Carbon Credit Incentives for Agroforestry

A Feasibility Study for Smallholder Farmers in Ghana's Ashanti Region

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TU Delft

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by

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Cover: Photo taken by the author on the 10th of June 2023 in one of the visited farming communities. Smallholder farmers being transported to the farm fields. Facial blurring was used to assure privacy.

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TU Delft

Preface

This research marks the culmination of my Master's degree in Complex Systems Engineering and Management, encompassing two years of learning to address intricate challenges, analyse them comprehensively, and devise innovative and effective solutions. Conducted in Ghana, this project provided me with a valuable opportunity to apply my skills in an unfamiliar context.

I would like to extend my gratitude to the individuals who supported me throughout this endeavour. Firstly, I wish to express my sincere appreciation to my collaborator in Ghana, Lewis. His assistance not only facilitated connections with key individuals relevant to my research but also offered unwavering support whenever I encountered challenges in his country. Lewis, alongside the Farmerline team in Kumasi, ensured that I felt at home and at ease during my research. My heartfelt thanks go out to everyone at Farmerline for their hospitality and contributions to my project. Medaase.

I also want to express my deep gratitude to my supervisors and advisor. Ellen, in addition to your invaluable scientific insights, I greatly appreciated your constant availability and concern for my well-being during my time in Ghana. Furthermore, I'd like to thank Jolien and Victor for keeping me intellectually engaged with thought-provoking questions and guiding me through the sometimes tumultuous path of refining my thesis. Your assistance has been instrumental in reaching this milestone.

Finally, I extend my gratitude to my family and friends for their unwavering support throughout the research journey. I would also like to offer a special thanks to my friends in Ghana, Flo, Martijn, Jorrit, and Friso, for the memorable adventures we shared during my time there.

Y.C.M. (Youp) Dumas
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Executive summary

Climate change is a pressing concern affecting the livelihoods of farmers in Ghana's Ashanti region due to erratic rainfall patterns, primarily impacting rain-fed agriculture. This research explores the potential of carbon credits to encourage smallholder farmers in the Ashanti region to adopt agroforestry practices as a solution. Agroforestry, if effectively implemented, not only helps combat climate change by capturing carbon but also improves soil fertility, protects crops from extreme weather, and offers various benefits to local farmers. This study delves into the complexities of this issue to propose innovative solutions benefiting both the local farming community and the global climate challenge.

The carbon-based agroforestry system consists of three main parts: the carbon credit system, the institutional system, and the socio-technical system. To study this complex system, we adopt an illustrative case study approach, focusing on the Ashanti region in Ghana. Our research follows a top-down approach, beginning with comprehensive desk research to build a foundational understanding, followed by in-depth interviews with local farmers and selected experts, including government agencies and an NGO, to gain a nuanced understanding of the Ashanti region's context.

Taking into account the carbon credit system, significant attention is devoted to crafting a project framework that aligns with rigorous carbon standards. The accumulation of carbon credits over time serves as a means to secure initial investments. Farmer involvement, particularly their commitment, assumes paramount importance in the context of the carbon credit system, given that only mature trees can generate carbon credits. Primary risks pertain to tree cutting or tree mortality. To mitigate these risks, farmers need comprehensive training and access to essential tools for tree maintenance.

The land tenure system in the Ashanti region is notably complex, predominantly relying on the customary framework. Insights garnered from farmer interviews underscore the pronounced tenure insecurity that impedes farmer participation in the system. Securing land tenure documents is pivotal to instilling confidence among farmers regarding the equitable distribution of system benefits. Notably, varying farmer characteristics and specific traditional areas wield varying degrees of influence over land tenure security and the complexity of acquiring such documents. For system feasibility, a targeted approach focusing on engaging landowners and dispelling misconceptions while emphasising the advantages of land tenure documents is essential. Incentivising landowners through a share of the carbon revenue may also be necessary to ensure their active participation.

Farmers in the Ashanti region grapple with diverse challenges, stemming from erratic rainfall patterns, pest infestations, weed proliferation, and soil nutrient depletion. These challenges are compounded by financial constraints, exacerbating the farmers' livelihood struggles. Notably, farmers place a higher premium on the tangible benefits of increased fruit tree yields as the primary incentive for system participation, displaying comparatively lesser interest in the intangible monetary returns from carbon credits. Effective communication with farmers necessitates addressing their immediate concerns. Consequently, the agroforestry system should be designed to incorporate intercropped fruit trees, delivering additional yields while preserving the cultural significance of existing crops and optimising the environmental advantages of the system. Given that farmers predominantly learn through visual exposure, the initiation of a pilot agroforestry system can substantially bolster their willingness to participate. Simultaneously, the development of tailored training programs and the provision of essential tools are indispensable for empowering farmers to proficiently maintain the trees.

The significance of carbon credits within the system primarily lies in compensating cooperating and financial parties, as farmers prioritise other benefits. The institutional system's challenges, particularly in securing land tenure documents, pose substantial feasibility hurdles for the system's viability. In future research on this topic, it would be valuable to seek the insights of traditional authorities.

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Nomenclature

Abbreviations

Abbreviation	Definition
CDM	Clean Development Mechanism
CERs	Certified Emissions Reductions
EPA	Environmental Protection Agency
ETS	Emissions Trading Systems
GHG	Greenhouse Gas
IS	Institutional System
JI	Joint Implementation
MOFA	Ministry of Food & Agriculture
NGO	Non-Governmental Organisation
SLF	Sustainable Livelihood Framework
STS	Socio-Technical System
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary Carbon Market

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Introduction

This introduction serves as the foundational point for commencing this study. The study at hand comprises a feasibility assessment focused on the potential implementation of agroforestry practices among smallholder farmers in the Ashanti region of Ghana, by connecting these farmers to the carbon credit market. Crucial to this academic research is the requirement to offer both societal relevance and scientific relevance. To achieve the research objective and address the primary research question within this report, the examination begins with the prevailing societal challenges that could be effectively addressed by the proposed system, thereby establishing its societal relevance. Simultaneously, a comprehensive literature review is conducted to pinpoint the gaps in existing academic knowledge that can be bridged by this research. The convergence of societal relevance and scientific relevance forms the basis for the research objective, which, in turn, shapes the primary research question. Due to the complex nature of the problem at hand, the system has been divided into three distinct parts, each to be addressed separately. These components align with the primary sub-questions.

1.1. The Proposed System

This research encompasses the following proposed system, containing two major parts from the thesis title: The feasibility of linking smallholder farmers in the Ashanti region to **the carbon credit market** through the application of **agroforestry practices**. Since the majority of the content in this report revolves around these two technical sub systems, a brief explanation of this carbon-based agroforestry system is provided below in table 1.1.

Table 1.1: The Proposed System, Key Concepts

Agroforestry practices involve the integration of trees and crops on the same land to achieve multiple benefits such as improved soil quality, increased biodiversity, and enhanced environmental sustainability. (Nair et al., 2021)
The carbon credit market is a mechanism aimed at mitigating climate change by enabling individuals or companies to offset their carbon emissions by investing in projects that reduce or capture carbon dioxide from the atmosphere, such as reforestation or renewable energy projects. (Lokuge et al., 2022)

1.2. Societal Relevance

The proposed agroforestry system utilising carbon credits presents the potential to address a spectrum of challenges, categorised into three scales: global, meso, and local. This section aims to identify the specific issues associated with the proposed system, followed by an examination of relevant literature to determine its capacity to effectively tackle these problems. With the combination of the current specific issues and the potential impact on these issues of the proposed system, this section is used to provide the societal relevance of this research.

1.2.1. Global Scale Level

Global Scale Issue

Climate change, a phenomenon characterised by alterations in climate patterns, stems from the emission of greenhouse gases (GHG), both originating from natural systems and human activities (Fawzy et al., 2020). The retention of heat in the Earth's atmosphere, primarily caused by these GHG, forms the basis of global warming. As the global economy has undergone rapid expansion in recent years, there has been an increasing reliance on fossil fuels for energy production, resulting in a significant increase in atmospheric CO2 pollutants (Kuppan et al., 2017). Human-induced activities have led to a substantial global temperature rise of approximately 1°C above pre-industrial levels, with projections indicating a continued upward trajectory. If current emission rates persist, the global temperature is anticipated to increase by 1.5°C between 2030 and 2052 (Fawzy et al., 2020). Under a high emissions scenario, where no efforts are made to reduce GHG pollution, the global temperature may escalate by 3.3°C to 5.7°C by the close of this century (Masson-Delmotte et al., 2021).

Already, the effects of climate change are evident, evidenced by a considerable rise in natural disasters, impacting numerous communities worldwide. In 2018 alone, approximately 68.5 million individuals were affected by these devastating events (Fawzy et al., 2020; Banholzer et al., 2014). Such consequences underscore the urgency to address the complex challenges posed by climate change on a global scale. As the planet grapples with these threats, understanding the mechanisms driving GHG emissions becomes paramount, guiding the development and implementation of mitigation and adaptation strategies to safeguard ecosystems, human well-being, and the planet's sustainability.

In 2015, the Paris Agreement was introduced as a global effort to restrict the rise in the average global temperature to a maximum of 2°C and strive for even more ambitious targets by limiting the increase to 1.5°C (Viñuales et al., 2017). However, the emergence of new technologies has raised concerns about potentially aggravating CO2 emissions, posing challenges for countries involved in the Paris Agreement to achieve their environmental goals by 2050 (Kuppan et al., 2017). To combat the accumulation of CO2 in the atmosphere, two primary approaches can be employed. Firstly, efforts can be directed towards reducing emitted carbon dioxide. Additionally, carbon sequestration techniques

can be employed to remove carbon from the atmosphere. Within the natural carbon cycle, vegetation plays a pivotal role in absorbing carbon dioxide through photosynthesis, mitigating GHG levels. Enhancing the strength of the natural carbon cycle presents a viable strategy to address the significant increase in atmospheric carbon dioxide. Achieving this goal involves encouraging the expansion of vegetation through incentivising green initiatives. The Clean Development Mechanism (CDM) under the Kyoto Protocol permits parties to offset their carbon emissions by investing in emissions reductions in other countries. By harnessing the potential of the CDM and the voluntary carbon credit market (VCM), landowners in developing nations can benefit financially from carbon sequestration efforts on their lands (González-Estrada et al., 2008).

Global Scale Impact

Agroforestry systems hold significant potential to contribute to global climate change mitigation efforts (U.S. Geological Survey (USGS), 2008). By integrating trees alongside traditional agricultural practices, the vegetation is increased, and these systems can effectively sequester carbon dioxide from the atmosphere through photosynthesis (Jose, 2009). The stored carbon helps reduce the concentration of GHG, contributing to the mitigation of global warming and strengthening carbon sinks that offset carbon emissions.

1.2.2. Mesoscale Level

Mesoscale Issue

In Ghana's mesoscale, the delicate balance between environmental stability and human-driven changes is significantly impacted by a number of factors, including climate change, intensifying agricultural practices, and population growth. The interplay between climate change, population growth, and intensifying agricultural practices, as shown in Figure 1.1, significantly impacts key environmental aspects in Ghana's mesoscale, including soil quality, biodiversity, water quality, and deforestation (Asante and Amuakwa-Mensah, 2014).

The impact of climate change on global temperatures and weather patterns has far-reaching consequences for Ghana's mesoscale. Rising temperatures, irregular rainfall, and more frequent extreme weather events pose challenges for farmers, ecosystems, and natural resources (De Pinto et al., 2012). As climate change disrupts traditional weather patterns, it drives shifts in agricultural practices and prompts the need for adaptive strategies to maintain ecological balance.

Population growth and urbanisation in Ghana exert increasing pressure on natural resources in the mesoscale. The expanding human footprint leads to greater demands for land, water, and food, fostering the intensification of agricultural practices (Antwi-Agyei, Dougill, Stringer, and Codjoe, 2018). The expansion of agricultural activities, while crucial for food security, often comes at the cost of deforestation, affecting vital ecosystems and biodiversity (E. O. Acheampong et al., 2019). Moreover, intensifying agricultural practices, driven by population growth and economic demands, are altering the quality of soil in Ghana. The increased use of agrochemicals and industrial farming techniques impacts soil health and raises concerns about soil degradation, erosion, and nutrient depletion (Kotu et al., 2017). Consequently, understanding the consequences of intensification on soil quality and devising sustainable land management practices becomes critical to safeguarding agricultural productivity and environmental sustainability. Ghana's mesoscale hosts an exceptional diversity of plant and animal species, making it a biodiversity hot spot. However, the combined effects of climate change, deforestation, and habitat fragmentation threaten this rich biodiversity (Tetteh et al., 2018; E. O. Acheampong et al., 2019). Expanding human settlements, agricultural activities, and other land-use changes encroach upon natural habitats, calling for conservation efforts and the establishment of protected areas to preserve Ghana's unique flora and fauna. Water quality, an essential component of environmental stability, faces mounting pressures due to intensifying agriculture. The use of agrochemicals and inadequate waste management contribute to water pollution, impacting aquatic ecosystems and human health (Karikari et al., 2006). As the effects of climate change exacerbate water scarcity and variability, responsible water resource management becomes indispensable for sustaining ecological integrity and meeting the needs of Ghana's growing population.

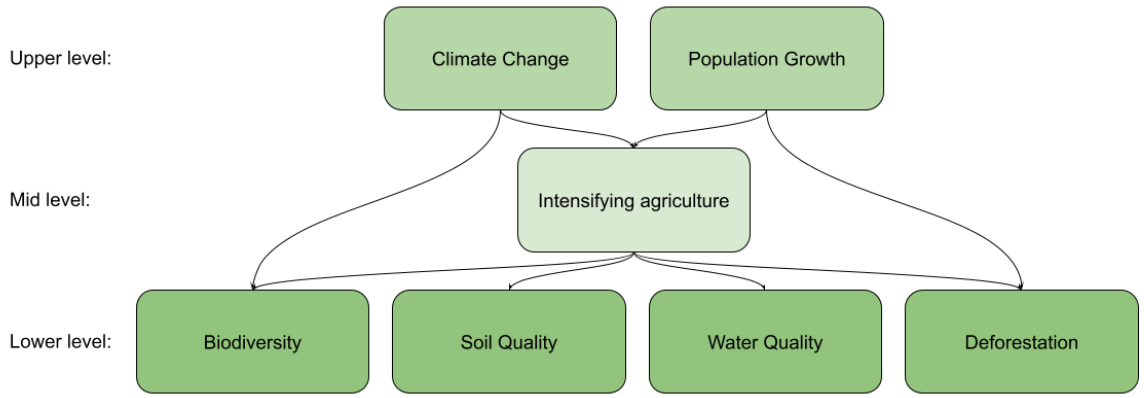

Figure 1.1: Relationships Meso Scale Impacts in Ghana

Mesoscale Impact

At the mesoscale, agroforestry systems offer substantial contributions to various environmental and socioeconomic aspects. These systems play a crucial role in improving soil quality by stabilising the soil, preventing erosion, and enhancing nutrient cycling (Jose, 2009). The presence of trees creates diverse habitats that support a wide range of plant and animal species, promoting biodiversity conservation (Jose, 2009; Jose, 2012). Furthermore, agroforestry systems contribute to water quality and conservation by reducing water runoff and minimising soil erosion, leading to enhanced water quality in nearby water bodies (Jose, 2009). The sequestration of carbon dioxide by trees aids in climate regulation at the regional level, positively impacting weather patterns and local climate conditions (Mbow et al., 2014; Vidhana Arachchi et al., 1997). Moreover, community-based management of natural resources through agroforestry systems enhances local community resilience to environmental and economic challenges. These systems deliver essential ecosystem services, including pollination, pest control, and microclimate regulation, all of which contribute to improved crop productivity and overall agricultural sustainability (Jose, 2009). Figure 1.1 illustrates the interconnectedness of impacts across various scales, commencing from the global level at the top and progressing toward the local level at the bottom of the diagram.

1.2.3. Local Scale Level

Local scale issue

Ghanaian farmers face a multitude of challenges that impact their livelihoods and well-being, summarised in Table 1.2. These agricultural communities, often reliant on rain-fed agriculture, confront various obstacles that hinder their productivity and economic prosperity (Antwi-Agyei, Stringer, et al., 2014).

As mentioned above, one of the most pressing challenges is the unpredictable weather patterns brought about by climate change. Prolonged droughts, heavy rainfall, and extreme weather events disrupt planting and harvesting seasons, leading to reduced crop yields and income losses (De Pinto et al., 2012; Ndamani et al., 2015). As farmers' incomes dwindle, their ability to invest in essential inputs, such as quality seeds and fertilisers, becomes constrained, perpetuating a cycle of low productivity (E. N. Acheampong et al., 2014; Darfour et al., 2016). Limited access to modern agricultural techniques and technologies is a significant constraint faced by Ghanaian farmers. Many smallholder farmers lack access to irrigation systems, machinery, and other innovative practices that could enhance productivity and resilience (Chamberlin, 2008; Darfour et al., 2016). Inadequate training and extension services further hinder the adoption of best agricultural practices, preventing farmers from optimising their yields and income potential. The high cost of inputs, coupled with fluctuating commodity prices, also poses a significant burden on farmers. Fertilisers, seeds, and pesticides often make up a substantial portion of farmers' expenses. Inadequate market linkages and price volatility can lead to situations where farmers struggle to earn a fair return on their hard work (Ndamani et al., 2015). These challenges are part of the sociotechnical system, the corresponding impact can be found in Table 1.2.

Another critical issue for Ghanaian farmers is land tenure insecurity. Many smallholder farmers lack formal land titles, exposing them to the risk of eviction and land disputes (Ibrahim et al., 2020; Kandel et al., 2021). This uncertainty hampers long-term planning, investment, and access to credit (Amoah, 2019). Furthermore, the increasing conversion of agricultural land to other uses, such as mining or urban development, further exacerbates land scarcity and puts additional pressure on farmers. The challenge regarding land tenure security is part of the institutional system affecting the potential feasibility, as indicated in Table 1.2.

Table 1.2: Challenges in Livelihood for Ghanaian Farmers within Sociotechnical System (STS) & Institutional System (IS)

System	Challenge	Livelihood impact
STS	Environmental	Reduced crop yields and income losses
		Disruptions in planting and harvesting seasons
	Economical	Increased expenses for farmers
		Uncertainty in earning fair returns
IS	Land tenure	Risk of eviction and land disputes
		Inhibited long-term planning and investment

Local Scale Impact

By implementing agroforestry practices, farmers can enhance their environmental sustainability while generating additional income through carbon credit trading. The financial compensation from carbon credits offers economic resilience for farmers. It provides a supplementary income source that is less susceptible to climatic uncertainties. This additional revenue can be utilised to invest in farm infrastructure, improve access to quality agricultural inputs, and adopt sustainable farming practices. Moreover, the financial stability provided by carbon credits empowers farmers to diversify their income sources, reducing their vulnerability to economic shocks and enhancing their overall well-being. Additionally, agroforestry could provide farmers with additional income streams from tree products such as fruits, nuts, and timber, thus diversifying their revenue sources and bolstering financial resilience at the local level (Adane et al., 2019).

The above-mentioned advantages of the agroforestry system concerning mesoscale issues are expected to have a positive impacts on farmers' harvest yields. The improved soil nutrients, enriched local ecosystem, more effective pest control, and enhanced water quality are expected to contribute positively to the harvest outcomes (Jose, 2009). These positive effects contribute to increased food security, improved income generation, and overall agricultural productivity. Moreover, the implementation of an agroforestry system linked to the carbon credit market also facilitates knowledge sharing and capacity building among farmers. Through participation in the carbon credit program, farmers gain access to technical expertise and resources that promote sustainable land management practices.

1.2.4. Farmerline

Founded in 2013, Farmerline is a Ghanaian enterprise that endeavours to accomplish an influence within Ghana's agricultural domain. It has successfully established connectivity with a substantial number of more than 800 smallholder farmers spanning across Ghana and Western Africa, with the objective of enhancing their agricultural output and increasing their financial prospects. Farmerline's approach is multifaceted, encompassing various strategies such as training programs, provision of high-quality agricultural inputs, and facilitation of market access, all of which collectively empower farmers to attain sustainable livelihoods and cultivate prosperous economic conditions. Throughout the course of this research, Farmerline has played an instrumental role in facilitating the interview process with local farmers. The support provided by Farmerline includes arranging interviews, engaging translators when necessary, and providing essential contacts affiliated with the Ghanaian government. Such assistance has significantly contributed to the smooth and effective execution of the interviews, enhancing the quality and comprehensiveness of the research outcomes. The findings of this research hold value not only for Farmerline but also for similar enterprises aiming to establish agroforestry systems for Ghanaian smallholder farmers. The insights garnered from this study can serve as a crucial resource

in informing the design and implementation of such systems, facilitating their successful integration into the agricultural landscape.

Ten Million Trees Initiative

The 'Ten Million Trees' initiative constitutes an agroforestry project led by Farmerline, aimed at sourcing and distributing saplings to farmers. The primary objective is to facilitate the planting of ten million trees across farmlands in Ghana, with the overarching goals of enhancing harvest efficiency and ensuring a sustainable income source for the engaged farmers. To achieve the ambitious target of tree plantation, it is imperative to devise effective incentives that will foster farmer engagement. Notably, the accrual of carbon credits necessitates a minimum investment period of three to five years, underscoring the imperative of long-term commitment from farmers to guarantee the initiative's success. A minimum allocation of 80 percent of the income derived from carbon credits shall be apportioned to the participating farmers, ensuring their fair share of the financial benefits.

Figure 1.2: Farmerline's 10 Million Trees Initiative

1.2.5. Conclusions Societal Relevance

Upon a brief examination of current issues, it becomes apparent that global warming presents a substantial challenge on a global scale, one that could potentially be mitigated, at least in part, through the adoption of the agroforestry system. On a smaller, more local scale, various concerns arise, including the impact of global warming on farmers' crop yields, food security, financial well-being, and institutional factors. These local challenges collectively affect the livelihoods of farmers within the region. Therefore, for this research to hold societal relevance, it is imperative to place farmers at the core of the investigation and provide recommendations for the design of the system with the goal of maximising its positive impact on the livelihoods of participating farmers. Hence, the research must adopt a farmer-centric approach.

1.3. Scientific Relevance

In light of section 1.2, which discussed the prevailing challenges and the potential of the agroforestry system, it is evident that significant academic attention has been devoted to research topics related to the proposed system. However, the specific focus of this thesis lies in the implementation of the carbon credit market through agroforestry practices in the context of the Ashanti region in Ghana. For the research to hold academic value, it is imperative to identify potential gaps in the existing literature regarding this particular implementation, considering the unique attributes of Ghana's Ashanti region.

This literature review aims to identify and explore potential academic knowledge gaps concerning the implementation of the agroforestry-based carbon credit market in Ghana. The investigation particularly focuses on four key areas: the extent of available information on agroforestry practices in Ghana, the current academic knowledge pertaining to the implementation of carbon credits in the Ghanaian context, the potential impact on the livelihood of Ghanaian farmers resulting from the implementation of the agroforestry system, and the impact of the Ashanti land tenure agreements on the implementation of the system. These four topics have been identified based on the nature of the proposed system, and the findings from the section on societal relevance literature, which underscored their significance.

By examining the literature for any gaps in these specific areas, this research aims to contribute to the academic discussion, uncover unexplored aspects, and determine the feasibility and potential success of the proposed agroforestry system in Ghana. To conduct the literature research, the WorldCat database is used. The search terms employed and the number of articles retrieved is documented in Appendix A.1 to ensure the reproducibility of this literature review.

1.3.1. Agroforestry in Ghana

An analysis of the existing literature on agroforestry in Ghana reveals three predominant thematic areas of investigation. Primarily, recent studies have predominantly focused on the perceptions of farmers (Yamoah et al., 2021; Owusu et al., 2022; Baziari et al., 2019; Akoto, Denich, et al., 2018). These investigations have focused on the perceptions of specific farmer categories, such as cocoa, shea, and bamboo producers, regarding their willingness to embrace agroforestry practices. It is worth noting that these studies were conducted in regions of Ghana distinct from the Ashanti region, and their findings are pertinent primarily to these specific farmer groups. Notably, an under explored topic pertains to the potential influence of the carbon credit market on farmers' perception of the adoption of agroforestry practices. Furthermore, the distinct socio-economic and environmental characteristics characterising farmers in the Ashanti region may shape their attitudes towards agroforestry methodologies. As emphasised in the section addressing societal relevance, the carbon-based agroforestry system is anticipated to enhance the livelihoods of a broad spectrum of farmers across the Ashanti region, rather than being limited to specific farming categories. Remarkably, the existing literature lacks comprehensive data on the perspectives of various farmer typologies concerning agroforestry methods within the Ashanti region. This research seeks to address this academic knowledge gap and elucidate the nuanced views and preferences of farmers within this specific context.

The second domain of academic research concerning agroforestry in Ghana pertains to economic analyses of agroforestry systems (Nunoo et al., 2017; Obiri et al., 2007). It is noteworthy that these sources do not consider the potential incorporation of the carbon credit market, which could offer an additional income stream for participating farmers.

Finally, a significant body of literature extensively explores the various benefits of agroforestry, particularly in relation to its positive impact on increased crop yield and enhanced soil nutrient content (Asase et al., 2010; Akoto, S. T. Partey, et al., 2020; Ashiagbor et al., 2020; Asigbaase et al., 2021; Asare et al., 2014; Kongor, De Steur, et al., 2018; Kongor, Boeckx, et al., 2019; Akesse-Ransford et al., 2021; Kaba et al., 2021; E. Acheampong et al., 2016; Anim-Kwapong et al., 2009; Appiah, 2012; Anglaaere et al., 2011; Dawoe et al., 2014). These sources delve into the specific impacts of agroforestry systems but do not address the system-level implementation of such systems. Notably, there exists a significant gap in academic literature regarding the comprehensive integration of the various sub-systems within the carbon-based agroforestry system within a single research framework.

Table 1.3: Considered Articles Agroforestry in Ghana

Source	Key topic	Specific topic
Yamoah et al., 2021	Farmer perception	Cocoa
Owusu et al., 2022	Farmer perception	Cocoa
Baziari et al., 2019	Farmer perception	Shea
Akoto, Denich, et al., 2018	Farmer perception	Bamboo, socioeconomic variables
Asase et al., 2010	Technical effects	Deforestation
Akoto, S. T. Partey, et al., 2020	Technical effects	Bamboo
Ashiagbor et al., 2020	Technical effects	-
Asigbaase et al., 2021	Technical effects	Cocoa, soil quality
Asare et al., 2014	Technical effects	Cocoa, forestry
Kongor, De Steur, et al., 2018	Technical effects	Cocoa, soil quality
Kongor, Boeckx, et al., 2019	Technical effects	Cocoa, soil quality
Akesse-Ransford et al., 2021	Technical effects	Cocoa, insects
Kaba et al., 2021	Technical effects	Nitrogen, biomass
E. Acheampong et al., 2016	Technical effects	-
Anim-Kwapong et al., 2009	Technical effects	Cocoa, fallow
Appiah, 2012	Technical effects	Plant species
Anglaaere et al., 2011	Technical effects	Cocoa, tree diversity
Dawoe et al., 2014	Technical effects	Soil quality
Nunoo et al., 2017	Financial analysis	Cocoa, economic effects
Obiri et al., 2007	Financial analysis	-

1.3.2. The Carbon Credit Market in Ghana

Turning to the literature on the carbon credit market in Ghana, the search revealed a lack of academic literature specifically focused on this topic. As of now, only two sources are accessible that directly examine the carbon credit market implementation in the Ghanaian context. The two available online articles related to the carbon credit market in the Ghanaian context are news pieces that highlight Ghana's efforts to position itself in the carbon credit market in the future. The first article discusses the ongoing development of the framework for the carbon credit market (Oppong-Ansah, 2022), while the second article reports the completion of the framework and Ghana's readiness for carbon credit market investments (Oppong-Ansah, 2023). However, there is a noticeable gap in the literature when it comes to exploration and analysis of the actual functioning and dynamics of the carbon credit market within the country, as functioning carbon credit projects do not yet exist.

Given the growing importance of carbon credits in the global efforts to combat climate change and the potential significance of their implementation in Ghana, it is essential for future research to fill this knowledge gap. An examination of the carbon credit market's feasibility, challenges, and impact on local communities and farmers would undoubtedly provide valuable contributions to the field of sustainability and climate change studies. By addressing this gap, this study tries to shed light on the practical implications and effectiveness of integrating agroforestry with the carbon credit market as a viable solution for sustainable development in Ghana.

1.3.3. The Livelihood of Ghanaian Farmers

Furthermore, several sources can be found that delve into the livelihood analysis of Ghanaian farmers, exploring various critical aspects such as the socio-economic impact of climate change on agricultural practices (Asravor, 2018; Fadairo et al., 2020; Amikuzuno, 2018; Asante, Guodaar, et al., 2021; Aniah et al., 2019; Yamba et al., 2017) and the role of women within farming communities (Ragsdale et al., 2022; Azumah et al., 2022). These studies have contributed valuable insights into the challenges and opportunities faced by farmers in Ghana, shedding light on their coping strategies and adaptive measures in the face of changing environmental conditions.

However, it is worth noting that while there is a considerable amount of literature on livelihood analysis and agroforestry individually, there is a notable absence of articles that specifically examine the combination of these two crucial elements within the researched region. This indicates a potential

knowledge gap in understanding how agroforestry practices intersect with the livelihoods of Ghanaian farmers. By focusing on this intersection, this research seeks to bridge this gap and provide a comprehensive analysis of how the implementation of the proposed agroforestry system, integrated with the carbon credit market, can influence and enhance the livelihoods of Ghanaian farmers. This study aims to explore the potential economic, social, and environmental implications of such an integrated approach, contributing valuable insights to the sustainable development discourse in the Ghanaian agricultural sector.

