ETH zürich

MASTER THESIS

DEVELOPING A MODEL TO ASSESS THE VIABILITY OF ACTION MEASURES TO ENHANCE RESILIENCE OF GHANAIAN COCOA FARMERS TO DROUGHT

A CASE STUDY IN THE DISTRICTS EJISU-JUABEN, OFFINSO SOUTH, SEFWI WIAWSO AND ELEMBELLE

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Assessing and Enhancing the Resilience of the
Tef and Cocoa value chains (AERTCvc)

PREFACE

The research of this master thesis is embedded in the research project 'Assessing and Enhancing the Resilience of the Tef and Cocoa value chains' (AERTCvc) in Ethiopia and Ghana. The AERTCvc project is a collaboration between the Kwame Nkrumah University of Science and Technology (KNUST), the Ethiopian Institute of Agricultural Research (EIAR) and ETH Zurich. As part of this project, a transdisciplinary platform with the key stakeholders of the value chains was established to promote co-learning, co-production and co-framing. A workshop with all the stakeholders involved in the cocoa value chain in Ghana was organized to identify possible interventions to enhance the resilience of the value chain. Two action plans were developed, one for the production group (input suppliers, farmers) and one for the post production group (traders, processors and retailers). This master thesis pursues the research of the AERTCvc project by focusing on the developed action plan to enhance the resilience of Ghanaian cocoa farmers to drought.

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Last but not least, many thanks to all cocoa farmers who were willing to participate in the survey and in the workshop. Without them this thesis would not have been possible.

ASSIGNMENT OF TASKS

Name of student		Braida Thom
Title		**Developing a model to assess the viability of action measures to enhance resilience of Ghanaian cocoa farmers to drought** A case study in the districts Ejisu-Juaben, Offinso South, Sefwi Wiawso and Elembelle
Objectives	- -	Design a model to assess the viability of action measures to enhance resilience of Ghanaian cocoa farmers to drought Demonstrate the applicability on a case study in Offinso South, Ejisu-Juaben, Sefwi Wiawso and Elembelle
Research question	-	What are the dimensions shaping the viability of action measures and how do Ghanaian cocoa farmers in different districts perceive these dimensions for AMs that are designed to enhance their resilience to drought?
Theoretical approach and methods	- - - -	Literature research to determine relevant dimensions and indicators for assessing the viability of action measures Selection of indicators and model development based on obtained information Designing a quantitative survey to test the model and assess the viability of action measures to enhance resilience of Ghanaian cocoa farmers to drought Contextualize the results and discuss cost-benefits of the action measures in focus groups during workshops
Expected results	- - - -	Literature review of the resilience concept and adaptation measures to climate change with focus on the viability of action measures A model to assess the viability of action measures to enhance resilience Model-based questionnaire to assess the viability of action measures to enhance resilience of Ghanaian cocoa farmers to drought Creating a better understanding for the dimensions shaping the viability of action measures
Supervisor **Co-supervisor**		Dr. Pius Krütli Dr. Jonas Joerin

DECLARATION OF ORIGINALITY

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A case study in the districts Ejisu-Juaben, Offinso South, Sefwi Wiawso and Elembelle

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Thom	Braida

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EXECUTIVE SUMMARY

Different shocks are affecting the cocoa value chain in Ghana and the actors of the value chain show different levels of resilience with cocoa producers having the lowest level of resilience. The cocoa production is highly affected by drought in terms of growth and yield and Ghanaian cocoa farmers perceive drought as the most devastating shock event happening on their farms. Therefore, this thesis aims to assess the viability of Action Measures (AMs) to enhance resilience of cocoa farmers to drought, by developing a general methodology on how to assess viability of AMs that covers three dimensions, namely: the asset-oriented 'feasibility' aspect, the psychological aspect of 'motivation' and the usefulness-oriented aspect of 'shock exposure, experience and perception'. The implementation of the AMs was used as a proxy to measure viability. Qualitative and quantitative methods were used to evaluate the viability of five AMs: 'irrigation technologies', 'shade trees', 'fire belts', 'keeping records on income and expenditures' and 'mulching'. The data collection took place between May and July 2018. A stratified random sampling technique was used within two regions to cover different Agroecological Zones (AEZs). The questionnaire-based survey was conducted with 307 farmers in four districts (Ejisu-Juaben, Offinso South, Sefwi Wiawso and Elembelle) and two workshops were conducted to share, validate and discuss the obtained data from the survey (Offinso South and Elembelle). The results show that the dimensions 'feasibility' and 'motivation' show some significance in explaining the implementation of AMs. However, no direct effect of 'drought exposure, experience and perception' on the implementation of AMs could be found in this thesis. Despite the differences in 'drought exposure, experience and perception', 'feasibility' and 'motivation' among the four districts, the AMs were not implemented significantly more in one district compared to another. These findings suggest that the implementation of AMs is more a function of the nature of the respective AM than a function of socio-economic and -demographic variables. The lowest implementation level was seen for 'irrigation technologies', followed by 'keeping records on income and expenditures'. 'Fire belts' and 'shade trees' were implemented with high frequencies and 'mulching' was implemented by all farmers. Hence, it can be assumed that the AM 'mulching' is the most viable AM, followed by 'shade trees' and 'fire belts'. 'Keeping records of income and expenditures' and 'irrigation technologies' are less viable and external support would probably be needed to overcome limits and barriers and increase 'feasibility' and 'motivation' of those AMs. The model was developed in such a way that it could be applied for different food systems, different stakeholders and different shocks. Further research would be needed to gain deeper understanding regarding the applicability of the model to other food systems, other stakeholders and other shocks.

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ABBREVIATIONS

AERTCvc	Assessing and Enhancing the Resilience of the Cocoa and Tef value chains
AEZ	Agroecological zone
AM	Action Measure
AM1	Action measure 1 ‘irrigation technologies’
AM2	Action measure 2 ‘shade trees’
AM3	Action measure 3 ‘fire belts’
AM4	Action measure 4 ‘keeping records on income and expenditures’
AM5	Action measure 5 ‘mulching’
BIB Design	Balanced Incomplete Block Design
CBA	Cost Benefit Analysis
CHED	Cocoa Health and Extension Division
COCOBOD	Ghana Cocoa Board
CRIG	Cocoa Research Institute of Ghana
EFA	Explorative Factor Analysis
EJ	Ejisu-Juaben
EL	Elembelle
FAO	Food and Agriculture Organization
GoG	Government of Ghana
IPCC	International Panel on Climate Change
KMO	Kaiser-Meyer-Olkin Test
K-W Test	Kruskal-Wallis H Test
M	Mean
OS	Offinso South
PCA	Principal Component Analysis
SD	Standard deviation
SW	Sefwi Wiawso
UNDP	United Nations Development Programme

VARIABLE DESCRIPTION

model dimension	variable name	variable label	variable description
farmer specific socio-economic and -demographic variables	age	age of farmer	continuous variable
	sex	gender of the farmer	nominal variable (female, male)
	edu	education of the farmer	nominal variable (none, basic education, secondary education, tertiary education, no answer)
	entit	entitlements	nominal variable (owning, renting, other (combination of owning and renting)
	hh_size	household size	continuous variable
	hh_inc	household income [Cedi/household/yr]	nominal variable (<6,500, 6,500-12,600, 12,601-18,700, 18,701-25,000, >25,000, no answer)
	f_size [ha]	total farm size	continuous variable
	area_cocoa [ha]	size of cocoa farm [ha]	continuous variable
	crop	land allocated to cocoa	nominal variable (0%-20%, 21%-40%, 41%-60%, 61%-80%, 81%-100%)
	cocoa_inc	share of household income from cocoa farm	nominal variable (0%-20%, 21%-40%, 41%-60%, 61%-80%, 81%-100%)
	n_farms	number of cocoa farms	continuous variable
	age_farm_mean	mean age of cocoa farms	continuous variable
farmer specific motivation	pr	pride	I'm proud of being a cocoa farmer
	per	satisfaction with farm	I'm satisfied with the performance of my farm
	adop	early adoption	I'm regularly trying out new things (farming practices) on my farm
farmer specific drought exposure, experience and perception	dd_15	damages of drought in 2015	the damages of drought were severe in 2015
	dd_16	damages of drought in 2016	the damages of drought were severe in 2016
	dd_17	damages of drought in 2017	the damages of drought were severe in 2017
	anc	drought management like ancestors	I manage drought in the same way as my ancestors
	help	helplessness	droughts make me feel helpless
	ext	interest in extension	I want to receive information form extension services about measures to minimize the adverse effects of drought
	dd_f	drought damages in future	I think the damages of drought will increase in the next ten years
	give	give up cocoa farming	If damages of drought increase, I will switch to other crops or give up farming
	d_se	severeness of shock	drought is the most devastating shock event happening on my farm

