (see table 8). Less than fifteen percent (12-13 farmers) appear to grow one or five different shade tree species and another four farmers grow six different tree species on their farm. Five percent of the farmers in Nyinahini mentioned to have eight different shade tree species on their farm, whereas another farmer stated to grow thirteen different tree species beside his cocoa trees. It appears that the farmers in Bia and Nyinahini grow three different tree species on their farm on average.

Table 8: Number of shade tree species per farm

Nr of different tree species per farmer	% Bia (n=50)	% Nyinahini (n=40)	Total (n=90)
1	10(5)	20(8)	14(13)
2	24(12)	23(9)	23(21)
3	26(13)	10(4)	19(17)
4	24(12)	20(8)	22(20)
5	10(5)	18(7)	13(12)
6	6(3)	3(1)	4(4)
8	0(0)	5(2)	2(2)
13	0(0)	3(1)	1(1)

Farmers' awareness of advantages and disadvantages of shade trees on cocoa farms:

Farmers were asked to mention their positive and negative arguments according to shade trees on cocoa farms. Table nine shows the results. During the individual interviews, farmers mentioned twenty different arguments why shade trees on a cocoa farm are an advantage, nine of these were mentioned by more than twenty-five percent of the farmers. It seems that the majority of the farmers that were interviewed individually (97%) are aware that shade trees improve the air and water quality. Ninety-one percent of the farmers indicated to grow shade trees for timber purposes. The majority of the farmers also stated that shade trees could be used for medicinal purposes (69%), firewood (61%) and extra sources of income (52%). Less than forty-five farmers (<50%)was aware that intercropping with shade trees help to increase the lifetime of cocoa trees (48%), to improve soil conservation (47%), to stick yams (30%) and as windbreak (26%). Other reasons for using shade trees were mentioned by ten percent of the farmers or less.

Table 9: Percentages of farmers that have mentioned a certain a positive or negative argument.

Advantages	Total (%) (n=90)	Bia (%) (n=50)	Nyinahini (n=40)
To protect cocoa trees form drying	97(87)	96(48)	98(39)
Timber	91(82)	96(48)	85(34)
Medicine	69(62)	78(39)	58(23)
Firewood	61(55)	62(31)	60(24)
Extra source of income	52(47)	74(37)	25(10)
Increased lifetime cocoa tree	48(43)	64(32)	28(11)
Improved soil conservation	47(42)	64(32)	25(10)
Sticking of yams	30(27)	40(20)	18(7)
Windbreak	26(23)	24(12)	28(11)
Improved air / water quality	10(9)	18(9)	0(0)
Erosion control	9(8)	12(6)	5(2)
Water storage for dry season	9(8)	16(8)	0(0)
Improved soil moisture	9(8)	16(8)	0(0)
Increased yield	8(7)	8(4)	8(3)
Fruit	8(7)	2(1)	15(6)
Cool down the land / place to rest	4(4)	6(3)	3(1)
Improved biodiveristy	3(3)	4(2)	3(1)
Increased rainfall	2(2)	0(0)	5(2)
Food from bark / leaves	2(2)	4(2)	0(0)
Reduced weeds and diseases	1(1)	2(1)	0(0)
Disadvantages			
Attraction of pests and diseases	30(33)	32(16)	28(11)
Damage by falling branches	20(22)	22(11)	18(7)
Competition with cocoa trees	14(3)	16(8)	13(5)
Food crops bear less fruit	3(3)	4(2)	3(1)
Competition for moisture	2(2)	4(2)	0(0)
Cocoa trees grow too tall	2(2)	4(2)	0(0)
Chainsaw operators destroy farm	2(2)	2(1)	3(3)
Harder to weed	1(1)	0(0)	3(3)
Too much moisture	1(1)	0(0)	3(3)

Farmers mentioned nine different reasons why shade trees on a cocoa farm could be a disadvantage. Three of those arguments were mentioned most. The risks to attract pest and diseases (mentioned by 30% of the farmers), damage by falling branches (20%) and competition with cocoa trees (14%) were mentioned most often as negative argument. The rest of the motivations why shade trees could be undesirable are only mentioned by a small minority of the farmers. Appendix V shows the number of times that a positive argument was mentioned per community. The number of times that a negative argument was mentioned per community is attached in appendix VI.

Relevance of arguments for farmers:

It appears that farmers consider positive effects on the environment as very relevant to grow shade trees on a cocoa farm. Table ten shows which arguments are most relevant for the farmers for planting shade trees on their cocoa farm. The most relevant advantage for farmers to plant shade trees is the improvement of air and (drinking) water quality (average of 6.1 points). Other arguments that make farmers decide to grow cocoa under shady circumstances are: cocoa trees become older when they grow under shade (5.7 points), medicinal uses of some trees to treat diseases (5.1 points), improved soil fertility (4.9 points), the production of timber as building material or to sell on the market (4.5 points) and the reduction of weeds and diseases on the farm (4.5 points). The other positive arguments seem to be less relevant for the farmers as they got four points or less on average. After sub-dividing the positive arguments into categories, it is possible to say that environmental services and the products that shade trees could provide are very important for the farmers and convince them to start producing cocoa under shady circumstances. However, there are also some arguments that might change a farmer's mind not to grow shade trees on a cocoa farm. The farmers in the focus groups have indicated that the arguments: chainsaw operators might come and destroy the farm (8.9 points), injury to the farmer by falling branches (7.6 points), attraction of pests and diseases (7.3 points) and the fact that cocoa trees grow too tall under shady circumstances (6.8 points) are very relevant for them and makes that they will not start planting shade trees in between their cocoa trees immediately. The rest of the negative are less relevant for the farmers. Again the arguments were sub-divided into categories and it looks like that the negative impact of shade trees on cocoa trees play an important role whether or not they will grow shade trees on their farm.

Table 10: Relevance of arguments by the different focus groups

Positive arguments	***Category***	**Average mark**	**Avg Mark Bia**	**Avg Mark Nyinahi**
Improved air / water quality	General environmental services	6,1	2,8	3,3
Increased lifetime cocoa tree	Environmental services to improve crop	5,7	3,0	2,7
Medicine	Tree products for home consumption	5,1	2,4	2,7
Improved soil conservation	General environmental services	4,9	3,2	1,7
Timber	Tree products for income generation	4,5	2,2	2,3
Reduced weeds and diseases	Environmental services to improve crop	4,5	2,2	2,3
Improved biodiversity	General environmental services	4,0	1,0	3,0
Improved soil moisture	General environmental services	3,7	1,4	2,3
Fruit	Tree products for home consumption / Tree products for income generation	3,2	1,2	2,0
Animal fodder	Tree products for home consumption	2,4	1,4	1,0
Firewood	Tree products for home consumption	2,3	1,0	1,3
Carbon sequestration	General environmental services	1,7	1,0	0,7
Windbreak	Environmental services to improve crop	1,6	0,6	1,0
Erosion control	General environmental services	1,5	0,8	0,7
Sticking of yams		1,4	1,4	0,0
Negative arguments	***Category***	**Average mark**	**Avg Mark Bia**	**Avg Mark Nyinahi**
Chainsaw operators destroy farm	Negative impact on cocoa growth or damage to farm	8,9	5,2	3,7
Injury to farmer by shade trees	Safety	7,6	2,6	5
Attraction of pests and diseases	Negative impact on cocoa growth	7,3	3,6	3,7
Cocoa trees grow too tall	Negative impact on cocoa growth	6,8	2,8	4
Competition with cocoa trees	Negative impact on cocoa growth	6	3	3
Reduced production	Negative impact on cocoa growth	4,5	4,5	0
Damage by falling branches	Damage to farm	3,9	2,2	1,7
Maintenance of trees necessary	More labor required	3,4	1,4	2