1.3.4. Land Tenure Security in Ghana

One of the issues underscored in the section addressing the societal relevance of this research revolves around the intricate challenges associated with land tenure security for farmers. The stability and security of land tenure arrangements wield considerable influence over farmers' decisions to engage with the proposed agroforestry system. Indeed, the certainty of land use is a pivotal factor when contemplating investments in agricultural lands, as highlighted in-depth by several studies (Akugre et al., 2021; Moses Kansanga et al., 2018; Asaaga et al., 2020; and Antwi-Agyei, Dougill, and Stringer, 2015). Moreover, the available body of literature, exemplified by Aha et al., 2017, extends its focus to explore the consequences of an increase in land value on the tenure security of Ghanaian farmers. Beyond this, research has also examined the specific challenges faced by various demographic groups, such as youth (Kidido et al., 2017) and women (Addaney et al., 2022), in their endeavours to acquire and maintain land for agricultural purposes. These multifaceted dynamics surrounding land tenure underscore the intricate interplay between socio-economic factors and the viability of agricultural investments, which, in turn, profoundly influence the success and sustainability of agroforestry initiatives within the Ghanaian context.

Upon reviewing this existing body of academic knowledge, a noticeable void emerges regarding the potential influence of an agroforestry system on land tenure dynamics within the Ghanaian context. Furthermore, there is a notable absence of research pertaining to the repercussions of carbon credits on land value, particularly after the initial investments have been made and trees commence their growth, subsequently generating carbon credits. This uncharted territory remains a critical facet that warrants exploration, as it holds significant implications for the prospective success of the proposed agroforestry system.

1.3.5. Conclusions Scientific Relevance

In the initial phases of the research, critical problems affecting the region were identified, encompassing environmental challenges, livelihood concerns, and the need for sustainable agricultural practices. The available literature on agroforestry in Ghana underscores a notable deficiency in information concerning the perceptions of farmers in the Ashanti region. Furthermore, the examination of farmer perceptions regarding agroforestry in conjunction with the carbon credit market remains unexplored, as does the comprehensive exploration of the system from a systemic perspective, as opposed to the predominant focus on specific system effects. In a broader context, there exists a substantial knowledge gap pertaining to the operation of carbon projects within the Ghanaian context, primarily due to the absence of established projects. Lastly, the impact of implementing a carbon-based agroforestry system on the livelihoods of participating farmers and their land tenure security remain largely uncharted territory. This knowledge gap prompted the evolution of the research question to explore how the proposed agroforestry system, combined with carbon credits, could potentially address the identified problems and enhance the livelihoods of smallholder farmers in the area.

1.4. Research Setup

1.4.1. Main Research Question

From both the societal relevance and the scientific relevance in the previous section, the research question emerged to assess the feasibility of, and methods to, integrating carbon credits as a mechanism to promote agroforestry practices in the smallholder farming communities of the Ashanti region in Ghana. The objective is to evaluate the potential implications of this integrated approach, contributing valuable insights to sustainable development efforts and fostering resilience in the face of climate change and environmental challenges. Through this research, valuable understanding can be gained on the

possibilities and limitations of implementing carbon credits for sustainable agroforestry practices.

How can carbon credits be implemented as a mechanism for promoting agroforestry in smallholder farming communities in the Ashanti region?

1.4.2. Research Objective

The primary aim of this research is to form key considerations for prospective stakeholders seeking to implement the proposed system. These considerations are to be at a systemic level, encompassing pivotal facets requisite for the conceptualisation of the system, encompassing both institutional and socio-technical dimensions. Subsequently, these considerations shall be synthesised into overarching recommendations for the system's design. The assessment of the system's feasibility shall be derived from these considerations and recommendations.

1.4.3. Delineation of the System

In order to address the research objective comprehensively, it is imperative to delve into the various components that constitute the proposed system. As established in earlier sections, the proposed system comprises the integration of both the carbon credit system and the agroforestry system, with each playing a pivotal role. During the literature review, it has become evident that the land tenure system in Ghana also holds significant importance in determining the feasibility of implementation. Thus, these three interrelated sub systems of the carbon credit based agroforestry system will serve as the foundational pillars of this research, converging to shape the final recommendations.

To commence, an examination of the carbon credit system is warranted, as it delineates the parameters within which the entire system must be conceived and underscores the associated risks that the design of the other two components must contend with. Subsequently, a thorough investigation into both the land tenure, or institutional, system and the agroforestry, or socio-technical, system is essential. The primary objective in exploring these aspects is to unearth insights and considerations that will inform the design and implementation of the system in the future.

For this reason, this research is divided into the following chapters. First and foremost, the research design for analysing the main components of the system are elaborated upon. Next, the carbon credit system is explored, seeking key considerations for implementing the proposed system. Subsequently, the institutional system is examined, delving into the relationship between the implementation of the proposed system and potential alterations in land tenure security for farmers. This chapter extracts essential insights regarding tenure agreements. Following that, the socio-technical agroforestry system is investigated, encompassing considerations on how to maximise the livelihood of participating farmers when utilising the system. Finally, the key considerations from the aforementioned chapters are combined, delineating the steps to be undertaken by each actor when implementing the system.

1.4.4. Research Sub Questions

From the system delineation, the following research sub questions for the various identified sub systems of the carbon credit based agroforestry system are formulated:

1. What research design methods or frameworks can be used to analyse the interrelated sub systems of the carbon credit based agroforestry system in the context of the Ashanti region?
2. How does the functioning mechanism of the carbon credit system in Ghana influence the potential impact of implementing carbon credit incentives on agroforestry adoption among smallholder farmers?
3. What are the key considerations for designing an institutional system that facilitates the implementation of promoting agroforestry among smallholder farmers in the Ashanti region using carbon credits?
4. What are the key considerations for designing a socio-technical system that facilitates the implementation of promoting agroforestry among smallholder farmers in the Ashanti region using carbon credits?
5. What are the key recommendations for the design of a carbon credit based agroforestry system in the context of the Ashanti region?

2

Research Design

In this chapter, the first research sub-question is addressed, focusing on the research design methods employed to analyse the identified subsystems of the proposed system. Initially, the overall research approach for the entire study is defined, selecting an illustrative case study methodology, and introducing the study area. The top-down approach is adopted to ensure a coherent framework throughout the research. Furthermore, research methods are delineated for all the sub-questions, encompassing the chapter structure and data acquisition methods, with an outline of the potential outcomes for each chapter.

2.1. Research Approach

2.1.1. The Illustrative Case Study

To find an answer to the research question and fulfil the research objective, a carefully chosen research approach is used to analyse the interplay of the institutional and socio-technical aspects of the system. The research objective, from Section 1.4, is to provide considerations for the identified sub systems and assess the feasibility of implementing an agroforestry-based system to link smallholder farmers in the Ashanti region to the carbon credit market. To achieve this objective, an understanding of the carbon credit market, and the institutional and socio-technical aspects of the complex system is essential. As the focus of this study is specific to the Ashanti region, choosing the right research method to thoroughly explore the intricacies of the local context is essential. Therefore, the most suitable approach for this research is an illustrative case study.

The illustrative case study method, as explained by Creswell et al., 2016, offers a qualitative research design that goes beyond analysis and delves deep into the complexities of the selected case or phenomenon. By investigating the agroforestry system's implementation in the Ashanti region, this research endeavours to provide an in-depth and descriptive account of the various factors at play. Through this approach, a thorough understanding of the institutional structures and policies around the carbon credit market and agroforestry practices in the region is attained. Simultaneously, the socio-technical aspects of the system are analysed to understand the interactions between the technical components of the system and the social dynamics of the farming communities.

The research follows the stages of the case study as proposed by Crowe et al., 2011. These stages include: (1) defining the case; (2) selecting the case(s); (3) collecting the data; and (4) analysing, interpreting, and reporting the findings. By adopting these stages, the research is framed and structured to address the sub-questions effectively. The initial two phases, namely, defining the case and selecting the case, are initially examined as these stages remain consistent throughout the entirety of the research. Subsequently, the data collection methods are expounded upon in the sections below, corresponding to the respective research sub-questions, as these methods vary across the various components of this research.

Defining the Case

In the preceding chapter, the case has been introduced, which comprises the carbon credit-based agroforestry system encompassing the carbon credit system, the institutional system, and the socio-technical systems. By elucidating the key considerations pertaining to each of these distinct factors, the path toward identifying key recommendations for the design of a potentially viable system is illuminated.

Selecting the Case

The study is situated within the Ashanti region, selected as the illustrative case study. This region constitutes one of Ghana's 16 administrative divisions, situated in the southern part of the nation, as illustrated in Figure 2.1. Of particular relevance is the Ejura-Sekyedumase district, situated within a transitional agro-ecological zone.

The diverse attributes of the Ashanti region, encompassing environmental, social, economic characteristics, as well as the prevailing institutional framework, exert a notable influence on the potential feasibility of the proposed system. Consequently, this illustrative case study necessitates a comprehensive exploration and analysis of these characteristics to gain a deeper insight into the critical considerations for the various sub systems, while duly taking into account the context specific to the Ashanti region. The context of the Ashanti region thereby defines the research scope, as the examined characteristics must primarily pertain to the Ashanti region. Consequently, factors influencing the various sub systems, which are consistent across different regions globally will not be subjected to as thorough research.

2.1.2. The Top-Down Approach

For the data gathering of the different systems affecting the implementation of the system, a top-down approach is chosen. The top-down approach in this research is essential for several reasons. Firstly,

1. Ejura
2. Nobewam
3. Tanoso
4. Adeito
5. Adansi Asokwa

Figure 2.1: Map of the Ashanti Region with Locations of Participating Farmers

the agroforestry system's implementation involves multiple stakeholders and interrelated factors, making it a complex system. By starting with a high-level analysis, the research gains an understanding of the broader context in which the system operates, including the institutional frameworks and socio-technical aspects. Moreover, the top-down approach allows for a more systematic and structured exploration of the research area. By beginning with a broad perspective, the research can identify potential gaps and areas that require further investigation. This approach acts as a guiding framework to ensure that no critical aspect is overlooked and that the subsequent research at the lower level is well-informed and relevant. As the top-down analysis progresses, the focus shifts to more specific research of the Ashanti specific situation, and farmers in the Ashanti region and their livelihoods. This shift is crucial for developing the Ashanti and farmer-centred approach, as their active participation and commitment are essential to the success of the agroforestry system.

2.2. Research Methods

2.2.1. The Carbon Credit System

Sub Question

How does the functioning mechanism of the carbon credit system in Ghana influence the potential impact of implementing carbon credit incentives on agroforestry adoption among smallholder farmers?

Methods

The development of the research sub question regarding the carbon credit system is detailed in the preceding chapter. The carbon credit system constitutes one of the sub systems within the proposed carbon credit-based agroforestry system, and it plays a crucial role in establishing guidelines and identifying barriers for the proposed system design. Based on the literature review conducted in the previous chapter, no information is available regarding the functioning of the carbon credit system within the Ashanti region, or even within the broader Ghanaian context.

To get a general understanding of the functioning of the carbon credit system for any context, in

Ghana or worldwide, first an introductory exploration of the establishment of the carbon credit market and the functioning of the carbon credit market must be established. This is in line with the top-down approach from Section 2.1.2, as the broadest form of the to be studied system needs to be understood first. This first part of getting to the considerations regarding the carbon credit system will be done using desk research. This initial phase of the carbon credit system research constitutes the broader segment of this sub research, as delineated in Table 2.1.

Following the top-down approach, the subsequent phase within this chapter delves into the specific context of the chosen illustrative case. As previously noted, there is a notable dearth of academic knowledge concerning the operation of the carbon credit market within the Ghanaian context. In a concerted effort to garner more insights into this operation and address one of the identified gaps in academic knowledge, this section of the chapter will be populated through a combination of desk research and in-depth interviews with pertinent stakeholders. The desk research component will encompass an exploration of carbon agroforestry projects undertaken in analogous settings, such as other African countries. While this approach may not yield comprehensive information about the distinct characteristics of the Ashanti context, it can provide valuable insights into potential system designs, thereby contributing to the formulation of interview questions tailored to the specific Ghanaian situation. Subsequently, in-depth interviews will be conducted with stakeholders directly associated with the proposed system or engaged in similar initiatives within Ghana. The selected stakeholder for the interviews is the Environmental Protection Agency (EPA), particularly the Carbon Registry of the Ghanaian government. Given their involvement in the registration of all projects related to the carbon market in Ghana, this party is uniquely positioned to furnish information pertaining to the functioning of the system within the specific context of the case study. This second phase of the carbon credit system research constitutes to the focus segment, as shown in Table 2.1.

Table 2.1: Top-Down Approach: The Carbon Credit Market

	Research method	**Research topic**
Broad	Desk study	Introduction and functioning of the carbon credit system
	Desk study	Carbon agroforestry projects in similar context
Focus	Expert interviews	The carbon credit system in Ghana

Potential Outcome

The data collected from both the desk studies and interviews will undergo analysis to address two distinct yet vital aspects of the carbon credit system within the proposed system. Firstly, the research aims to elucidate the role of the carbon credit system within the proposed structure, encompassing the specific functions that carbon credits will undertake in the context of establishing the agroforestry system in the Ashanti region. Secondly, the analysis seeks to identify the associated risks linked to the carbon credit system concerning the proposed framework. These two factors will assume pivotal roles in the subsequent research chapters, serving as foundational inputs for the discussions on the institutional and socio-technical systems that follow.

2.2.2. The Institutional System

Sub Question

What are the key considerations for designing an institutional system that facilitates the implementation of promoting agroforestry among smallholder farmers in the Ashanti region using carbon credits?

Methods

Section 1.2 and Section 1.3 underscore the significance of the institutional context to which farmers in the Ashanti region are subjected. This context is likely to exert a considerable influence on their willingness to engage with the proposed system, thereby impacting the feasibility of its implementation. In the preceding chapter, which focuses on carbon credits, the role of the carbon credit system and its primary associated risks are identified. The research into the carbon credit system highlights the critical importance of long-term commitment for the system's success and underscores land tenure insecurity as one of the foremost risk factors for farmers. This insecurity has the potential to affect both farmers'

willingness to participate and their long-term commitment. Taking these insights into consideration, this chapter is dedicated to finding the key considerations pertaining to the institutional system.

During the section on the scientific relevance of this research, it is clear that there is a lack of knowledge regarding the land tenure agreement and security when implementing the carbon-based agroforestry system. In line with the top-down approach from Section 2.1.2, the first step is to get a better understanding of the land tenure system in Ghana, providing a basis on which the more focused part of this sub research can be based. A more specified desk study will look into the specific situation of the Ashanti region, taking a closer look at the specific characteristics of this region, and its effect on land tenure in general. This initial, broad research phase is outlined in Table 2.2.

The top-down approach dictates that the subsequent research step must be more specific in relation to the selected case. Interviews with the primary stakeholders, potentially participating farmers, are conducted to fulfil two principal objectives. Firstly, these interviews serve the purpose of validation, ensuring alignment between the information derived from the existing literature and the farmers' firsthand experiences. Secondly, the engagement with farmers through interviews aims to elicit insights into the farmer-specific characteristics that influence their land tenure insecurity and, consequently, their prospective willingness to engage with the proposed system. This interview phase is being executed in two distinct stages. Initially, an assessment of the farmers' prevailing land tenure security is being undertaken through a combination of focus group discussions and in-depth one-on-one interviews. The focus group, comprising ten farmers from a specific farming community in the Ejura-Sekyedumase district, as illustrated in Figure 2.1, offers a platform for collective insights. To ensure representation of less influential farmers and augment the data set, eight in-depth interviews are being conducted with individual farmers from a different farming community within the same area. These interviews are guided by a study conducted by Nara et al., 2021, which assessed the land tenure security of farmers in a distinct region of Ghana, thus facilitating a comprehensive understanding of the subject matter. Secondly, the farmers characteristics affecting their land tenure security are analysed using a group interview with farmers from the Nobewam, Tonoso, Adeito, and Adansi Asokwa regions, as visually presented in Figure 2.1. Furthermore, as highlighted in the chapter pertaining to the carbon credit system, illegal logging has been identified as one of the risks. This aspect will be assessed by inquiring about farmers' experiences with regard to illegal logging during both the focus group session and the individual one-on-one interviews.

The data gathered from the farmers will undergo analysis using MergeData, a software tool developed by Farmerline designed for data storage and analysis. Responses from the participants will be systematically compared and subjected to thematic analysis to identify patterns and derive meaningful conclusions.

Consequently, in-depth interviews with experts are scheduled to gain a deeper understanding of land tenure issues in the Ashanti region, as illustrated in Table 2.2 These interviews serve multiple purposes: validating the findings of the desk study with real-life stakeholders, providing insights into potential outcomes if the carbon-based agroforestry system is implemented, and obtaining recommendations for addressing land tenure issues. Several expert stakeholders have been identified for these in-depth interviews. First and foremost, an interview has been conducted with the Ministry of Food and Agriculture (MOFA), given its extensive involvement with farmers and, consequently, the land tenure system within its projects. MOFA is well-placed to corroborate the desk research findings and offer considerations for enhancing farmers' land tenure security. Furthermore, in-depth interviews will be conducted with Colandef, an NGO specialising in securing land agreements for individuals with limited land tenure security. Engaging with Colandef will provide additional insights into the mechanisms for establishing robust land tenure agreements, thereby enhancing land tenure security. Leveraging their expertise, Colandef can offer guidance on the process of bolstering land tenure security for potential participating farmers. Lastly, the EPA will furnish information on how other projects have addressed tenure insecurity. Their insights will contribute valuable perspectives on mitigating land tenure issues within similar initiatives.

Table 2.2: Top-Down Approach: The Institutional System

	Research method	Research topic
Broad	Desk study	Land tenure system in Ghana and the Ashanti region
Focus	Expert interviews	Land tenure security in the proposed system
	Farmer interviews	Status of tenure insecurity
	Farmer interviews	Characteristics affecting tenure security
	Expert interviews	Increasing the land tenure security

Potential Outcome

In addressing the research sub-question, it is imperative to furnish key insights regarding the institutional system. The information derived from the literature review in the introduction, coupled with the insights garnered from expert interviews in the chapter dedicated to the carbon credit system, underscores the critical importance of securing land tenure to foster farmers' willingness to participate in the system. Consequently, the primary focus of this chapter revolves around elucidating the means to obtain land tenure documents and ensure land tenure security for the farmers. By meticulously analysing the current circumstances of the farmers, as evidenced by data from the focus groups and farmer interviews, and aligning this with the information gleaned from literature and the knowledge gleaned from expert interviews, the recommendations furnished by the experts can be considered. The envisaged outcome will take the form of a guideline delineating the steps for acquiring land tenure documents when embarking on the carbon-based agroforestry project. Furthermore, by comparing the responses of different farming groups regarding their tenure security and correlating these responses with their distinctive characteristics, insights can be gleaned into the factors influencing tenure security. These insights could prove to be valuable in the endeavour to implement the proposed system successfully.

2.2.3. The Socio-Technical System

Sub Question

What are the key considerations for designing a socio-technical system that facilitates the implementation of promoting agroforestry among smallholder farmers in the Ashanti region using carbon credits?

Methods

The section on the societal relevance of this research underscores the paramount importance of placing farmers at the centre of the study. This strategic positioning ensures that the considerations for system design directly impact the livelihoods of participating farmers, thereby maximising the research's societal relevance. The socio-technical system can be tailored in various ways to address the specific challenges faced by farmers in the Ashanti region. The design of the socio-technical system encompasses several facets, including the configuration of the agroforestry system, the development of methods to engage farmers in the system, and the formulation of strategies to secure farmer commitment to the initiative. This chapter is dedicated to providing pivotal considerations concerning the socio-technical system.

In adherence to the top-down approach, this chapter commences by acquiring a comprehensive grasp of the overarching challenges faced by farmers in the Ashanti region. This initial understanding is attained through an extensive desk study, encompassing multifaceted aspects such as the influence of climate change on local farmers, the prevailing economic conditions of farmers in the region, and the agricultural culture inherent to the selected context. Addressing these issues through the proposed system could potentially engender a positive effect on farmers' willingness to engage with the system. Moreover, these identified issues will be instrumental in formulating interview questions for more context-specific research in the subsequent stages of this chapter.

The literature review has revealed a notable absence of information regarding farmers' preferences for specific agroforestry systems, despite the availability of data on the potential benefits of various agroforestry models. To ensure a comprehensive understanding of the factors affecting the livelihoods of participating farmers and to serve as a foundation for designing questionnaires, the research adopts the Sustainable Livelihood Framework (SLF). The SLF has been applied in numerous studies to assess

the impacts of agroforestry systems and related interventions on livelihoods, as evidenced in previous research (Hanif et al., 2018; Dube et al., 2022; Ken et al., 2020; Lambini et al., 2014). It serves as a robust framework for evaluating the livelihood conditions of individuals, with a particular emphasis on their central role in the developmental process. Within the SLF framework, the primary focus centres on evaluating the various assets possessed by individuals. These assets encompass human capital, physical capital, natural capital, social capital, and financial capital—each of which significantly influences livelihood outcomes. Given the pivotal role of farmers in this research, their transition to agroforestry as a development process, and the importance of assessing their present conditions, willingness to participate in the proposed system, and long-term commitment, the adoption of the SLF is judicious. The SLF and literature employing this framework are further elucidated in Appendix A.2.

Similar to the chapter addressing the institutional system, the interviews with farmers are conducted using two distinct methodologies. Initially, a focus group involving 10 farmers is convened, followed by a series of 10 in-depth individual interviews, both located in the Ejura-Sekyedumase region. The interview questions are carefully crafted with reference to the Sustainable Livelihood Framework (SLF), considering the insights gleaned from the earlier segment of this chapter which elucidated farmer issues. By probing farmers about their present circumstances with respect to the five distinct livelihood capitals, this research seeks to elucidate their needs and preferences concerning the design of the socio-technical system. This research phase assumes a more specific focus, honing in on the unique context of the Ashanti region, as delineated in Table 2.3. Again, the data gathered from the farmers will undergo analysis using MergeData, a software tool developed by Farmerline designed for data storage and analysis. Responses from the participants will be systematically compared and subjected to thematic analysis to identify patterns and derive meaningful conclusions.

Drawing upon the literature elucidating the specific potential benefits of agroforestry systems, a group of farmers from the Nobewam, Tonoso, Adeito, and Adansi Asokwa regions were invited to partake in a Q-method interview game. To investigate the potential design of the technical system and understand how the agroforestry system would best benefit farmers in the Ashanti region, a Q-Method interview is conducted. The Q-Method is a research technique that allows for a systematic exploration of individuals' subjective viewpoints and opinions on a particular topic (Brown, 1980). By using Q-Method interviews, valuable insights can be gained into factors within the system that are particularly important to the farmers in the region. This approach helps in identifying their preferences and priorities, which are crucial in designing an effective technical system that meets the needs of the farmers and aligns with their perspectives.

Furthermore, expert interviews are conducted to facilitate a more profound comprehension of the implementation of such initiatives within the Ashanti context and to glean insights from previously executed similar projects. The chosen experts for this purpose are the MOFA and the EPA, selected for their extensive knowledge regarding farmers' behaviours and project requirements within such contexts. As established in the chapter pertaining to the carbon credit system, it is crucial to engender farmers' willingness to participate in the proposed system. To address this aspect, the expert stakeholders offer valuable insights into the system's design. Moreover, the MOFA and the EPA provide valuable information pertaining to the design of the agroforestry system and the associated training methods.

Table 2.3: Top-Down Approach: The Socio-Technical System

	Research method	**Research topic**
Broad	Desk study	Exploration of farmer issues in the Ashanti region
Focus	Farmer interviews	Current farmer livelihood, using SLF
	Farmer interviews	Benefits of the proposed system
	Expert interviews	Fostering farmer participation
	Expert interviews	The design of the agroforestry system
	Expert interviews	Design of farmer training

Potential Outcome

To address the research sub-question effectively, it is imperative to delineate key considerations pertaining to the socio-technical system. Aligned with the central focus on farmers, it is essential that these considerations yield a positive impact on the livelihoods of farmers in the Ashanti region. By comparing the insights from experts with the perspectives of farmers, this chapter discerns the paramount benefits attributed to the agroforestry system, as perceived by farmers. These considerations take into account the expert input and aim to prioritise the aspects that farmers deem most significant. Furthermore, this chapter offers insights into methodologies that can facilitate farmer participation and design considerations for the farmer training system.

2.2.4. Recommendations for the Implementation of the System

Sub Question

What are the key recommendations for the design of a carbon credit based agroforestry system in the context of the Ashanti region?

Methods

In contrast to the preceding chapters, this section does not draw upon previously unmentioned data. Instead, it serves as the culminating stage for formulating definitive recommendations for the design of the various sub-systems, as delineated in the earlier sections. These ultimate recommendations encompass key considerations for the carbon credit system, the institutional system, and the socio-technical system, with the aim of providing conclusive guidance for stakeholders involved in the proposed system. The synthesis of insights from different chapters informs the development of these recommendations.

Potential Outcome

The outcome of this chapter will yield a set of recommendations, each tailored to the respective stakeholders. These recommendations will coalesce into an actionable plan, providing guidance to the various stakeholders engaged in the implementation of the system.

2.3. Conclusions on the Research Design

To ensure the optimal research approach for conducting a feasibility study of the carbon-based agroforestry system in the Ashanti region, the chosen methodology is the illustrative case study. In this case study, the focal point is the carbon-based agroforestry system, while the geographical context is the Ashanti region of Ghana. The system is deconstructed into three primary sub-systems: the carbon credit system, the institutional system, and the socio-technical system. This study aims to provide key recommendations for each sub-system, addressing the corresponding sub-questions. Each of these chapters adheres to a consistent structure rooted in the top-down approach. The research process commences with a desk study, facilitating a comprehensive grasp of the overarching system. Subsequently, interviews are conducted with both farmers and expert Ghanaian entities to bridge the identified academic knowledge gaps, particularly within the context of the Ashanti region. Finally, the key considerations amassed from these chapters are amalgamated into a concluding chapter, offering essential recommendations tailored to the stakeholders involved with the system. In Figure B.1 in Appendix B, a simplified version of a research flow diagram is depicted, aligning with the findings presented in this chapter.

3

The Carbon Credit System

In this section, the key recommendations for implementing the agroforestry system in conjunction with the carbon credit system will be provided. Following the top-down approach, the first part will present an overview of the establishment and general operation of the carbon credit system based on desk studies. To gain a deeper understanding of the relevance of the carbon credit system in the Ashanti region, further desk studies on agroforestry projects with carbon credits in similar contexts will be conducted. Additionally, insights from an interview with the Carbon Registry will be incorporated to understand the process of setting up a carbon project in the Ghanaian context. This analysis aims to identify crucial considerations related to the procedures for initiating a carbon project in Ghana, the role of carbon credits in the proposed system, and the associated risks related to the carbon credit system.

3.1. Introduction to the Carbon Credit System

As delineated in Chapter 2, the present chapter concerning the carbon credit system initiates with a comprehensive literature review. This review delves into the establishment and operational principles of carbon credit projects at a general level, without specific emphasis on agroforestry projects or the Ashanti region. The chronological establishment of the carbon credit market's establishment elucidates the underlying rationale for its inception. Subsequently, the ensuing discussion encompasses the requisite procedures applicable to carbon projects on a global scale, given their substantial implications for the envisaged system's design.

3.1.1. Establishment of the Carbon Credit System

The Kyoto Protocol

Carbon markets play a crucial role in enabling countries, organisations, and individuals to offset their GHG emissions by purchasing emission reduction certificates from elsewhere (Blum, 2020). As the urgency to combat climate change intensifies, carbon markets have emerged as one of the key mechanisms to incentives and finance climate mitigation efforts worldwide. These markets operate on the principle of carbon trading, where carbon credits represent a specific amount of GHG emissions reduced or removed from the atmosphere. By purchasing carbon credits, entities can effectively compensate for their own emissions by supporting emission reduction projects in other regions or sectors. This system creates a financial incentive for the development of projects that contribute to a low-carbon economy and promote sustainable practices.

The framework of carbon trading was initially established within the ambit of the Kyoto Protocol under the United Nations Framework Convention on Climate Change in 1997 (United Nations, 1998). This pioneering protocol paved the way for developed nations (referred to as Annex I) with carbon emissions surpassing stipulated thresholds to procure carbon credits from endeavours focused on carbon sequestration—primarily afforestation and reforestation projects (Perez et al., 2007). These initiatives constituted a subset of what came to be known as the compliance market. The compliance market is a designated arena for carbon trading characterised by a regulatory framework and binding emission reduction targets set forth by governments or international accords. This intricate construct serves as a conduit for countries and corporations to fulfil their obligatory commitments for emission reduction through diverse mechanisms, encompassing the CDM, Emissions Trading Systems (ETS), and Joint Implementation (JI). Notably, the CDM empowered Annex I nations to invest in emission mitigation ventures in developing nations, thereby earning Certified Emission Reductions (CERs) for the authenticated emissions curtailment realised through these projects. Subsequently, these CERs could be harnessed to satisfy the emission reduction goals of Annex I countries. An underpinning facet of the CDM projects lay in the adherence to stringent and standardised methodologies, discussed later in this chapter. These protocols were structured to safeguard environmental integrity and uphold the efficacy of the emission reduction endeavours.