AM specific feasibility	f_i_1	money	I possess the money needed to optimally implement the AM_i
	f_i_2	time	I have the time needed to optimally implement the AM_i
	f_i_3	tools	I possess all tools needed to optimally implement the AM_i
	f_i_4	knowledge and information	I have all the knowledge and information required to optimally
	f_i_5	accessibility	I have access to all inputs and resources needed to optimally implement the AM_i
	f_i_6	governmental support	I receive support from the government to optimally implement the AM_i
	f_i_7	information from extension	I receive information from an extension officer about an optimal implementation of the AM_i
AM specific motivation	m_i_1	usefulness	I think an optimal implementation of the AM_i is useful to minimize the adverse effects of drought
	m_i_2	earning more money	I can earn more money if the AM_i is optimally implemented
	m_i_3	recommendation	I often recommend to other farmers to optimally implement the AM_i
	m_i_4	motivation	I'm motivated to optimally implement the AM_i
	m_i_5	satisfaction	to see an optimally implemented AM_i gives me satisfaction
	m_i_6	implementation on other farms	most cocoa farmers in my community have optimally implemented the AM_i

Note: i=1,2,3,4,5 for AM1, AM2, AM3, AM4, AM5

1 INTRODUCTION

Today we are facing many challenges, like the eradication of poverty and hunger under a changing climate, environmental degradation, growing population and growing demand for agricultural products (Altieri, Nicholls, Henao, & Lana, 2015; Godfray et al., 2010a; Rosegrant & Cline, 2003). Agriculture in Sub-Saharan Africa is particularly vulnerable to climate change (Altieri et al., 2015; Shiferaw et al., 2014) which will most likely aggravate food security in regions already vulnerable to hunger and undernutrition (Altieri et al., 2015; Lobell et al., 2008; Wheeler & von Braun, 2013). To address these challenges, well-functioning food systems are important and it is crucial to build resilience to the drivers of change, varying from sudden shocks to long-time stressors (Ericksen, 2008; Wheeler & von Braun, 2013; Wisner, Blaikie, Cannon, & Davis, 2004).

The agricultural sector in general and the cocoa value chain in particular dominates the economy of Ghana in terms of food security, employment, income and export earnings (Kongor et al., 2017; Stanturf et al., 2011). Cocoa is a cash crop and therefore an "important indirect contributor to food security in Ghana" (Monastyrnaya, Joerin, Dawoe, & Six, 2016, p.1) and an important driver of poverty reduction (Kongor et al., 2017; Stanturf et al., 2011). Price fluctuations, natural hazards, biological shocks, changes in governmental policies, etc. are emerging shocks which have adverse effects on the cocoa value chain. The different actors of the value chain show different levels of resilience. While governmental input supply, internal marketing and processing overall have a high level of resilience, the cocoa producers have the lowest level (Monastyrnaya et al., 2016). Manifold aspects emphasize the importance of cocoa farmers becoming resilient to climate change in general and to drought in particular. Shiferaw et al. (2014) state that the impacts of droughts are huge in terms of economic, social and environmental costs and losses, potentially leading to a reverse of recent economic and development gains. Previous research of the 'Assessing and Enhancing the Resilience of the Cocoa and Tef value chains' (AERTCvc) showed that drought is the most devastating shock event for cocoa farmers in Ghana (Monastyrnaya et al., 2016). Therefore, the focus of this research will be on Action Measures (AMs) that enhance resilience of cocoa farmers to drought.

1.1 BACKGROUND METHODOLOGY

There is not a lot of research done yet about the assessment of the viability of AMs in the resilience concept. However, Joerin, Tendall, Kopainsky, and Six (2016) developed guidelines to assess and build resilience to shocks in food systems. They suggest four stages to assess and build resilience: (1) identifying and framing of the problem, (2) defining the system; (3) assessing the resilience and (4) designing interventions and evaluate the results. The focus of this thesis will be on the fourth step of the food system resilience guidelines, namely on evaluating interventions for building resilience.

Food systems are shaped by the decisions of their actors and therefore it is important to understand the reasons behind their behavior when aiming at enhancing food system resilience (Blackstock, Ingram, Burton, Brown, & Slee, 2010). One believes that it is not enough to develop measures that enhance resilience. Those measures also have to be perceived as viable by the respective stakeholder in order to be implemented (Lim, Spanger-Siegfried, Burton, Malone, & Huq, 2004) and hence, truly enhance resilience. Therefore, it is important to better understand the drivers, limits and constraints shaping the viability of measures that enhance resilience (Niles, Lubell, & Brown, 2015). The viability of AMs is often assessed considering interests and success factors defined by policy makers or donors, which usually only include economic and technical aspects. Empirical research on implementation of adaptation measures has often neglected the importance of the human dimension, of measurable and alterable psychological factors like interest and motivation (Frank, Eakin, & López- Carr, 2011; Grothmann & Patt, 2005; Wheeler & von Braun, 2013). Comprehensive key indicators determining the viability of AMs to enhance resilience have not yet been identified. This research aims to identify and assess what factors lead to viability of AMs by developing a methodology and applying the methodology for cocoa farmers in Ghana.

1.2 RESEARCH QUESTION

It is believed that it is possible to develop indicators for assessing the viability of AMs to enhance resilience of different actors of different value chains in different countries. The built indicators to assess viability should cover an asset-oriented aspect, a psychological aspect and a usefulness- oriented aspect. Furthermore, it is important to understand the factors limiting the viability of a specific AM to be able to provide external support needed to overcome them. It is though not clear whether the characteristics of a specific AM, the characteristics of the region where it should be implemented or the characteristics of the actor itself influence the viability most. Therefore, the aim of this thesis is to answer the following research question:

WHAT ARE THE DIMENSIONS SHAPING THE VIABILITY OF ACTION MEASURES AND HOW DO GHANAIAN COCOA FARMERS IN DIFFERENT DISTRICTS PERCEIVE THESE DIMENSIONS FOR AMs THAT ARE DESIGNED TO ENHANCE THEIR RESILIENCE TO DROUGHT?

1.3 METHODOLOGY

The methodology for this thesis has been developed in collaboration with Luzian Messmer who applied the methodology for tef farmers in Ethiopia. Therefore, the methodology and the theoretical background of the method have been written jointly in such a way that the method is applicable for different value chains in different countries. The case studies in Ethiopia and Ghana will point out the applicability of the methodology at farm level and further identify the potential, barriers and limits of five selected AMs regarding their viability. The implementation of the AMs will be used as a proxy to measure viability.

1.4 STRUCTURE OF THE THESIS

This master thesis is structured as follows: The subsequent chapter provides information about the conceptual background and defines the underlying theories of the developed methodology. Chapter 3 introduces the reader into the study area, describes the evaluated action measures and furthermore explains the procedure and the methods used. The results are presented in chapter 4, followed by the discussion in chapter 5. The thesis ends with a brief outlook and recommendations for further research.

2 VIABILITY OF ACTION MEASURES TO ENHANCE FOOD SYSTEM RESILIENCE

The term 'viability' is defined as the "ability to work successfully" (Oxford Dictionaries, 2018b). This definition of working successfully is used to assess specific AMs designed to enhance resilience in food systems. Hence, in a first step the term 'food system' and the 'resilience' concept will be discussed and tailored to the specific problem. Then, crucial dimensions defining the viability of AMs will be specified based on literature. Since most dimensions as well as viability itself are not measurable directly, indicators will be determined for each dimension. The measures actual state of implementation will serve as a proxy for 'viability'.