A difference between the most mentioned arguments and most relevant arguments:

There is a difference between the number of times that an argument was mentioned during individual interviews and how relevant that argument was found. Table eleven gives an overview of the differences. The first left part of the table (relevance by focus groups) indicates the average mark (number of stones) that was given to the argument by the focus groups in the two project areas and in total. The higher the mark, the more relevant the argument was found. The right part of the table shows the percentage of the individually interviewed farmers that mentioned this argument. The arguments 'improvement of air and water quality (6.1 points) ' and 'the increased lifetime of cocoa trees'(5.7 points) were found most relevant by the farmers to plant shade trees on a cocoa farm. However, those arguments were not mentioned most often during the individual interviews. The first argument was only mentioned by ten percent (9) of the farmers and 'increased lifetime of cocoa trees' by forty-eight percent of the farmers. The arguments that shade trees help to protect cocoa trees from drying out and that they could be used for timber production were mentioned by ninety-seven and ninety-one percent of the farmers. The most relevant argument why farmers would not to grow shade trees on a cocoa farm was that chainsaw operators could come to the farm to cut the shade trees (illegally) and destroy the cocoa trees (5.1 points) while this was only mentioned by two percent of the farmers. Other negative arguments that were found relevant by the focus groups are damage or injury by falling branches, attraction of pests and diseases, competition for sun light and nutrients and reduced production. Again those arguments were not mentioned most often.

Table 11: Relevance of arguments and the number of times that it was mentioned

Motivations	Relevance by focus groups			Percentage of farmers that mentioned an argument.					
				Total		Bia		Nyinahini	
Positive arguments	total	Avg Bia	Avg Nyinahini	indiv int (%) (n=90)	Foc gr (%) (n=9)	indiv int (%) (n=50)	Foc gr (%) (n=5)	indiv int (%) (n=40)	Foc gr (%) (n=4)
Improved air / water quality	6.1	2.8	3.3	10	78	18	60	0	100
Increased lifetime cocoa tree	5.7	3.0	2.7	48	33	64	40	28	25
Improved soil conservation	4.9	3.2	1.7	47	67	64	80	25	50
Improved biodiversity	4.0	1.0	3.0	3	22	4	0	3	50
Improved soil moisture	3.7	1.4	2.3	9	56	16	60	0	50
Carbon sequestration	1.7	1.0	0.7	0	22	0	0	0	50
Windbreak	1.6	0.6	1.0	26	56	24	40	28	75
Erosion control	1.5	0.8	0.7	9	22	12	20	5	25
Sticking of yams	1.4	1.4	0.0	30	67	40	60	18	75
Cool down the land / place to rest				4	0	6	0	3	0
Alternative host for pests and diseases				0	22	0	40	0	0
To protect cocoa trees from drying out				97	78	96	100	98	50
Improved rainfall				2	22	0	40	5	0
Water storage for dry season				9	0	16	0	0	0
Medicine	5.1	2.4	2.7	69	89	78	100	58	75
Reduced weeds and diseases	4.5	2.2	2.3	1	0	2	0	0	0
Timber	4.5	2.2	2.3	91	100	96	100	85	100
Fruit	3.2	1.2	2.0	8	22	2	0	15	50
Animal fodder	2.4	1.4	1.0	0	11	0	0	0	25
Firewood	2.3	1.0	1.3	61	67	62	60	60	75
Extra source of income				52	33	74	60	25	0
Food from bark / leaves				2	0	4	0	0	0
Increased yield				8	11	8	20	8	0
Negative arguments				Total		Bia		Nyinahini	
Chainsaw operators destroy farm	8.9	5.2	3.7	2	33	2	40	3	25
Injury to farmer by shade trees	7.6	2.6	5	0	67	0	80	0	50
attraction of pests and diseases	7.3	3.6	3.7	30	78	32	100	28	50
cocoa trees grow too tall	6.8	2.8	4	2	33	4	20	0	50
Competition with cocoa trees	6	3	3	14	67	16	80	13	50
reduced production	4.5	4.5	0	0	33	0	60	0	0
Damage by falling branches	3.9	2.2	1.7	20	78	22	100	18	50
maintenance of trees necessary	3.4	1.4	2	0	0	0	0	0	0
too much moisture				1	0	0	0	3	0
competition for moisture				2	0	4	0	0	0
harder to weed				1	0	0	0	3	0
Food crops bear less fruit				3	0	4	0	3	0

Farmers seem to be aware of most advantages and disadvantages that shade trees could provide. This raised the question why farmers have not planted (more) shade trees before. Table twelve shows the different answers that were given and the percentage of farmers (per project area) that mentioned those arguments. No access to seedlings and the unawareness of the advantages of shade trees before seem to be the main factors that determined the motivation of farmers not to plant (more) shade trees on their farm. Most farmers mentioned to had shade trees on their farm already, even before they became aware of the advantages, because they were unable to remove the large trees. It was not clear for the majority of the farmers which risks came along with shade trees on a cocoa farm and chose not to produce cocoa under shady circumstances. Farmers who had shade trees on their cocoa farms already started to see the advantages and stopped removing the natural regenerated seedlings on their fields. Another reason why they have not plant (more) shade trees on their farms (before)was because
there was no knowledge on how to nurse and raise seedlings.

Table 12: Motivations why farmers have not planted (more) shade trees before.

Why not planted (more) shade trees (before)	Total (%) (n=90)	Bia (%) (n=50)	Nyinahini (%) (n=40)
No access to (more) seedlings	51.1 (46)	54.0 (27)	47.5 (19)
Unaware of advantages before	34.4 (31)	32.0 (16)	37.5 (15)
Afraid of negative effects of shade trees (before	14.4 (13)	20.0 (10)	7.5 (3)
No knowledge how to nurse and raise seedlings	2.2 (2)	2.0 (1)	2.5 (1)
not allowed by landowner to plant shade trees	2.2 (2)	0.0 (0)	5.0 (2)
New land, no time to plant	1.1 (1)	0.0 (0)	2.5 (1)
thought to have enough shade trees already	1.1 (1)	2.0 (1)	0.0 (0)

Farmers mentioned that they could be assisted with producing cocoa under shady circumstances by establishing a nursery to raise shade tree seedlings. Farmers also mentioned trainings on how to raise and nurse seedlings and which advantages come along with the introduction of shade trees on cocoa farms (see table 13). The list in table thirteen show the three possibilities mentioned above including the number of times that it was mentioned.