The Paris Agreement

Under the Kyoto protocol trading, entities seeking to curtail emissions encountered a relatively uncomplicated landscape, where cost-effective options for carbon reduction were readily available. The advent of the Paris Agreement emanated from the 21st convocation of the Conference of the Parties (COP) under the the United Nations Framework Convention on Climate Change (UNFCCC) in 2015 (UNFCCC, 2015). Similar to the Kyoto Protocol, the Paris Agreement is embedded within the wider UNFCCC framework and extends from previous agreements (Hoch et al., 2019). The objective of the Paris Agreement entails constraining global temperature rise to below 2.5°C, striving for an even more ambitious target of 1.5 °C. To realise this vision, each nation that has signed the agreement submits its distinct strategy for addressing climate change, encapsulated in a Nationally Determined Contribution (NDC). These blueprints delineate a country's intended trajectory for GHG emissions reduction and its preparedness to contend with the repercussions of climate change. Significantly, the NDCs are envisioned to undergo refinement and enhancement over successive iterations, signifying a marked departure from the Kyoto Protocol era, where emission reduction commitments were primarily the prerogative of affluent nations.

An overarching feature of the Kyoto era was the concept of offsetting, where affluent nations could extend financial support to projects in less developed countries aimed at emissions abatement. This approach facilitated sustainable development in the latter, while the former leveraged the resulting emissions reductions towards fulfilling their own targets. In contrast, the Paris Agreement introduces a layer of complexity to this paradigm. While every nation commits to emissions reduction, the increase in such efforts limits the availability of excess emissions reductions.. Nonetheless, the notion of offsetting remains relevant within the framework of the Paris Agreement, as elucidated in Article 6, which underscores the potential for international collaboration through the transfer of emissions reductions (UNFCCC, 2015). A stipulation, however, dictates that if a country permits another entity (be it another nation or organisation) to account for an emissions reduction towards their own target, that same reduction cannot be concurrently counted towards the country's own emissions target. Thus, the Paris Agreement firmly disavows the practice of "double counting" among nations (Broekhoff et al., 2019).

Types of Carbon Credit Markets

Carbon credits can be traded in either the mandatory compliance market or in the voluntary carbon market (VCM). A compliance market caters to regulated entities, such as firms, which are bound by legal obligations to reduce their GHG emissions. Examples of compliance markets include programs like California's Cap-and-Trade Program and the previously stated mechanisms such as the CDM and JI. On the other hand, VCMs are designed for businesses and individuals who voluntarily seek to offset some or all of their GHG emissions without being legally obligated to do so. Corporate sustainability reporting often involves participation in VCMs (Aiken, 2021).

Relevance to the Proposed System

Within the Ashanti region's carbon-based agroforestry system, the sequestration of carbon stemming from trees cultivated on the land of participating farmers aligns with the aforementioned principles of the VCM. Consequently, entities generating emissions can engage in the acquisition of carbon credits, thereby enabling them to mitigate their own carbon emissions.

3.1.2. Functioning of the Carbon Credit System

The Carbon Credit Project Timeline

The literature used in this section is the article: "Securing climate benefit: a guide to using carbon offsets" by Broekhoff et al., 2019. According to this article, the carbon credit project life-cycle follows the following steps:

1. Methodology development
2. Project development, validation, and registration
3. Project implementation, verification, and offset credit issuance
4. Offset credit transfer

For a comprehensive grasp of the carbon credit project life-cycle, this section delves into the sequential stages of a carbon credit's evolution. The initial phase entails 'Methodology Development', where project proprietors must establish that the carbon credits generated by their project adhere to specific criteria. This necessitates a methodology tailored to the project's distinct offset nature. While a diversity of methodologies is available for various carbon credit projects, developers also retain the option to devise custom methodologies. After approval of the methodology, project implementation ensues. In their discussion of the 'Project Development, Validation, and Registration' phase, Broekhoff et al., 2019 states that an offset project is designed by project developers, financed by investors, validated by an independent verifier, and registered with a carbon offset program. Once officially registered, the project gains approval from the program and becomes eligible to generate carbon offset credits upon operation initiation. Subsequently, the Project Implementation, Verification, and Offset Credit Issuance' phase follows. Upon implementation, an offset project undergoes continuous monitoring and periodic verification to assess its generated emission reductions. The frequency of verifications may vary, usually spanning a year. Verification reports, endorsed by a carbon offset program, lead to the issuance of carbon offset credits, corresponding to the quantified CO2-equivalent GHG reductions achieved. These offset credits are commonly allocated to the project developer's account within a registry system administered by the offset program. Finally, in the 'Offset Credit Transfer' phase, carbon offset credits

are shifted among accounts within an offset program's registry. Transfers result from purchases or trades, relocating credits from the project developer's account to the purchaser's. Buyers may choose to retire, retain, or further transfer credits to other accounts. Offset credits can change hands multiple times before eventual retirement and utilisation.

Carbon Standards

In the Verification stage of carbon credits, various standards can be selected for the project's compliance. Notable high-level standards include the Verified Carbon Standard, the American Carbon Registry, the Climate Action Reserve, and Plan Vivo (Pan et al., 2022). When projects successfully satisfy the criteria set by these esteemed carbon credit verification bodies, the resulting carbon credits are of superior quality. These high-grade carbon credits hold value within the carbon market, reflecting the project's adherence to rigorous environmental and sustainability criteria. The selection of such recognised standards ensures transparency, credibility, and accountability throughout the carbon credit generation process. By aligning with these standards, projects demonstrate a commitment to not only mitigating climate change but also maintaining the highest standards of environmental integrity.

Furthermore, opting for these well-established verification standards can have far-reaching implications for the project's reputation and investor appeal (Pan et al., 2022). Investors and stakeholders are more likely to engage with projects that have obtained carbon credits from reputable verification bodies, as it signifies a rigorous evaluation of the project's emission reduction activities. Consequently, the utilisation of these high-grade carbon credits can serve as a catalyst for attracting sustainable investments and fostering partnerships with environmentally-conscious entities. The significance of adhering to recognised carbon credit verification standards goes beyond immediate financial gains. It contributes to the broader global effort to combat climate change by ensuring that emission reduction activities are measured, verified, and reported accurately. As these high-grade carbon credits enter the market, they provide a tangible representation of the project's positive impact on reducing GHG emissions, thereby contributing to a more sustainable and resilient future for both local communities and the planet as a whole.

Monitoring of Tree Growth

For the step on 'Project implementation, verification, and offset credit issuance', carbon growth must be monitored. There are several ways to monitor the carbon accumulation of the trees on the agroforestry farmlands. Nowadays, the mostly used methods rely on airborne or satellite data, as mentioned by Zhao et al., 2018. These (LiDAR) monitoring systems are a technology that uses laser pulses to measure distances and create detailed and accurate three-dimensional representations of objects and landscapes. It operates by emitting laser beams and measuring the time it takes for the light to bounce back after hitting an object or surface. By analysing the time-of-flight data and the returned signals, the LiDAR system can accurately calculate the distance between the sensor and the object.

Since the carbon accumulation monitoring process remains consistent in the Ghanaian context as well as in other global agroforestry systems, this study does not delve into investigating monitoring techniques extensively. A substantial body of existing literature already covers carbon credit monitoring (Dalponte et al., 2019; Godwin et al., 2015; Meng et al., 2022), which can readily apply to agroforestry systems within the Ashanti region.

Relevance to the Proposed System

In the Ashanti context, the deployment of the carbon-based agroforestry system necessitates adherence to the procedures outlined by Broekhoff et al., 2019 and the selection of an applicable carbon standard, as underscored by Pan et al., 2022.

3.2. Carbon Projects in a Similar Context

The preceding section elucidated the operational mechanisms of the carbon credit system and the protocols for establishing a carbon credit project applicable in various global contexts. In this subsequent section, in accordance with a top-down approach, a more specialised examination will be conducted focusing on projects akin to the selected case or within the Ashanti region.

3.2.1. Agroforestry Carbon Projects in a Different Location

Several business cases of carbon projects already executed on the African continent can be located online. For instance, there exists a compelling business case for an agroforestry project in Kenya by VI Agrofrestry, documented in VI-Agroforestry, 2019. This project has successfully connected 60,000 farmers to the carbon credit market through the implementation of agroforestry techniques. It operates under the Verified Carbon Standard (VCS) and has laid the foundation for the Vm0017 carbon standard, similar to the steps in Section 3.1.2 and mentioned by Pan et al., 2022. Notably, 60% of the carbon revenue generated from this project is allocated to the participating farmers, while the remaining 40% is utilised to cover administrative costs incurred by other project stakeholders. Additionally, another noteworthy initiative, outlined in Soubre, 2022, involves a collaboration between the FarmStrong Foundation and Rabobank Acorn, with the aim of linking cocoa farmers in Ivory Coast to the carbon credit market. This linkage is achieved through the practice of intercropping shading trees. This project adheres to the Plan Vivo carbon standard, and its success serves as a compelling example of the potential for sustainable practices in African agriculture to contribute to carbon credit markets. This carbon standard is also mentioned by Pan et al., 2022 in Section 3.1.2.

In conclusion, the emergence of these practical business cases underscores the real-world application and potential benefits of integrating agroforestry with the carbon credit market in African countries, presenting a promising avenue for sustainable development and climate change mitigation. Conversely, there is an absence of Ghana-specific information pertaining to the operational dynamics of the carbon credit system at a systemic level — a crucial aspect that demands comprehension for the effective functioning of the proposed system. The exemplars drawn from alternative African carbon-based agroforestry initiatives underscore the imperative of selecting an appropriate carbon standard, as emphasised by Pan et al., 2022, and the establishment of carbon standard methodologies, as delineated by Broekhoff et al., 2019.

3.2.2. Different Carbon Projects in the Same Location

In pursuit of an understanding of the existing carbon credit initiatives in Ghana, as well as to ascertain the developmental stage of these projects and extract valuable insights from their experiences, an interview is orchestrated with the EPA. The EPA holds responsibility for overseeing both the Carbon Market Office (CMO) and the Carbon Registry, making it a pivotal source of information for this endeavour. The EPA possesses the capacity to elucidate the process of establishing a carbon credit project within Ghana's procedural framework while also offering insights into potential risks associated with carbon-based agroforestry projects in the Ashanti region.

The EPA states that the establishment of the CMO signifies a proactive effort towards facilitating the execution of carbon projects within the context of the Ghanaian framework. The CMO has adopted diverse modalities to engender involvement in carbon projects, namely:

1. Bilateral agreements between governments: Adhering to the stipulations of Article 6.2 of the Paris Agreement (UNFCCC, 2015), which delineates the prerequisites for engagement.
2. Collaborations between the Government of Ghana and private sector entities (e.g., BP): This avenue caters to the aspirations of private stakeholders seeking to cultivate carbon assets within Ghana's domain.
3. Active participation within the VCM.
4. Pivoting ongoing projects towards the novel mechanisms prescribed by Article 6.4 of the Paris Agreement (UNFCCC, 2015).

According to the EPA, the spectrum of ongoing carbon projects in Ghana currently, in May 2023, stands at a total of 14 initiatives, each situated at distinct developmental stages. Notably, Ghana has entered into bilateral agreements with several countries, including Switzerland, Sweden, South Korea, and Singapore. These agreements are positioned at varying stages of progress. Particularly noteworthy is the advanced stage of the agreement with Switzerland, a culmination of a signing in 2020, followed by parliamentary ratification in 2021. Precedence is set by an exemplary project orchestrated in collaboration between the Ministry of Agriculture, the Ministry of Environmental Sciences & Technology, and the EPA. Facilitated through a grant from the United Nations Development Programme, this

initiative seeks to effect emission reduction through a trade arrangement with the Swiss government. Specifically, the project is centred around rice farming, encompassing an extensive expanse of 22,000 hectares throughout Ghana.

Agroforestry projects, such as the proposed system fall under 'Active participation within the VCM', according to the EPA. The EPA further states that the Carbon Registry currently encompasses the registration of three distinct carbon credit projects making use of the VCM. These projects are positioned at various junctures of development, although they collectively represent relatively nascent endeavours. Consequently, the EPA encountered limitations in extending supplementary insights concerning the subsequent procedural steps, as mentioned in Broekhoff et al., 2019, relevant to carbon projects within Ghana that cover the range of advanced implementation stages.

3.2.3. Agroforestry Projects in Ghana

During the interview with the EPA, an inquiry is raised concerning the ongoing evolution of carbon credit projects in Ghana within the realm of the VCM, particularly those employing agroforestry practices. As previously discussed, the EPA communicated that no carbon credit projects in Ghana have advanced to the phase of disbursing monetary rewards. Notably, the furthest-progressing private project is presently engrossed in the finalisation of their project documentation—an essential precursor to the subsequent stages of validation and monitoring pertaining to carbon credits, which is in line with the new articles found by Oppong-Ansah, 2022 and Oppong-Ansah, 2023 in Section A.

3.3. Key Considerations Regarding the Carbon Credit System

3.3.1. Functioning of Carbon-Based Agroforestry Projects in Ghana

The investigation conducted by Broekhoff et al., 2019 outlines the universal stages that carbon projects must traverse across global contexts. Meanwhile, the illustrations provided by VI-Agroforestry, 2019 and Soubre, 2022 offer more nuanced insights into the processes entailed in establishing a carbon-based agroforestry system within the African continent. Furthermore, an interview with the Carbon Registry of the EPA will yield additional insights into the prerequisites for the proposed project's implementation in Ghana, with a particular focus on the Ashanti region. Consequently, the EPA interview can serve as a means of validating the findings from the literature and the two exemplar projects.

In the Ghanaian context, the EPA delineates distinct phases within the methodology development section. The primary step involves the creation of a comprehensive project document, containing all relevant project details, to be shared with the Carbon Registry. Presently, only a singular entity has advanced to this stage. Subsequent stages for this company, as well as other organisations seeking to initiate a carbon project in Ghana, encompass project Validation (by all stakeholders), issuance of a letter of recommendation, project registration, execution, continuous monitoring, progress verification by an auditor, and ultimately, the disbursement of carbon payments, similar to the study by Broekhoff et al., 2019. According to the EPA, the attainment of carbon credits of high quality is imperative for the project's prosperity.

Table 3.1: Key Considerations: Carbon Projects in Ghana

In the Ghanaian context, the development of a methodology in alignment with global carbon standards is essential for the implementation of a carbon project. The selection of a high-quality carbon standard is a critical factor that significantly influences the system's success.

3.3.2. Risks of Implementation

Once the project progressed through the implementation phases as delineated by the Carbon Registry's protocols, additional risks become apparent. The EPA states that only mature trees have the capability to produce carbon credits, implying that carbon credits can be generated from the third to fifth year onward. During the initial years, trees must grow to reach this mature stage, during which the accumulated carbon cannot be converted into carbon offsets. Consequently, trees younger than 5 years old can be incorporated into the agroforestry project, enabling them to commence generating carbon credits at an earlier stage. Throughout the initial five years of the project, particularly for newly

planted trees, participants will be responsible for maintaining and nurturing the trees to ensure their survival. Trees that do not reach the stage where carbon credits can be accumulated (from the third to fifth year on wards) will be unable to generate carbon credits. In such cases, the trees will require replanting, thereby initiating the first phase anew.

As noted by the EPA, the primary risk entails the potential reluctance of farmers to engage in the agroforestry system. This hesitancy could stem from several factors. Initially, farmers might perceive a risk in adopting an unfamiliar system, as it involves transitioning away from their established farming practices. Therefore, it is imperative to introduce the system in a manner that underscores its potential to enhance their livelihoods. Addressing farmer participation for this reason is delved into in Chapter 5. Furthermore, it is crucial that farmers possess the requisite knowledge to effectively manage the trees. Equipping farmers with the tools and the necessary skills for practising agroforestry becomes imperative, necessitating proper training. The intricacies of this training aspect are explored in Chapter 5.

Another factor contributing to non-participation, according to the EPA, could be farmers' uncertainties about their land tenure status. This uncertainty may cast doubts on their ability to secure carbon credit income, as they might not continue farming the land in the future, as highlighted as a challenge in Section 1.2.3. Consequently, ensuring land tenure security for farmers beforehand becomes crucial, and this aspect is explored in Chapter 4. Moreover, land tenure security could also pose a risk to farmers' commitment to the system. Conflicts with landowners could substantially undermine the effectiveness of the agroforestry system. Thus, it becomes pivotal to familiarise landowners and authorities with the system to minimise potential conflicts throughout its lifespan, an aspect discussed in Chapter 4.

Beyond concerns about farmers' participation and long-term commitment, the EPA addresses another risk which pertains to trees failing to mature to the stage of carbon credit generation, or being prematurely harvested – a situation commonly known as illegal logging. This illicit practice poses a significant threat to the system's viability and is consequently explored in Chapter 4. It is noteworthy that the scope concentrates on illegal logging, rather than phenomena like wildfires, due to the specificity of factors influencing illegal logging, particularly within the Ashanti context.

Table 3.2: Key Considerations: Risks of Implementation

Significant risks associated with the carbon system in the agroforestry project pertain to the possibility of trees not reaching the stage where monetary returns are realised. The commitment of farmers plays a pivotal role in ensuring the system's success, and the impact of the land tenure system on farmer willingness to participate and their commitment cannot be overstated.

3.3.3. The Role of Carbon Credits in the Proposed System

By comprehending the fundamental principles of the carbon system, and within the context of the VCM, wherein carbon sequestration from trees on the properties of participating farmers is transacted to emitting entities, the function of carbon credits within the proposed system can be delineated.

Facilitating the Development of the System

To institute the system effectively, a series of initial investments is imperative, including the establishment of the project, encompassing all the procedures expounded upon by Broekhoff et al., 2019, which requires the proactive involvement of the organisation spearheading the system implementation, such as Farmerline. The anticipation of obtaining a portion of the revenue generated from carbon credits serves as a compelling incentive for these entities to allocate resources towards these initial investments. The allocation of carbon credits follows a similar pattern in both VI-Agroforestry, 2019 and Soubre, 2022.

Facilitating the Participation and Commitment of Participating Farmers

In addition to the array of advantages inherent to an agroforestry system, the allure of an additional income stream that offers greater resilience against seasonal fluctuations, which could potentially devastate conventional crops, could stand out as a compelling incentive for farmers to engage. While

farmers are required to maintain the trees, as previously highlighted, the introduction of carbon credits ensures that this extra effort is compensated. Moreover, the integration of carbon credits could create a motivational framework for farmers to commit to the system over an extended duration. The commencement of carbon credit accumulation after a span of three to five years provides an ongoing incentive, to deal with the main risks indicated by the EPA.

Table 3.3: Key Considerations: Role of Carbon Credits in the Proposed System

Carbon credits play a dual role within the system. Firstly, they provide assurance to investors of a future monetary return, and secondly, they serve as a persuasive factor in convincing farmers to participate.

3.4. Conclusions Carbon Credit System

Hence, the carbon-based agroforestry system in the Ashanti region will employ the VCM, where the carbon sequestered within trees on the lands of participating farmers will be traded to entities seeking to offset their emissions. There is an intricate procedure of establishing a carbon credit project, spanning worldwide contexts as elucidated by Broekhoff et al., 2019 and verified by insights from the EPA interview in Ghana. Investments for project development can be sourced from interested parties, who stand to receive a share of the future carbon credits, mirroring practices in VI-Agroforestry, 2019 and Soubre, 2022. In the course of developing the carbon credit project, the meticulous selection of a verification standard holds paramount importance, with the quality of carbon credits being a critical determinant for project success.

Significant risks revolve around potential farmer non-participation due to their inherent risk aversion. The financial compensation offered through carbon credits could serve as a catalyst for enhancing farmer engagement. Additionally, as trees become eligible for carbon credit generation after three to five years, ongoing risks encompass the possibility of farmers discontinuing their participation or trees being prematurely felled. Notably, the EPA underscores that land tenure insecurity among Ashanti region farmers remains a prominent obstacle to their willingness to participate in such initiatives.

4

The Institutional System

In this section, the objective is to identify key considerations related to the land tenure system in the Ashanti region. Employing a top-down approach, the methodology involves conducting a desk study to gather comprehensive knowledge about the existing land tenure system in Ghana, with a specific focus on the Ashanti region. Subsequently, interviews, both in the form of focus groups and one-on-one sessions, will be conducted with potentially participating farmers. This aims to gain insights into their perceived land tenure insecurity, particularly in the context of integrating trees into the agricultural system. Another aspect of the research will involve examining farmer characteristics that influence their land tenure security. To generate recommendations for the system, interviews will be conducted with representatives from the MOFA and Colandef to explore avenues for obtaining land tenure documents, both through government channels and alternative methods. By combining the insights gathered from these interviews with the responses from farmers, a set of key considerations will be formulated.

4.1. Terminologies Pertaining to the Land Tenure System in Ghana

Definitions of Ownership
(from Nara et al., 2021)

- **Landholder** refers to an individual who possesses land and holds associated land rights, irrespective of ownership status, as long as they directly benefit from it through activities such as residence and cultivation. To simplify, land can be possessed and utilised by anyone, yet not all landholders are actual landowners.
- In the patrilineal customary system, **Landowners** are predominantly males who exert exclusive land rights over individuals beyond their landowning group, even if those individuals are currently in de facto possession of the land.
- **Settler** denotes an individual who arrives at a location more recently than the landowners, often not being a member of the landowning group. This implies that settlers interact with individuals who are already residing there, referred to as landowners. Despite not holding land ownership, settlers frequently engage in smallholder farming on these lands and commonly establish permanent residences in the new area.

Varieties of Land Ownership
(from Josiah-Aryeh, 2008)

- **Allodial interest** pertains to the highest level of land ownership wherein an individual or entity possesses absolute and unrestricted rights over the land. In this structure, the landowner exercises full control and can employ, transfer, or dispose of the land without any external limitations or obligations to higher authorities.
- **Customary freehold** signifies a type of land tenure prevalent in traditional or customary societies. Under this arrangement, individuals or families hold land rights indefinitely based on customary laws and practices rather than formal legal documentation. Customary freehold grants a sense of ownership and control over the land, but it may be subject to the rules and traditions of the community.
- **Leaseholds** correspond to a form of land tenure where the landowner grants a lease or rental agreement to another party, known as the tenant or lessee, for a specified duration. Throughout the lease period, the tenant possesses the right to use and occupy the land as stipulated in the lease agreement. However, once the lease concludes, the land returns to the landowner unless the lease is renewed or extended.

4.2. The Land Tenure System

In accordance with the designated research structure, this chapter commences by conducting a desk study on the overall dynamics of the land tenure system in Ghana, followed by a specific focus on the Ashanti region. This initial step serves to establish a comprehensive foundational understanding, upon which the subsequent sections of the chapter and interview inquiries can be anchored.

4.2.1. The Land Tenure System in Ghana

The concept of land tenure encapsulates the intricate regulations that govern access to land resources and the diverse mechanisms by which land is possessed, accessed, or exchanged (Bugri, 2008). In Ghana, the management of land resources operates within a complex framework characterised by legal pluralism, signifying the coexistence of diverse sources of authority, rules, and norms governing land utilisation (Obeng-Odoom, 2014). Within this context, formal and informal legal frameworks coalesce, enjoying equal recognition. As underscored by (Larbi, 1996), two distinct forms of land ownership garner recognition within Ghana: state (or public) land and customary (or private) land. This delineation is further enshrined in the 1992 Constitution of the Republic of Ghana (Republic of Ghana, 1992), which explicitly acknowledges the duality of land tenure, encompassing both public and customary realms.

Public land is procured by the Government of Ghana through legislative instruments such as the Lands Commission Act, 2008 (Act 767) and The State Lands Act, 1962 (Act 125), primarily designated for public interests and objectives (Ministry of Lands and Forestry, 1999). Customary land, in contrast,

is held by traditional authorities represented by families, clan heads, and chiefs, embodying the collective interests of their respective communities (Akaateba, 2019). In quantifying the distribution of land ownership in Ghana, an approximate breakdown reveals that approximately 78% falls under the auspices of the customary system, with 20% vested under the formal purview of the Ghanaian government. A marginal fraction, amounting to 2%, represents jointly owned parcels of land shared between the government and customary landowners (Interview Colandef, 2023, Appendix D). In essence, the intricate landscape of land tenure in Ghana is characterised by a harmonious coexistence of distinct systems, each underpinned by its unique set of regulations and social underpinnings. This pluralistic approach to land governance significantly shapes the socio-economic fabric and developmental trajectories within the Ghanaian context.

Government Initiatives to Enhance Land Tenure Security in Ghana

The existing legal pluralism, particularly the customary land system, poses significant challenges to land tenure security for smallholder farmers in Ghana. Although customary land tenure systems are recognised and governed by customary law, the lack of documentation for land agreements under this system contributes to insecurity. The growing population and increased land commercialisation further exacerbate the pressure on land tenure among the Ghanaian people (Obeng-Odoom, 2014). In response to these issues, the Ghanaian government has undertaken initiatives to enhance land tenure security through projects like the Ghana Land Administration Projects (LAP I and LAP II), with a focus on supporting vulnerable groups. The LAP I aimed to implement legal and institutional reforms to ensure transparent and secure access to land, fostering national development (Anaafo, 2015; Lands et al., 2011). Building on the achievements of LAP I, the LAP II focuses on strengthening land administration and promoting transparency in land transactions by reforming various land sector agencies to better meet client needs (Lands et al., 2011). To improve the overall land governance in traditional land-owning areas, Customary Land Secretariats have been established, providing support for the operations of customary tenure systems (Lands et al., 2011). These measures aim to address the challenges posed by legal pluralism and improve the land tenure security for smallholder farmers in Ghana.

Enhancing the Authority of Traditional Control

In Ghana, the process of monetising land transactions is on the rise due to an increase in land prices. This trend is prompting a reevaluation of the effectiveness of customary systems (Ubink, 2007). The elevated land values and associated transaction costs are affording greater influence to customary chiefs, empowering them to oversee and direct the economic benefits associated with this phenomenon. Although a noticeable shift towards commercialising land transactions is taking place, it is crucial to recognise the concurrent absence of necessary tools and mechanisms for the proper administration of land. This issue becomes particularly evident when considering the growing demand for land due to its commercial appeal, set against the existing shortcomings within customary lands administration (Paaga et al., 2013). As the commercial value of land increases, the importance of reliable record-keeping, accurate land boundary delineation, and consistent enforcement of regulations becomes paramount. Unfortunately, the lack of these foundational elements within the land administration system has contributed to a higher likelihood of frequent land disputes. This situation casts a shadow over the otherwise positive prospect of increased monetisation. To fully capitalise on the advantages of this evolving economic trend and ensure equitable access to land, a proactive approach is necessary to enhance and modernise land administration practices. Such measures will help mitigate potential complexities and conflicts that may arise in the future.

4.2.2. The Land Tenure System in the Ashanti region

The concept of land ownership within the customs of Ghana varies across different regions. In the Ashanti region, customary land is commonly denoted as ”stool” land, a term originating from the symbol of chieftainship, the stool, which is believed to embody ancestral spirits. This emblematic representation holds special significance in Ashanti culture and is referred to as the ”Golden Stool” (Ubink, 2008).

The term ”chief” can create confusion as it is employed to denote varying tiers of traditional leadership, as shown in Table 4.1. This study centres on several examples, including the Asantehene, who holds the position of chief or king among the Asantes; the paramount chief; the village chief; alongside several sub-chiefs aligned with either the paramount chief or the village chief. Sub-chiefs operate as

advisers to the chiefs, while the advisers of lower-level chiefs are referred to as elders (Ubink, 2008). Land ownership presents a complex notion, as the ultimate -allodial- title to stool land resides with the community, while individuals or families hold usufructuary interests, and the chief is designated as the custodian. This multi-layered customary arrangement provides room for struggles centred around the increasing value of land in the Ahanti region. At the core of these conflicts are matters of authority regarding the allocation of village land to external parties and the entitlements to the resulting benefits. An associated concern pertains to whether allocation documents necessitate the chief's signature, and if so, the identity of the signatory and the corresponding signing fee. These discussions transpire within communities and among the various echelons of chieftaincy.

Table 4.1: General Hierarchy of Chiefs and Leadership Roles, Adapted from Ubink, 2008 with Modifications

Chief Title	Description
Asantehene	Chief or king of all Asantes
Paramount Chief	Chief in charge of a large area or region
District Chief	Chief responsible for a district within a region
Village Chief	Chief governing a specific village or locality
Sub-Chiefs	Advisor to higher-ranking chiefs; titles based on various functions
Landowners	Individuals or families holding land rights

4.3. Land Tenure Security for the Proposed System

In order to gain deeper insights into land tenure security in the context of implementing the carbon-based agroforestry system in Ghana, interviews with pertinent subject matter experts have been undertaken. This step is necessitated by the absence of scholarly literature addressing the system's impact on farmers' land tenure security, as indicated in Chapter A.

As detailed in Chapter 2, the chosen experts for obtaining insights into the system's implementation effects are the MOFA and Colandef. The MOFA, through its extensive engagement with farmers, has frequently encountered land tenure agreements as a significant hurdle in the successful execution of various projects. Colandef, an NGO possessing substantial expertise in collaborative documentation initiatives spanning the spectrum from local communities to the national level, has been actively engaged in this endeavour. Notably, since 2018, Colandef has undertaken a dedicated initiative named the Customary Land Rights Documentation Project. This project is designed to elevate land tenure security by facilitating the progression of obtaining documentation for land agreements. Colandef operates across various regions in Ghana, encompassing the Ashanti region as well, where their initiatives span five distinct traditional areas.