2.1 SUSTAINABLE FOOD SYSTEMS AND FOOD SYSTEM RESILIENCE

The term 'food system' is widely used across many disciplines involved in production, distribution and consumption of food (Rutten, Yaroch, & Story, 2011). Rastoin and Ghersi (2010, p. 565) define a food system as "an interdependent network of stakeholders [...] localized in a given geographical area [...], participating directly or indirectly in the creation of a flow of goods and services geared towards satisfying the food needs [...] of consumers [...]." In accordance with previous, Godfray et al. (2010b) define a food system as complex system, with physical, biological and socio-economic determined processes and dynamics. This indicates that food systems are seen as social-ecological systems (Ericksen, 2008; Ostrom, 2009) linking societal, ecological, economic and political contexts (Rutten et al., 2011). Often the focus lies on the stakeholders themselves. This makes it crucial to put them in the center of the viability assessment because they determine when and how commodities are produced, distributed and consumed (Jacobi et al., 2018). Food system entities can be classified pursuant to the spatiality (Colonna, Fournier, & Touzard, 2013). For the Ghanaian case study, the focus lies on the farmer-centered food system.

It is a global priority to go beyond a sole functioning of food systems but rather aim at achieving sustainability. However, in literature there are different views on how it might be achieved (Garnett, 2014). For a long time, food systems were designed for economic efficiency only and they now have to be re-evaluated for sustainability. Fresco (2009) and Rist et al. (2016) make some attempts to classify sustainability in food systems. Both declare a food system as sustainable if: (1) it is productive and guarantees food security; (2) it fulfils the right to food; (3) it reduces poverty and inequality; (4) it exhibits a high environmental performance and resource efficiency; and (5) it exhibits high levels of social-ecological resilience being responsive to changes, shocks and transformation while reducing the vulnerability (Garnett, 2014). Especially the resilience, mentioned in (5) receives high attention in the context of growing volatility induced by challenges such as climate change, population growth and constraining resources. The time for building resilience in food systems has never been more crucial for understanding the long-term sustainability of food systems (Cabell & Oelofse, 2012; Seekell et al., 2017).

The actual concept of resilience was introduced by Holling (1973) in a paper about the capacity of ecosystems persisting in the initial state subject to disturbances (Folke et al., 2010). Since then, and due to the flexibility and openness of the resilience concept (Adger, 2000; Herrera, 2017), multiple definitions and uses of the concept have been linked to social-ecological systems and have also been applied to complex systems (e.g. food systems) in multiple spatial scales (Bullock et al., 2017; Darnhofer, 2014). Most of the used concepts focus on three aspects: the persistence, the adaptability and the transformability of a system (Darnhofer, 2014; Folke et al., 2010) to withstand disturbances without compromising their long-term prospects (Adger, 2000; Tesso, Emana, & Ketema, 2012). The disturbances and changes in food systems are often classified as either shocks or stresses and include various forms, namely: internal or external; cyclical or structural; sudden or gradual; environmental, political, social or economic caused (Adger, 2000; Speranza, Wiesmann, & Rist, 2014; Tendall et al., 2015).

In the food systems literature, a number of studies use the resilience framework for analyzing systems in order to understand how they can persist, adapt and transform in the presence of transient shocks and persistent stresses (Darnhofer, Fairweather, & Moller, 2010) while still contributing to sustain a food system and guarantee food security (Herrera, 2017). Béné, Frankenberger, and Nelson (2015) state that for designing resilience measures, information about the contributing factors and the type of shock or stress are crucial. Knowing the contributing factors and types of shock or stresses resilience thinking has an enormous potential to contribute to design, plan and monitor development projects and policies, including adaptation measures to minimize the adverse effects of climate change (Speranza et al., 2014).

Despite a growing interest in the resilience thinking concept, a number of factors (e.g. the priority of food security, rather than main focus on the economics, the complexity and the variability in space and time) mean that these works are not yet readily adoptable for food systems (Stone & Rahimifard, 2018). Further, an analytical validation of food system resilience in its multidimensional and abstract nature is difficult. This is the reason why methods for tracking resilience changes in food systems have had limited application until now (Cumming et al., 2005; Seekell et al., 2017; Tendall et al., 2015). Often, index based methods which use surrogates to measure resilience aspects are recommended (Cabell & Oelofse, 2012; Seekell et al., 2017; Tendall et al., 2015). Cabell and Oelofse (2012) present an index of 13 behavior-based indicators to approximate the resilience within agroecosystems that are otherwise too complex to assess in any precise manner.

As there is no generally accepted definition of food system resilience, it will be relied on the definition of Tendall et al. (2015, p. 19) for assessing action measures, saying that food system resilience is "the capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances". Further, the resilience of food systems can be subdivided into (1) the robustness to withstand the shock or stress, (2) the redundancy of the system, (3) the flexibility and rapidity to recover and (4) the resourcefulness and adaptability of the food system (Tendall et al., 2015).

AMs designed to enhance resilience to shocks can be compared with measures to enhance the adaptive capacity, because resilience and adaptive capacity are strongly linked (Adger et al., 2007). Hence, the reports of the Intergovernmental Panel on Climate Change (IPCC) on adaptation to climate change (Intergovernmental Panel on Climate Change [IPCC], 2007, 2014) were used as the starting point defining the relevant dimensions and measurable indicators. The Qualitative Impact Protocol (QUIP) contributes to elaborate the method with the aim of assessing "credible, timely and cost- effective evidence of impact based on [...] rural livelihood interventions without the need for a control group" (Copestake, 2014, p. 1).

Three main dimensions are of great interest with respect to AM viability: (1) the 'feasibility' of implementing a particular AM; (2) the 'motivation' to implement this AM; and (3) the 'exposure, experience and perception' of actors to/of shock events. The 'feasibility' and the 'motivation' dimension can lead to possible constraints or limits (Klein et al., 2014). Constraints are defined as making "adaptation planning and implementation more difficult" (ibid., p. 906), while limits are restrictive and lead to outcomes that are "not sustainable in a changing climate" (ibid.). In our model this means that constraints and limits affect the viability, and consequently the implementation of AMs. Figure 1 shows the basic concept of the model with the three dimensions, which served as starting point. The next section provides an in-depth study of the dimensions providing the theoretical background for elaborating the indicators characterizing the dimensions.

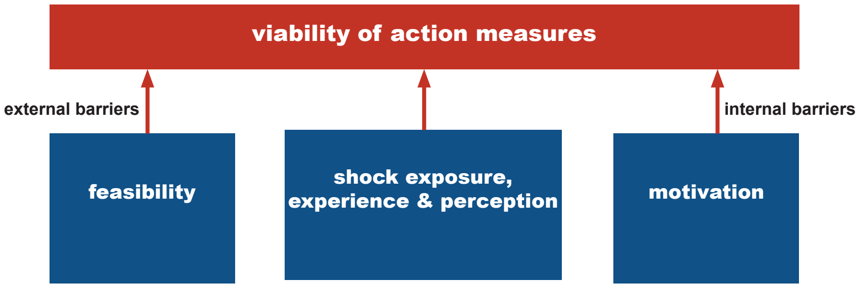

Figure 1: Simplified model of implementation of AMs

2.2 DEFINITION OF FEASIBILITY

Various indicators for feasibility can be found in the literature inter alia in the literature about feasibility studies. Mesly (2017, p. 78) states in his book about "Project Feasibility" that: "The goal of the feasibility expert is to evaluate methodically whether the proposed project has any chance of meeting its objectives; [...] they must set the parameters that help determine whether a project is a success or a failure". He describes eight elements that have an influence on the success or failure of a project, namely the: financial, organizational, environmental, technological, marketing, socio-cultural, legal and political contextual risk (ibid., p.85). After all, a predefined setup for conducting a feasibility study does not exist and the format has to be adapted to the project being evaluated, taking into account the project's goals (ibid., p. 94).

In this case the 'project's' goal is to enhance resilience of an actor to a shock. In the IPCC report from 2014, the attractiveness and feasibility of adaptation measures to climate change is illustrated in circles as can be seen from the following Figure 2. The outermost circle represents the effects of climate change, for which AMs are needed in order to adapt. The second circle shows to which extend one can adapt to the effects of climate change considering technical and physical limits. The next circle shows what adaptation measures are desirable, considering available resources (such as money) and the innermost circle shows what is possible considering political and institutional constraints (Chambwera et al., 2014).