Table 13: Farmers responses to what kind of assistance is needed to promote shade trees.

How to help?	*Nr of farmers*
Set up a nursery	37
Training on how to raise and nurse seedlings	16
More training on the advantages of shade trees	10

Differences between communities within a project area:

A comparison was made between the different communities and project areas, to see if there is a difference in the number of times that a certain answer was given during the individual farmer interviews. It became clear that there is a small difference. However, the main difference is the number of times that an argument was mentioned within one of the project areas. For this reason the answers of the communities within the same project area were combined.

The tree species that were found most desirable or undesirable by the focus groups.

The assignment whereby farmers had to discuss which tree species they have found most desirable or undesirable to grow on a cocoa farm during the focus groups was used to create a list of tree species that were found most desirable or undesirable by the farmers in Nyinahini and Bia. Table fourteen is the result. A total of nine tree species was found most desirable, whereby another six tree species were found most undesirable.

Table 14: Tree species that are found most desirable or undesirable during focus groups

Most desirable tree species by farmers		
Local name	**Scientific name**	**Nr times mentioned**
Ofram	Terminalia superba	8
Mahogany	Khaya spp.	7
Emire	Terminalia ivoriensis	7
Odum	Milicia exelsa	6
Baku / Makore	Thieghemella heckelii	4
Otio	Pycnanthus angolensis	4
Sesemasa	Newbouldia leavis	4
Mansonia		3
Nyamedua	Alstonia boonei	3
Most undesirable tree species by farmers		
Local Name	**Scientific name**	**Nr times mentioned**
Nyankerene	Ficus exasperata	8
Onyina	Ceiba pentandra	5
Wawa	Triplochition scleroxylon	5
Esa	Celtis Milbraedii	5
Mango	Magnicifera indica	4
Kakapenpen		3

Desirable and undesirable shade tree species according to different stakeholders:

A total of ten different tree species was found most desirable by five different stakeholders (see table 15). Those stakeholders include, the farmers of the Nyinahini project, the farmers of the Bia project and the list of desirable and undesirable shade tree species from the Cocoa Research Institute of Ghana (CRIG). Furthermore it contains the lists of tree species that are promoted by Asare, R. (2006) and Anglaaere, L.C.N., (2005). Table fourteen shows the tree species that were found most desirable or undesirable by the farmers during focus groups. The lists of tree species that were found most desirable or undesirable by the other stakeholders is attached in appendix VIII.

Table 15: The tree species that were found most desirable by different stakeholders

Tree species		Desirable					
Scientific name	Local name	Nyin	Bia	CRIG	L1	L2	Nr
Terminalia ivoriensis	Emire						5
Melicia exelsa	Odum						5
Terminalia superb	Ofram Framo						5
Alstonia boonei	Nyamedua						4
Pycanthus angolensis	Otie						4
Entandrophragma angolense	Edinam						3
Entandrophragma cylindricum	Sapele						3
Tieghemella heckelli	Baku Makore						2
Khaya spp. (3x)	Mahogany						2
Entandrophragma utile	Utile						2

Explanation of abbreviations: Nyin, farmers Nyinahini; Bia, farmers Bia; CRIG, Cocoa Research Institute of Ghana; L1, Literature source 1 (Asare, R., 2006); L2, Literature 2 (Anglaaere, L.N.C., 2005).

Most tree species were not found really undesirable as most of them were mentioned desirable as well as undesirable. However, a research that was conducted by the Cocoa Research Institute of Ghana (CRIG) in 1987 concluded that a few tree species are really undesirable to grow in combination with cocoa trees as those tree species host the Swollen-shoot virus or give too much shade for example. Table sixteen show this list. Farmers mentioned that a field guide would be very useful to see which tree species are really desirable or undesirable to grow on a cocoa farm and for what purposes they could be used. The lists of tree species in the tables fifteen and sixteen were used to create the field guide 'Shade tree guide for Ghanaian Cocoa farmers'. Images of this field guide are attached as figure four, five and six. A mix of tree species was not recommended by the different organizations as each farmer has his own preferred purpose that a tree should have.

Table 16: The tree species that are found most undesirable by different stakeholders.

Tree species		Undesirable					
Scientific name	Local name	Nyin	Bia	CRIG	L1	L2	Nr
Myrianthus arboreus	Nyankoma						1
Musanga cecropioides	Odwuma						1
Chlamydocola chlamydantha	Osonkrobia Penamfera Kra-Bise						1
Carapa procera	Sua-bise Kwakuo-bise						1
Cola gigantean	Watapuo						1

Explanation of abbreviations: Nyin, farmers Nyinahini; Bia, farmers Bia; CRIG, Cocoa Researc Institute of Ghana; L1, Literature source 1 (Asare, R., 2006); L2, Literature 2 (Anglaaere, L.N.C 2005).

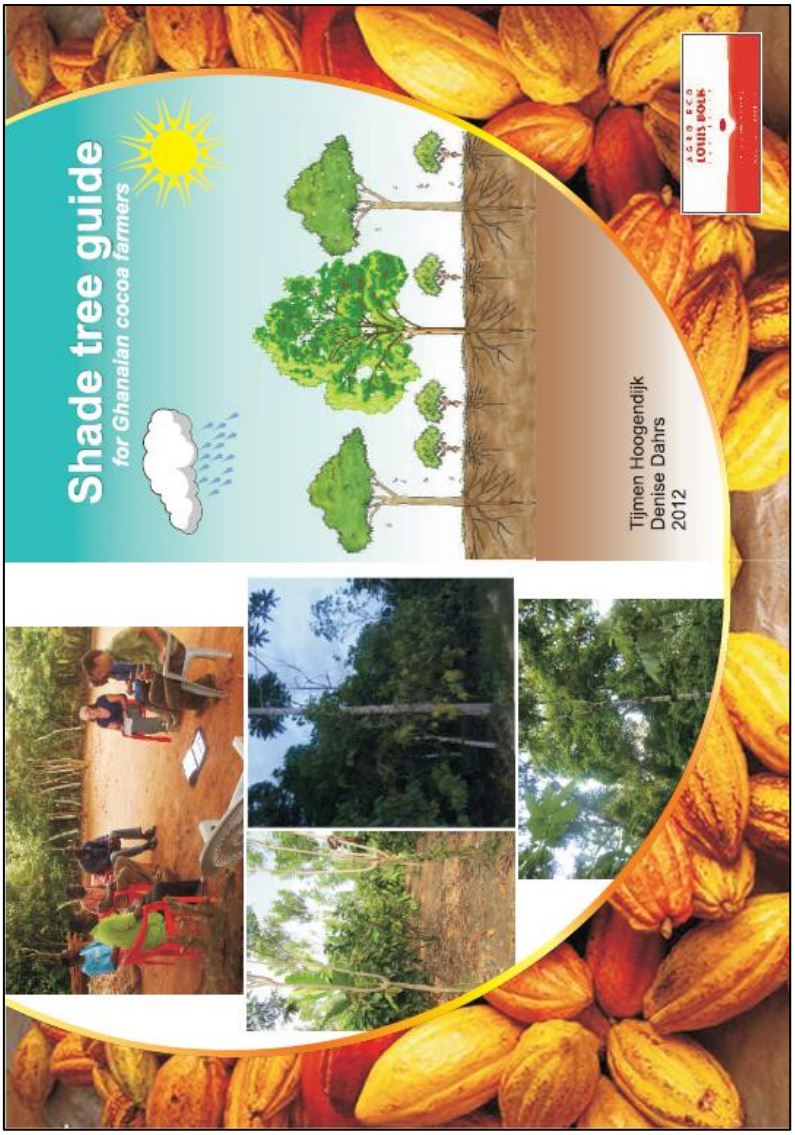

Fig 4: Cover of the field guide ‘Shade tree guide for Ghanaian Cocoa farmers’.