4.3.1. Transitioning to the Agroforestry System

Both MOFA and Colandef state that in the existing land tenure framework, particularly within districts with many settles in the Ashanti region, farmers possess leasehold rights over the land. This arrangement primarily involves two principal entities: the farmers themselves and the landowners, often represented by chiefs or families occupying lower positions within the hierarchical structure. The land's established function, historically designated for leasing to settlers for cultivating annual crops, reflects the intention of the landowner with allodial interest or the customary community, as previously elucidated and confirmed by the MOFA. Notably, the prevailing interest in the land has remained relatively unchanged. However, a transformative shift emerges when the land's purpose undergoes alteration, as exemplified in the proposed agroforestry system. This innovative approach entails settlers engaging in longer-term agricultural activities, necessitating sustained participation in the system, as expounded in Section 1.2.4. Notably, such a transition in land use cannot be unilaterally executed by local chiefs or landowners occupying lower echelons, mentions Colandef. Given that the ultimate allodial rights over the land are vested in the broader (Ashanti) community, significant alterations to land use necessitate the involvement of higher-ranking figures within the hierarchical structure, provided this option is even

feasible. The MOFA asserts that the authorisation for altering land tenure in favour of transitioning to an agroforestry system must be officially sanctioned by the Ashanti king. Conversely, Colandef contends that such authorisation can be established through agreements with lower-ranking authorities, including district or village chiefs.

According to MOFA, in many regions, farmers obtain short-term contracts, primarily for annual crops, which poses a challenge for engaging in activities requiring long-term commitments, such as growing tree or perennial crops. Due to the rotation period associated with tree crops, certain landowners exhibit reluctance in leasing out their lands for tree cultivation. This hesitation on the part of landowners is frequently attributed to the perception that tree planting could serve as a strategy employed by lessee farmers to extend their tenure on the land, potentially implying a degree of land ownership, as discussed by Odoom, 1999 and confirmed by Colandef.

Colandef highlights the significance of enacted law (Lands et al., 2011), emphasising the need for documenting oral transactions under customary law. This emphasis is rooted in the heightened significance of Ghana's increasingly scarce land resources, a trend also corroborated by Ubink, 2007. While oral agreements retail validity and trustworthiness, Colandef underscores that farmers stand to benefit from obtaining formal documents for their agreements. On the other hand, Colandef mentions that landowners frequently express concerns regarding the potential of signing a contract to lead to a lasting relinquishment of their land rights, even when the agreement is meant for a specific duration. This concern emanates from the fear that recording the agreement might potentially culminate in the irrevocable cession of their land rights.

4.3.2. Conflict Resolution and Government Involvement

As noted by Colandef, the land agreement operates within the scope of customary law, which delineates the functioning of land ownership and tenure. When conflicts or tensions arise, they frequently involve the traditional legal system of the local area, further complicating the resolution process. In instances where land is subject to the customary system, the MOFA mentions that the Ghanaian government possesses limited capacity to influence or mediate in these agreements. In regions governed by customary practices, local traditions and customs exert a significant impact on the formation of land agreements and the resolution of disputes. Local chiefs and community leaders assume a pivotal role in resolving conflicts, drawing upon longstanding traditions that have been transmitted across generations. Consequently, the Ghanaian government's direct intervention or alteration of these customary agreements is notably constrained. This intricate interplay between customary law, traditional leadership, and land tenure underscores the multifaceted legal and societal milieu in the area. While the government might wield authority over specific legal and administrative aspects, its jurisdiction remains circumscribed when addressing matters deeply entrenched in local customs and community dynamics, particularly concerning land agreements. Consequently, the resolution of conflicts and land management typically resides within the realm of local traditions and practices.

> *As the land belongs to the chiefs (or other customary authorities), they have the right to do whatever they want with the land. It is difficult to form regulations on the property of these institutions, the government is only able to regulate the land owned by the government. - Ministry of Food & Agriculture, 2023*

4.3.3. Importance of Land Tenure Security for Success of the Proposed System

The imperative to fortify land tenure security within the envisioned system encompasses two pivotal dimensions. Initially, a primary concern revolves around farmers' hesitance to engage when they lack confidence in their land tenure, as mentioned by the EPA in Chapter 3. The prospect of committing to a long-term endeavour, coupled with the risk of imperilling their livelihoods and potential earnings derived from current annual crop harvests, may constitute a substantial deterrent to their active participation. Conversely, as discussed in Section 1.2.4 and elaborated upon in Chapter 3, a protracted commitment to the system spanning a minimum of three to five years is crucial before carbon credits can be accumulated and realised as tangible benefits. Instituting secure land tenure at the project's commencement significantly heightens the probability of progressing to this crucial stage, wherein financial returns commence flowing back to stakeholders.

4.4. Status of Tenure Insecurity

Given that the land tenure security of farmers emerges as a critical determinant influencing their willingness to engage with the system, this research delves into the existing state of land tenure security among potentially participating farmers in the Ashanti region. As outlined in Section A, the nexus between land tenure security and the envisaged carbon-based agroforestry system lacks comprehensive scholarly investigation. Therefore, farmers will be queried about the implications of their participation in the system on their land tenure security.

Regional Context

Ejura, a locality situated in the northern part of the Ashanti region, has become a destination for numerous farmers from the northern areas of Ghana due to its more favourable climate featuring two rainy seasons. Research conducted by Antwi-Agyei, E. D. Fraser, et al., 2012 highlights the area's relative resilience to climate change impacts in the agricultural sector. Farmers in Ejura primarily engage in the cultivation of annual crops such as maize and beans. This preference is attributed to the uncertainty surrounding their land tenure security. Given that many of these farmers are settlers, landowners exhibit reluctance in entering long-term agreements, as they are sceptical about the continual cultivation of the same lands by these settlers, as found in Section 4.3. The absence of assurance regarding future land usage compels farmers to predominantly opt for the cultivation of annual crops.

4.4.1. Focus Group

Focus Group Setup

The initial phase of this study entails an examination of the existing landscape of land tenure insecurity in the Ashanti region. Pertinent data will be gathered from farmers positioned to potentially engage in the proposed system, with a specific focus on the agricultural communities nestled within the Ejura-Sekyedumase district, which maintains a connection with Farmerline. In the course of fieldwork endeavours, a focus group discussion is convened, comprising ten farmers hailing from a discrete farming community [1]. The delineated farming community within the Ejura-Sekyedumase district showcased a methodical organisational framework, overseen by a board encompassing a treasurer, a secretary, and a leader, with the latter two being present during the focus group.

The interactive dialogue with the farmers, expounded upon in Appendix B, is informed by a research conducted by Nara et al., 2021 that probed customary land rights among smallholder farmers in an alternate region of Ghana. These questions were tailored to address the potential introduction of the agroforestry system and its interconnectedness with the domain of the carbon credit market. The focus group was conducted within the farming community, with farmers selected by the community leader convening for the study. The interview queries were presented to the farming group with the assistance of a translator, ensuring that all participating farmers had the opportunity to respond. A consensus-seeking approach was employed during the interviews: when farmers concurred with the statements provided by the initial respondent, they were required to confirm their agreement; conversely, if they held differing viewpoints, they were encouraged to provide their own insights, thereby stimulating discussions within the farming group.

The focus group session unravelled along three principal axes. Initially, farmers offered insights into the current land tenure framework, encompassing the time period of their agreements, the payment methods, and the presence or absence of legal documentation approving their entitlement to cultivate designated parcels within specific time frames, similar to Nara et al., 2021. Subsequently, inquiries were directed toward tree ownership on their plots, crucial for the distribution of monetary returns, and the potential alteration of the agricultural system. These questions were tailored to address the proposed system. Conclusively, farmers were questioned regarding any instances of conflicts they may have encountered with landowners, alongside an exploration of the likelihood of landowners discontinuing their agricultural pursuits in the foreseeable future. Given the enduring commitment requisite for the agroforestry system and the latent monetary returns from carbon credits, safeguarding the farmers' assurance in perpetuating their agricultural undertakings upon the same lands emerges as an overarching priority.

[1] The appellation of which is withheld for privacy considerations

1. Land tenure framework
2. Ownership of trees
3. Past conflicts

Focus Group Results

Based on the farmers' input, the lands within the district are under the ownership of the local chief. Every year, farmers must visit the chief to renew their lease agreements, accompanied by the mandatory cash rent payment. This annual tradition generates a sense of uncertainty among the farmers, as failure to make payments or delays could potentially result in the loss of their land rights. However, once the rent is settled, a feeling of reassurance settles among the farmers, guaranteeing their right to cultivate the land for the subsequent year.

When contemplating the prospect of engaging in an agroforestry system connected to the carbon credit market, farmers acknowledge the chief's crucial role. Any modifications to their farming practices or land usage necessitate the chief's consent, making this a significant factor in their decision-making process. Upon reaching an understanding with the chief to participate in the agroforestry system, farmers anticipate securing their farmland for a more extended period. This assurance holds particular importance, especially when accounting for the delayed financial returns from the carbon credits, projected after a four-year span. Farmers' confidence in retaining their land during this interval profoundly influences their readiness to embrace the agroforestry system and its potential advantages.

The dynamic between farmers and chiefs comes with its share of challenges. As disclosed in discussions, conflicts with chiefs are commonplace experiences among the farmers, or at least they are aware of such disputes occurring within the community. Rent payments appear to play a pivotal role in maintaining a positive rapport with the chiefs and ensuring continued access to the land.

Key Findings

- *Land Tenure Framework*: The district's lands are owned by the local chief, requiring annual lease renewals with cash rent payments, creating uncertainty but subsequent reassurance for farmers regarding land cultivation rights. None of the farmers received documents regarding land agreement.
- *Ownership of Trees*: Farmers acknowledge the chief's crucial role in the agroforestry system linked to carbon credits, necessitating permission for practice and influencing participation decisions; agreement provides extended land security amid delayed carbon credit returns.
- *Past Conflicts*: Farmer-chief relationships encompass challenges, including conflicts and payment influencing favourable relationships and sustained land access.

4.4.2. In-Depth Interviews

In-Depth Interview Setup

Following the focus group discussion with one farming community, another community is selected for conducting one-on-one in-depth interviews. This approach aimed to gain a more comprehensive understanding of the land tenure insecurities among farmers and to gather additional data points. In the focus group discussion, the influential members, such as the head and the treasurer, were suspected to have a significant impact on the community's responses. Therefore, the in-depth interviews are designed to capture the perspectives of individuals in the community who might have a weaker position and could be more vulnerable to potential changes brought about by the adoption of an agroforestry system.

The questions used in the in-depth interviews closely mirrored those used in the group discussion. Specifically, the interviews focused on three main aspects: 1) the current land tenure situation of individual farmers, 2) tree ownership on their lands, and 3) conflicts with landowners and the potential implications of joining the agroforestry system. This approach allowed for a more nuanced and detailed exploration of the farmers' experiences, providing valuable insights into the challenges and opportunities they might face in embracing the new system.

A total of 8 farmers from this community are invited to participate in the in-depth interviews, which lasted approximately 30 minutes each, including a section on the socio-technical aspects of the system that will be discussed in the subsequent chapter. Among the participants, 6 are male, and 2 are female, representing a diverse group with varying sizes of farmlands and different periods of farming experience in the area, further specified in Appendix E

In-Depth Interview Results

The land of all 8 of the farmers is owned by the local chief. Similar to the farmers from the group discussion, the lease period is two seasons, or one year, and the rent is being paid in cash. None of the farmers had received a document stating that they were legally farming a specific piece of land, for a specific amount of time. There are some farmers that thought they would be able to receive a receipt for the agreement, but the receipt would only state the date and the amount of money paid to the local chief.

There is a divergence of opinions among the farmers regarding the ownership of the trees if they were to participate in such a project. Four farmers firmly believed that the trees on their farmland would always belong to them, as long as they were allowed to farm on that land. In contrast, one farmer expected the chief to claim ownership of the trees on the land. The remaining three farmers acknowledged that negotiations with the chief would be necessary to establish ownership rights over the trees.

> *Planting trees could become a problem. Once the trees are starting to provide revenue, landowners could come to the land and tell you to start farming in a different area. Landowners will take the revenue and you will have to start again. - Farmer H, 2023*

The majority of farmers in the area primarily engaged in cultivating annual crops, such as maize and beans. Only two out of the eight farmers had previous experience with tree crops on their farms. One farmer had been cultivating mango trees for over a decade and continues to do so. However, the other farmers had previously planted mango trees but eventually abandoned them due to the trees overgrowing the land and negatively impacting the yields of their maize and bean crops. Despite not encountering any issues with the local chief concerning the cultivation of mango trees, all eight farmers expressed concerns about the insecurity of their land tenure, which hindered their willingness to participate in a project involving tree cultivation.

All eight of the farmers unanimously expressed concerns about the chief's ability to halt their farming activities on their current farmland in the near future. Their main apprehensions revolved around the chiefs' potential to claim ownership of the land once the trees planted for the agroforestry system start generating income. In particular, two farmers feared that the chiefs might delay taking action until the farmers had invested time and effort in maintaining the trees, only to seize the land once the monetary returns from the carbon credits arrive after the four-year period.

Another issue raised within the community related to urban development, particularly the construction of a prison within the traditional area. Several farmers experienced being forced to stop farming on specific plots of land to make way for the prison's establishment, resulting in their relocation to more distant locations away from the urban areas.

> *I remember a couple of years ago, a new prison was build close to here. Farmers that were currently farming those lands were informed on short notice and had to start farming on a different plot. This hinders farmers to commit to long term projects. - Farmer B, 2023*

> *The main reason for conflict is when chiefs rent out the farmland to two different farmers at the same time. Both farmers feel like they have the right to farm on the same piece of land, leading to conflict. - Farmer G, 2023*

When inquiring about conflicts with the chiefs, six farmers reported personal experiences of conflict, while two farmers were aware of such conflicts happening but had not experienced them firsthand. The farmers identified two primary reasons for these conflicts. The first reason is related to the timing

of rent payments for farmland. When one farmer pays the rent for a specific piece of land before another farmer, it allows the paying farmer to cultivate that land, leading to disputes with the farmer who had previously been using that piece of land. The second reason for conflicts arises when the chief decides to repurpose farmland. This often occurs when the land is earmarked for urban development or designated for constructing facilities such as prisons. As a result, farmers are compelled to relocate and change their farmland, causing tension and disputes.

Key Findings

- *Land Tenure Framework*: The district's lands are owned by the local chief, requiring annual lease renewals with cash rent payments, creating uncertainty but subsequent reassurance for farmers regarding land cultivation rights. None of the farmers received documents regarding land agreement.
- *Ownership of Trees*: Farmers acknowledge the chief's crucial role in the agroforestry system linked to carbon credits. There is a lack of consensus regarding tree ownership, from farmers believing the trees will belong to them, to farmers expecting local customary authority to claim ownership of trees.
- *Past Conflicts*: Farmer-chief relationships encompass challenges, including conflict related to rent payment and authorities deciding to repurpose farmland. Participating farmers unanimously stated customary authorities hold the power of claiming ownership of the farmland.

4.4.3. Conclusions Perceived Land Tenure Insecurity

Based on insights gleaned from both the focus group discussion and the comprehensive in-depth interviews, a clear consensus emerges: farmers within the Ejura-Sekyedumaase district grapple with a notable range of land tenure insecurity, varying from pronounced (as voiced in focus groups) to remarkably acute (as unveiled in the in-depth interviews). The weight of this insecurity significantly influences farmers' willingness to engage in the agroforestry system interwoven with the carbon credit market. The authority of the chiefs holds considerable sway, which hinders farmers' participation in systems like the agroforestry system. Farmers appear to lack a long-term plan or vision for the future, as their focus remains on sustaining their current livelihoods. Adding to the land tenure insecurity, the absence of documented land agreements poses a challenge for obtaining carbon credits. Farmers report that landowners are hesitant to provide written agreements, and instead, rely on oral arrangements for renting the farmland. This lack of formal documentation further complicates the implementation of initiatives like the carbon credit market. Farmers face challenges in securing land agreements on paper independently, necessitating the involvement of collaborating parties in projects involving carbon credits. To support farmers in such initiatives, partners must actively facilitate the development of documented land agreements and participate in the negotiation process as allies to ensure greater land tenure security and successful project implementation. The approaches implemented by the Ghanaian government to enhance land documentation within traditional areas, as noted by Anaafo, 2015, and detailed in the Ministry of Lands and Forestry, 1999, appear to lack effectiveness.

4.5. Farmer Characteristics Affecting Land Tenure Security

4.5.1. Interviews

Interview Setup

To successfully implement the agroforestry system with monetary returns from the carbon credit market, it is crucial to analyse the impact of various farmer characteristics on land tenure security. This analysis will aid in identifying specific farmer groups that are more likely to participate in the system, thereby reducing the risk of potential failure. By understanding how different farmer traits influence land tenure security, targeted approaches can be developed to engage farmers effectively and ensure the sustainability of the agroforestry initiative.

To gain a comprehensive understanding of the diverse farmer profiles in the region, brief interviews were conducted with four distinct farmer groups from various locations in the Ashanti region. The interviews aimed to gather insights into the land tenure securities of these groups. Participants were asked about the type of farms they operated and their respective locations. These factors will be carefully considered as potential determinants influencing land tenure security for each group. By

examining these variables, we can better comprehend the unique challenges and opportunities faced by different farmer categories in relation to land tenure.

Interview Results

The table below provides information on the location of the farms and certain characteristics of their land agreements. During the interviews with the farmer groups, those engaged in annual crop farming, such as vegetables or rice, exhibited similar levels of land tenure security as the farmers from the Ejura-Sekyedumase district. Notably, the farmer community primarily harvesting tomatoes showed higher tenure security. This group had longer land agreements because the landowners were aware of the farmers cultivating perennial crops, which often involve more long-term commitment compared to annual crops, a fact confirmed by Colandef. As per Colandef's insights, specific regions within the Ashanti area have historically engaged with farmers cultivating perennial crops, imparting a familiarity with the ramifications of extending long-term agreements. In contrast, in areas characterised by farmers cultivating annual crops, landowners exhibit hesitance in providing land tenure agreements exceeding one year.

One of the farmers mentioned that they belonged to a farming association, which appeared to slightly increase their land tenure security. As an association, these farmers could more easily negotiate agreements, including potential conflicts related to tree ownership, collectively rather than individually. Lastly, one of the farmer groups cultivated land that belonged to a school. This significantly altered the dynamics of land tenure, as no monetary return was paid to the landowner for renting the farmland. This unique arrangement brought about distinct implications for their land tenure security.

Table 4.2: Land Tenure Characteristics of Different Farmer Groups (* after negotiation)

Location	Harvest	Ownership	Document	Length of rent	Tree Ownership
Central	Tomatoes	Rent	Receipt	3 years	Negotiation
North	Vegetables	School land	No financial commitment		Negotiation
South	Vegetables	Rent	No	1 year	Landowner
Central	Rice	Rent	For farming association	1 year	Farmer*

Key Findings

- *Land owner*: Farmers cultivating lands under ownership structures distinct from customary authorities, such as those held by educational institutions, exhibit a heightened perception of land tenure security compared to their counterparts engaged in agricultural activities within the purview of the customary system.
- *Type of crops*: Farmers engaged in the cultivation of tree crops manifest elevated levels of tenure security in contrast to their counterparts involved in the cultivation of annual crops.
- *Collaboration*: Farmers affiliated with robust regional farming associations possess heightened negotiating influence when interacting with customary authorities, as opposed to their counterparts lacking such affiliations.

Farm Location

According to the MOFA, the location of the farmland significantly impacts the willingness of landowners to sign long-term contracts. Urban expansion poses a challenge for traditional landowners, as the land may be needed for different purposes. This concurs with the noted observations. During the in-depth interviews, farmers underscored the impact of a prison construction within the district, prompting their relocation. To ensure long-term agreements, the MOFA advises farmers to seek land farther from expanding urban areas, where customary land authorities are more willing to sign agreements.

Conclusions Farmer Data

The data gleaned from farmer interviews reveals the presence of several influential factors shaping farmers' land tenure security. Foremost among these factors is whether farmers cultivate annual or perennial crops, as landowners in regions where perennial crops predominate have accrued more familiarity with providing extended land agreements. Moreover, the geographical location of the farm

appears to be a pivotal determinant in securing long-term agreements and thereby enhancing tenure security. Additionally, participation in a farmers' association potentially bolsters the bargaining position of farmers during negotiations.

4.6. Increasing the Land Tenure Security

As previously noted, interviews with both the MOFA and Colandef have been conducted to glean insights into strategies for enhancing land tenure security among farmers who may potentially engage with the carbon-based agroforestry system. The MOFA is well-positioned to furnish insights on the process of securing land tenure through governmental channels, while Colandef offers valuable perspectives on their existing methods for acquiring land tenure documentation through their distinctive approach.

4.6.1. Securing Land Agreement Documents through Government Channels

As land belongs to chiefs or customary authorities, they hold significant power over its use. According the to MOFA, the government can regulate only land owned by the government, making it difficult to establish regulations on property belonging to these institutions. There are regulations in place to protect individual land ownership within families, ensuring that clan heads cannot seize a person's land. To address the need for long-term land agreements, government parties assist farmers in establishing leasing agreements with landowners. These documents, known as the land agreement and deed of conveyance, specify details such as land size, duration, location, and purpose, are mostly used for those families.

The MOFA is actively involved in agroforestry projects related to the carbon credit market, where these documents serve as evidence of land ownership for participating farmers. For those without ownership documents, the lease document is a simplified form of the contract, providing farmers with certain rights to use the land for their farming activities. The lease period is often indefinite, allowing farmers to continue their activities as long as they remain within the specified use. However, if the land's purpose changes, the lease contract becomes void, and ownership reverts to the landowner. At present, farmers typically do not approach the government to set up such contracts; rather, governmental parties approach farmers to explain the potential benefits of securing these agreements. Presently, the ministry employs templates for both these documents, offering requisite legal information in a standardised format that is pertinent to the majority of farmers' circumstances.

These findings are congruent with the existing literature concerning the Ghanaian government's endeavours to enhance land documentation, as evidenced by studies such as Obeng-Odoom, 2014 and Anaafo, 2015, as well as articulated in official governmental documents such as Lands et al., 2011, all of which are addressed in section 4.2.1. Conversely, the insights conveyed by farmers through focus group discussions and interviews depict an alternate narrative. Despite the implementation of these initiatives, farmers have not yet attained the documentation for their land agreements. Notably, the efforts of governmental bodies to facilitate farmers' acquisition of land agreements or deeds of conveyance have not, as of yet, translated into tangible outcomes for farmers. This suggests that these measures have not significantly altered the farmers' circumstances or provided them with the means to engage the government in procuring these crucial documents.

4.6.2. Other Approaches for Increasing the Land Tenure Security

Different Traditional Areas

In the context of state-owned lands, regulations are governed by written state law, whereas within customary areas, land governance varies according to the customs of each respective locality. The rights associated with land use, methods of transferring land rights, and other related aspects diverge across different traditional areas. Colandef maintains a comprehensive document containing information about traditional areas and their boundaries. It's noteworthy that when a divisional chief attains the status of a paramount chief, a novel traditional area emerges. Initially, this new area typically adheres to the regulations of its predecessor, but these rules can evolve over time. Colandef diligently updates their database to ensure their awareness of these evolving traditional areas. They maintain an inventory encompassing all areas, detailing the specific type of land governance for each, and including other

pertinent information crucial for understanding land agreements and land agreement documents.

Building the Institutional System

Colandef initiated its efforts by offering technical assistance to customary authorities, facilitating the establishment of a system that ensures the security of land ownership. This involved providing frameworks based on existing agreements, aiding customary authorities in navigating the intricacies of document creation. The complexity often arises from situations where a single piece of land could encompass multiple ownership arrangements that require documentation. Alongside the technical system implementation, Colandef collaborates with traditional authorities to develop templates and assign responsibilities for contracts. Notably, there isn't a centralised documentation system in place. In the case of Ejura, the paramount chief is responsible for reviewing and endorsing/validating the contracts. Local courts and commissioners of oath within traditional areas assist in crafting templates tailored to specific contract types, such as those related to the development of agroforestry farmland, and incorporating provisions for benefit sharing within the document. By aligning the document with the customary rules of the traditional area, the resulting agreement gains enforceability. A significant challenge arises from the limited capacity of traditional areas to handle document creation and agreement enforcement. In instances where records of agreements are absent due to capacity constraints, enforcing these agreements becomes more challenging for traditional authorities.

Introduction of Trees

Introducing trees into the equation introduces added complexities, mentions Colandef. The presence of trees alters the dynamics of existing agreements between farmers and their tenure arrangements, as found from farmer interviews in Section 4.4. In the context of Ejura, a significant proportion of settlers originate from the North. Land 'owners' find it acceptable to lease their land for annual crop cultivation to transient settlers from the North, viewing this as a short-term farming arrangement. However, when considering the cultivation of trees, a nuanced approach is required. Engaging with individuals holding usufruct interests is recommended, as they have a longer-term presence within the community. The transient settlers are more likely to come and go. Obtaining agreements from local inhabitants, who are expected to remain in the region for an extended duration, is comparatively simpler. These indigenes are projected to maintain a prolonged presence, ensuring the longevity of trees on their land and securing their land tenure. The forestry commission provides guidelines for tree tenure, but farmers generally prioritise securing land tenure prior to addressing tree tenure arrangements.

Setting up Land Agreement Documents

Colandef states that the fundamental components underpinning an agreement tailored for the agroforestry carbon system can be encapsulated through the acronym PPPPS: Parties, Period, Parcel, Price, Signature. Colandef's engagement in the Ejisu traditional area encompassed a project involving rice farmers, wherein documented agreements were established, and templates for these documents were devised. Initially, the agreements for rice cultivation were set on an annual basis, but a pivotal modification was introduced. The documentation stipulated that while the agreements need not be resigned each year, they would be automatically renewed upon the farmer's fulfilment of the rent payment to the landowner. The newly devised agreement adopted an open-ended duration, which aligned with pre-existing arrangements. By integrating the landowners into the project and conveying information regarding the project's duration, a sense of assurance was cultivated. Establishing a consensus on the mechanics of the system and how it benefits all stakeholders is integral. This entails fostering shared understanding and collective buy-in to ensure the system's viability and success.

According to Colandef, government intervention primarily occurs during the registration phase, particularly concerning customary land. Following the establishment of the document, registration with the land administration introduces an additional layer of protection for the involved parties. While governmental entities may not directly provide the documents, they stipulate the requisites for document validity. The government offers parties a certificate as substantiation of the documented land agreement, thereby enhancing the credibility and legal standing of the accord.

Strategy of Approaching Stakeholders

In Colandef's view, confirmed by the EPA in the interview on the carbon credit system, the initial step involves communicating your intentions to the traditional authorities. These authorities hold insights

into the established frameworks within their respective traditional areas for farmers' land leasing arrangements. In the Ashanti region, it is common for families to possess usufruct rights over the lands, constituting the counterpart of the farmers' current agreement. These individuals, who hold the usufruct rights, are pivotal contacts to engage with. They can also provide guidance on whether consultation with higher-ranking individuals within the hierarchy is necessary when instituting such a system.

Community entry strategies should commence with establishing contact with the traditional authority, given their overarching jurisdiction over all land matters. Simultaneously, an understanding of the community's internal power dynamics is essential; identifying key figures vested with authority within the community is paramount. An introductory approach is advisable—introducing both yourself and the project to these figures. The traditional authorities have the potential to mobilise farmers inclined to participate, rendering their involvement pivotal.

It is imperative to address the authorities before engaging with farmers, as a premature discussion with farmers might inadvertently disseminate misinformation to those overseeing the land, potentially derailing the project's progress. Worth noting is that each traditional authority operates within distinct rules and customs regarding land use. Instead of focusing solely on communicating with farmers, it is prudent to initiate discussions with landowners first. This approach circumvents the misconception that the primary benefits solely accrue to the farmers. In cases involving areas with tree crops, the landowner's position remains relatively unaltered—the existing agreement undergoes documentation, ensuring continuity and transparency in the arrangement.

Farmer Grouping

Colandef declares that efficiency is enhanced when farmers are grouped for discussions regarding land agreements. Having all farmers present during the deliberations about contract terms and potential template creation yields advantages. This approach fosters transparency among all parties, thereby augmenting the efficacy of the discourse. Nonetheless, a fundamental emphasis remains on initially addressing the landowners in a separate context. Offering them a comprehensive understanding of the project's nature and seeking their perspective on the concept is paramount. Subsequently, presenting and discussing the system with both the landowners and the tenant farmers becomes essential.

When engaging with the traditional authorities, it is pivotal to provide them with a concise yet comprehensive overview of the system's fundamental aspects, key objectives, and primary benefits for all involved parties. While the traditional authorities necessitate awareness of the project's activities within the communities, their direct involvement need not be as extensive. This strategic separation ensures a balanced and efficient engagement while maintaining a clear line of communication with all stakeholders.

Inclusivity and Gender Equality

In the process of establishing such systems and devising potential documentation for agreements with landowners, there exists an opportunity to more inclusively incorporate the perspectives of women within the community. Presently, the needs and desires of women in the community are often overlooked due to the traditional practice of men being the spokesperson for the family. However, in the course of designing new agreements, it becomes feasible to address the specific requirements of women, Colandef proclaims. Currently, women are marginalised in land decision-making processes, as the traditional norms dictate that men predominantly voice the family's concerns. This disparity in gender involvement holds distinct implications for men and women, potentially affecting them in divergent ways. In the current paradigm, women primarily access farmlands through their husbands, underscoring the existing gender dynamics at play.

4.7. Illegal Logging

As highlighted in Chapter 3, the issue of illegal logging emerged as one of the potential risks impacting the successful implementation of the carbon credit system. To gain deeper insights into the likelihood of this risk materialising, the interviewed farmers are questioned about their personal encounters with illegal logging. This inquiry aimed to assess whether illegal logging poses a significant threat to the

system's effectiveness.