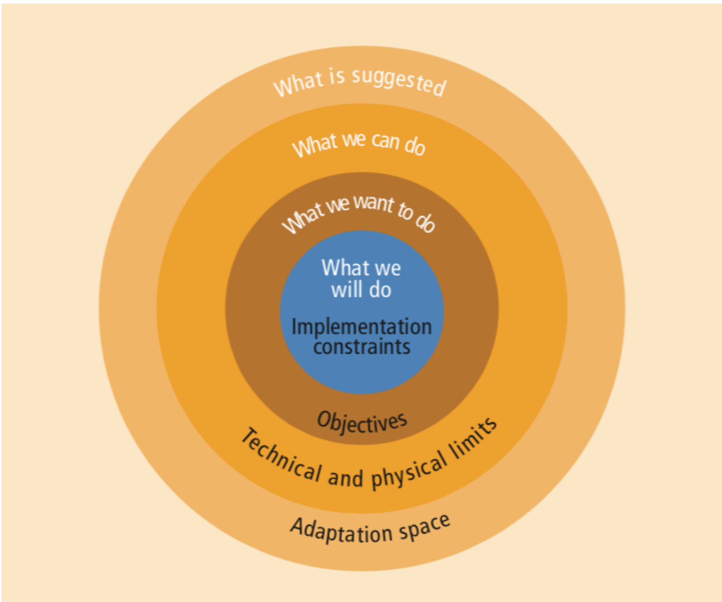

Figure 2: Feasibility of adaptation measures (Chambwera et al., 2014, p. 952)

Below et al. (2012) highlight that the feasibility of measures to adapt to climate change depends on biophysical and socio-economic factors, like natural, physical, financial and social capital.

Hassan and Nhemachena (2008) show that adaptation to climate change at farm level in Africa is influenced by farm assets, access to extension services, access to technology and information, and knowledge about the adaptation measure. Furthermore, the feasibility of a measure depends on how easy it is to implement it not only in terms of costs but also in terms of non-financial factors, like time (Lim et al., 2004). They emphasize the importance of involving the affected stakeholders in the process of the feasibility assessment, since adaptation measures must be feasible for the stakeholders who are to implement them (ibid.). Different AMs can have different requirements in terms of capital, knowledge and time needed for their implementation. Therefore, it is important to look at the AM specific feasibility.

These definitions of feasibility indicators and feasibility studies were the basis for developing the feasibility indicators of the model. The indicators found in the literature were tailored to the goal of the model, to assess the viability of AMs designed to increase the resilience of a defined stakeholder group to a defined shock. The indicators used in the model are following: technical resources, financial resources, natural resources, knowledge, time and institutional support.

2.3 DEFINITION OF MOTIVATION

Motivation is "a reason or reasons for acting or behaving in a particular way" (Oxford Dictionaries, 2018a). The motivation is one of the fundamental pillars of creating a certain behavior of stakeholders to act, in this case to build and enhance resilience (Broussard & Garrison, 2004; Guay et al., 2010). Grothmann and Patt (2005) emphasize the need to include socio-cognitive variables in models of adaptation to climate change. Different motivation theories have been reviewed in order to serve as a basis to develop measurable indicators of motivation.

The expectancy-value theory says that motivation is boosted by two main drivers, namely by the perceived outcomes of a certain action and by the value that is attributed on this outcome (Ajzen & Fishbein, 1980; Atkinson, 1964), in this case by the usefulness of a particular AM to minimize the adverse effects of a shock and the value that is attributed to it. According to Ajzen and Fishbein (1980) behavior intention does not only depend on the personal perceived outcomes and their values but also depends on the personal perceived social pressure (ibid.). In this case, social pressure can be created by the peers, namely other stakeholders in the same geographical area. Therefore, it is expected that AMs that are implemented by the peers are more likely to be adopted.

According to Geen (1995), motivation is a process consisting out of three different steps. The first step is defining a goal which the person wants to reach. The second step is having the intention to achieve the goal, and the third step is defining a strategy on how to initiate the necessary behavior. The goals are chosen in a way that they "satisfy either personal needs or situational demands" (ibid., p. 20). One of the variables that influence the commitment to a goal and consequently the motivation is the reward that a goal involves (e.g. financial rewards) (ibid.).

The self-concordance model of Sheldon and Elliot (1999) explains to what degree the goal pursuit is consistent with personal interests and values. The self-concordance model describes four different pillars, namely intrinsic, identified, introjected and external motivation. Intrinsic motivation is based on the subjective interest, pleasure, enjoyment and satisfaction and no other reasons are needed for the formation of the goal intention and the goal pursuit. In this case, this relies to the satisfaction, enjoyment and pleasure with a particular AM. Identified motivation is consistent with personal interest and values and is based on the personal importance and conviction of certain actions or behaviors. In other words, something is done or pursued because it is believed to be the right thing and often this is also communicated to the outside by recommending certain behaviors to the peers. Introjected motivation is based on reasons of goal pursuit that are already internalized, but not your 'own', which means that you do something because you are told so. External motivation is solely influenced by external factors, such as environmental pressure or monetary rewards. Due to the different degrees of internalization, the self-concordance is lowest when based on external motivation and highest when based on identified and intrinsic motivation (Deci & Ryan, 1985; Sheldon & Elliot, 1999; Sheldon & Houser-Marko, 2001).

2.4 SHOCK EXPOSURE, EXPERIENCE AND PERCEPTION

The 'action measure assessment model' is designed with a direct influence of shock exposure, experience and perception on the viability of the AM. A precondition for perceiving an AM as viable towards a shock is that the stakeholder first has to notice that this shock occurs and affects him/her and that a change in the system is needed (Bryan, Deressa, Gbetibouo, & Ringler, 2009). Silvestri, Bryan, Ringler, Herrero, and Okoba (2012) stated the same direct relationship for implementation of potentially useful adaptations to climate change. Like Bryan et al. (2009), they expect that a stakeholder needs to notice an alteration in climate, before they will implement measures. A shock can have many different impacts on the livelihood, like production failure, unemployment, erosion of assets, decrease in income and worsening of living conditions (Duguma, Brüntrup, & Tsegai, 2017). According to the Food and Agriculture Organization [FAO] (2016, p. 4) three main groups of shock affecting food systems can be defined, namely: (1) natural hazards and climate-related disasters, (2) food chain crises and (3) protracted crises. All three affect livelihoods leading to increased vulnerability and food insecurity. One solution to enhance the resilience towards these shocks is implementing viable action measures.

Successful implementation of action measures in the context of shocks is highly dependent on individual risk perceptions (Bubeck, Botzen, & Aerts, 2012; Grothmann & Patt, 2005; cited by van Duinen, Filatova, Geurts, & van der Veen, 2015). Van Duinen et al. (2015) stress a positive causal relationship between shock perception and adaptive decision-making, explaining farmers' adaptive behavior based on shock experience (Arbuckle et al., 2013).

One can expect that if no shock is experienced, the actor does not have any needs to implement AMs against this particular shock. To describe the shock experience in more detail, information about the severity, the perceived importance of the shock for the actor, the future trend of occurrence and the negative effects and damages are essential.

3 METHODS AND PROCEDURE

The following Figure 3 shows the detailed 'action measure assessment model' with its three dimensions and respective indicators. The questionnaire was designed based on this model and questions were developed such as they cover all indicators. The model serves as a basis for decision- making whether or not a particular AM is perceived as viable to enhance resilience to a shock. It is expected that the three previously described dimensions and all the relevant and associated indicators contribute to viability. Before determining whether an AM is viable or not a need to adopt new measures or strategies must arise and be recognized. This need presupposes a certain vulnerability of the stakeholder and an involved vulnerability risk increased by shock occurrence. The 'shock exposure, experience and perception' creates this need for building an enhancing resilience to the shock. There are many different measures and strategies which can satisfy this need. Though, for some of them the stakeholder itself has scope for action while for others not. As a result, it is essential to present appropriate AMs with scope of action to the stakeholder for a viability assessment.