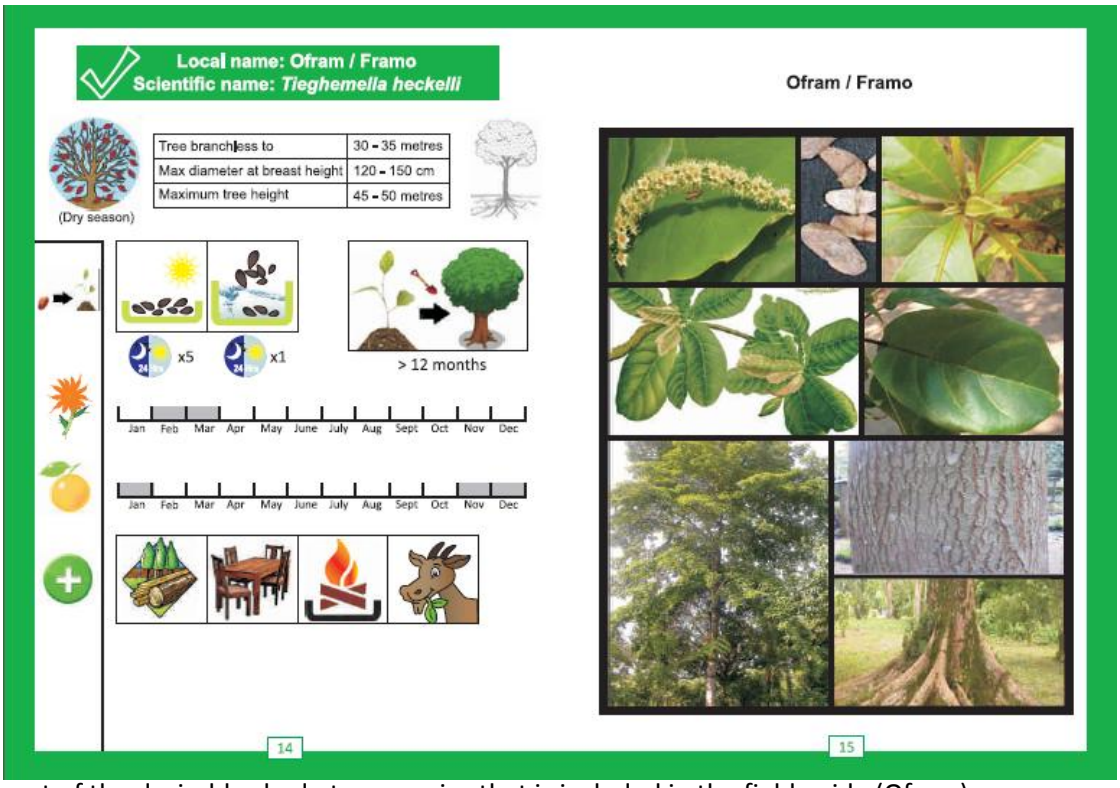

Fig 5: Layout of the desirable shade tree species that is included in the field guide (Ofram).

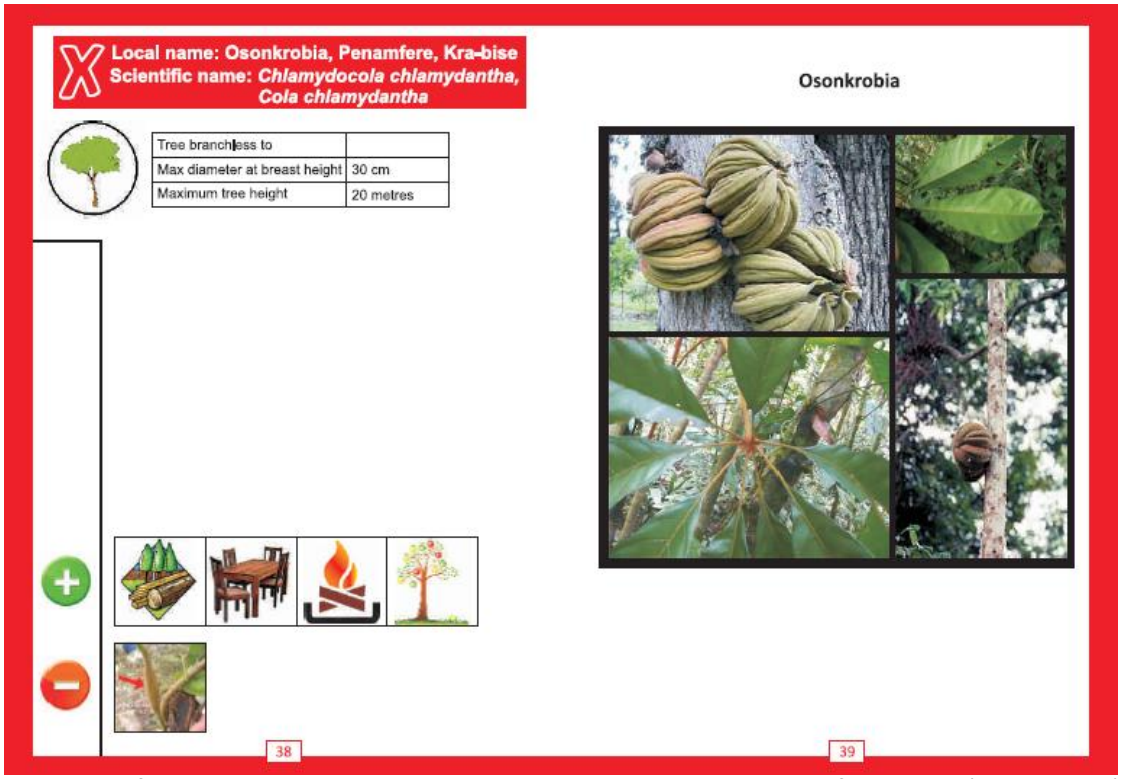

Fig 6: Layout of the undesirable shade tree species that is included in the field guide (Osonkrobia).