During the focus group discussions, participating farmers shared that incidents of illegal logging had not occurred on their own lands or on the lands of neighbouring farmers. They expressed the belief that implementing the agroforestry system would not likely lead to a substantial risk of illegal logging, as local customs prioritise respecting trees on another person's farmland. However, this perspective diverged when comparing the findings from the in-depth interviews. Among the eight farmers interviewed, seven mentioned that they had encountered instances of illegal logging in the past. Among these farmers, one mentioned uncertainty regarding the culprits behind the unauthorised tree removal on his land. Meanwhile, four farmers pointed out that cases of illegal logging were orchestrated under the direction of the local chief. Additionally, two farmers noted that trees on surrounding farmlands had been unlawfully felled by individuals from outside the community. They specifically emphasised that larger trees like teak were targeted due to their utility for construction purposes, whereas smaller trees like mango trees were considered less susceptible to this risk. This divergent perception among farmers underscores the complex nature of the illegal logging risk and the need for context-specific considerations when addressing it within the agroforestry system.

> *I had several trees growing on my farmland. After I went away for a week, when I returned, the trees were gone. I do not know what happened to the trees. - Farmer A.*

4.8. Key Considerations

The existing literature, insights from focus group discussions and interviews with farmers, and expert input consistently highlight the issue of inadequate land tenure security among smallholder farmers in the Ashanti region. Given the critical role of farmer engagement and commitment in ensuring the effective implementation of the system, this section presents key considerations aimed at enhancing tenure security and facilitating the provision of comprehensive land agreement documents.

4.8.1. Choosing Farmers to Participate

Within the Ashanti region, a diverse spectrum of farmers exhibits distinct characteristics that contribute to variations in their inclination to engage with the proposed agroforestry system. The predisposition of certain farmers to participate is intricately linked to their prevailing land tenure circumstances, which, in some cases, presents challenges that could impede their integration into the agroforestry framework aligned with the carbon credit market. The elucidation of these land tenure complexities necessitates an examination of barriers tied to existing tenure arrangements that may hinder farmer involvement. The aggregation of insights gleaned from focus group sessions and in-depth interviews conducted with farmers in the Ejura-Sekyedumase region exposes a prevailing struggle with land tenure security, predominantly stemming from the farmers' socio-cultural standing within their respective communities. Through a uniform assessment of land tenure security across farmers of diverse profiles, insights are derived to discern the underlying factors shaping land tenure security within the Ashanti region. This comprehensive understanding is further enriched by combining empirical data acquired from these sessions with existing literature concerning analogous farming contexts, and through consultations with pertinent stakeholders including the MOFA and an NGO specialising in land tenure enhancement for farmers (Colandef). The ensuing analysis endeavours to distill the intricacies of land tenure security in the region.

Commencing the implementation of the agroforestry system, initially engaging farmers with established land ownership, government land, or more accessible conditions, presents the path of least resistance. However, it is essential to recognise that one of the central aims of the system is to generate supplementary income and enhance the practices for farmers currently facing difficulties. Prioritising the integration of these struggling farmers into the system is justifiable, given that the potential impact of the system could profoundly influence their circumstances.

In the initial stages of developing an agroforestry system coupled with carbon credits, it's recommended to initiate a system pilot involving a selected group of farmers. This pilot approach enables an assessment of the system's effects within a controlled environment. In this context, the following section will provide insights into the characteristics of the participating farmers, along with the ease of

obtaining land agreement documentation. Balancing a farmer group that presents manageable conditions with the goal of testing the system for potential barriers becomes crucial during this pilot phase.

Farming Practices and Land Tenure Security

Upon comparing the distinctions between the farmers interviewed in the focus group and in-depth interviews within the Ejura-Sekyedumase district with the different types of farmers across the Ashanti region, a notable pattern emerges: the nature of farming significantly influences land tenure security. Evidently, farmers engaged in cultivating tree crops tend to possess higher land tenure security compared to those practising annual crop cultivation. This observation is consistent with the findings of Lambrecht et al., 2016, who also highlights the superior tenure security enjoyed by tree crop farmers in contrast to their counterparts involved in annual crop cultivation. The presence of tree crops signals a sense of commitment and permanence to both parties involved in the land agreement, facilitating more stable and longer-term land arrangements for these farmers. In contrast, farmers focused on annual crops, who are expected to rotate their cultivation, face a more uncertain tenure situation. This observation is further reinforced by the data from both the literature and the participating farmers in this study. Expert interviews provide additional depth to this understanding. Colandef, an organisation specialised in enhancing land tenure security, offers insights that shed light on the issue. According to Colandef, efforts to extend land agreements for the agroforestry system align these arrangements more closely with those of tree crop farmers. It is worth noting that landowners accustomed to leasing farmland to annual crop farmers are less experienced in managing long-term agreements. Their hesitance to grant permission for tree planting on a long-term basis stems from concerns over the potential relinquishment of ownership rights. As a result, farmers dealing with landowners who are familiar with long-term agreements hold a favourable position compared to those engaged in annual crop farming.

Table 4.3: Key Considerations: Farming Practices

Farmers presently involved in cultivating tree crops experience greater land tenure stability compared to those engaged in annual crop farming. The existing setups for tree crop farmers align more closely with the structure of the agroforestry system, thereby facilitating a smoother process for acquiring long-term land tenure documents.

Traditional Areas and Land Tenure

Insights garnered from interviews with Colandef illuminate a crucial aspect regarding the influence of the farmer's traditional area on land tenure security, particularly concerning the feasibility of securing long-term and documented land agreements for participants in the agroforestry system. While not explicitly articulated by the farmers or prominently addressed in existing literature, there appears to be a discernible correlation between the character of the traditional area and the potential attainment of documented land agreements. Numerous factors contribute to this dynamic.

Firstly, analogous to the earlier discussion, traditional areas with a history of accommodating tree crop farming exhibit a higher level of familiarity with longer-term agreements. This knowledge equips such traditional areas to better facilitate the process of securing necessary documentation. Additionally, the size of the traditional area emerges as a significant determinant in the feasibility of acquiring land agreement documentation. This factor influences the potential in two distinct ways. Firstly, in smaller traditional areas, it is relatively simpler to establish direct communication channels with individuals in higher hierarchical positions who wield decision-making authority regarding the potential implementation of the agroforestry system. Conversely, as articulated by Colandef, the traditional area must possess a structured framework or system capable of managing the documentation of land agreements. Smaller traditional areas frequently lack the requisite infrastructure for executing these documentation procedures, necessitating the establishment of such systems prior to launching the agroforestry system. Larger traditional areas are presumed to be equipped to manage these documentation processes. This dichotomy creates a challenging scenario in setting up the agroforestry system, demanding a nuanced approach to determine an appropriate traditional area size that optimally facilitates the development of the agroforestry project in tandem with carbon credit mechanisms.

Table 4.4: Key Considerations: Traditional Area

The extent of the traditional area significantly influences the feasibility of establishing long-term land tenure agreements. In smaller traditional areas, accessing individuals with the authority to modify land usage is simpler, although documentation processes might be lacking. In contrast, larger areas tend to have established documentation systems, but connecting with higher-level authorities can be more challenging. Traditional areas with a higher proportion of tree crop farmers tend to exhibit a more comprehensive comprehension of long-term agreements.

Proximity to Urban Areas and Land Tenure

The geographical location of the farm emerges as a pivotal determinant significantly influencing the land tenure security of smallholder farmers, consequently impacting the feasibility of the agroforestry system. The participants in this research have already raised concerns about the potential vulnerability of their land to urban development or other construction projects. Their apprehensions stem from the realisation that their farmland could be requisitioned for such purposes, potentially rendering their participation in the agroforestry project futile. One participant offered an illustrative scenario of a prison being erected on land that was once used for farming. The repercussions of such a scenario occurring on agroforestry fields, whether during the carbon credit accumulation phase or at any other juncture, would be highly detrimental. Reverting to the initial stages of agroforestry implementation would necessitate reinvestment, the repetition of significant efforts by farmers and other stakeholders, thereby resulting in substantial losses. This concern was also echoed by the MOFA, who underscored the additional challenge of achieving long-term agreements for farmers operating in close proximity to urban areas. The potential risk of urban development encroaching upon farmland underscores the need for strategic planning and land use considerations in the design and execution of the agroforestry system, particularly in regions with impending urban expansion.

Table 4.5: Key Considerations: Farm Location

Securing long-term land agreements for farms situated in proximity to urban areas proves to be a more challenging endeavour. Consequently, initiating agroforestry projects in close proximity to urban developments is discouraged.

4.8.2. Achieving Land Tenure Cocuments

Securing land agreement documentation holds paramount significance within the context of the system for two distinct reasons. Primarily, land documentation plays a pivotal role in the carbon credit framework, ensuring the accuracy of carbon credit accounting and verifying the rightful ownership of the land by the eligible beneficiary for the monetary returns, as indicated in Chapter 3. Furthermore, the absence of a formalised land agreement dissuades farmers from engaging in a system that entails long-term commitments. This sentiment was underscored by farmers during both the focus group and the in-depth interviews.

While existing literature provides insights into the state of land tenure in Ghana, including the Ashanti region, and its repercussions for smallholder farmers, there is a notable gap concerning strategies for attaining land agreement documents specifically tailored to the agroforestry system with carbon credits. Contact with farmers involved in this research, who could potentially participate in the agroforestry initiative, revealed that these farmers lack the capacity and resources to independently secure land agreement documents. Interviews conducted with the MOFA and Colandef illuminated potential measures to consider when establishing the system and ensuring documented land agreements for participating farmers.

Order of Approaching Stakeholders

Highlighted by Colandef, the EPA, and the MOFA, a crucial step is to engage with traditional landowners before approaching potential participating farmers. According to the EPA, initiating any communication about the system should begin with the local village chief, who can assist in identifying suitable

farmers for participation. Colandef suggests that contacting lower-ranking chiefs offers insight into the institutional landscape. These chiefs can advise whether higher-ranking chiefs' involvement is necessary to secure land agreement documents and, for annual crop farmers, to facilitate the transition to tree crops, enabling longer-term agreements. Colandef further stresses the importance of initially consulting traditional authorities to enhance their understanding of the potential benefits of establishing extended contracts. As highlighted in Section 4.6.2, traditional authorities may harbour concerns about relinquishing land rights through long-term agreements and document issuance. Addressing these misconceptions becomes a prerequisite before engaging with farmers. Effective communication with stakeholders involves delivering a comprehensive overview of the agroforestry system, elucidating the significance of carbon credits in its framework, and outlining the primary objectives and benefits that accrue to all stakeholders. Once traditional authorities are well-informed through this information dissemination, they will possess a clear understanding of the system's mechanics, subsequently reducing their necessary involvement in the implementation process.

The experts emphasised that communicating with farmers before traditional authorities or landowners could potentially hamper project progress. Premature outreach to farmers might result in the dissemination of misinformation due to their limited comprehension of the system. Should such misinformation reach landowners or traditional authorities, persuading them to allow farmer participation could prove challenging.

Involving landowners at an early stage presents a potential solution to address the concern of illegal logging discussed in Section 4.7. Farmers conveyed that instances of illegal logging were attributed to local chiefs who orchestrated the unauthorised felling of trees on farmers' lands. Integrating these key stakeholders into the system could significantly mitigate the risk of illegal logging. By incorporating them as active participants, the likelihood of such illicit activities could be notably reduced.

Table 4.6: Key Considerations: Approaching Stakeholders

Initiating contact with landowners is a vital initial step to mitigate any potential misunderstandings about the system. Landowners can facilitate the allocation of farmers who wish to participate in the program. Equally crucial is the imperative to enhance the understanding of land tenure documentation among all stakeholders, thereby minimising the likelihood of conflicts.

Developing a Template

Highlighted by Colandef, employing a singular template across a diverse spectrum of farmers in distinct traditional areas would not be effective. Templates should be tailored and adapted to suit the specific characteristics of farmers within each traditional area. Utilising a universal template for all participants in the agroforestry system could result in conflicts and misunderstandings, as it may not accommodate the area-specific and farmer-specific nuances during the document signing process. These templates should be developed only after a comprehensive understanding of the preferences and requirements of both parties has been established. As emphasised by Colandef, conducting group discussions with farmers is crucial for gaining insights into their preferences and needs. This approach allows for a more accurate identification of the key points to include in the document template, and ensures that all farmers feel engaged in the process. Engaging in group discussions with a wide range of farmers enhances the transparency of the process, facilitating the smoother advancement of the system. While the MOFA currently possesses templates for governmental projects, Colandef suggests that tailor-made templates for various scenarios are imperative for the intricate agroforestry system.

Table 4.7: Key Considerations: Template Development

Templates can contribute significantly to simplifying the land documentation process for farmers. However, given the substantial regional variations, it becomes imperative that these templates are tailored to suit the specific circumstances of each region.

Distribution of Benefits

As detailed in Section 1.2.4, the project's objective is to ensure that 80% of the monetary proceeds from carbon credits are directed to the participating farmers. In this framework, 10% will be assigned to the entity responsible for initiating the project, such as Farmerline, while an additional 10% will be allocated to a financial entity engaged in the sale of carbon credits. Insights gathered from expert interviews underscore that to facilitate the establishment of land agreements, a portion of the monetary returns might need to be apportioned to the landowners or traditional authorities associated with the project. This financial incentive for these parties could expedite the development of the agroforestry system. Although the primary intention of the system is to optimise the increase of livelihoods for participating farmers, this approach might be a strategic necessity. Traditional landowners and authorities wield substantial influence over the lands leased to farmers, as discussed in Section 4.4 and highlighted during expert interviews.

Table 4.8: Key Considerations: Benefit Distribution

Ensuring landowners' willingness to permit farmers on their land to participate in the system and provide long-term land agreements may necessitate allocating a portion of the carbon credit payments to landowners.

Obtaining Land Agreement Documents Timeline

1. Introduce yourself and the project to the village or local chief.
2. Explain the proposed system of transitioning to agroforestry and its link to the carbon credit system.
3. Consult the local traditional authority to determine if higher-level approval is necessary.
4. With authorisation from relevant stakeholders, collaborate with the village chief to mobilise participating farmers.
5. Provide a detailed explanation of the system to farmers, gathering specific requirements and preferences.
6. Organise group sessions involving all farmers to encourage collective engagement.
7. Work alongside farmers and an authorised traditional representative to establish a template for the land agreement document.
8. Once land agreement documents are signed, approach government agencies to register agreements for added security.

4.9. Conclusions Institutional System

Chapter 3 underscores the critical significance of establishing secure land tenure for farmers to render the system feasible. In-depth interviews with farmers illuminate the current precarious state of their land tenure security, characterised by an absence of official documentation pertaining to land use. Consequently, farmers' forward-looking perspectives are hindered, with their primary focus centred on immediate livelihood sustenance. Elevating the land tenure security of farmers emerges as an indispensable prerequisite for their active participation in the agroforestry system.

The process of transitioning farmland from annual crops to tree crops presents inherent challenges, given the communal interests vested in the land. Any alteration in land use must receive explicit authorisation from a duly appointed chief. Remarkably, farmers already engaged in cultivating perennial crops exhibit the highest levels of land tenure security. Additionally, the dimensions and historical context of traditional land holdings wield substantial influence over the potential for augmenting land tenure security among farmers. Furthermore, the geographical proximity of farms to urban areas emerges as a determinant factor in land tenure security.

To facilitate the acquisition of land tenure documentation, it is imperative to initiate dialogue with landowners at the outset, thereby dispelling any misconceptions about the system. Grouping farmers for collective discussions enhances operational efficiency. Subsequently, the development of tailor-made templates, customised to accommodate diverse regional contexts and varying farmer profiles,

becomes an imperative strategy. Moreover, allocating a portion of the monetary returns derived from carbon credits to landowners may be deemed necessary to ensure their cooperation and active engagement in this collaborative endeavour.

5

The Socio-Technical System

In this section, the objective is to identify key considerations related to the socio-technical aspect of the system. Following the top-down approach, the chapter commences with a desk study to investigate the current challenges faced by farmers in the Ashanti region. This preliminary research is essential as various designs of the agroforestry system may address distinct issues. Subsequently, farmer interviews, encompassing both focus groups and one-on-one sessions, will be conducted to gain a deeper understanding of the farmers' existing livelihoods, employing the SLF as a guiding framework.

Furthermore, farmers will be queried about the most significant benefits they anticipate from the agroforestry system. Insights will also be sought from experts, including representatives from the MOFA and the EPA. These experts will provide insights into their current approaches, as well as approaches employed by other parties, in areas such as fostering farmer participation, agroforestry system design, and farmer training. By combining the perspectives of experts with the input gathered from farmers, the research aims to formulate considerations pertaining to the design of the socio-technical system.

5.1. Issues in the Ashanti Region

Expanding upon the content presented in Section 1.2, this segment further elucidates prevailing challenges within the Ghanaian context that stand to benefit from the proposed shift in the socio-technical system, specifically towards the envisioned agroforestry system.

5.1.1. Climate Change Impact on the Ashanti Region

The Ashanti region is located in Central Ghana, in the Forest-Savannah Mosaic zone. This zone exhibits a distinctive climate characterised by a combination of forested and Savannah ecosystems (Ministry of Food and Agriculture Ghana, 2021). The region's proximity to the equator contributes to its overall warm and humid conditions throughout the year. The annual precipitation in the Forest-Savannah Mosaic zone is approximately 1000 millimetres, with the highest rainfall occurring during the wet season, typically between April and October, as mentioned by (Julier et al., 2018). Intense thunderstorms and occasional downpours are characteristic features of the wet season, fostering lush vegetation growth. Conversely, the dry season spans from November to March, during which precipitation significantly diminishes. This period is characterised by drier and warmer conditions. The lack of rainfall and higher temperatures contribute to water scarcity, reduced soil moisture, and heightened risk of wildfires in the region. The Forest-Savannah Mosaic zone's climate plays a crucial role in shaping the diverse ecosystems found within the region. The combination of ample rainfall during the wet season and the drier conditions of the dry season influences vegetation patterns, species composition, and agricultural practices. Farmers in this zone must navigate the distinct climatic patterns to optimise crop production and effectively manage natural resources in accordance with the prevailing climate dynamics. Understanding the complexity of the climate in this region is essential for shaping sustainable land use practices and promoting climate-resilient agricultural strategies.

As detailed in Section 1.2, the Ghanaian context grapples with the repercussions of climate change, marked by rising temperatures, shifts in rainfall patterns, and heightened occurrences of extreme weather events (De Pinto et al., 2012). De Pinto et al., 2012 and Ndamani et al., 2015 underscore the challenges these climate and weather shifts pose for Ghanaian farmers, while Boko et al., 2007 asserts that Sub-Saharan African nations, given their constrained adaptive capacity, are exceptionally susceptible to climate change impacts. The agricultural sector, particularly vulnerable, bears the brunt of climate change impacts, with potential ramifications for rural livelihoods and food security, as noted by the IPCC (IPCC, 2014). In light of climate change, the past three decades since the 1970s have witnessed a notable escalation in drought occurrences across Sub-Saharan Africa (Sarr, 2012). Climate change projections portend a drier future for West Africa, heightening the vulnerability of the region (Boko et al., 2007). This impending shift poses a grave threat to the livelihoods of millions, given that nearly half of Sub-Saharan Africa's populace relies on rain-fed agriculture (Christensen et al., 2007).

5.1.2. Financial Status of Farmers in the Ashanti Region

The economy of the Ashanti region in Ghana has a significant dependence on agriculture, which plays a pivotal role in their overall economic landscape. In the Ashanti region, agriculture serves as a key economic sector, employing a significant portion (60%) of the population and contributing to both domestic consumption and export earnings (50%) (Boahen et al., 2007). The region benefits from favourable agro-ecological conditions, including fertile soils and adequate rainfall, which support diverse agricultural activities. Smallholder farmers are engaged in the cultivation of staple crops such as maize, yam, cassava, plantain, and cocoa.

Smallholder farmers are farmers with limited land availability, fragmented holdings and limited financial resources (Chamberlin, 2008). According to Peprah et al., 2020, approximately 70% of the five million farming household population in Ghana are made up of smallholder farmers, of which the majority live in rural areas. To increase the efficiency of the agricultural system, most developing countries are expected to go through a transformation, in which the current agricultural practices are modernised. The inclusion of the smallholder farmers, often predominant in developing agricultural economies, such as Ghana, is of major importance. Chamberlin, 2008 also states that the characteristics of the smallholder farmers are constraints for the necessary transformations, whilst this group is more vulnerable to risks. The adoption of the use of more modern agricultural technologies, such as irrigation, the use

of fertilisers, the use of resistant varieties, and good planting and harvesting times, has started, but is hindered by the lack of financial resources (Darfour et al., 2016; E. N. Acheampong et al., 2014). Ghana, alongside with other countries in sub-Saharan Africa (SSA), struggles with achieving food security for its population, with a 25% prevalence of food insecurity in the total population, according to Unicef and World Health Organization, 2017.

5.1.3. Agricultural Culture in the Ashanti Region

In their study exploring traditions within farming communities in Northern Ghana, Kansanga et al., 2019 reveal that transitioning to a new agricultural approach could profoundly impact the food culture of these communities. The act of cultivating crops has ingrained itself as a pivotal element of the local food culture, as harvests have come to hold significant importance. Notably, Kansanga et al., 2019 also uncover that farmers in the Northern region of Ghana predominantly adhere to traditional farming methods, encompassing traditional land preparation practices and limited use of machinery or tools. Moreover, as delineated in Section 1.2, agriculture in Ghana has undergone intensification driven by the escalation in agrochemical usage, primarily attributed to soil depletion (Kotu et al., 2017). Finally, n a bid to address reduced yields and productivity, farmers turn to the application of pesticides. Pesticide utilisation among Ghanaian farmers has experienced a notable upsurge in recent times, particularly in the context of weed and pest control, as well as the preservation of harvested crops (Horna et al., 2008; Imoro et al., 2019).

In Ghana, the art of farming is a skill imbibed from childhood, with children forming an integral part of the family's workforce. Over the course of their lives, farmers seek guidance from elders and more seasoned farmers when encountering agricultural challenges (Bonye et al., 2012). The transference of farming knowledge occurs through diverse avenues, including informal discussions during daily life, farmer group dialogues, cooperative farming endeavours, and visits to fellow farmers. Farmers possess their distinct lexicon, tools, and methods for learning and exchanging insights, readily embracing knowledge aligned with their own context. Indigenous farming practices have been honed, practised, and passed down over several generations (Aniah et al., 2019). While some adjustments have been introduced to accommodate evolving socio-economic conditions, these practices have largely remained resilient over time.

5.2. Current Farmer Situation

This section serves the purpose of ascertaining farmers' perceptions regarding the proposed system, addressing an academic knowledge gap identified in Chapter 1. Furthermore, the concerns identified in the literature review above will be cross-referenced with the data collected from farmers. The SLF is employed to gain deeper insights into the farmers' existing livelihoods, aiding in the optimal design of the agroforestry system to address their current challenges and serving as a foundation for establishing design requirements. Furthermore, participating farmers undertook the task of ranking the benefits associated with the system. Similar to the farmer interviews conducted for the institutional system analysis, the same group of smallholder farmers were interviewed for the socio-technical system assessment. The data collection process involved two main phases.

Firstly, a focus group session was held with the farming community in the Ejura-Sekyedumasi district. Through collective discussions among the ten participating farmers, responses to these questions were generated. Secondly, akin to the previous chapter, a series of eight individual in-depth interviews were conducted with farmers from another farming community in the Ejura-Sekyedumasi district. These interviews offered a more detailed examination of specific farmer characteristics and their unique requirements towards the proposed system.

5.2.1. Farmer Perception & Knowledge

Initially, the study will assess the farmer's perception of climate change and the proposed system. This data will offer valuable insights into the farmers' willingness to participate, as their understanding of climate change may serve as an incentive to engage. Additionally, a positive outlook on the agroforestry

system will shed light on their readiness to be involved. Lastly, farmers' knowledge of carbon credits will be explored to gauge their opinions on this aspect of the system.

Farmers in the studied farming community exhibit a level of awareness regarding the impacts of climate change, having received information from diverse sources. The concept of agroforestry is also familiar to them, as the government previously introduced a project involving the distribution of saplings to be planted between crops. However, the farmers hold a negative perception of this agroforestry system, expressing concerns that the trees might overshadow and adversely affect the yield of their current maize and beans crops. Overall, the farmers have a degree of scepticism towards projects such as to the one proposed in this research. They perceive that they have been exposed to numerous such initiatives at their early stages, yet few have materialised into opportunities for tangible benefits. Furthermore, the farmers within this farming community lack knowledge about carbon credits, indicating a dearth of understanding regarding this potential aspect of the proposed project.

> *Several organisations have been to our farming community with these type of projects. People from these organisations promise a potential positive effect of their idea, but normally we never hear from them again. We need to be promised that the project will be realised and that it is actually feasible. - Farmer during focus group, 2023*

Among the eight farmers interviewed in-depth, five of them were familiar with the concept of agroforestry. Among these, one farmer had participated in a government project that distributed cashew saplings to farmers. Another farmer mentioned the potential wind break benefits of an agroforestry system. However, the remaining three farmers were only acquainted with the general idea of agroforestry and could not offer further details. Regarding awareness of the carbon credit market, half of the farmers acknowledged its existence, but none could provide additional information about it.

5.2.2. The Sustainable Livelihood Assets

In order to gain insights into the current needs of smallholder farmers in the Ashanti region and explore how the agroforestry system can enhance their livelihoods, the SLF by DfID, 1999 was employed. The analysis of the livelihoods was conducted through two distinct interview settings with farmers from the Ejura-Sekyedumasi district. Initially, a focus group session was conducted with ten participants from a farming community, where questions were posed to gauge the farmers' current livelihoods. Subsequently, in-depth interviews were carried out with eight individual farmers from a different farming community within the same area. The questions in the individual interviews mirrored those discussed during the focus group discussion.

The primary objective of these interviews was to obtain a comprehensive understanding of the farmers' existing livelihoods, with the aim of assessing how the agroforestry system with carbon credits could potentially improve their quality of life. It is expected that an enhanced livelihood would motivate farmers to participate in the system and foster long-term commitment as key stakeholders. The information gathered from the farmers' responses will be instrumental in shaping the design and implementation of the agroforestry system. As discussed in Chapter 2, the questions posed to the farmers are aligned with those explored in studies dealing with comparable contexts, such as Hanif et al., 2018 and Dube et al., 2022. Complementing this approach, the issues identified in the literature review pertaining to high-level socio-technical problems, detailed in 5.1, have furnished the foundational framework for formulating these questions.

Natural Capital

The interviews conducted with farmers in the Ashanti region have shed light on the challenges they are facing due to climate change. One prominent issue is the unpredictability of rainfall, which has become a major concern for farmers as it adversely affects their agricultural activities. The majority (five out of eight) of farmers from the in-depth interview identified this problem as the most significant issue they have encountered in the past five years, in line with found literature by De Pinto et al., 2012 and Ndamani et al., 2015. The erratic weather patterns disrupt their planting and harvesting schedules,

leading to decreased crop yields and financial losses.

Another pressing problem reported by farmers is the increasing incidence of pests and weeds on their farmlands, especially in the farming community of the focus group members and indicated by two farmers in the in-depth interview group as their main issue. During the discussion, farmers in the focus group, indicated that conventional methods of pest control and weed management that used to be effective are no longer providing the desired results. This has led to additional costs and efforts to combat these challenges, further straining the livelihoods of the farmers, which was also found by Horna et al., 2008. Furthermore, one farmer reported a decline in the nutritional value of their soil over time as the main challenge, despite their efforts to improve soil quality through various agricultural practices, a correlation identified in the investigation by Kotu et al., 2017. This decrease in soil fertility poses a significant threat to the sustainability and productivity of their farmlands, making it even more difficult for them to maintain stable crop production.

Table 5.1: Key Considerations: Natural Capital

The interviews have highlighted the multifaceted impacts of climate change on the farming community in the Ashanti region. The combination of unpredictable rainfall, declining soil quality, and escalating pest and weed pressures has created a complex and challenging environment for the farmers. Addressing these issues will require innovative and sustainable approaches that not only tackle the immediate problems but also provide long-term resilience and adaptation strategies for the region's agricultural sector.

Financial Capital

After conducting interviews with farmers in the Ashanti region, it has become evident that limited access to financial resources is a major obstacle for the farmers. Two out of the eight interviewed farmers emphasised that the financial aspect of running a farm nowadays is one of the primary challenges. This lack of financial capacity serves as the foundation, leading to insufficient funds for investing in quality farming inputs, resulting in reduced yields and limited access to pesticides, a finding mirrored in the literature found in 5.1. As a result, the farmers find themselves trapped in a vicious cycle.

The diminishing yields on their farmland due to various challenges, including unpredictable weather conditions and declining soil fertility, create uncertainty among the farmers. This uncertainty makes it difficult for them to generate sufficient income to meet their financial obligations, such as paying the rent for the farmland. Consequently, the inability to pay the rent further exacerbates the lack of investment in the farming operations, as also found by Darfour et al., 2016, leading to increased land tenure insecurities as illustrated by farmers in Chapter 4. With limited financial resources, the farmers struggle to adopt modern agricultural practices, acquire improved seeds, invest in better irrigation systems, or implement pest control measures. This lack of investment, in turn, hinders their ability to enhance productivity and improve the overall conditions of their farmlands.

Table 5.2: Key Considerations: Financial Capital

The vicious circle continues as diminishing yields lead to insecurity about meeting financial commitments, which then prevents the farmers from making much-needed investments. Breaking this cycle is crucial to empower the farmers in the region to improve their agricultural practices, increase productivity, and achieve economic stability.