However, not only a given need and appropriate measures shape the viability. In addition, one can expect that the dimensions 'feasibility' and 'motivation' interplay and weaken or strengthen the perceived viability of AMs. The 'feasibility' and 'motivation' depend strongly on the nature of the measure itself but also on the stakeholder's socio-economic and -demographic background. A constraint of implementation due to 'feasibility' is caused by a gap between the AM's feasibility requirements and farmers assets (e.g. lack of money or time or input access). In the model this gap is phrased as 'external barriers'. Referring to 'motivation' constraints, one observes similar barriers but at internal level. This internal barrier occurs when the required motivation for successful implementation does not match with the stakeholder's perceived motivation towards an AM (e.g. unrecognized usefulness). The perceived motivation itself depends on the personality and environment of a stakeholder but also on the characteristics of the measure.

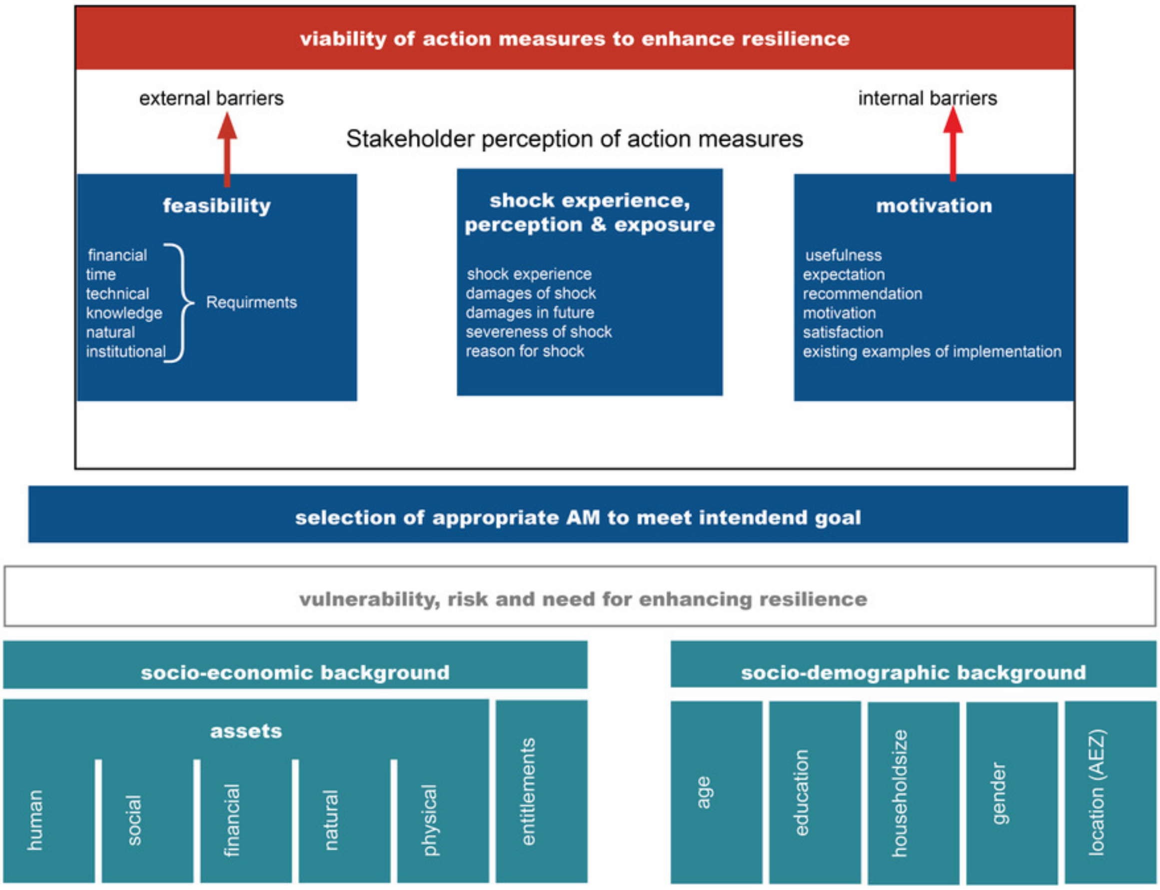

Figure 3: Action measure assessment model

The previously described model was applied on cocoa farmers in Ghana to assess the viability of AMs that enhance their resilience to drought. The following section starts with a description of the importance and the challenges of cocoa production in Ghana. Then, climate change scenarios for Ghana and the vulnerability of the cocoa production to drought is described, followed by a description of the assessed AMs. In a next step the questionnaire design is outlined, then the data collection with an overview of the study area, followed by a description of the data analysis and validation.

3.1 BACKGROUND COCOA PRODUCTION IN GHANA

Ghana is, after Côte d'Ivoire, the second largest cocoa producer in the world and known for its premium quality cocoa (Läderach, Martinez-Valle, Schroth, & Castro, 2013). Agriculture in general and cocoa in particular is of great importance for Ghana's economy, since it accounts for 30% of the total exports, 8.2% of the country's gross domestic product (GDP), and supports the livelihoods of about 800,000 smallholder farmers (Anim-Kwapong & Frimpong, 2006). Cocoa farming contributes to 70-100% of the annual household income of smallholder farmers and the farm sizes range from 0.4 to 4.0 hectares (ibid.). Cocoa farming in Ghana is a rather low input sector and the average yields per hectare are around 250 kg, which is much lower than in other cocoa producing countries like Cote d'Ivoire and Indonesia. In those countries, the annual yields are 600kg/ha and 1,000kg/ha, respectively (ibid.). The lower yields are attributed to the age of the cocoa farms and the age of the cocoa farmers. About one third of the cocoa farms are over 30 years old and therefore less productive than younger farms. The farmers are often unwilling to take risks and invest in strategies for yield improvement, mainly because of the perceived very high costs of inputs compared to the producer cocoa price (ibid.). Another reason for the low productivity is the very low income of Ghanaian cocoa farmers, which inhibits the adoption of more advanced farming practices, like the use of adequate amounts of fertilizers and pesticides and this situation leads again to low productivity (Hainmueller, Hiscox, & Tampe, 2011). These circumstances and the worldwide increasing cocoa demand call for a sustainable increase in agricultural productivity, in other words, a sustainable intensification that meets the growing demand without expanding the agricultural land use and compromising the environment (Godfray et al., 2010a; Kongor et al., 2017; Wheeler & von Braun, 2013). Therefore, resilient farms should be aspired, which can maintain or increase their productivity despite the effects of climate change.

3.2 CLIMATE CHANGE AND VULNERABILITY

Climate change scenarios predict a decrease in annual rainfall and an increase in the mean annual temperature, variability and weather extremes (Anim-Kwapong & Frimpong, 2006; Government of Ghana [GoG], 2015; United Nations Development Programme [UNDP], 2012). Owusu and Waylen (2009) support the assumption that annual rainfall in Ghana will decrease in future and emphasize differences between regions: the southwestern forest region experiencing the largest proportional decrease in rainfall and the transitional zone a potential shift from a bimodal rainfall regime to an unimodal. Läderach et al. (2013) support the prediction of a future increase in temperatures but predict only very small changes in rainfall, though highlighting that increased temperatures lead to an increase in potential evapotranspiration. This development will aggravate water and soil moisture conditions during the dry season and increase the vulnerability of cocoa production to the effects of climate change (Anim-Kwapong & Frimpong, 2006).

Cocoa production in Ghana is mostly rain-fed and therefore dependent on the amount and distribution of the annual rainfall (Antwi-Agyei, Fraser, Dougill, Stringer, & Simelton, 2012). The cocoa production is highly affected by drought in terms of growth and yield, and its cropping system is associated to the rainfall distribution. The rainfall distribution is bimodal resulting in two growing seasons, the major growing season from March/April to July and the minor growing season from September to November (Anim-Kwapong & Frimpong, 2006).