4. Conclusion

The purpose of the research was to understand the motivation of Ghanaian cocoa farmers in the Nyinahini and Bia project of the Agro Eco – Louis Bolk Institute whether or not to produce cocoa under shady circumstances with environmental, social and financial benefits. Furthermore, it focused on the shade tree species that were found most desirable or undesirable by different stakeholders. Ninety farmers were interviewed individually and another ninety joined during focus groups. People from different age categories participated in the research.

It was expected that most farmers were not familiar with the advantages that shade trees could provide. Furthermore, it was assumed that most of the farmers produce cocoa in monocultures, because they are afraid that shade trees attract pests and diseases which effect the cocoa trees and decrease their yield. The results of the research are described below.

The field research showed that the intercropping of cocoa trees with crops is very common in the area. Most farmers grow cocoa trees in combination with crops to produce more products for home consumption or the market and for providing temporary shade to the cocoa trees. The most common crops in cocoa plantations are: plantain, cassava, yam and cocoyam. Scientific research indicated that shade trees help to maintain cocoa yield. In regard to changes in the cocoa yield, more than half of the farmers (56%) faced an increase in yield, whereas forty-two percent had to cope with a decrease in production. Main reasons that explain the increase in yield are: input of organic fertilizers and spraying of organic pesticides. Farmers mentioned that the decrease in production could be explained by the fact that farmers did not use fertilizers and pesticides. This lack of input caused that cocoa trees became vulnerable and infected by pests and diseases. The vast majority of the interviewed farmers mentioned to grow cocoa as their main crop. Each farmer sold 17.6 bags of cocoa beans on average last year.

All farmers stated that they have shade trees on their farm already and that some of them have even planted shade trees. However, most of the farmers are interested in growing more shade trees on their farms. Farmers seem to be very much aware of the range of advantages and disadvantages that shade trees might bring and mentioned around twenty different positive arguments for using shade trees. Furthermore, they identified nine negative arguments for growing shade trees in combination with cocoa trees. The advantages that were mentioned by more than half of the farmers are: shade trees protect cocoa trees from drying out, the trees could be used for timber, to produce medicines, as firewood or to provide extra income. That shade trees might attract pest and diseases was the most mentioned disadvantage. It appeared that farmers consider positive effects of shade trees on the environment as being very important for intercropping cocoa with shade trees. Furthermore, it seemed that environmental services that improve the production circumstances for cocoa and extra products provided by the shade trees are both important motivations for farmers to produce cocoa under shady circumstances. Negative impacts on cocoa growth caused by chainsaw operators who destroy the farm during the (illegal) felling of shade trees and the increased risk of falling branches may discourage farmers from using shade trees. However, the vast majority of the interviewed farmers see shade trees on a cocoa farm as a big advantage and would like to grow more of them!

A list of the seventeen most desirable and undesirable shade tree species was composed after combining the desirable and undesirable shade tree species lists of different stakeholders. The most desirable shade tree species are *Terminalia ivorensis* (Emire), *Melicia exelsa* (Odum), *Terminalia superba* (Ofram, Framo), *Alstonia boonei* (Nyamedua), *Pycanthus angolensis* (Otie), *Entandrophragma angolense* (Edinam), *Entandrophragma cylindricum* (Sapele), *Tieghemella heckelli* (Baku, Makore), *Khaya spp.* (Mahogany),

Newbouldia laevis (Utile), *Myrianthus arboreus* (Nyankoma), *Canthium gladrislorum* (Gyapam, Nteteadupan). The tree species that were found most undesirable are, *Musanga cecropioides* (Odwuma), *Chlamydocola chlamydantha* (Osonkrobia, Penamfera , Kra-Bise), *Carapa procera* (Sua-bise, Kwakuo-bise), *Cola gigantea* (Watapuo).

Discussion:

The result of the research do not seem to match with the expected result. It was expected that the farmers were not familiar with the advantages that shade trees could provide. However, the majority of the farmers appeared to be conscious of the positive effects of shade trees. This could be explained by the fact that some farmers joined trainings wherein the advantages of shade trees were explained. Those farmers started to grow shade trees on their cocoa farms. The effects became visible and more farmers saw the advantages that shade trees could give and started to grow them on their cocoa fields. The arguments 'improvement of air and water quality' and 'the increased lifetime of cocoa trees' were found most relevant by the farmers to plant shade trees on a cocoa farm. However, those arguments were not mentioned most often during the individual interviews. The first argument was only mentioned by ten percent (9) of the farmers and 'increased lifetime of cocoa trees' by forty-eight percent of the farmers. The arguments that shade trees help to protect cocoa trees from drying out and that they could be used for timber production were mentioned by ninety-seven and ninety-one percent of the farmers. The most relevant argument why farmers would not to grow shade trees on a cocoa farm was that chainsaw operators could come to the farm to cut the shade trees (illegally) and destroy the cocoa trees (5.1 points) while this was only mentioned by two percent of the farmers. It appears that the arguments that were found most relevant during the focus groups were not mentioned most often by the rest of the farmers. This investigation did not focus on how this could be explained and follow-up research is necessary to understand this difference.

Recommendations:

There was no information available on the differences between communities within a project area, so communities were selected randomly. This makes that it was not possible to say if there any external factors that influence the motivations of farmers whether or not to intercrop cocoa trees with shade trees. Further research could focus on this to see if external factors influence the motivations of cocoa farmers whether or not to grow cocoa under shady circumstances.

It is clear that more and more farmers become aware of the advantages of shade trees. The field guide "Shade tree guide for Ghanaian cocoa farmers" was created to provide information which shade trees that are really desirable and undesirable on a cocoa farm, how the different tree species could be recognized and for what purposes they could be used. Information on how to pre-germinate the seeds from the different tree species was also included. Trainings wherein those methods are explained and how to set up a nursery might be an important next step in stimulating farmers to grow cocoa under shady circumstances. Furthermore, it is important to find out an effective method how the farmers could register their planted trees. This registration is necessary to make sure that they are the legal owners of the trees and that timber companies or chainsaw operators will not come to the cocoa farms to cut the shade trees for timber without permission of the farmer. A case study that focuses on how much income a farmer could generate could also motivate farmers to change their cocoa production systems. More research if there is an increase in negative effects of shade trees on cocoa farms under certain circumstances might also be interesting to prevent this in the future.