Social Capital

Based on the interviews conducted with farmers in the Ashanti region, it is evident that the current farming knowledge is deeply rooted in the local culture and traditions. The passing down of agricultural knowledge from one generation to another holds immense significance for the farming communities

in the region, as indicated in the study by Aniah et al., 2019. The traditional knowledge and farming practices have been refined over the years, becoming an integral part of their cultural heritage. The farmers take great pride in preserving and passing on these techniques, as -for them- they hold the key to successful crop production and sustainable farming methods.

The production of their currently farmed crops holds a central place in the local food culture, according to the farmers. These crops not only provide sustenance but also form an essential part of the region's culinary traditions. They are woven into various dishes and culinary practices, shaping the dietary preferences and food habits of the farming communities, as found in Kansanga et al., 2019. Every interviewed farmer has emphasised the significance of their harvest in their food culture. The deep connection between farming and culture fosters a sense of identity and belonging among the farmers. It imbues a strong sense of community and a shared responsibility for preserving their traditional way of life. Farmers have inherited generations of crop cultivation wisdom and knowledge, which strengthens the cultural fabric of the region.

Recognising the value of this cultural heritage and its relationship with agriculture is crucial for the sustainable development and prosperity of the farming communities in the Ashanti region. Preserving and promoting this interplay between farming knowledge and culture can empower the farmers to face contemporary challenges while remaining grounded in their proud heritage. Emphasising the importance of this cultural aspect can further enhance their commitment to sustainable agricultural practices and ensure the preservation of their unique way of life for generations to come.

Table 5.3: Key Considerations: Social Capital

Interviews with Ashanti region farmers reveal that their farming knowledge is deeply intertwined with local culture and traditions, passed down through generations. This traditional knowledge is not only integral to successful crop production but also central to the region's food culture, shaping dietary preferences and fostering a strong sense of identity and belonging. Acknowledging and nurturing this connection between farming and culture is vital for sustainable development, enabling farmers to confront modern challenges while preserving their heritage for future generations.

Physical Capital

From the interviews conducted with farmers in the area, the prevailing issue of limited access to machinery and tools emerges as a significant hindrance to agricultural progress. In particular, the transition to an agroforestry system necessitates the utilisation of various tools to ensure its successful implementation. The farmers expressed an understanding of the importance of having appropriate tools and machinery when adopting agroforestry practices. However, their inability to access such essential equipment poses a considerable challenge, as illustrated by E. N. Acheampong et al., 2014 and Kansanga et al., 2019. After discussions in the focus group and during the in-depth interviews, one tool stood out as the most important: a spraying machine for applying pesticides high up in trees. This tool was mentioned by half of the interviewees, highlighting its significance in their agroforestry practices, in line with the study by Horna et al., 2008 and Imoro et al., 2019. The second most important tool, according to the focus group, was a machine for pruning, which was also indicated by the other half of the in-depth interview participants. All farmers emphasised that proper pruning was essential as growing trees without it would lead to overgrowth, ultimately diminishing the yield of their current harvest.

In the context of agroforestry, the presence of trees as a vital component calls for effective pest management strategies. The spraying machine plays a crucial role in addressing pest-related challenges that affect tree crops. By enabling farmers to apply pesticides at elevated heights, the spraying machine ensures comprehensive coverage and protection of the trees from harmful pests. Without this specialised equipment, farmers face difficulties in effectively managing pest infestations in the upper canopy of trees, which could result in potential yield losses and decreased overall productivity.

The machine for pruning, mentioned as the second most important tool by the farmers, plays an equally essential role in agroforestry practices. Pruning is necessary to maintain the proper structure and growth of the trees. By selectively removing unwanted branches, farmers can ensure optimal sunlight penetration and airflow within the canopy, promoting healthier tree growth and enhancing fruit production, whilst assuring sufficient sunlight to reach the crops underneath the trees. Neglecting to prune trees could lead to overcrowding, reducing the overall quality of the harvest and impeding the potential benefits of the agroforestry system.

Table 5.4: Key Considerations: Physical Capital

Interviews with local farmers underscore the substantial obstacle posed by limited access to machinery and tools in advancing agriculture, particularly for the transition to agroforestry. While the significance of appropriate equipment is acknowledged by farmers, their lack of access to essential tools is exemplified by E. N. Acheampong et al., 2014 and Kansanga et al., 2019. A key tool, a spraying machine for applying pesticides to trees' upper reaches, emerged as pivotal in agroforestry practices. The second crucial tool identified by farmers, a pruning machine, facilitates optimal tree growth by ensuring sunlight penetration and proper structure, mitigating potential yield losses and fostering improved fruit production.

Human Capital

As revealed through the interviews with farmers in the area, it is evident that there is limited knowledge of cultivation practices beyond the conventional agricultural methods currently employed. A moderate proportion of the farmers, less than half, have received any formal agricultural training, and the knowledge they possess primarily stems from traditional farming techniques passed down through family or community members, as mentioned in Section 5.2.2 and found by Aniah et al., 2019. Despite the lack of formal training, the farmers displayed a keen interest in acquiring new knowledge and adopting innovative agricultural methods. However, their willingness to learn new techniques is contingent on the assurance of a positive impact on the yield of their current crops. Farmers are receptive to learning new methods that have the potential to enhance their agricultural productivity and overall livelihood.

Notably, the topic of pruning emerged as a point of contention among the farmers. While some farmers acknowledged the benefits of pruning, others expressed reluctance due to concerns about potential fruit loss during the pruning process. This hesitancy highlights the importance of providing farmers with a thorough understanding of the benefits and best practices of pruning, ensuring they can make informed decisions about adopting this technique.

Table 5.5: Key Considerations: Human Capital

A significant number of farmers, constituting less than half, lack formal agricultural training and rely on traditional techniques passed down within their families or communities. Despite this, farmers demonstrate enthusiasm for embracing new agricultural methods, contingent upon these methods yielding positive impacts on their current crop yields. The topic of pruning evokes mixed sentiments among farmers, with some acknowledging its benefits while others express reservations due to potential fruit loss, underscoring the need for comprehensive education to empower informed decisions about adopting such practices.

5.2.3. Benefits of the Proposed System

Focus Group and In-Depth Interviews

In both the focus group and the in-depth interviews, participants were tasked with identifying the most significant benefit of the agroforestry system for them. In the focus group discussion, the consensus among farmers was that the foremost advantage of an agroforestry system would be the supplementary

harvest, thus favouring a design incorporating tree crops, also mentioned by during the expert interviews in Section **??**. During individual in-depth interviews, farmers were given the opportunity to select their primary and secondary preferred benefits from the system. Among the eight participating farmers, seven chose the additional fruit yield from fruit trees as their most favoured benefit, further underlining their inclination toward including tree crops in the agroforestry setup. Another benefit, favoured by four out of the eight farmers, centred on the system's potential to enrich soil nutrients. Tailoring the selection of specific trees with better nutrient retention capabilities could address this concern. Additionally, two farmers emphasised that protection against extreme weather, primarily strong winds, constituted a significant benefit, potentially influencing the spatial arrangement of the agroforestry system during its design phase. Lastly, improved water quality and the prospect of carbon credit payments were each mentioned once by participating farmers. Also highlighted in the expert interview is this limited influence of carbon credits on farmers' inclination to engage in the system.

Q-Method Interview

To further refine the design of the agroforestry system and place greater emphasis on specific benefits, modifications can be made, such as altering the tree species used. Given that the focus group and in-depth interviews highlighted numerous benefits that were deemed important by the farmers, a Q-method interview was conducted to gather additional insights. During this interview, farmers were asked to rank the benefits of the agroforestry system based on their individual preferences, as described in Chapter 2. The Q-method interview involved a diverse group of farmers from four different regions of the Ashanti region, totalling 24 participants, with each group represented by one member. The representative engaged in discussions with their respective group members to arrive at a consensus on their rankings. The aim of this session was to identify the most significant benefits according to the farmers' perspectives, thereby enabling the design of the socio-technical system to prioritise these key benefits. The results of the Q-method interview can be found in Appendix E. Because of a potential misunderstanding of the interview method by the participants, the findings have not been accorded significant weight in the analysis, described in Chapter 8.

Table 5.6: Key Considerations: System Benefits

Throughout the focus group, in-depth interviews, and the Q-method interview, farmers consistently emphasised that the primary benefit of the agroforestry system is the additional yield derived from the trees. Other benefits mentioned include the enhancement of soil nutrients and the safeguarding of their existing crops against extreme weather conditions.

5.3. Fostering Farmer Participation

As elucidated in both Chapter 3 and Chapter 4, it has become unequivocally clear that securing land tenure is of paramount importance for farmers' engagement in the carbon-based agroforestry system. Once this foundational aspect is in place, the subsequent step involves engaging with farmers to cultivate their willingness to participate. To shed light on effective approaches, interviews were conducted with representatives from the MOFA and the EPA. These interviews were conducted based on their extensive experience in diverse agricultural projects, albeit not exclusively carbon-based agroforestry ventures. Nevertheless, some of these projects involved significant shifts in agricultural practices, thereby allowing for valuable comparisons with the proposed system.

Tangible Demonstrations

The MOFA highlighted valuable insights derived from their existing agricultural and agroforestry projects. These projects have revealed that the most effective approach to encouraging farmer participation is through tangible demonstrations of the system's impact. For instance, when fellow farmers observe the benefits of intercropping agroforestry in action, they are more inclined to adopt this approach, according to the MOFA. Notably, it was emphasised that simply explaining the system and its advantages does not significantly influence farmers' willingness to engage. Instead, witnessing and experiencing the tangible benefits that the system offers serve as a compelling way to communicate its advantages. The EPA confirmed these dynamics of farmer participation in transformative projects. A key challenge

observed in such projects is the mode of farmer learning. Farmers exhibit a preference for experiential learning over mere verbal communication. To address this, the EPA mentions the strategic approach wherein farmers with sizeable land holdings, typically around 10 acres, were encouraged to allocate a smaller plot, approximately an acre, for adopting the new farming method. Through hands-on demonstrations, project representatives showcased the benefits of the new approach on these designated plots, effectively influencing farmers to embrace the new method.

Peer-to-Peer Learning

The MOFA underscored the effectiveness of peer-to-peer learning within farming communities, as is currently happening, mentioned in Section 5.2.2. Farmers tend to learn more readily from their peers than from experts in the field. This observation underscores the importance of facilitating knowledge exchange among farmers themselves, as it can accelerate the adoption of innovative agricultural practices.

Compensation of Farmers

The EPA states that monetary incentives play a role in fostering farmer participation. Addressing risk aversion emerges as a crucial consideration when enticing farmer participation. Farmers express reluctance to take on additional costs or risks, emphasising the need for assurances that their engagement will not result in losses. Overcoming this entails showcasing the efficacy of the proposed systems before farmers commit. Compensating farmers for practices that entail higher manpower input, and navigating the intricacies of land tenure systems, are also pivotal in ensuring successful participation. Additionally, establishing a high-quality carbon asset is of paramount importance, and this asset's quality is clearly stipulated within the pre-project agreement.

5.4. Design of the Agroforestry System

In addition to capturing the wishes of farmers regarding the agroforestry system's design, it proves valuable to gather insights on designing agroforestry systems within the Ghanaian context from experts affiliated with the MOFA and the EPA. These organisations possess comprehensive knowledge garnered from observing the implementation of agroforestry principles among Ghanaian farmers, thereby offering valuable information on the successful agroforestry systems prevalent within the Ashanti region. Subsequently, this acquired information can be amalgamated with the farmers' preferences to derive comprehensive design considerations for the agroforestry system.

Additional Harvest

In conversations with the MOFA, insights were gained into the ongoing agroforestry initiatives in Ghana. The current projects involve the cultivation of commodities such as cashew, mango, and moringa. This approach stems from the understanding that integrating trees with current agricultural practices can yield valuable products. It is worth noting that the utilisation of trees offering tangible benefits alongside crops forms the foundation of all active carbon credit projects. During discussions, the rational behaviour of farmers came to the forefront. The concept of carbon credits, intended to encourage sustainable practices, was found to have limited appeal for farmer participation in Chapter 5.2. According to the MOFA, the motivation to partake in these projects is not substantially influenced by the argument of climate change mitigation either. This lack of alignment with personal gains dampens the enthusiasm for carbon credits as a primary incentive. Farmers recognise that the true value lies in the additional harvest from tree crops, creating an extra income stream. In this context, carbon credits are perceived as a supplementary benefit.

Communicating the Solution-Oriented Benefits

The MOFA highlighted the necessity of emphasising the enhanced crop production as the pivotal advantage when communicating with farmers. The amplification of current crop yields takes precedence in discussions, while the surplus harvest from tree crops assumes a secondary role. Carbon credits, in this context, are regarded as an additional bonus, reinforcing the idea that tangible benefits hold more sway in motivating farmer involvement. The significance of strategic communication emerges as a pivotal factor according to the EPA, with expectation management occupying a central role. A cautious approach is advised to avoid overemphasising potential carbon credit income, as any disparity between projected and actual revenues can jeopardise farmers' commitment to the project. Instead, the EPA

mentions that the focus should pivot towards elucidating how the new system could ameliorate existing challenges faced by farmers. Establishing a mutually beneficial arrangement prior to project initiation is essential, delineating the distribution of benefits among involved stakeholders, be it in the form of tangible assets or financial compensation. To facilitate the latter, financial institutions and loan associations can play a pivotal role in executing cash-based arrangements. The communication strategy should spotlight the protective attributes of trees, such as shielding against heat and preserving crop integrity, fostering a comprehensive understanding of the manifold benefits the agroforestry system offers.

Value of Intercropping

In terms of project implementation trees are intentionally integrated into the existing agricultural landscape in current project, according to the MOFA. This method contrasts with establishing separate fields for trees. For instance, mango and cashew trees are deliberately grouped in dedicated blocks, with food crops strategically planted in the spaces between the trees. This design optimises land utilisation, considering planting distances of around 8 meters by 8 meters for mango trees and 10 meters by 10 meters for cashew trees. By eschewing monoculture, which is viewed as inefficient, farmers benefit from reduced weed control costs, improved soil structure, and heightened nutrient levels, especially when indigenous plants are introduced. The post-harvest phase also plays a role in nurturing the land; the residual matter from annual crops enriches the soil and supports the growth of tree crops. Insights from the EPA underscore the substantial environmental advantages inherent in agroforestry projects. Such initiatives encompass emission reduction, enhancements in air quality, amplified farmer yields, improved livelihoods, safeguarding against forest loss, and the preservation of vital environmental services within forestry systems. The EPA emphasises that the primary benefits of the agroforestry system are most effectively realised when the trees are intercropped within the crops.

5.5. Design of Farmer Training

The concluding phase in the agroforestry system design pertains to farmer training. It is imperative to provide training to farmers to ensure the survival of the trees, as emphasised in Chapter 2.1. Effective tree maintenance necessitates adequate training, as the existing agricultural knowledge among farmers is deemed insufficient, as corroborated by the farmers themselves in Section 5.2. Drawing upon the MOFA experience in implementing farmer training programs, an interview with MOFA will be conducted to solicit insights and considerations in the design of the farmer training system.

Benefits of Pruning

In discussions with the MOFA, an insightful perspective emerged regarding farmers' attitudes toward pruning practices. Traditional farming approaches have instilled a reluctance among farmers to engage in cutting their plants. This reluctance stems from a prevailing fear that the removed plant parts might have eventually borne fruit, which could have been sold for profit. Despite the potential yield-boosting benefits of pruning, the perception persists that cutting back plants would actually diminish overall crop yield. In light of this, efforts have been directed towards conducting practical demonstrations to showcase the positive impact of pruning.

Demonstrations of Best Method

A noteworthy approach in addressing this mindset involves implementing demonstrations that allow farmers to witness firsthand the effects of pruning. These demonstrations employ a specific methodology wherein a portion of a farmer's land, typically around one acre, is designated for implementing best-practice pruning techniques. Concurrently, the remainder of the farmland is maintained using the farmers' customary methods. This deliberate division enables farmers to directly compare the outcomes of the "best practice" approach with their conventional methods. Notably, it has been observed that some farmers readily adopt these new practices upon witnessing the demonstrable benefits, often without requiring external intervention or persuasion. This approach underscores the power of experiential learning and peer influence within the farming community. The tangible impact of seeing positive results firsthand serves as a compelling catalyst for change, demonstrating how pragmatic, field-level interventions can effectively transform traditional mindsets and practices.

5.6. Key Considerations

To address the research sub-question effectively, it is imperative to furnish essential considerations pertaining to the design of the socio-technical system. This section combines data derived from diverse farmer interviews with expert insights from the MOFA and the EPA. The initial consideration involves scrutinising the requirements articulated by the farmers for the agroforestry system. These farmer-stated prerequisites will be juxtaposed with the expert perspectives to inform the selection of tree species, the choice of agroforestry methods, and the formulation of a strategy for providing the requisite tools to sustain the agroforestry system. Subsequently, the section delves into the strategies proposed by the experts for persuading farmers to participate. Additionally, it outlines considerations in designing training systems aimed at equipping farmers with the skills to maintain the agroforestry trees effectively.

5.6.1. Requirements of the Agroforestry System

The foundation for shaping the agroforestry system will be rooted in the insights gained from the focus group discussions, in-depth interviews, and the Q-method interview. These sessions aimed to illuminate the precise demands that farmers possess concerning the design of the agroforestry system. Complementing this farmer-centric perspective, the experts' input, coupled with their accounts of ongoing agroforestry endeavours in Ghana, will set the parameters within which the system's blueprint must be crafted.

The design process of the agroforestry system is influenced by several crucial factors. Foremost among these is the tree selection, which wields a substantial influence on the range of benefits that the agroforestry system can offer. The choice of trees plays a pivotal role in determining whether the focus will be on higher carbon payments due to trees with robust yearly carbon uptake or on trees renowned for enhancing soil nitrogen content, thereby augmenting the crop yields of participating farmers. Additionally, the agroforestry design encompasses considerations such as tree placement, distribution, and the requisite tools for effective tree maintenance. The meticulous crafting of this system holds the potential to secure the active participation and unwavering commitment of smallholder farmers to its implementation.

Tailoring the ultimate agroforestry system calls for a customised approach that aligns with the distinctive requirements of the participating farmers. Diverse categories of farmers harbour varying preferences and necessities, underscoring the need for a targeted agroforestry system that caters to these specific demands. This process of customisation ensures that the chosen agroforestry system is finely attuned to the unique characteristics and aspirations of the participating farmers.

Tree Selection

As highlighted by participants in both the focus group discussions and the in-depth interviews, especially in Sections 5.2.2 and 5.2.2, farmers emphasised that the primary advantage they see in the agroforestry system is the potential increase in harvest through fruit trees. In Appendix A, a brief literature review has been conducted focusing on specific tree categories and their corresponding species. When crafting an agroforestry system, four primary tree categories are considered: nitrogen-fixing trees, fodder trees, fruit trees, and shade trees.

From the gathered interviews, it became evident that farmers exhibit a higher willingness to engage when fruit trees are incorporated into the agroforestry system. Drawing insights from literature provided by Elechi et al., 2022 and informed by input from the MOFA and the EPA regarding ongoing agroforestry projects, the primary fruit tree species selected for the agroforestry system include mango, moringa, and cashew. These are also the tree species that emerged as preferred choices among farmers during the in-depth interviews. In addition to being a source of fruits, cashew trees also function as shade trees, rendering them valuable for cacao farmers practising agroforestry, as cacao requires shade for growth. Conversely, for farmers cultivating annual crops, shade trees are not beneficial, given the sunlight requirements of their crops.

In addition to the enhanced harvest benefits for farmers, the trees selected should also exhibit substantial carbon accumulation to render the system economically viable for other stakeholders. While

there is a lack of available literature detailing the annual carbon sequestration rates of the chosen tree species in Ghana, studies conducted in India provide insights. According to these studies, cashew trees have the potential to sequester approximately 8.46 tonnes of CO_2 per hectare annually, while mango trees exhibit an annual sequestration potential of approximately 5.46 tonnes of CO_2 per hectare (Rupa et al., 2013; Ganeshamurthy et al., 2019). Although there is no exact data accessible in literature concerning the annual carbon sequestration potential of moringa trees, a study in Ethipia by Chauhan et al., 2021 illustrates the carbon sequestration potential of this tree species.

Among the interviewed farmers, a subset of two participants expressed a specific interest in cultivating trees like mahogany and teak for timber production. It is important to note that these particular tree species might not align well with agroforestry practices, primarily due to the requirement of prolonged tree retention on the land to facilitate carbon credit accumulation. This discordance arises from the specific growth characteristics and harvesting timelines of these species, potentially rendering them less compatible with the objectives of the agroforestry system. The hazard of illegal logging, outlined in Chapter 4, highlighted that the primary motive behind illegal logging predominantly centred on obtaining wood for roofing purposes. Opting for relatively smaller fruit trees, as opposed to larger teak and mahogany trees, mitigates the risk to illegal logging activities.

Table 5.7: Key Considerations: Tree Species

Ensuring an additional yield from the trees is crucial for farmers. The agroforestry system can incorporate mango, cashew, or moringa trees, with cashew trees potentially serving as a viable option within the agroforestry system for cacao farmers as well.

Agroforestry Method Selection

In accordance with insights provided by the EPA, the configuration of the agroforestry system holds significant implications for the farming practices of participating farmers as well as the resultant benefits of the system. A concise literature review on various agroforestry methods has been carried out in Appendix A. The available methods encompass alley cropping, silvopasture, windbreaks, riparian buffer strips, and forest farming.

As emphasised by the EPA, the primary benefits of the agroforestry system are most effectively realised when trees are intercropped within the crops, aligning with the alley cropping method. Within this approach, trees are planted in alleys at specific intervals between the crops. This technique ensures adequate sunlight for crops growing beneath the trees, addressing a primary concern raised by farmers during the focus group and in-depth interviews. The EPA underscores that intercropping is the recommended approach for agroforestry systems, yielding the maximum benefits. Although farmers might experience a more substantial transition from their current methods, the advantages of increased soil nutrients, indicated by farmers as the second most important benefit, and the reciprocal nutrient exchange facilitated by fallen leaves from trees enriching the crops and vice versa present significant benefits.

> (On intercropping) *The potential environmental advantages of implementing an agroforestry project are enormous. These benefits encompass emission reduction, enhancements in air quality, increased agricultural yields for farmers, improved livelihoods, safeguarding the environment from forest loss, and ensuring the provision of vital environmental services within forestry systems. - EPA, 2023)*

When devising the framework for the agroforestry system, a pivotal aspect to take into account is to prevent any negative impact on the performance of the existing crops. This scenario could arise, for instance, if the trees begin to overshadow the cultivated crops. It is imperative to uphold the cultural significance of food production, as expounded upon in Section 5.2.2. Thus, it remains crucial to ensure the continued cultivation of the current crops by the participating farmers within the proposed system.

Table 5.8: Key considerations: Agroforestry Method

Incorporating intercropping is recommended within the agroforestry approach. While farmers might have reservations about potential tree overgrowth in relation to their existing crops, there are numerous advantages to intercropping. Pruning will play a crucial role in managing intercropping dynamics.

Tools for Maintenance

From the discussions in Section 5.2.2, it has become evident that the current arsenal of tools possessed by farmers is inadequate for the upkeep of trees within the agroforestry system. Addressing the concerns raised earlier, farmers have expressed apprehensions about the system's viability, particularly due to the potential encroachment of trees on their existing annual crops, leading to a possible reduction in yields. During the interviews, farmers were queried regarding the specific year in which these maintenance tools would be necessary. As elucidated in Section 5.2.2, the financial constraints faced by farmers prohibit them from acquiring these tools before the commencement of carbon credit income. Interestingly, their responses indicated that tools for maintenance would be required starting from the second year (as cited by two farmers), the third year (as mentioned by one farmer), the fourth year (as indicated by one farmer), and the fifth year (as shared by two farmers). This underscores the imperative for external provision of maintenance tools to ensure the proper care of trees. The potential threat of trees encroaching on current crops could deter farmer commitment to the system. Hence, supplying the necessary tools not only mitigates this issue but also serves as an incentive, reinforcing long-term commitment. For instance, offering tools in the third year could serve as a tangible reward, motivating farmers to strive towards achieving this milestone in their engagement with the system.

The tools to be furnished include the power sprayer and the pruner, as specified by the farmers. Two approaches can be considered for the distribution of these tools. The first approach entails individual provision of tools to each farmer, whereas the second approach involves equipping an entire farming community with the tools. In the latter case, it would be imperative to establish well-defined regulations governing the utilisation of the tools among various stakeholders to ensure efficient and equitable tool-sharing practices.

Table 5.9: Key Considerations: Tools

Farmers face financial constraints that hinder their ability to purchase tools for tree maintenance. Given the significance of proper tree maintenance for the success of the system, it is imperative to provide farmers with necessary tools, including spraying machines and pruning equipment. Pruning holds particular importance as it ensures the yield of existing crops, which plays a crucial role in the local food culture.

5.6.2. Requirements of Farmer Training System

Assuring Farmer Participation

Both the MOFA and the EPA have acknowledged farmers' enthusiasm to engage in such initiatives and adopt novel agricultural techniques. However, both entities have also emphasised the challenge of farmers being more receptive to learning through observation rather than verbal explanation. This underscores the fact that solely elucidating the intricacies of the agroforestry system may not be sufficiently effective in garnering their active involvement. To address this, it is paramount that farmers have the opportunity to directly witness the agroforestry system in action and grasp its practical benefits. Two principal methods can be considered for achieving this objective.

Firstly, as suggested by the MOFA and the EPA, a small portion of farmland owned by a participating farmer or a designated plot within the farming community's vicinity can serve as a platform to showcase the new "best practice method" (agroforestry). This hands-on approach would enable farmers to directly observe the system's outcomes. Obtaining the use of a portion of farmland might involve ob-

taining consent from fellow community members or even negotiating with landowners who are already engaged in the early phases of the project, as elaborated in Section 4.8. Furthermore, the establishment of a pilot site, as also mentioned in Section 4.8, could be initiated. This site would serve as a practical testing ground for the agroforestry system. Farmers from various regions within the Ashanti area could be transported to this pilot site to witness firsthand the tangible effects of the agroforestry system. Such an approach has the potential to significantly bolster the confidence of farmers and motivate their active participation in the system.

Table 5.10: Key Considerations: Assuring Participation

Farmers acquire knowledge through observation. Therefore, setting up a designated field to demonstrate best practices could be a compelling approach to convince them of the advantages of the agroforestry system. Additionally, showing farmers an agroforestry pilot project could also yield positive outcomes.

Ensuring Healthy Trees

Providing farmers with training is an essential component in equipping them with the necessary skills to effectively maintain the trees within the agroforestry system. This aspect gains particular significance as discussed in Chapter 3, emphasising the imperative for the trees to have a prolonged lifespan to enable carbon credit generation, especially during the initial five years when carbon credits are not produced. The feedback obtained from both the focus group and the in-depth interviews underscored that many farmers lack the expertise required for tree management and cultivation. This sentiment was echoed by six out of eight farmers during the in-depth interviews, reinforcing the importance of training.

During the interactions with the farmers, inquiries were made regarding their past experiences with agricultural training, the formats of such training, and their preferences regarding the training structure. The focus group participants shared a common thread of having undergone farmer training within their own farming community. This localised approach proved beneficial, enabling the farmers to engage in training within the familiar context of their own fields. Similarly, three of the eight farmers interviewed had previous agricultural training experiences, with one receiving education at a college and the other two partaking in on-farm training sessions within their farming community. The insights gleaned from the farmers, coupled with the pedagogical principle of learning through observation advocated by the MOFA and the EPA, collectively advocate for a community-based training approach. This approach resonates as the most effective means to ensure that farmers acquire comprehensive knowledge and practical skills in tree cultivation, with training sessions strategically conducted within their own farming communities.

Table 5.11: Key Considerations: Farmer Training

Farmers possess limited expertise in tree maintenance. Ideally, training sessions should be conducted within the farming communities of the participating farmers.

5.7. Conclusion Socio-Technical System

Farmers in the Ashanti region grapple with a spectrum of challenges, encompassing erratic rain patterns, pest and weed infestations, and the depletion of soil nutrients. Moreover, financial constraints limit their resource access and investment capabilities. An essential consideration when transitioning to an agroforestry system is the preservation of currently cultivated crops, as they hold significant cultural value within the communities.

In the design of the agroforestry system, it becomes evident that farmers seek tangible benefits, including the yield of tree fruits and enhanced harvests due to soil nutrient enrichment. Carbon credits, while a factor, play a lesser role in motivating farmer participation. As per insights from the MOFA and the EPA, farmers derive the most benefit from a system that yields additional crops like mangoes,

cashews, and moringa. Emphasising intercropping is crucial, although it may not align with farmers' preferences, primarily due to the added environmental advantages. To ensure tree health and prevent overshadowing of crops underneath, training initiatives must be organised, and tools should be provided to farmers, considering their limited financial resources. Notably, farmers are visual learners, emphasising the importance of demonstrating the system's effectiveness by taking them to functioning agroforestry plots.

6

Recommendations

This chapter aims to establish crucial recommendations for the design of the proposed system. It initiates by revisiting the distinct chapters with the intention of translating the considerations derived from these chapters into actionable recommendations. These recommendations will be closely tied to specific actors within the system, encompassing the carbon credit system, the institutional system, and the socio-technical system.