Cocoa farmers are highly vulnerable to the effects of drought, mainly because of their low income levels, their high dependency on cocoa and the resulting inability to implement measures and practices to mitigate the effects of drought and to adapt to climate change (ibid.; Stanturf et al., 2011). Antwi-Agyei et al. (2012) show that the vulnerability to drought in Ghana does not just depend on the Agroecological Zone (AEZ) and the respective rainfall pattern but also on the socio-economic pattern of the region. The most vulnerable regions are those with low levels of social, human, financial, natural and physical assets. One of the objectives of the 'Ghana's National Climate Change Adaptation Strategy' is to "enhance the adaptability of vulnerable ecological and social systems by increasing the flexibility and resilience of these systems" (UNDP, 2012, p.17).

3.3 SELECTED AMs

The assessed AMs were elaborated by cocoa farmers in a previous workshop of the AERTCvc project. Out of the 25 proposed AMs to enhance the resilience to drought five AMs were selected for the assessment. The selection process was based on the criterion that farmers should have the ability to influence the implementation of the chosen AMs on their own. All AMs have been classified according to this criterion in collaboration with different experts of the ETH Zurich and the KNUST Kumasi.

3.3.1 AM1 'IRRIGATION TECHNOLOGIES'

Only a very small part of the worldwide cocoa production is irrigated (Carr & Lockwood, 2011). The annual rainfall of the different cocoa growing regions of the world lies between 1,250 and 2,800 mm (Wood & Lass, 2008). According to Wood and Lass (2008), cocoa should not be grown if the annual rainfall lies below 1,250 mm. Under these conditions water loss through evapotranspiration is likely to exceed precipitation and therefore cocoa should only be planted if irrigation is possible (ibid.). Irrigation technologies are implemented only by few Ghanaian cocoa farmers and hence, drought often results in soil water deficit, which leads to damages mainly in form of a high seedling mortality (Anim-Kwapong & Frimpong, 2006; Carr & Lockwood, 2011). Drought can furthermore affect the bean size, result in yellowing and wilting of leaves, premature leave fall and lead to lower yields and increased damages of capsid bugs (mirids) (Anim-Kwapong & Frimpong, 2006). There is very little literature though assessing and quantifying the effects of irrigation on cocoa yields and other possible benefits. Therefore, recommendations on specific irrigation technologies for cocoa and their practical application are hard to find (Carr & Lockwood, 2011). While some research found that high rainfall in one year leads to higher yields in the following year (Brew, 1988; Skidmore, 1929), Ali (1969) found positive correlations between rainfall and cocoa yields in some months and negative correlations in others. The positive correlations were found during the dryer season from February to April and during

the minor growing season from September to October (ibid.). Several reports on adaptation to climate change in Ghana mention irrigation technologies among other AMs as possible adaptation strategy (Anim-Kwapong & Frimpong, 2006; Stanturf et al., 2011). In the 'Manual for Cocoa Extension in Ghana' drip irrigation is recommended during the establishment phase of cocoa to prevent mortality and promote growth (CCAFS, 2018). The Ghana Cocoa Board (COCOBOD) has started an irrigation project to increase yields (Ghana Cocoa Board [COCOBOD], 2018). The project is still in a basic and explorative phase but is planned to be disseminated in 2019. One part of the project will consist of farmers' education to prevent an increase of black pod through wrongly applied irrigation. The recommended irrigation technology depends on the planting pattern and on the available water resources (personal communication CHED [COCOBOD]).

3.3.2 AM2 'SHADE TREES'

Cocoa in West Africa is mostly grown under full sun (Ofori-Frimpong, Afrifa, & Acquaye, 2010). Anim-Kwapong and Frimpong (2006) emphasize the importance of promoting shade trees among other AMs measures in order to adapt to climate change. The cocoa Research Institute of Ghana (CRIG) recommends based on Manu and Tetteh (1987) to keep 16 to 18 evenly distributed and mature shade trees per hectare on a cocoa farm with cocoa trees planted on a 3x3 m spacing (Ofori-Frimpong et al., 2010; personal communication CHED (COCOBOD)). Shade trees have several benefits on cocoa farms, such as reducing extremes in soil and air temperature, reducing evapotranspiration of cocoa, increasing humidity, higher water use efficiency, improving nutrient recycling, suppressing weed growth, protecting the cocoa from heavy rainfall and harsh winds, prolonging the economic life of cocoa trees, provision of mulch, reduced need for agrochemicals (compared to full sun cocoa), income/product diversification (fruit and timber trees) and carbon storage (Beer, 1987; Carr & Lockwood, 2011; Dohmen, Noponen, Enomoto, Mensah, & Muilerman, 2018; Ofori-Frimpong et al., 2010). The main disadvantages of shade trees are: lower yields compared to full sun cocoa, competition for water during the dry season and competition for nutrients (Beer, 1987). Latest research has found that the benefits and disadvantages of shade trees depend on the proportion of shade tree cover. Blaser et al. (2018) show that a shade tree cover up to 30% does not compromise with yields while at the same time reducing the pressure from pests and diseases, decreasing diurnal temperatures, increasing aboveground carbon storage and promoting biodiversity, even though not at as much as in systems with higher shade tree cover.

3.3.3 AM3 'FIRE BELTS'

Bushfires are one of the major factors inducing environmental degradation in Ghana. They are often caused by human activities, such as using fire to clear lands (slash and burn agriculture), using fire to hunt and cook. Bushfires are often occurring on an annual basis and it is expected that their occurrence will increase as a consequence of the drier and hotter climate (Appiah, Damnyag, Blay, & Pappinen, 2010; Stanturf et al., 2011). The spread of bushfires can be controlled by constructing fire belts around cocoa farms before the dry season, before burning and clearing lands or when informed of nearby fire outbreaks (Amissah, Kyereh, & Agyeman, 2010; Appiah et al., 2010). Fire belts in Ghana are typically showing a width from 2 to 3 m, but there is a lack of research about the effectiveness of these fire belts. Taking into account that many farmers construct fire belts, one can assume that they often serve their purpose (Amissah et al., 2010). Furthermore, they are a traditional technique for preventing fire outbreaks and protecting the cocoa farm from bushfires (Ampadu-Agyei, 1988). The risk of fire is not everywhere equally high and depends on the kind of vegetation with which the cocoa farm shares boundaries. The risk of fire is higher if the farm shares boundaries with fallow land or bush, and lower if the farm shares boundaries with other cocoa farms (personal communication of representative from CHED [COCOBOD]).

3.3.4 AM4 'KEEPING RECORDS ON INCOME AND EXPENDITURES'

For any kind of business, small or large scale, record keeping is crucial for a successful management (Muchira, 2012). Deficient financial management is often the main cause of failure in small and medium enterprises in developing countries (ibid.; Mutua, 2015). Mutua (2015) found that bookkeeping positively influences the growth and profitability of small and medium enterprises in Chuka Town in Kenya and concludes that it is important for the economy as a whole to promote bookkeeping in those enterprises. Cocoa is a cash crop and therefore cocoa farming should be seen as a small scale business, in other words as an agricultural enterprise (Matthess, 2015). Profitability of cocoa farming and growth is not only important for the farmers, but also for the whole country, considering that cocoa contributes to 8.2% of Ghana's GDP (Asante-Poku & Angelucci, 2013). Record keeping provides important information about the performance of the business/farm which are important for any economic decisions (Muchira, 2012). It is a good tool for the organization and planning of the farm and the identification of possible problems (CCAFS, 2018). Farm planning is crucial to know the situation on the farm and prepare for the future, regardless of the effects of climate change (Dohmen et al., 2018). Calculating the costs and benefits give an overview of the financial situation (profitability of the farm) and is a prerequisite to get access to loans (CCAFS, 2018). Besides financial records in cocoa farming, it is also important to keep production and labor records. Production records should cover the varieties grown, the amount of inputs and the date of harvest, and labor records should not only cover the cost of hired labor but also records on family labor (ibid.).