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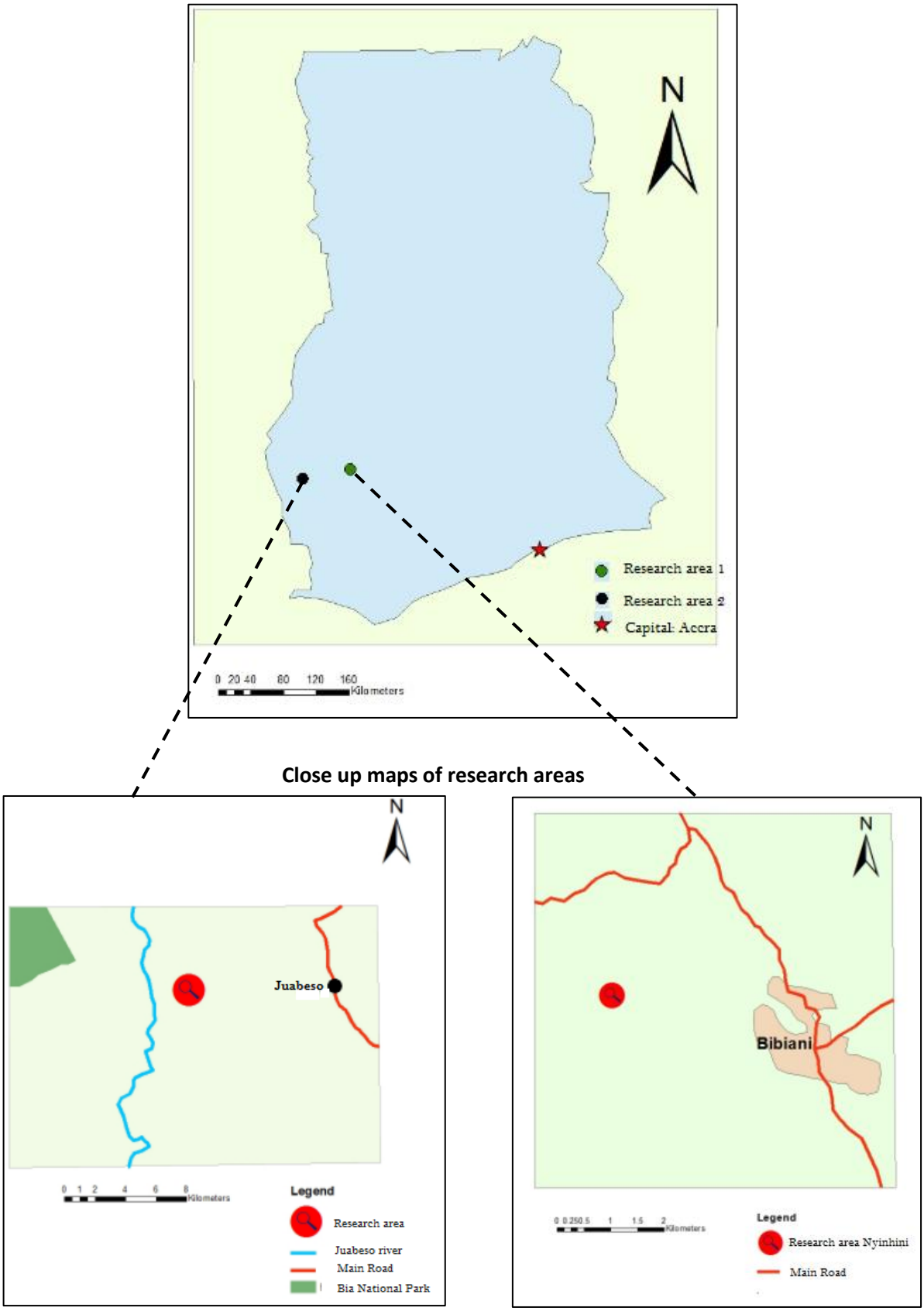
Appendix I: Map of the research areas 'Nyinahini'and 'Bia', Ghana, West-Africa



Appendix II: Individual interview form

1. *General farmer info*

1.1 Date interview		By:	Translator:
1.3 Nr farmer			
1.4 Name farmer			
1.5 Male / female			
1.6 Community			
1.7 Age			
1.8 Education	O never been to school O primary drop out O primary completed O junior high school O Senior high school O University		
1.9 Able to read	Yes / No		
1.10 Able to write	Yes / No		
1.11 Married	Yes / No	1.12 Divorced Yes / No	1.13 Widow(er) Yes / No
1.14 Nr of children:			
1.15 Does partner help on farm	Yes / No		
1.16 Other occupations (beside farming)			

2. *General farm info*

2.1 Landowner /do you hire the land or are you an employee of the landowner?		
2.2 What part do you hire from someone else? O No land rented O < 1/3 O 1/3 – 2/3 O >2/3		
2.3 Do you rent out a part of your farm to someone else? Yes / No		
2.4 Size farm land	Acres	
2.5 Distance of farm field to home	Min of walking	
2.6 Number of cocoa fields <10 yrs old		
2.7 Number of cocoa fields > 10 yrs old		
2.8 How many bags did you sell last season in total?	bags	
2.9 Production over the years has	declined / increased	
2.10 Can you explain this?		
2.11 Number of people working on the land		
2.12 How many total hours of work per week (average)		
2.13 How many hours do you work per week (average)		

3. *Cocoa production*

3.1 Cocoa as main crop	Yes / No
3.2 Which varieties do you grow?	O Hybrid O Amelenado O Tetteh Quarshie O unknown
3.3 In what year were most of the cocoa trees planted?	

4. Crop production

Mixed with other crops	Yes / No				
Crops	Quantity GhC	Home cons	Sale	Temp shade	Other reason

5. Trees on farm

5.1 Other tree species than cocoa trees on farm	Yes / No		
5.2 Local name	5.3 Nr of trees	5.4 Planted	5.5 >10 yrs
5.6 Why did you plant / leave those species on the farm?			
5.7 Why didn't you plant more trees on your farm?			

6. Opinion farmer about trees

6.1 Do you see shade trees on a cocoa plantation as an advantage / disadvantage?	
6.2 Can you give examples of advantages that shade trees might give except for shade?	
Examples advantages	
O Firewood	O Medicine
O Reduced incidence of weeds and diseases	O Extra sources of income
O Increased lifetime of cocoa trees	O Carbon storage
O Timber	O Sticking yams
O Fruit	O More rain
O Erosion control	O
O Improved biodiversity / wildlife	O
O Improved soil conservation / fertility	O
O Windbreak	O
O Improved air and water quality	O
Examples disadvantages	
O Competition with cocoa trees	O
O Timber companies come and destroy farm	O
O Damage by falling trees or branches	O
O Reduced production of cocoa trees and food crops	O
O Necessary to maintain trees	O
6.7What factors determine your motivation to have other trees beside your cocoa trees?	
6.8 Do you want more shade trees? Yes / No	
6.9 Why (not)?	

7. *Opinion on field guide*

Do you think that a field guide to identify the tree species and their purposes is useful?	Yes / No
Should we include only the desirable or also the undesirable tree species?	Only desirable / both
Why?	
Other ideas how we can help and stimulate you to make cocoa production under shady circumstances more attractive?	

Appendix III: Field form focus groups

Date	
Community	
Nr Focus group	

Possitive arguments	***Negative arguments***

Positive arguments	*Relevance*
Firewood	
Less weeds and diseases	
Increased lifetime cocoa trees	
Timber	
Fruit	
Erosion control	
Habitat for wildlife	
Improved air/water quality	
Medicine	
Shade for moisture	
Carbon storage	
Windbreak	
Fertilizes the soil	
Food for animals	
Host for Yam	

Negative arguments	*Relevance*
Competition with cocoa trees	
Timber companies come and destroy farm	
Damaged cocoa trees by falling trees or branches	
Damage to farmer by falling trees or branches	
Cocoa trees grow too tall	
Necessary to maintain the trees	
Attracts pests, weeds and diseases	
Reduced production	

Desirable tree species (Twi Name)

Undesirable tree species (Twi Name)

Appendix IV: General information of farmers, farm and yield per community.