6.1. Recommendations for the Stakeholders

The cornerstone of successful implementation of the carbon-based agroforestry system in this farmer-centric research is the willingness of farmers to participate. The design of all three systems - carbon credit, institutional, and socio-technical - must prioritise augmenting farmer engagement. This section synthesises findings from all three major research chapters to formulate conclusive recommendations aimed at maximising farmer willingness to participate and commit.

6.1.1. Recommendations for the Carbon Credit System

Revisiting Chapter 3

How does the functioning mechanism of the carbon credit system in Ghana influence the potential impact of implementing carbon credit incentives on agroforestry adoption among smallholder farmers?

In the initial phase of this study, an examination of the carbon credit market was undertaken to discern its mechanics and implications for the proposed system. This exploration began with a global overview of the carbon credit market, revealing the system's positioning within the voluntary carbon credit market. Despite the scarcity of available scientific data online, insights from the interview with the EPA contributed previously undisclosed knowledge. Upon contextualising the agroforestry system within the Ashanti region, it became evident that several ramifications of the carbon credit market could impact the system's feasibility and efficacy. The system's alignment with high-grade carbon credits, which necessitates adherence to specific requirements, holds significance for its success. High-value carbon credits within the market can be attributed to this alignment, thus influencing the potential triumph of the agroforestry endeavour.

An assessment of risks linked to the system in relation to the carbon credit market reveals its pivotal reliance on farmers. Given the core objective of enhancing the livelihoods of smallholder farmers in the Ashanti region, the system's design must prioritise meeting the farmers' needs. Farmer participation is paramount for accruing carbon credits, which, in turn, is crucial for the system's functionality. The EPA highlighted that carbon credits are accrued by mature trees, underscoring the importance of planting trees with a long-term commitment in mind. Thus, the system must be structured to ensure farmers' sustained engagement.

Perceived risks encompass the possibility of trees no longer generating carbon credits due to factors such as cutting or mortality, necessitating the replanting of trees. Farmers' ability to maintain trees effectively is essential, entailing comprehensive training and the provision of necessary tools. Additionally, the threat of illegal logging looms large, potentially undermining the project by leading to tree removal and the ensuing need for replanting, thereby disrupting income streams for farmers and other stakeholders within the system.

Regarding the influence of carbon credits on the agroforestry system's implementation, a dual effect is observed. Firstly, the prospect of financial returns offers an incentive for parties to invest in agroforestry systems for smallholder farmers who lack the financial means to do so independently. This financial aspect, in turn, can motivate farmers to actively participate in and commit to the system over the long term.

Recommendations Carbon Credit System

The research on the carbon credit market has underscored the significance of farmer commitment to the system, given that only mature trees can generate carbon income. Any actions such as cutting down or the death of trees would have a detrimental impact on the system. Therefore, concerning the carbon credit system, it is imperative for farmers to receive training and acquire the necessary tools, facilitated by the coordinating party involved in establishing the system. This is crucial for these parties as it ensures the generation of carbon credits and, consequently, income to offset their initial investments. Moreover, the coordinating and financial parties must ensure that their system adheres to high-quality carbon standards to guarantee the value of the generated carbon credits. The actions to be implemented, along with the respective actors, are presented in Table 6.1.

Table 6.1: Key Recommendations Carbon Credit System

Actor	Action
Coordinating party	Arrange training and tools for participating farmers to maintain trees
Coordinating & financial parties	Assure system adheres to high-quality carbon standards

6.1.2. Recommendations for the Institutional System

Revisiting Chapter 4

What are the key considerations for designing an institutional system that facilitates the implementation of promoting agroforestry among smallholder farmers in the Ashanti region using carbon credits?

In Chapter 1 and Chapter 3, the issue of land tenure security for potential participant farmers was identified. A review of the literature revealed the intricate nature of Ghana's land tenure system due to legal pluralism. This implies the coexistence of formal and customary legal systems, wherein public lands are under the jurisdiction of the Ghanaian state, and customary lands fall within the purview of traditional authorities. These traditional authorities often include entities such as chiefs, clans, and families. Notably, around 80% of land in Ghana is governed by the customary system, encompassing a significant portion of the Ashanti region. Addressing this customary framework becomes crucial for the proposed system's success, ensuring secure land tenure for smallholder farmers to encourage their participation and facilitate the receipt of monetary returns once the system matures.

A focus group session and a series of in-depth interviews conducted with farmers in the Ashanti region underscored the prevalent land tenure insecurity experienced by these farmers. This insecurity emerges as a deterrent to their engagement in the agroforestry system involving carbon credits. Farmers express the need for assurance that they will indeed receive monetary returns from the system, coupled with concerns that a chief's decision might result in their displacement from the land. Chiefs hold significant authority in this context, as they play a pivotal role in granting land agreements essential for initiating agroforestry systems on farmlands. However, farmers exhibit uncertainty regarding the consequences of planting trees on their lands.

Considering farmer characteristics, it is observed that settler farmers face the highest degree of land tenure insecurity. These farmers originate from different regions and predominantly cultivate annual crops, reflecting the historical uncertainty surrounding their settlement. This contrasts with tree crop farmers who tend to possess longer-term land agreements. Additionally, participation in large farmer associations enhances some farmers' land tenure standing.

It is imperative for landowners to grasp the mechanics of land agreement documents, as apprehensions and misconceptions often hinder their willingness to sign such documents, stemming from a fear of permanent land loss. Within the traditional legal framework, not all traditional areas are equipped to handle documentation adequately. Smaller traditional areas lack the necessary knowledge and systems for land documentation, while larger areas face challenges in engaging individuals at higher hierarchical levels to facilitate transitions to agroforestry. Some traditional areas, owing to a higher proportion of tree farmers, possess more substantial knowledge about navigating longer-term agreements.

Initiating the process of securing land agreement documents necessitates commencing with a local chief due to concerns of information leakage to traditional authorities and the desire to avoid disappointing farmers. This chief can determine whether higher-level permission is required or if they possess the authority to grant permission and documentation. Chiefs also play a pivotal role in mobilising farmers to partake in the system. If implementation is feasible, tailored template documents for land agreements can be developed, catering to the specific nuances of the local context. Allocating a portion of the carbon credit system's benefits to traditional authorities might be requisite to ensure their active collaboration.

Key Recommendations

The research on the land tenure system in the Ashanti region was pivotal because farmer willingness to participate in the system hinges on the security of land tenure. Without secure land tenure, the benefits of the carbon credits will not accrue to the participating farmers. Presently, land tenure security is found to be extremely low, prompting the coordinating party to prioritise increasing land tenure security. By procuring land tenure documents for the farmers, their land rights can be safeguarded, and the carbon-sequestering trees can be allocated to specific farmers. Insights from interviews with the MOFA and Colandef revealed that obtaining documentation necessitates following critical steps. The coordinating party should initiate the process by engaging with local chiefs is crucial, given the potential for misconceptions to undermine the system's development. Moreover, the coordinating party should promote awareness and understanding among all stakeholders regarding the advantages and intricacies of land tenure agreements.

Several factors influence the land tenure security of farmers and their ability to obtain land tenure documentation. As highlighted in Chapter 5, farmers tend to learn best through practical experience, and establishing a pilot field for agroforestry can be instrumental in convincing farmers to join the system. When setting up a pilot project, the coordinating party should carefully select a pilot area where land tenure documents can be readily obtained. In cases where challenges arise in arranging tenure documents, the coordinating and financial parties can explore the option of modifying the distribution of benefits to address these issues. The steps to take, along with the corresponding actors, are detailed in Table 6.2.

Table 6.2: Key Recommendations Institutional System

Actor	Action
Coordinating party	Engage with local chiefs first
Coordinating party	Promote awareness and understanding among all stakeholders regarding the advantages of land tenure agreements
Coordinating party	Select a pilot area where land tenure documents can be readily obtained
Coordinating & financial parties	Explore the option of modifying the distribution of benefits

6.1.3. Recommendations for the Socio-Technical System

Revisiting Chapter 5

What are the key considerations for designing a socio-technical system that facilitates the implementation of promoting agroforestry among smallholder farmers in the Ashanti region using carbon credits?

Farmers within the Ashanti region contend with the repercussions of global climate change, evidenced by heightened aridity and erratic rain patterns. This environmental shift significantly impacts the entire regional populace, given its reliance on rain-fed agriculture as a predominant livelihood source. The interviewed farmers exhibit a conscious awareness of climate change phenomena and a palpable willingness to engage in initiatives aimed at augmenting their livelihood prospects.

The insights gleaned from the interview sessions elucidate the manifold challenges faced by farmers operating within the ambit of the SLF. These challenges manifest in the form of unpredictable rainfall patterns, escalating pest and weed pressures, and the gradual depletion of soil nutrient content. Financial constraints further compound the predicament, limiting access to crucial resources and impeding capital investments. Traditional agricultural practices remain deeply ingrained, and the crops in cultivation hold significant cultural significance for local communities. The farmers' constrained access to requisite machinery and tools further compounds their difficulties, with the transition to agroforestry necessitating considerations for power spraying and pruning equipment. Despite an acknowledged knowledge deficit pertaining to tree maintenance, the farmers evince a fervent eagerness to assimilate novel agricultural methodologies.

Deliberations with experts from the MOFA and the EPA underscored the strategic importance of framing the proposed system as a remedial avenue addressing the immediate challenges faced by farmers. The judicious selection of tree species for the agroforestry framework emerges as a crucial determinant, favouring species that offer supplementary harvests to farmers, exemplified by mangoes, cashews, or moringa. Although initial hesitancy is apparent, the incorporation of trees amid existing crops garners favour, contingent upon meticulous attention to ensure the unimpeded access of incumbent crops to sufficient sunlight. This necessitates the integration of prudent pruning practices, bolstered by the provision of pruning tools to participants in the third year, thus constituting an incentivising mechanism for sustaining long-term involvement.

In the context of the farmers' predilection for observational learning, strategies aimed at their engagement warrant an approach characterised by the pragmatic demonstration of the system's operational dynamics. Facilitating the showcasing of optimal practices through live demonstrations on designated farmland parcels or orchestrated visits to pilot study sites holds promise in effecting substantial impact. Pertaining to instructional methodologies, the proposition of conducting training sessions directly on farmers' own fields, wherein trainers deliver guidance at the point of implementation, emerges as a compelling and effective approach.

Key Recommendations

Farmers in the Ashanti region confront various challenges that the proposed agroforestry system aims to address. Insights from interviews with MOFA and the EPA underscore the importance for the coordinating party to effectively communicate how the agroforestry system can alleviate these challenges for farmers, all while avoiding overemphasis on potential benefits, to garner maximum farmer willingness to participate. Given that farmers learn best through practical experience, establishing a pilot study can significantly enhance efforts to persuade farmers to join the system.

The design of the system should prioritise the cultivation of fruit-bearing trees intercropped within farmers' existing crops. This approach not only maximises farmer willingness to participate but also leverages the ecosystem services provided by the agroforestry system. Furthermore, the coordinating party should supply farmers with saplings, training, and necessary tools, recognising that many farmers lack the financial resources to procure these items independently. Table 6.3 outlines the actions to be executed, along with their respective actors.

Table 6.3: Key Recommendations Socio-Technical System

Actor	Action
Coordinating party	Communicate how the agroforestry system can alleviate challenges for farmers
Coordinating party	Establishing a pilot study and invite farmers to see the effect of agroforestry
Coordinating party	Select an appropriate tree species that yields additional fruit harvest and formulate an intercropping system
Coordinating & financial parties	Distribute saplings and necessary tools to the farmers
Coordinating party	Develop training sessions customised for farmers within their own farming communities

7

Conclusion

This chapter addresses the primary research question concerning the role of carbon credits as incentives for agroforestry. It consolidates the findings from the preceding chapters to elucidate the role of carbon credits within the various subsystems and, consequently, within the overarching system. Additionally, it evaluates the overall feasibility of the system, considering the challenges identified in the institutional aspect that could impact feasibility. Finally, it delves into the connection between the research and its relevance to the Master's degree program.

7.1. Revisiting the Main Question

How can carbon credits be implemented as a mechanism for promoting agroforestry in smallholder farming communities in the Ashanti region?

The central inquiry of this research focuses on the implementation of carbon credits as a mechanism for promoting agroforestry among smallholder farming communities in the Ashanti region. Chapter 3 offers key insights into the role of carbon credits within the system, where they facilitate its development by offering potential monetary returns to coordinating and financial parties while also serving as a potential incentive for farmer participation.

Establishing a carbon credit project within the Ashanti region involves navigating a complex process, as outlined in Chapter 3. Similar projects, such as Soubre, 2022 and VI-Agroforestry, 2019, allocate a portion of the monetary returns from carbon credits to the coordinating and financial parties involved in system setup, emphasising the pivotal role of carbon credits in the system's financial viability. Additionally, the prospective implementation of the agroforestry system holds significant societal relevance on both global and local scales, as highlighted in Chapter 1. Chapter 5 underscores the potential benefits of the system for Ashanti region farmers who lack the financial resources and knowledge to initiate agroforestry independently. Thus, carbon credits and parties involved with these credits play a crucial role in improving farmers' livelihoods through agroforestry, despite Chapter 5 indicating that carbon credit payments are not the primary incentive for farmer participation. Moveover, the state of land tenure security for smallholder farmers in the Ashanti region underscores the importance of carbon credits. The involvement of coordinating and financial parties through carbon credits can provide farmers with much-needed support in securing land tenure documents, significantly enhancing their prospects and livelihoods.

In summary, while carbon credits may not be the primary motivator for farmer participation in the agroforestry system, their presence ensures the involvement of parties capable of supporting farmers by introducing agroforestry with its benefits and by enhancing their land tenure security.

7.2. Feasibility of the System

Closely intertwined with the central inquiry is the examination of the system's feasibility. While the answer appears to lean towards a potential feasibility, it is important to note that the existing institutional framework poses significant challenges and may hinder a straightforward adoption of the system in the near future. The insights gleaned from literature, expert interviews, and particularly the perspectives of potential farmers emphasise a notable point: farmers exhibit risk aversion and are reluctant to engage in a system that could demand substantial efforts with uncertain outcomes. Despite their overall enthusiasm for embracing novel systems and embracing new agricultural practices, the unresolved issue of land tenure undermines the system's potential effectiveness.

This study underscores the significance of addressing customary authorities before reaching out to individual farmers, as emphasised in the 'key recommendations' section. A historical perspective highlights that the land tenure insecurity faced by farmers is not a recent phenomenon, but rather a persistent challenge. The customary system, despite being acknowledged and discussed over the years, appears to maintain a rigidity when it comes to the concept of land tenure. Significant alterations within the existing land tenure system are imperative for the successful operation of the proposed system. However, given its historical continuity, effecting substantial changes within the institutional framework for the seamless implementation of the system could prove to be a challenging endeavour. Beyond the institutional framework, the agroforestry methods appear to hold the potential to considerably enhance the livelihoods of the prospective participating farmers.

In broader context, the primary objective of this research centres on exploring the feasibility of enhancing the livelihoods of smallholder farmers within the Ashanti region. The study maintains a farmer-focused approach, ensuring that any proposed system doesn't inadvertently sideline their interests in favour of other stakeholders. While some farmers, particularly those who cultivate their own land, might find it comparatively easier to adopt the system, the core aim remains the same: to craft a solution that

uplifts the livelihoods of all farmers, as outlined in Chapter 4.

As previously discussed, reallocating the financial compensation from carbon credits might enhance the traditional authorities' inclination to allow farmers' participation in the system on their farmlands. However, a pertinent question arises: does the system's objective encompass providing financial gains to already influential figures within the Ashanti system? This scenario involves adapting to the existing dynamics within that context, and if this approach is the sole feasible strategy, it might warrant consideration.

7.3. Relation to MSc CoSEM

This research marks the end of the Master's degree in Complex Systems Engineering and Management, necessitating the application of skills acquired throughout the courses. At its core, the proposed agroforestry system embodies a complex system, characterised by a multitude of stakeholders and interconnections. This research operates within a socio-technical framework, addressing both the technical aspects of the carbon credit and agroforestry systems, as well as the intricate social dimensions encompassing farmers' livelihoods, cultural considerations, and institutional challenges. The coursework in law, offered as part of the Master's degree, has been instrumental in comprehending the intricacies of the land tenure system in the Ashanti region. Moreover, courses emphasising systems thinking and analytical methods from the program have proven invaluable in dissecting the complex interplay of various systems and stakeholders influencing potential outcomes. Additionally, while the research primarily focuses on the carbon credit market, it also intersects with the energy domain, aligning with coursework related to energy systems within the degree program. This knowledge about carbon credits may hold significance for the future of energy-related endeavours.

8

Discussion

This discussion section critically examines the research methodology, focusing on how the research was conducted in Ghana, the relevance of the responses obtained, and the availability of participants. Additionally, it explores the perception of the carbon credit market, addressing topics such as green-washing and the potential for the system to inadvertently perpetuate neocolonialism.

8.1. Position of Researcher in Ghana

Conducting research in Ghana has illuminated the distinct role that a European researcher assumes in shaping research outcomes. Cultural disparities and divergent viewpoints between the researcher and study participants underscore the complexity of this dynamic. Notably, what may seem apparent from a European perspective might be unfamiliar to research participants, and vice versa. These variations highlight the challenge of comprehending the nuances of the Ghanaian context from a European vantage point, particularly in matters involving traditional authority, hierarchy, and power dynamics that differ between the two regions.

Throughout this research endeavour, a recurring theme emerged: Ghanaians often hold foreigners in high regard. This phenomenon, while beneficial for facilitating communication and participant engagement, also presents certain challenges. The willingness of participants to share their insights enthusiastically facilitated the research process. However, it also surfaced a potential issue—when participants lacked familiarity with certain subjects, they might provide affirmative responses to questions to maintain positive interactions. Subsequent discussions revealed that in some cases, the questions were not fully understood, underscoring the need for careful consideration of communication strategies. Particularly in the Q-method interviews, farmers encountered challenges in comprehending how to assess the benefits of the system. They perceived all the benefits as significant, making it intricate to elucidate the functioning of the ranking system. While responses were eventually provided, uncertainties surround their validity. Consequently, the research has provided a concise discussion of the results, with limited incorporation of the outcomes in formulating system recommendations.

In essence, the role of a European researcher in Ghana brings to light a complex interplay of cultural disparities and perceptions that influence the research process. The researcher's position as both an outsider and a source of expertise can shape participants' responses and interactions. Striking a balance between leveraging the advantages of cross-cultural collaboration and mitigating potential biases is essential for conducting comprehensive and credible research that captures the authentic insights of Ghanaian participants.

8.2. Relevance of Farmer's Responses

As mentioned earlier, there are various factors that warrant a closer examination of the relevance of participant responses within the system for scientific research. When reflecting on the importance of the interviews carried out in Ghana, two primary considerations stand out.

8.2.1. Downside of Working with a Translator

To begin with, during the interviews conducted with potential farmers, a translator was utilised due to their inability to communicate in English. The translator translated the research questions from English to the local language Twi, and subsequently translated the farmers' responses back into English. This translation process introduced the possibility of losing valuable information during the interviews. The conversion between languages could lead to the omission of specific details within the questions and the potential loss of complete answers. At times, it was evident that farmers provided comprehensive responses, consisting of multiple sentences, whereas the translator summarised their input in a concise manner, likely resulting in the loss of substantial information. Furthermore, some farmers possessed a limited understanding of English, rendering the interviews more challenging and prone to misunderstandings. Conversely, interviews with experts were conducted in English and proceeded more smoothly for this reason. The fact that Ghana is an English-speaking country facilitated the research process.

Alongside working with a translator, challenges arose due to participants holding diverse interpretations of certain concepts. This was particularly pronounced in discussions concerning the institutional aspect, which is less directly connected to the skills acquired in the Master CoSEM program. The term 'chief', for instance, exhibited varying usages across participants in the study, including experts. Similarly, 'landowner' and 'contract' were employed by study participants to convey different meanings on each occasion.

8.3. Availability of People within the Research

For a European researcher, establishing connections with relevant individuals to participate in the study can be quite challenging. In this particular instance, Farmerline proved instrumental in facilitating contact with governmental entities and farmers who could contribute to the research. Given the limited time frame available for conducting the study, partnering with Farmerline was crucial in streamlining this process. However, there were stakeholders outside of Farmerline's direct network, such as (local) chiefs, who could have provided valuable insights to the research but remained inaccessible. With a more extended research timeline, incorporating the perspectives of traditional authorities like chiefs would be advantageous.

8.4. Perception of the Carbon Credit Market

While the carbon credit market holds the promise of augmenting the livelihoods of smallholder farmers in the Ashanti region and presenting a strategy to mitigate carbon emissions, it is not immune to criticism. Two primary concerns emerge from critiques of the system. Firstly, there's apprehension that the system could be viewed as a form of greenwashing, potentially lacking substantive impact. Secondly, there are reservations that the system might inadvertently bear resemblances to neocolonialism, raising questions about power dynamics and influence.

8.4.1. Greenwashing

Amid the discourse surrounding carbon offset programs, concerns arise regarding the phenomenon of greenwashing – a practice in which companies project an environmentally responsible image while not genuinely addressing their carbon emissions. Carbon offset programs, while capable of reducing emissions or increasing carbon storage, may fall short in effectively tackling primary sources of carbon emissions, such as fossil fuel usage. Critiques from prominent international non-governmental organisations, including Friends of the Earth, Greenpeace, and World Wildlife Fund-UK, have underscored these shortcomings, contending that such projects can inadvertently perpetuate a culture of climate pollution, as discussed by Raji, 2023.

An added dimension of concern emerges when examining carbon offset projects that rely on land use practices in developing nations. This dynamic potentially transfers the responsibility of emissions reduction from wealthier countries to regions already grappling with the adverse impacts of the climate crisis. A case in point is the adoption of large-scale tree plantations, which can exacerbate soil degradation and introduce bio security risks, thus undermining the intended environmental benefits. Underpinning the concept of greenwashing in carbon offset initiatives are several factors:

1. Neglecting In-House Emissions Reduction: Greenwashing occurs when companies prioritise carbon offset programs over the reduction of in-house emissions. This renders the authenticity of their offset initiatives questionable, as they may merely offset a fraction of their overall emissions. Moreover, temporary carbon offset projects can lose their efficacy if the sequestered greenhouse gases are eventually released back into the atmosphere.
2. Double-Counting Carbon Credits: Greenwashing takes shape when a company's emissions reductions are double-counted – once by the company itself and again by the host country reporting its climate targets. This practice distorts the actual emissions reductions achieved and contributes to a misleading perception of progress.
3. Lack of Additionality: Another facet of greenwashing arises when companies invest in projects that generate carbon credits from activities that would have occurred regardless of their involvement. In such cases, the offset projects lack genuine "additionality" – the true contribution to lowering emissions. Notable instances include carbon credits obtained for conserving forests that were never at risk of deforestation, which were then purchased by companies like Shell and Phillips 66 as part of their offset programs.

8.4.2. Neocolonialism

Within the sphere of carbon offset projects, there's a growing apprehension that these endeavors, while designed to curb carbon emissions, might inadvertently embody a contemporary version of neocolonialism. Neocolonialism involves leveraging economic, global, and cultural influences, along with condi-

tional aid, to exert control over other nations. A notable perspective advanced in Taiwo, 2019 posits that affluent countries can wield dominance over less powerful countries through initiatives that ostensibly address climate change, giving rise to a phenomenon labelled as climate colonialism. In this context, economically advanced nations invest in the Global South and dictate land and forest management, sometimes sidelining local knowledge that spans generations.

The repercussions of this dynamic can be significant, leading to instances where the interests of powerful entities collide with the traditional land-use practices of indigenous communities. Such discord may result in displacement, conflicts, and even violence. A case in point occurred in 2014, involving the Kenya Forest Service, which, backed by the World Bank, employed aggressive tactics, including violence and arrests, to acquire land for carbon offset forestry, impacting the Sengwer community. Similarly, a 2016 United Nations session witnessed an Indigenous leader accusing developed nations of commercialising their sacred lands and forests. (Wang, 2021)

The geographical distribution of carbon offset projects exacerbates these concerns. A significant number of these projects are concentrated in the Global South, such as Ghana, while the primary beneficiaries tend to be in the Global North. This skewed allocation raises questions about whether affluent nations are using carbon offset as a means of environmental absolution, while sidestepping significant changes to their consumption and production patterns. This essentially shifts the burden of emissions reduction onto developing nations, which already bear the brunt of climate change impacts. While discarding carbon offsets entirely may not be the solution, stringent regulation is crucial. Existing not certified schemes within the carbon market underscore the need for robust oversight. Governments, non-governmental organisations, and industry associations must take on a central role in monitoring and verifying offset programs.

8.5. Research Limitations & Recommendations for Future Research

Owing to the relatively constrained time frame of the study, certain factors influencing the viability and effectiveness of the proposed system remained unexplored. Notably, the research was unable to encompass all pertinent variables. Primarily, traditional authorities, including chiefs and landowners, were notably absent from the scope of this investigation. These stakeholders exert considerable influence on land tenure agreements, a pivotal aspect of this study. In-depth inquiry involving these traditional entities could introduce a distinct perspective and validate the insights offered by the experts interviewed.

Furthermore, the intricacies of the carbon credit market were not exhaustively addressed. During the formulation of the comprehensive agroforestry system, the investigation of payment intervals and methods could emerge as a significant phase, potentially enhancing farmers' inclination to participate and make enduring commitments. Delving deeper into the allocation of payments and benefits among stakeholders could also yield valuable insights. Assigning a portion of benefits to landowners or traditional entities might prove instrumental in swiftly establishing a functional system.

Additionally, due to time constraints and limited local contacts, the discourse on tree tenure was largely confined to the perspective of farmers. Ghana's Forestry Commission, operating at a national level, could wield a noteworthy influence in shaping the agroforestry system. While the experts in the study unanimously acknowledged the complexity of land tenure, prompting the research's focus on the institutional facet of the study, the exploration of land tenure was intentionally prioritised given the available resources.

In sum, the abbreviated time frame of the research hindered a comprehensive analysis of certain critical elements. Acknowledging the absence of traditional authorities, a more comprehensive assessment of the carbon credit market, and the scope limitations concerning tree tenure, these unexplored dimensions underscore the potential avenues for further research and enhancement of the proposed agroforestry system in the Ashanti region.

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A

Literature reviews

A.1. Literature Review - Finding the Academic Knowledge Gap

The following search terms were used in the literature review, the number of found articles in indicated in the table below. For agroforestry in Ghana, only peer reviewed articles were taken into account, from the last 20 years. For the search term ”ti:(Agroforestry Ghana)”, two sources have been excluded as there was little to no link to agroforestry. For the search term ”Livelihood analyses & ti:(farmers Ghana)” 7 sources have been excluded, as they were not scientific papers.

Agroforestry	ti:(Agroforestry Ghana)	n=24, 2 duplicates
Carbon credit market	ti:(”Carbon market” Ghana) ti:(”Carbon credits” Ghana)	n=2 n=2
Livelihood analyses	ti:(farmers Ghana) livelihood	n=35, 15 duplicates
Land tenure insecurities	ti:(Ghana land tenure) kw:(farm)	n=9, 2 duplicates

Table A.1: Search Terms and Articles Found, Literature Review

Agroforestry in Ghana	**Livelihood of farmers**	**Land tenure systems**
Yamoah et al., 2021	Asravor, 2018	Antwi-Agyei, Dougill, and Stringer, 2015
Asase et al., 2010	Bannor et al., 2022	Aha et al., 2017
Owusu et al., 2022	Ragsdale et al., 2022	Kidido et al., 2017
Baziari et al., 2019	Fadairo et al., 2020	Moses Kansanga et al., 2018
Akoto, Denich, et al., 2018	Amikuzuno, 2018	Nara et al., 2021
Nunoo et al., 2017	Asante, Guodaar, et al., 2021	Asaaga et al., 2020
Akoto, S. T. Partey, et al., 2020	Darkey et al., 2014	Akugre et al., 2021
Ashiagbor et al., 2020	Aniah et al., 2019	Addaney et al., 2022
Asigbaase et al., 2021	Bukari, 2013	
Asare et al., 2014	Ameleke et al., 2008	
Kongor, De Steur, et al., 2018	Azumah et al., 2022	
Kongor, Boeckx, et al., 2019	Yamba et al., 2017	
Akesse-Ransford et al., 2021	Mumuni et al., 2016	
Kaba et al., 2021		
E. Acheampong et al., 2016		
Anim-Kwapong et al., 2009		
Appiah, 2012		
Anglaaere et al., 2011		
Dawoe et al., 2014		
Obiri et al., 2007		

Table A.2: Considered Articles in the Literature Review

A.2. Literature Review - The Sustainable Livelihood Framework

The Sustainable Livelihood Framework (SLF) has been developed by the Department for International Development of the British government and was adopted to compare before-after livelihood conditions (DfID, 1999), and is often embedded in programs related to poverty alleviation (Dube et al., 2022; Ota et al., 2020). The SLF serves as a comprehensive framework for evaluating the livelihood conditions of individuals, emphasising their central role in the process of development. Within the SLF framework, the primary focus lies on assessing various assets possessed by individuals, which include human capital, physical capital, natural capital, social capital, and financial capital, all crucial factors influencing livelihood outcomes. Given the centrality of farmers in this research and their transition to agroforestry as a process of development, the selection of the SLF is appropriate for the purpose of evaluating the present condition of farmers, their will to engage in the proposed system, and their commitment to the system over the long term.