3.3.5 AM5 'MULCHING'

Mulching is a farming practice where by definition "at least 30% of the soil surface is covered by organic material" (Erenstein, 2003, p.18). This threshold level is rather arbitrary, and a higher share of soil cover should be aspired. Mulch functions as both soil protection and soil amelioration (Dohmen et al., 2018; ibid.). The protective function includes preventing soil erosion, where the prevention increases with increasing soil cover. Furthermore, it enhances the aggregate stability of the soil surface, protects the soil from heavy rainfall, slows down run-off, improves infiltration and conserves water by reducing evaporative water losses. The ameliorating function includes improving soil fertility, promoting the activity of soil organisms and reducing soil temperature extremes. Another benefit of mulching is suppression of weeds through cutting off the source of sunlight (CCAFS, 2018; Erenstein, 2003). Mulching is particularly important and beneficial during the establishment of cocoa farms, after planting the cocoa seedlings. The mulch, consisting of dry plant material or plantain pseudostems should be spread around the cocoa seedlings especially before the dry season to retain soil moisture. (Carr & Lockwood, 2011; CCAFS, 2018) Using plantain pseudostems as mulch is particularly recommended in drier climates because of the added water through the pseudostems (Dohmen et al., 2018). On a young cocoa farm, there is usually not much mulch available and the costs of growing, transporting and spreading mulch around the cocoa seedlings can be exorbitant (Carr & Lockwood, 2011). Once the cocoa trees are mature, there is usually enough mulch available in form of cocoa leaves and prunings (personal observation).

3.4 QUESTIONNAIRE DESIGN

The questionnaire was designed based on the developed 'action measure assessment model' and tailored to assess the viability of the previously mentioned AMs. In order to get comprehensive results, a methodological triangulation has been applied (Leeuw & Vaessen, 2009). Qualitative and quantitative methods were used to evaluate the viability of the proposed AMs. The questionnaire was divided into three main parts: socio-economic and -demographic questions, questions about 'drought exposure, experience and perception', overall farmer specific 'motivation', and specific questions about the AMs containing the aspects of 'feasibility' and 'motivation'. The responses were scaled by using a five-point Likert scale combined with a visual illustration to facilitate the choice for the respondent. The visual Likert scale can be found in Appendix I. Most of the questions showed the typical format of the scale, namely the categories 'strongly disagree', 'somewhat disagree', 'neither agree nor disagree', 'somewhat agree' and 'strongly agree'.

The socio-economic and socio-demographic indicators were based on adaptation measure literature and tailored to the specific stakeholder group of Ghanaian cocoa farmers (Amare & Simane, 2017; Armah, Al-Hassan, Kuwornu,

& Osei-Owusu, 2013). The categories of the indicators were designed based on the Ghana Living Standards Survey (Ghana Statistical Service, 2014) and adjusted in collaboration with sociologists of the KNUST Kumasi.

The first idea was to definite distinct levels of implementation that are possible for each AM. To do so, different experts were consulted. Unfortunately, this has proved to be a difficult matter. For some AM, it would have been possible to define optimal levels of implementation but for others not due to lack of research and experience with some AMs, and due to the farmers' subjective perception of optimal implementation. Therefore, the approach had to be slightly changed, resulting in a method on which the farmers themselves can state their opinion about an optimal level of implementation of the respective AM. The questions about the 'motivation' and 'feasibility' of the respective AMs were always asked in regard to the perceived optimal level of implementation.

A balanced incomplete block design was used and only two of the five AMs were randomly assigned to each farmer to reduce the duration of the interview and thus avoid tiredness and loss of interest by the respondent. Question interdependencies of 'feasibility' and 'motivation' have been controlled for by designing two versions of the questionnaire with altered order (Rea & Parker, 2014). This procedure resulted in 20 different versions of the questionnaire. In each surveyed village, all 20 versions of the questionnaire have been covered at least once and were attributed randomly to the interviewed farmers. A more detailed explanation about the attribution of questionnaires to the farmers can be found in Appendix II.

A first draft of the questionnaire has been validated and discussed with agronomists and sociologists from the KNUST in Kumasi and tested in the field. With the adjusted questionnaire, two local facilitators have been trained before starting the survey. The questionnaire can be found in Appendix II.

3.5 DATA COLLECTION

The data collection took place between May and July 2018. The survey was conducted in the two most important cocoa producing regions, namely Ashanti and Western Region (Monastyrnaya et al., 2016). A stratified random sampling technique was used within the two regions to cover different AEZs with different rainfall patterns and therefore different possible experiences of drought. Covering sites with different rainfall patterns was a criterion in the selection of the sample sites, because the former exposure to drought is assumed to influence whether farmers implement AMs to increase their resilience to drought or not. Figure 4 shows the locations of the selected sample sites.

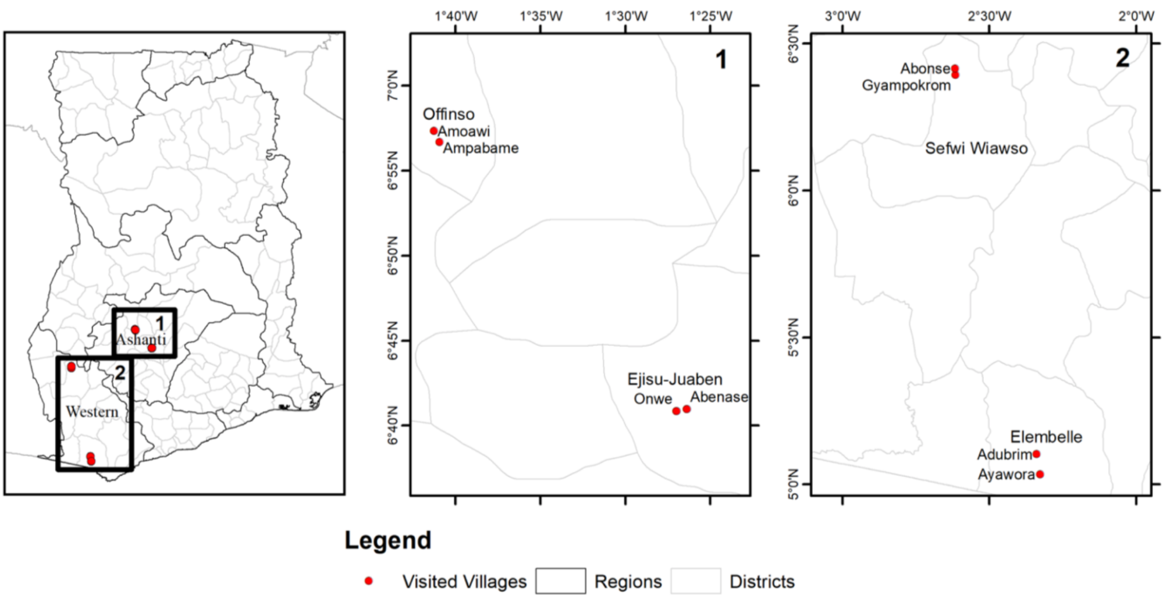

Figure 4: Map of locations of selected sample sites

As can be seen in Figure 4, four different districts were chosen and per district two villages, namely: Amoawi (n=40), Ampabame (n=40), Abenase (n=34), Onwe (n=38), Gyampokrom (n=40), Abonse (n=40), Adubrim (n=40) and Ayawora (n=35). The districts Offinso South, Ejisu-Juaben and Sefwi Wiawso were already covered by former research of the AERTCvc project and were chosen again for reasons of continuity and in order to facilitate a possible future comparison of the data. The district Elembelle was added to the sample to cover an additional site in the region with the highest rainfall of Ghana (Antwi-Agyei et al., 2012; GoG, 2015).

After completion of the data collection two workshops have been organized in two (Offinso South and Elembelle) of the four districts to share, validate and discuss the obtained data with the surveyed farmers. Preliminary findings have been presented and then discussed in two focus groups. In the first part of the workshop, the farmers were asked to discuss about the optimal level of implementation of the AMs and conduct a cost benefit analysis (CBA) of this optimal implementation. The CBA was framed based on the FAO briefing note of 2018 (Giacomo, 2018). Furthermore, they were asked to rate the potential of the respective AM to enhance the resilience to drought and the desirability of the AMs on a scale from zero to ten. In the second part of the workshop, the main stated limitations and barriers of the AMs were presented. The focus groups discussed potential reasons for the existence of these limitations and what could be done to overcome them at different levels, from the household level to the governmental level. The workshop finished with a short presentation of the outcome of each focus group and a questions and answers round.