Community	Nyinahini project				Bia project					Total	Average
	Pasoro	Nyame-dadom	Kwabena Fori	Anansu	Eteso	Dominbo	Asuontaa	Asempaneye	Adjoafua		
Male	9	9	4	8	7	4	5	6	8	*60*	
Female	1	2	6	1	3	6	5	4	2	*30*	
Total	*10*	*11*	*10*	*9*	*10*	*10*	*10*	*10*	*10*	*90*	
Age 21 -30	0	3	2	1	1	2	0	0	0	*9*	
Age 31 - 40	2	3	0	2	1	0	4	1	5	*18*	
Age 41 - 50	1	3	3	2	4	3	2	3	3	*24*	
Age 51 - 60	5	1	2	2	3	1	2	4	0	*20*	
Age > 60	2	1	2	2	3	1	2	4	0	*17*	
Average	*53*	*40*	*49*	*48*	*53*	*49*	*47*	*55*	*42*		*43*
Never been to school	2	5	3	2	2	5	4	4	3	*30*	
Primary Schl. drop out	0	0	1	1	1	1	0	0	2	*6*	
Primary Schl. completed	2	1	3	3	1	1	1	2	0	*14*	
Senior high school	4	2	1	2	2	0	0	2	5	*18*	
University	0	0	0	0	0	0	0	0	0	*0*	
Total	*8*	*8*	*8*	*8*	*6*	*7*	*5*	*8*	*10*	*68*	
Able to read	7	3	7	5	4	2	4	4	5	*41*	
Able to write	7	3	7	5	4	1	3	5	4	*39*	
Total	*14*	*6*	*14*	*10*	*8*	*3*	*7*	*9*	*9*	*80*	
landowners	9	7	8	9	10	10	10	10	10	*83*	
Farmers that rent land	0	3	2	1	0	0	0	0	0	*6*	
Farmers with incr. yield	3	6	7	8	5	4	6	7	6	*52*	*11.2*
Farmers with decr. yield	6	5	2	1	5	6	4	3	6	*38*	*7.8*
Nr of cocoa fields	2.3	1.9	2.4	2.4	2.1	2.7	2.1	1.5	1.3		*1.8*
Bags of cocoa sold last yr	16.2	16.2	9.0	22.4	19.8	11.9	17.8	17.7	19.2		*15*
Working hours per week	28	31	24	31	16	30	19	20	28		*22*
Minutes walking to farm	40	30	35	50	60	45	60	40	50		*41*

Appendix V: Number of times positive arguments are mentioned per community.

Motivation mentioned	Total nr of times motivation mentioned	AVG	Pas	Nyd	KwF	Ana	Ete	Dom	Asu	Ase	Adj
Timber	82	9.1	10	11	8	5	10	10	10	9	9
Medicine	62	6.9	7	8	6	2	8	8	10	3	10
Firewood	55	6.1	5	9	8	2	9	7	8	0	7
Extra source of income	47	5.2	4	2	2	2	5	8	9	6	9
Increased lifetime cocoa tree	43	4.8	1	3	3	4	7	7	7	3	8
Improved soil conservation	42	4.7	4	1	3	2	9	6	3	7	7
Sticking yams	27	3.0	1	5	0	1	9	7	0	1	3
Windbreak	23	2.6	4	5	2	0	1	0	4	4	3
Improved air / water quality	9	1.0	0	0	0	0	1	2	3	0	3
Water storage for dry season	8	0.9	0	0	0	0	0	1	4	1	2
Erosion control	8	0.9	0	0	2	0	0	0	2	2	2
Improved soil moisture	8	0.9	0	0	0	0	1	1	4	0	2
Increased yield	7	0.8	0	0	2	1	0	1	2	1	0
Fruit	7	0.8	1	2	3	0	1	0	0	0	0
Cool down land/ place to rest	4	0.4	1	0	0	0	0	0	0	1	2
Improved biodiversity	3	0.3	1	0	0	0	0	1	0	1	0
Increased rainfall	2	0.2	1	0	1	0	0	0	0	0	0
Food from bark	2	0.2	0	0	0	0	1	1	0	0	0
Red weeds and diseases	1	0.1	0	0	0	0	0	1	0	0	0
Carbon storage	0	0.0	0	0	0	0	0	0	0	0	0
Av nr adv aware of per farmer	22	5.8	4.8	5.1	4.9	2.9	7.2	7	7.6	5	7.9

	Community	Project area
Pas	Pasoro	Nyinahini
Nyd	Nyameadom	Nyinahini
KwF	Kwabena Fori	Nyinahini
Ana	Anansu	Nyinahini
Ete	Eteso	Bia
Dom	Dominbo	Bia
Asu	Asuontaa	Bia
Ase	Asempaneye	Bia
Adj	Adjoafua	Bia

Appendix VI: Negative motivations why farmers have not planted more shade trees before.

Motivation mentioned	Total nr of times motivation mentioned	AVG	Pas	Nyd	KwF	Ana	Ete	Dom	Asu	Ase	Adj
Competition with cocoa trees	13	1.4	4	1	0	0	1	1	3	1	2
Chainsaw operators destroy farm	2	0.2	0	0	0	0	1	0	0	0	1
Damage by falling branches	18	2.0	5	0	2	0	3	3	1	3	1
maintenance of trees necessary	0	0.0	0	0	0	0	0	0	0	0	0
Food crops bear less fruit	3	0.3	0	1	0	0	1	1	0	0	0
attraction of pests and diseases	27	3.0	8	1	2	0	2	5	2	2	5
harder to weed	1	0.1	1	0	0	0	0	0	0	0	0
competition for moisture	2	0.2	0	0	0	0	1	0	0	1	0
too much moisture	1	0.1	0	0	1	0	0	0	0	0	0
cocoa trees grow too tall	2	0.2	0	0	0	0	1	1	0	0	0
Why not planted (more) shade trees (before)	Total nr of times motivation mentioned	AVG	Pas	Nyd	KwF	Ana	Ete	Dom	Asu	Ase	Adj
No access to (more) seedlings			3	9	3	4	3	3	9	8	4
Unaware of advantages before			1	1	5	8	3	5	4	1	3
afraid of negative effects of shade trees (before)			2	0	0	1	1	4	1	2	2
not allowed by landowner to plant shade trees			1	1	0	0	0	0	0	0	0
New land, no time to plant			0	0	1	0	0	0	0	0	0
Unaware of desirable tree species			1	0	0	0	0	0	0	0	0

	Community	Project area
Pas	Pasoro	Nyinahini
Nyd	Nyameadom	Nyinahini
KwF	Kwabena Fori	Nyinahini
Ana	Anansu	Nyinahini
Ete	Eteso	Bia
Dom	Dominbo	Bia
Asu	Asuontaa	Bia
Ase	Asempaneye	Bia
Adj	Adjoafua	Bia

Appendix VII: Nr of times tree species mentioned as desirable or undesirable by focus groups.