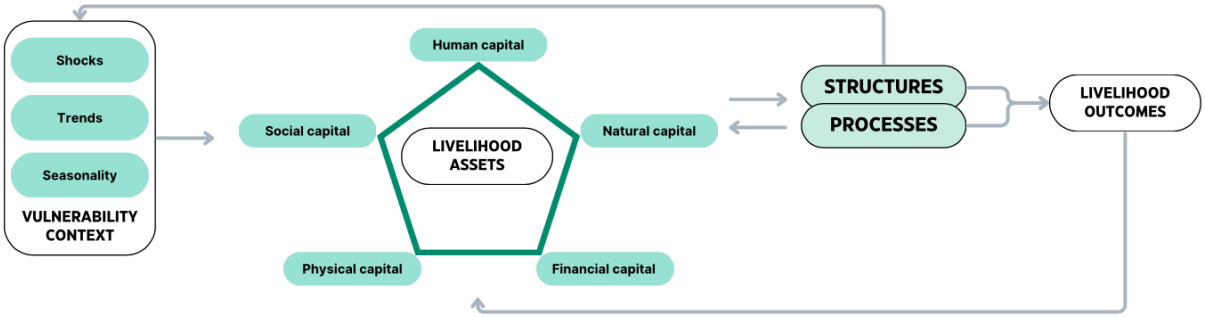

Figure A.1: The Sustainable Livelihood Framework, Figure from UK DfID DfID, 1999

In reviewing the literature, it is evident that the SLF has been utilised in various studies examining agroforestry systems, with a total of seven sources identified. Additionally, three sources have applied the SLF in analysing carbon credits, highlighting its relevance in this context. Moreover, the SLF has been employed in 24 instances to analyse Ghanaian communities, indicating its widespread application within this geographical context. A brief overview of selected articles can provide valuable insights into the potential applications of the SLF.

Search terms	Number of sources
”sustainable livelihood framework” & agroforestry	n=7
”sustainable livelihood framework” & carbon credits	n=3
”sustainable livelihood framework” & Ghana	n=24

Table A.3: Search Terms on Worldcat, Topic: SLF

The SLF has been employed in several studies to analyse the effects of agroforestry systems and related interventions on livelihoods. For example, Hanif et al., 2018 conducted a comprehensive analysis using the SLF, focusing on the five main assets outlined in the framework. The study assessed the improvement of human capital through the examination of farmers’ knowledge, management capacity, and overall farming skills. In terms of social capital, the article investigated conflicts with neighbouring farmers, participation in social organisations such as NGOs, and relationships with other communities. The assessment of physical capital encompassed forest productivity, household infrastructure, and fuel wood production. Changes in soil conditions and agricultural productivity were categorised under natural capital. Furthermore, the study considered financial capital by examining income derived from farmlands and the socioeconomic status of the farmers. Another notable example of SLF application is evident in the work of Dube et al., 2022, who analysed the impact of forest carbon projects on livelihoods. Additionally, Ken et al., 2020 conducted a study on the livelihood effects of deforestation projects, while Lambini et al., 2014 examined the influence of institutional property rights on forest livelihoods. These studies illustrate the versatility and applicability of the SLF in assessing the multifaceted dimensions of

livelihoods within various contexts. The insights derived from these papers serve as a guiding framework for this study, delineating the utilisation of livelihood assets within the context of such a system.

A.3. Literature Review - Agroforestry Tree Selection

Nitrogen-fixing trees play a pivotal role in the conversion of atmospheric nitrogen into a usable form by other plants, facilitated through a symbiotic association with root-nodule-dwelling bacteria (Johnson et al., 2001).This process entails the conversion of nitrogen into ammonia, which subsequently aids the tree's growth. The presence of nitrogen-fixing trees can have substantial effects on the soil ecosystem. Noteworthy nitrogen-fixing tree species prevalent in Ghana are **Acacia**, **Gliricidia** and **Leucaena** (Vidhana Arachchi et al., 1997).
Fodder trees, grown specifically for their leaves, twigs, and bark, serve as sources of animal feed. These trees offer valuable nutrients for livestock while concurrently improving soil quality and mitigating erosion, as mentioned by Simbaya et al., 2020. **Acacia** (Degen et al., 1995), **Gliricidia** (Elevitch et al., 2006), and **Leucaena** (Simbaya et al., 2020) are fodder tree species found in Ghana.
Fruit trees play a significant role in agroforestry systems by increasing crop productivity and contributing to biodiversity conservation. They offer a valuable food source and income stream while simultaneously improving soil health and mitigating erosion. Fruit trees are typically arranged in rows or blocks, with saplings being the preferred planting material due to their higher survival rates. In the context of agroforestry systems in Ghana, potential fruit tree species include **Mango**, **Cashew**, **Moringa**, and **Orange** (Elechi et al., 2022). These species are promising for integrating fruit production within agroforestry systems to promote sustainable agricultural practices.
Shade trees offer the benefit of providing shade to crops cultivated on farmlands, thereby improving the microclimate and promoting biodiversity. These trees can be strategically planted in rows to protect the crops from sunlight. In addition to their shading function, shade trees contribute to soil enrichment and erosion control. Shade trees are an integral part of cacao farms in the Ashanti region in Ghana (Graefe et al., 2017). Promising shade tree species suitable for agroforestry systems in Ghana include **Ficus** and **Orange** (Kyereh, 2017), and **Gliricidia** (Köhler et al., 2009). By incorporating these shade trees into agroforestry practices, farmers can optimise growing conditions, conserve soil resources, and foster a diverse ecological environment.

Table A.4: Potential tree types for the agroforestry system

A.4. Literature Review - Agroforestry Methods

Alley cropping is a distinct agroforestry technique characterised by the deliberate planting of rows of trees or shrubs within rows of agricultural crops (Beetz, 2011). The placement of tree rows at adequate intervals allows for mechanical operations and adequate exposure to sunlight. This practice imparts various advantages to the agricultural system. The trees serve as a source of shade, windbreaks, and microclimate regulation, thereby enhancing the growth and productivity of the crops. Additionally, they contribute to soil enrichment by facilitating nutrient cycling, preventing erosion, and augmenting organic matter content. Furthermore, the trees can be managed for the production of timber, fruits, nuts, or other valuable commodities, thereby generating supplementary income streams for farmers.
Silvopasture entails the integration of trees or woody plants within livestock grazing systems (Mosquera-Losada, 2018). This approach combines the advantages of trees, forage crops, and livestock in a mutually beneficial arrangement. Silvopasture systems vary in complexity, ranging from trees offering shade to grazing animals to more complex systems where trees are intentionally planted in a managed pattern alongside forage crops. The trees fulfil multiple functions, including providing shade, shelter, and fodder for the animals, while their root systems contribute to soil vitality and erosion prevention. Silvopasture systems have the potential to enhance livestock productivity, facilitate carbon sequestration, and offer economic diversification opportunities for farmers.
Windbreaks, also known as shelterbelts, involves the strategic planting of trees and shrubs to reduce wind speeds and minimise the impacts of wind erosion on agricultural crops (Beetz, 2011). Windbreaks act as physical barriers, reducing wind velocity and creating sheltered microclimates protecting crops from the wind. In addition to mitigating wind erosion, windbreaks play a crucial role in retaining soil moisture and preventing soil erosion. Moreover, windbreaks serve as habitats for beneficial insects, birds, and other wildlife, thereby contributing to the preservation of biodiversity.
Riparian buffer strips, as a form of agroforestry practice, encompass the deliberate planting of trees and shrubs along the edges of rivers, streams, and other water bodies (Beetz, 2011). These strips serve as protective buffers between agricultural areas and the adjacent riverbeds, yielding various advantageous outcomes. They play a crucial role in filtering sediments, nutrients, and pollutants from surface runoff, thereby enhancing water quality. Riparian buffer strips also provide valuable contributions to flood regulation, soil erosion prevention, and wildlife habitat provision. Additionally, they enhance the visual appeal of landscapes and offer opportunities for the sustainable extraction of non-timber forest products.
Forest farming is an agroforestry practice that involves the intentional cultivation of non-timber forest products, such as herbs, mushrooms, fruits, nuts, and ornamental plants, within the forest ecosystem (Mosquera-Losada, 2018). Forest farming aims to mimic natural forest conditions while managing the forest for specific products. It combines sustainable forest management principles with agricultural practices, providing economic opportunities while promoting forest conservation. Forest farming can be practised in various types of forests, including both natural and plantation forests, and contributes to biodiversity conservation and the preservation of traditional knowledge related to forest products.

Table A.5: Methods of agroforestry

B

Research flow diagram

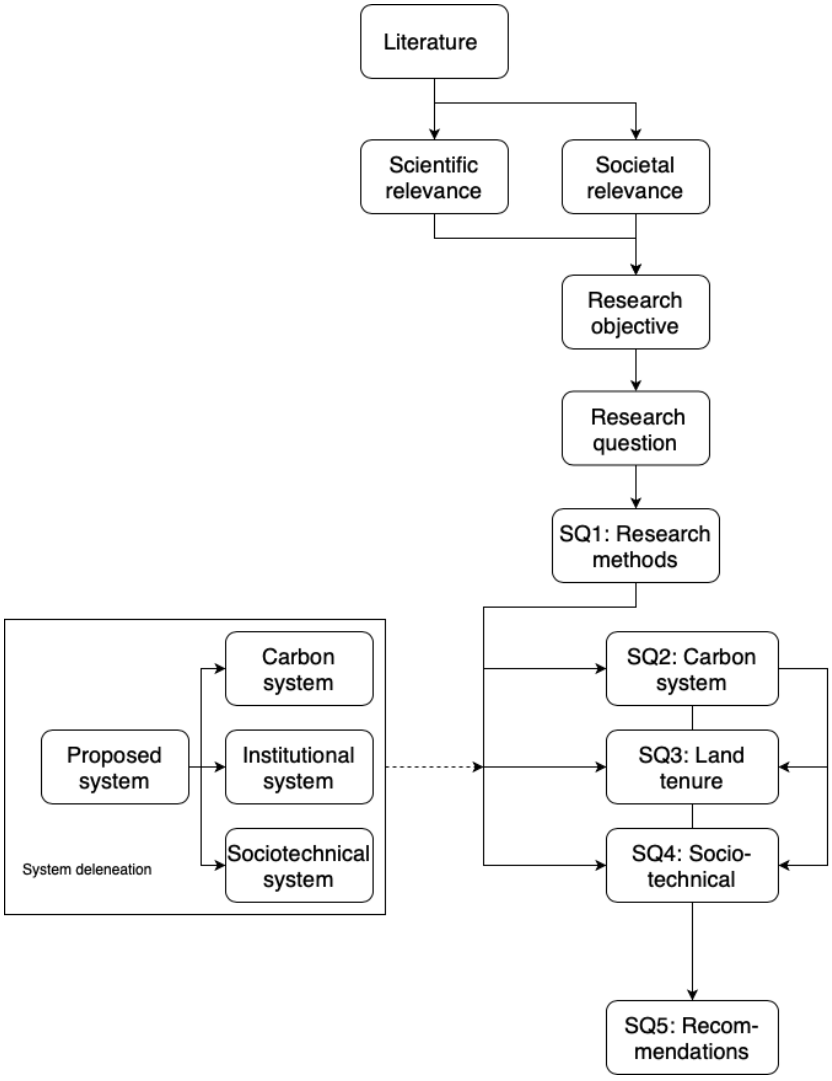

Figure B.1: Simplified representation of the research flow

C

Interview guides

Preparation: Interview topics MOFA

1. **Land Tenure Security and Regulations:**
    - Discussion on existing regulations ensuring secure land tenure for farmers over extended periods.
    - Exploration of the utilisation of these regulations in comparable projects.
2. **Land Tenure in REDD+ and Other Projects:**
    - Examination of land tenure and ownership processes within the REDD+ program, government initiatives, and private projects.
    - Insights into the timeline for farmer participation in these projects.
    - Evaluation of community satisfaction with the design of these systems.
    - Analysis of interactions between traditional authorities (chiefs) and farmers within these contexts.
        - Chiefs' attitudes towards these interventions.
    - Identification of documents employed to validate farmers' land ownership during rental periods.
    - Inquiry into the existence of frameworks for proving farmers' land ownership recognised by Ghanaian authorities.
3. **Current and Future Carbon Credit Projects:**
    - Awareness of ongoing or forthcoming carbon credit projects in Ghana.
    - Status assessment of these projects in terms of their development stages.
    - Geographical areas where these projects are being implemented.
    - Distinction between government-involved carbon credit initiatives and those driven by private institutions.
4. **Duration of Farmer Contracts:**
    - Examination of the duration of contracts signed by participating farmers in relevant projects.

Preparation: Interview topics EPA

1. **Current and Future Carbon Credit Projects in Ghana:**
    - Discussion of ongoing or forthcoming carbon credit projects in Ghana.
    - Assessment of the developmental stages of these projects.
    - Identification of geographical areas where these projects are being implemented.
2. **Land Tenure and Ownership in REDD+, Government, and Private Projects:**
    - Examination of processes for validating land tenure and ownership in REDD+, government, and private carbon credit projects.

- Inquiry into documents utilised for proving farmers' land ownership during rental periods.
- Exploration of available methods or frameworks for proving land ownership of farmers recognised by Ghanaian authorities.

3. **Incentives for Farmer Participation in Agroforestry and Carbon Credit Projects:**
   - Analysis of incentives provided to farmers to encourage their participation in agroforestry and carbon credit projects.
4. **Community Land Use Plans for Future Projects:**
   - Examination of strategies for determining community land use plans for future projects, particularly in the context of agroforestry and carbon credits.
5. **Carbon Credit Payments for Agroforestry in Ghana:**
   - Inquiry into whether Ghana has received carbon credit payments for agroforestry.
   - Identification of the locations of farmers associated with these payments.
   - Clarification on whether the payments were for planting new trees or maintaining existing ones.
   - Analysis of the documentation used by farmers to validate land ownership for these payments.
6. **Environmental and Food Security Risks of Carbon Credit Projects:**
   - Exploration of potential risks to the environment and food security in specific types of carbon credit projects, such as agroforestry.
   - Examination of environmental benefits associated with specific agroforestry methods.
     - Identification of agroforestry methods with the most significant positive environmental impact.
   - Discussion of other potential risks linked to carbon credit projects.

Preparation: Interview topics Colandef

1. **Process of Engagement with Farmers and Chiefs:**
   - Explanation of the procedure for initiating contact with farmers and chiefs.
   - Description of the project timeline from the initial meeting to the document signing phase.
2. **Communication of Key Benefits and Incentives to Stakeholders:**
   - Discussion of the primary advantages emphasised when presenting the contract to stakeholders.
   - Identification of incentives used to ensure participation of both farmers and chiefs.
3. **Considerations in Final Contracts:**
   - Exploration of factors taken into account during the formulation of final contracts.
   - Inquiry into whether the contract specifies the exact farm location for the farmer.
4. **Longest Renting Period in Contracts:**
   - Discussion on the maximum duration of renting periods that can be included in the contract.
5. **Ghanaian Rules and Regulations Applicable to Contracts:**
   - Examination of official rules and regulations from Ghana that pertain to contracts.
   - Identification of specific regulations related to land tenure that can be enforced.
   - Exploration of documents or proofs of ownership that establish the farmer's land ownership during the specified period.

Category	Question and Description
	Farmer Perception:
1	Have you heard of agroforestry? If yes, elaborate:
2	Have you heard of carbon credits? If yes, elaborate:
	Farmer STS data:
3	What type of crops do you farm on your land? (Characteristics)
4	Are your crops of cultural importance to your family? (Social)
5	How would growing trees alongside your crops impact the culture in your community? (Social)
6	Have you grown tree crops on your land in the past? (Characteristics)
7	Are you still growing trees on your land? (Characteristics) If yes: What risks are involved with growing trees on your land? (System design)
8	Do you think you have the knowledge to grow trees on your land? (Human)
9	What is the size of your farmland? (Characteristics)
10	Would you prefer to intercrop trees or dedicate a separate piece of land? (Benefits) If separate field, what can be the size of this field? (Benefits)
11	What issues have you had on your farm in the last 5 years? (General SLF)
12	What agricultural tools and machinery are you currently using? (Physical)
13	How do you finance buying tools and machinery? (Financial)
14	How are you currently maintaining good soil quality? (Natural)
15	Have you thought about growing trees on your farmland? (Benefits) If yes, what trees did you consider? (Benefits) If yes, what were the drawbacks you anticipated? (Benefits) If yes, how many years did you think it would cost to grow these trees? (Benefits)
16	Have you bought any tree saplings in the past? If yes, how did you finance this? (Financial)
17	Do you have the tools to maintain trees? (Physical) If no, what tools are missing? (Physical) If no, when would you need these tools? (System design)
18	Have you had agricultural training in the past? (Human) If yes, what was the topic of this training? (Human) If yes, where and when did it take place? (System design)
19	What are key characteristics for tree selection in your situation? (System design)
20	Have you experienced illegal logging in the past? (Institutional) If yes, can you explain what happened? (Institutional)
	Farmer tenure data:
21	Who is the owner of the land you are farming on?
22	How are you paying the landowner?
23	Is there an official document on this agreement?
24	How long is the period you are renting this land for?
25	How easy is it for the landowner to stop you from farming in the future?
26	Who is the owner of the trees on the land you are farming on?
27	Have you experienced conflicts related to land ownership that could impact the proposed agroforestry system?

Table C.1: Farmer In-Depth Interview Questions and Corresponding Research Categories

D

Expert interview summaries

D.1. Interview: Ministry of Food and Agriculture

In Ghana, the land tenure system is complex as land belongs to families, clans, and chiefs, not the government. While farmers mostly acquire land on short-term contracts for annual crops, this poses challenges for long-term commitment and perennial crop farming. In some areas, farmers can get land permanently, while in others, families may grant land for extended periods. However, short-term contracts become problematic for activities requiring long-term commitment.

The land belongs to chiefs or customary authorities, making it challenging to regulate their property. The government can only regulate land owned by the government. There are institutions addressing land tenure issues, ensuring respect for family-owned land.

For long-term land acquisition, government parties assist farmers in setting up leasing agreements with landowners. These agreements specify land size, location, and purpose. The government facilitates and ensures compliance with the documents.

Two official documents play crucial roles in land ownership. The first document, the land agreement, is used in agroforestry projects related to the carbon credit market. It proves the farmer's ownership of the farmland. The second document is the deed of conveyance, used to prove lawful ownership. Farmers without the second document use the lease document, a simplified contract.

Currently, most lease contracts have indefinite periods, allowing farmers to conduct farming activities as long as they wish. However, if the land use changes, the contract becomes void, and the land reverts to the landowner. It covers activities like growing crops, trees, or tree crops.

The government initiates setting up contracts rather than farmers approaching the government. Land location is critical; urban expansion deters traditional landowners from signing contracts. The chief may offer an alternative location to ensure land availability and income security.

In the Ashanti region, all land belongs to the king, making it necessary to get the king's agreement, which can be challenging. District chiefs lack the authorisation to sign such contracts.

Ghana has several carbon credit projects, including Ghana Cacao REDD+ Project, carbon credits on rice, and cashew agroforestry projects. Current projects involve commodities such as cashew, mango, and moringa, combining tree crops with existing crops.

Farmers see the extra harvest from tree crops as an additional income stream, while carbon credits alone don't incentivise participation. Governments emphasise increased crop production as the main benefit, with carbon credits as an extra.

In agroforestry projects, trees are integrated into one block with food crops planted in between. Farmers observe the benefits of inter cropping agroforestry from other farmers, rather than expert explanations.

Demonstrations prove the benefits of pruning over cutting, encouraging farmers to adopt best practices. Joining the system involves verifying land ownership and setting up necessary contracts.

In the Ashanti region, some farmers have documents on land usage, but the process is viewed as tedious. Collaboration between private entities and the government drives current projects, with private parties initiating projects independently.

Note: Land tenure issues are the primary challenge in agroforestry systems.

D.2. Interview: Environmental Protection Agency

The Environmental Protection Agency (EPA) in Ghana is keen on exploring opportunities within the private sector due to the limited influence of the government in this domain. To facilitate this, the EPA has established the Carbon Market Office (CMO) and the Carbon Registry. The Carbon Registry serves as the body responsible for registering all carbon-related projects in Ghana, ensuring accurate tracking and recording of carbon assets to create a comprehensive database.

In the voluntary carbon market (VCM) space, the EPA's role is somewhat limited. However, the Carbon Market Office (CMO) has devised several ways to engage in carbon projects:

- Government-to-Government Bilateral Agreements: These agreements, governed by Article 6.2 requirements, set the rules for engagement.
- Government of Ghana to Private Sector Entities: In this scenario, private parties seek to create carbon assets within Ghana.
- Voluntary Carbon Market: The EPA actively participates in the voluntary carbon market.
- Transitioning Projects to New Article 6.4 Mechanism: The CMO focuses on transitioning projects to the new Article 6.4 mechanism.

Presently, Ghana has entered into bilateral agreements with several countries, including Switzerland, Sweden, South Korea, and Singapore. These agreements are at different stages of development, with the agreement with Switzerland being the most advanced. It was signed in 2020 and subsequently ratified by the parliament in 2021. Under this agreement, 14 projects are under development, with one noteworthy initiative being the rice project. This collaboration involves the Ministry of Agriculture, Ministry of Environmental Sciences & Technology, and the EPA, supported by a grant from the UNDP. The project's objective is to trade emission reductions with the government of Switzerland and spans across 22,000 hectares of rice farms in various regions of Ghana.

Apart from carbon removal, the rice project addresses water scarcity issues, benefiting farmers by reducing water usage and, consequently, production costs. To foster farmer participation, project organisers use a smart irrigation approach and engage farmers by demonstrating the benefits of the new farming methods on small plots of their farms.

While the focus on carbon credit projects is evident, the EPA also acknowledges the importance of strategic communication to manage farmers' expectations. It is vital not to oversell potential income from carbon credits, as this could lead to disillusionment if actual revenues fall short. Therefore, highlighting the additional benefits, such as protection against heat and crop preservation, is essential to garner farmer interest.

The EPA realises that the success of agroforestry projects depends on farmer involvement and has noted that farmers are more receptive to learning from each other rather than from experts. To mitigate risks, the EPA aims to assure farmers that their participation will not lead to losses and intends to provide adequate compensation for additional efforts. The issue of land tenure is another important

consideration, and the EPA collaborates with local chiefs and community leaders to establish beneficial arrangements before project registration.

Despite these challenges, the environmental benefits of agroforestry projects, such as emission reduction, improved air quality, and enhanced yields, are significant. Proper documentation, including agreements with landowners and the assignment of carbon rights, is vital to ensure smooth project implementation.

In summary, the EPA's exploration of carbon market opportunities in Ghana requires effective communication, risk management, and collaboration with relevant stakeholders. By focusing on environmental benefits, strategic communication, and engaging farmers in the decision-making process, the EPA aims to establish successful and sustainable carbon projects that benefit both the environment and the local communities.

Note: Carbon projects in the private sector present significant opportunities for environmental benefits and collaboration between the government and private entities is essential for successful implementation.

D.3. Interview: COLANDEF

Colandef, an organisation experienced in working with communities at both the local and national levels, has been actively involved in the Customary Land Rights Documentation Project since 2018. This project aims to enhance land rights documentation in Ghana, where both state and customary arrangements coexist. While the constitution recognises customary law, its influence on land rights for customary communities often lacks proper documentation. This text explores the complexities of land tenure in Ghana, highlights the importance of considering women's rights in land decision-making, and delves into Colandef's efforts to create a more inclusive land governance system.

Understanding Customary Land Rights and Usufruct Interest:
In Ghana, customary land constitutes 80% of all land, with the remaining 20% designated as state land. Customary law plays a significant role in influencing land rights for communities following traditional customs. An essential aspect of customary land tenure is the usufruct interest, granted as a right to indigenes within a community. Usufruct interest allows individuals to utilise and benefit from the land without owning it outright. Though usufruct interest is often not formally documented, it remains legally recognised, providing a form of tenure security.

Distinguishing Between State and Customary Land:
The process of acquiring land rights depends on whether the land falls under state or customary authority. For state land, individuals seeking usufruct rights do not need to involve customary authorities. However, if the land falls under customary authority, dealing with the customary authorities is necessary. The constitution recognises customary law, which influences land rights for customary communities. While oral agreements are recognized under customary law, the Land Act now requires translating them into written documents to minimise disputes.

Importance of Documenting Land Ownership:
Land ownership in Ghana is fixed, and competition for land is increasing. While customary law and oral agreements are trusted, documenting land ownership becomes crucial for added security and clarity. Proper documentation helps prevent disputes and ensures land rights are adequately recognised and protected. Recognising the importance of documentation, Colandef provided technical support to customary authorities, enabling them to build a reliable land ownership system. This support involved documenting agreements and addressing complexities, such as multiple ownership schemes, which is common in customary land tenure.

Challenges and Misconceptions in Land Agreements:
The process of land documentation is not without challenges. One significant challenge lies in miscon-

ceptions among the involved parties. Oral agreements often remain undocumented due to misunderstandings about the implications of documentation. Some fear that signing a contract will permanently relinquish their land rights. To address these challenges, Colandef collaborated with traditional authorities to develop templates and allocate responsibilities for contracts. By clarifying the benefits of documentation, Colandef aimed to encourage more parties to participate in formalizing their land agreements.

Customary Land Tenure and Tree Crops:
The dynamics of land agreements change when tree crops enter the picture. In regions where tree crops dominate, agreements often involve longer terms. This is exemplified by Colandef's experience in the Ejisu traditional area with rice farmers. The agreements were initially annual but were later adjusted to an open term to accommodate the existing arrangement. Through transparent discussions with landowners and farmers, Colandef ensured that the agreements aligned with the needs of all parties involved.

Inclusivity and Women's Rights in Land Decision-making:
Women's rights and perspectives are often overlooked in traditional land decision-making processes. The male head of the household typically represents the family, leading to limited consideration of women's needs. However, when designing new land agreements, there is an opportunity to incorporate the wishes of women within the community more comprehensively. By acknowledging and incorporating women's requirements in the design of new land agreements, a more equitable and inclusive land tenure system can be achieved. Colandef recognizes the significance of promoting women's rights and participation in land matters.

Understanding Ghana's Diverse Traditional Areas:
Ghana's traditional areas have diverse governance structures and customs, based on their unique histories. It is essential to update records to ensure that land agreements align with the specific traditions and rules of each traditional area. Colandef maintains updated data on traditional areas, ensuring that they are well-informed and tailored to each region's needs.

Conclusion:
The Customary Land Rights Documentation Project in Ghana has provided valuable insights into the complexities of land tenure in the country. By strengthening land rights documentation and considering the needs of women in land decision-making, Colandef has made significant strides in creating a more inclusive and equitable land governance system. The organisation's efforts continue to have a positive impact on communities, empowering them to secure their land rights for future generations. Through partnerships with traditional authorities, transparency in land agreements, and a focus on women's rights, Colandef's work contributes to a more sustainable and just land tenure system in Ghana.

E

Data farmer interviews

Question	Farmer A	Farmer B	Farmer C
3	-	-	Maize, Beans
4	Yes	Yes	Yes
6	Yes	No	No
7	Yes	No	No
8	Yes	No	No
9	14	4	12
10	Dedicated field	Dedicated field	Dedicated field
13	Saved up	Saved up	Saved up
14	Crop rotation, green manuring	Specific plowing technique	Green manuring
15	No	Yes	Yes
16	No	No	No
17	No	No	No
18	No	Yes	Yes
19	Extra fruits, soil quality	Extra fruits, soil quality	Carbon payments, extra fruits
20	Yes	Yes	Yes
21	Chief	Chief	Chief
22	Cash	Cash	Cash
23	No	No	No
24	1	1	1
25	Really easy	Really easy	Really easy
26	Farmer	Landowner	Farmer

Table E.1: Farmer In-Depth Interview Answers (Farmers A, B and C)

Question	Farmer D	Farmer E	Farmer F
3	Maize, Beans	Maize, Beans, Rice	Maize, Beans
4	Yes	Yes	Yes
6	No	Yes	No
7	No	Yes	No
8	No	Yes	No
9	5	10	2
10	Dedicated field	Dedicated field	Dedicated field
13	Saved up	Saved up	Saved up
14	Green manuring	Crop rotation	Green manuring
15	Yes	Yes	Yes
17	No	No	No
18	No	No	No
19	Extra fruits, soil quality	Extra fruits, water quality	Soil quality, protection extreme weather
20	Yes	Yes	Yes
21	Chief	Chief	Chief
22	Cash	Cash	Cash
23	No	No	No
24	1	1	1
25	Really easy	Really easy	Really easy
26	Negotiation	Farmer	Unsure

Table E.2: Farmer In-Depth Interview Answers (Farmers D, E and F)

Question	Farmer G	Farmer H
3	Maize, Beans	Maize, Beans, Mango
4	Yes	Yes
6	No	Yes
7	No	Yes
8	No	Yes
9	6	2
10	Dedicated field	Intercropping
13	Saved up	Saved up
14	Crop rotation	Crop rotation, green manuring
15	Yes	Yes
17	No	No
18	Yes	No
19	Extra fruits, protection extreme weather	Extra fruits, protection extreme weather
20	No	Yes
21	Chief	Chief
22	Cash	Cash
23	No	No
24	1	1
25	Really easy	Really easy
26	Negotiation	Farmer

Table E.3: Farmer In-Depth Interview Answers (Farmers G and H)

-3	-2	-1	0	1	2	3
Sustainable resources	Climate change	Less deforestation	Improved pest control	Extra farming knowledge	Improved food security	Improved crop resilience
Carbon sequestration	Extra tools	Better water management	Better air quality	Improved soil	Income from tree crops	Income from carbon credits
		Biodiversity	Documented lease agreement	Diversified income	Income of fruit from tree crops	
			Strong community			

Table E.4: Ranked Benefits of the Agroforestry System - Q-Method Interview