	Tree species		Nr of times mentioned as	
Nr	Local name	Scientific name	Desirable	Undesirable
1	Ofram	Terminalia superba	8	
2	Emire	Terminalia ivoriensis	7	
3	Mahogany	Khaya spp.	7	
4	Odum	Milicia exelsa	6	3
5	Otie	Pycanthus angolensis	4	2
6	Baku/ Makore	Thieghemella heckelli	4	
7	Sesemasa	Newbouldia leavis	4	
8	Onyina	Ceiba pentandra	3	5
9	Nyamedua	Alstonia boonei	3	1
10	Mansonia		3	
11	Wawa	Triplochiton sceleroxylon	2	5
12	Odwuma	Musanga cecrepioides	2	2
13	Akasa	Chrysophyllum albidum	2	
14	Asamfena	Pouteria alnifolia	2	
15	Asanfran	Amphimas	2	
16	Edinam	Entandrophragma angolense	2	
17	Sapele	E. cylindricum	2	
18	Esa	Celtis mildbraedii	1	5
19	Mango	Magnicifera indica	1	4
20	Akata, Akonkodie	Bombax buonopozense	2	2
21	Kuokuonisuo		1	2
22	Mama		1	2
23	Utile	Etandrophragma	1	1
24	Apru		1	
25	Asia		1	
26	Avocadopear		1	
27	Coconut		1	
28	Ehye Dua		1	
29	Fuburewgu		1	
30	Glycidia		1	
31	Konkroma	Morinda lucida	1	
32	Kyenkyen	Anitaris toxicaria	1	
33	Kyereye	Pterygota macrocarpa	1	
34	Orange		1	
35	Owale		1	
36	Pea		1	
37	Prekese	Tetrapleura tetraptera	1	
38	Seiba		1	
39	Sidera		1	
40	Sidiala		1	
41	Tamatama		1	
42	Tweneboa	Cordia platythyrsa	1	
43	Wotowoto		1	
44	Nyankerene	Ficus exasperata		8
45	Kakapenpen			3

46	Cola tree			2
47	Dananyi			2
48	Fotie	Hannoa klaineana		2
49	Klata puo			2
50	Pepea	Margaritaria discoidea		2
51	Teak	Tectona grandis		2
52	Abisia			1
53	Akume Dua			1
54	Akye	Blighia sapida		1
55	Amankye Dua			1
56	Amazona			1
57	Asan			1
58	Cekure			1
59	Dwuma			1
60	Eplo			1
61	Ewale			1
62	Klontong			1
63	Kroma	Klainedoxa trillesii		1
64	Memfo			1
65	Nyankana			1
66	Ofapuo			1
67	Ofuntum			1
68	Ojuma			1
69	Pampena	Albizia adianthifolia		1
70	Tanuro	TrichiliaMonadelpha		1
71	Yaya	Amphimas pterocarpoides		1
72	Zkore			1
73	Zpam			1

Appendix VIII: List of tree species mentioned as desirable or undesirable by different stakeholders.

Desirable and undesirable tree species mentioned by the Cocoa Research Institute of Ghana (CRIG)

Desirable shade tree species		
#	Twi Name	Botanical Name
1	Odum	*Chrorophora excelsia*
2	Awiemfo, Semina	*Albizia coriaria*
3	Ofram / Amire	*Terminalia sp.*
4	Otei	*Pychanthus angolensis*
5	Adinam " Cedar"	*Entandrophragma angolense*
6	Ofruntum	*Funtumia elestica*
7	Nyame Dua	*Alstonia boonei*
Undesirable shade tree species		
1	Anyankoma	*Myrianthus arboreus*
2	Dwindwera	*Lecaniodiscus cupanoides*
3	Sua – Bise "Kwakuo –bise"	*Carapa procera*
4	Ankyewobiri	*Blighia welwitschii*
5	Onyina	*Ceiba pentandra*
6	Gyapam, Nteteabupan	*Canthium glabrislorum*
7	Watapuo	*Cola gigantean*
8	Odadee	*Adansonia digitata*
9	Osonkrobia, Penamfera "Kra- bise"	*Cola chlamydantha*
10	Odwuma	*Musanga cecropioides*

Desirable and undesirable tree species mentioned by the Literature source 1, Asare, R. (2006)

Scientific name	Local Name
Alstonia boonei	Nyamedua
Antiaris toxicaria/africana	Kyen-kyen
Ceiba pentandra	Onyina
Entandrophragma angolense	Edinam
E. cylindricum	Penkwa/Sapele
E. utile	Utile
Milicia excelsa	Odum
Pycnanthus angolensis	Otie
Terminalia ivorensis	Emire
T. superba	Ofram
Triplochiton scleroxylon	Wawa

Desirable and undesirable tree species mentioned by the Literature source 2, Anglaaere L.C. N. (2005).

Tree species	Local name
Albizia	Pampena
Albizia ferruginea	Awiemfosamina
Albizia zygia	Okoro
Alstonia boonei	Nyamedua
Celtis mildbreadii	Esa
Celtis zenkeri	Esakokoo
*Entandrophragma angolense***	Edinam
Entandrophragma cylindricum	Penkwa/Sapele
*Entandrophragma utile***	Utile
Ficus capensis	Odoma/Nwamdua
Funtumia africana	Okae
Funtumia elastica	Fruntum
Grewia mollis	Kyapotoro
Hannoa klainniana	Fotie
Irvingia gabonensis	Besebuo
*Khaya anthotheca***	Kruba
Khaya ivorensis	Dubini
Lophira alata	Kaku
Maesopsis eminii	Onwamdua
Milicia excelsa	Odum/Iroko
Milicia regia	Odum-nua/Iroko
Morinda lucida	Konkroma
Morus mesozygia	Wonton
Myrianthus arboreus	Nyankumabere
Myrianthus libericus	Nyankumanini
*Newbouldia laevis***	Sesemasa
Parkia bicolour	Asoma
*Pericopsis elata***	Kokrodua
Petersianthus macrocarpus	Esia
Piptadeniastrom aficanum	Dahuma
Pycnanthus angolensis	Otie
Rauvolfia vomittoria	Kakapenpen
Ricinidendron heudelotti	Wama
Solanum erianthum	Pepediawuo
Spathodea campanulata	Akuakuo-ninsuo
Spondias mombin	Atoa
Strombosia glaucescens	Afena
*Terminalia ivorensis***	Emire
Terminalia superba	Ofram
*Tetrapleura tetraptera***	Prekese
Tieghemella heckelii	Baku/Makore
Treculia aficana	Brebretim
Trema orientalis	Sesea
Turreanthus africanus	Avodire/Apapaye