3.5.1 STUDY AREA

The district Offinso South is located in the north-western part of the Ashanti Region, covers a land area of 1,350 km2 and lies within the latitudes 6°45’N and 7°25’S and longitudes 1°65’W and 1°45’E (Boamah, 2012, 2013; GoG, 2017f). The district’s population is 138,676, of which 58% live in rural areas and 42% in urban areas (Boamah, 2012, 2013; GoG, 2017c). The topography of the district is undulating with an altitudinal range from 180 to 300 meters above sea level (GoG, 2017f).

The district Ejisu-Juaben covers a land area of 640 km2 and lies within the latitudes 6°42’N and 6°83’N and longitudes 1°25’W and 1°58’W (Chemura, van Duren, & van Leeuwen, 2015). It is located in the central part of the Ashanti region with proximity to the Kumasi Metropolis (GoG, 2017e). The district’s population is 143,762, out of which 72% live in rural areas and 28% in urban areas (GoG, 2017a). The topography of the district is undulating with an altitudinal range from 240 to 300 meters above sea level (GoG, 2017e).

The district Sefwi Wiawso is located in the northern part of the Western region, covers a land area of 1,557 km2 and lies within the latitudes 6°00’ and 6°30’N and longitudes 2°15’ and 2°45’W (Nunoo, Frimpong, & Frimpong, 2014; Vordzogbe, Attuquayefio, & Gbogbo, 2005). The district’s population is 139,200, out of which 64% live in rural areas and 36% in urban areas (GoG, 2017d). The topography of the district is undulating and with an altitudinal range from 152 to 510 meters above sea level (GoG, 2017h).

The district Elembelle is located in the southern end of the Western Region, covers a land area of 1,468 km2 and lies within the latitudes 4°40’N and 5°20’N and longitudes 2°05’W and 2°35’W (Edjah, Akiti, Osae, Adotey, & Glover, 2017; GoG, 2017g). The district’s population is 87,501, out of which 79% live in rural areas and 21% in urban areas (GoG, 2017b). The topography of the district is in general undulating and has its highest point at 137 meters above sea level (GoG, 2017g).

The following Table 1 shows the sample size and a short description of the agroecological characteristics of the districts. A brief description of the transitional zone has been added to the table, since the district Offinso South is located on the border of the transitional zone and the deciduous forest.

Table 1: Sample size and agroecological characteristics

sampled regions	sampled districts	sampled villages	sampled HH	AEZ	biophysical characteristics
				Transitional Zone	rainfall (bimodal): 1200 mm/year major growing season: March-July minor growing season: September-October mean annual temperature: 27 °C
Ashanti	Offinso South	Amoawi	n=40	Deciduous Forest	rainfall (bimodal): 1400 mm/year major growing season: March-July minor growing season: September-November mean annual temperature: 26.4 °C
		Ampabame	n=40		
	Ejisu-Juaben	Abenase	n=34		
		Onwe	n=38		
Western Region	Sefwi Wiawso	Gyampokrom	n=40		
		Abonse	n=40		
	Elembelle	Adubrim	n=40	Rain Forest	rainfall (bimodal): >2000 mm/year major growing season: March-July minor growing season: September-November mean annual temperature: 26.4 °C
		Ayawora	n=35		
n=2	n=4	n=8	N=307		

Source: (Antwi-Agyei et al., 2012; GoG, 2015; Issaka, Buri, Tobita, Nakamura, & Owusu-Adjei, 2012)

Note: 'N' refers to the overall sample and 'n' refers to a subsample

Figure 5: Data collection in Onwe, Ejisu-Juaben

3.6 DATA ANALYSIS AND VALIDATION

The data processing and the statistical analysis was done with IBM SPSS Statistic Version 25© (IBM, 2017). After the digitalization, the data was cleaned and prepared for the analysis. The reliability of the data was controlled, and unreliable values double checked with the raw data of the original questionnaires. In SPSS, all variables and the respective possible answers were labeled and missing values defined. Five samples were excluded from the analysis because the farmer did not harvest any cocoa yet, in other words the cocoa farm had only been established very recently. After noticing this problem in the field, interviews were not conducted anymore with farmers who didn't harvest any cocoa yet.

The analysis of the data was done using descriptive statistics, inferential tests, Principal Component Analysis (PCA) and binary logistic regression models. Continuous and ordinal data were described using means and standard deviation, while nominal data was described using frequencies and valid percent. To test for differences between two groups, a Mann Whitney-U Test was used, and to test for differences between three or more groups, a Kruskal-Wallis H (K-W) Test was used. Both tests can only be applied on continuous or ordinal data and therefore, a Pearson Chi-Square Test was applied on nominal data. Post hoc Dunn-Bonferroni Tests were conducted for pairwise comparison of the groups. To compare the 'drought exposure, experience and perception', the 'feasibility' and the 'motivation' among districts and AMs, a PCA has been conducted for each dimension.

The independent variables used for the regression were socio-economic and -demographic variables and the 'feasibility', the 'motivation' and the 'drought exposure, experience and perception' components that resulted from the PCA. The nominal socio-economic and -demographic variables used for the regression were coded as dichotomous variables. A more detailed description of the statistical tests and the procedure of the PCA and the binary logistic regression can be found in Appendix IV.

3.6.1 INFLUENCE OF QUESTION SET-UP

A possible effect of the order of the 'feasibility' and 'motivation' questions was tested using a Mann-Whitney-U Test for non-parametric data. The null hypothesis there is no significant difference of the two versions, cannot be rejected at alpha level <0.05 for most (63 out of 65) 'feasibility' or 'motivation' answers of the different AMs and for none of the means of the 'feasibility' or 'motivation' answers. Hence, in this survey no influence of the order of the 'feasibility' and 'motivation' questions can be seen.

3.6.2 INFLUENCE OF INTERPRETER

A possible effect of the interpreter was tested using a Mann-Whitney-U Test for non- parametric data. The null hypothesis there is no significant difference in obtained responses between the interpreter 1 and 2 cannot be rejected at alpha level <0.05 for most (342 out of 416) of the variables and the null hypothesis there is no significant difference in obtained responses between the interpreter 1 and 3 can also not be rejected at alpha level <0.05 for most (383 out of 416) of the variables. Differences between interpreter 2 and 3 have not been tested, because they did not conduct interviews in the same district.

4 RESULTS

The results section starts with a description of the profile of the interviewed cocoa farmers and a description of the farm characteristics. Then, the overall results of 'drought exposure, experience and perception', 'feasibility' and 'motivation' are presented followed by the results of the PCA. The three dimensions of the model are compared among the districts and among the assessed AMs using the components resulting from the PCA. In a next step, the implementation of AMs is analyzed, and the results of the binary logistic regression presented. The section ends with an overview about the results of the workshops.

4.1 PROFILE OF COCOA FARMERS AND FARM CHARACTERISTICS

Table 2 shows the means (*M*) and standard deviations (*SD*) of the continuous socio-economic and -demographic variables and Table 3 shows the frequencies of the nominal socio-economic and - demographic variables.

Table 2: Mean, SD and K-W Test for differences of socio-economic and -demographic data in the four districts

	region										
	national (N=302)		Ejisu-Juaben (n=71)		Offinso South (n=77)		Sefwi Wiawso (n=79)		Elembelle (n=75)		Kruskal-Wallis
variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	
age	50.5	13.2	52.4	11.3	58.2	13.2	49.7	10.9	41.9	11.6	<0.001***
household size	8.8	6.4	9.2	4.1	11.5	10.4	7.3	3.7	7.0	3.4	<0.001***
total farm size [ha]	5.2	4.3	6.2	4.9	5.3	4.8	4.9	4.1	4.3	3.2	0.024**
area cocoa [ha]	4.3	3.7	5.3	4.4	4.0	3.6	4.2	3.7	3.7	2.6	0.021**
number farms	2.1	1.5	2.7	1.8	1.6	0.8	2.0	1.0	2.3	1.9	<0.001***
mean age farms	14.2	10.8	9.0	4.8	21.7	16.0	13.4	7.5	12.1	5.8	<0.001***

** significant at 5% probability level, *** significant at p 1% probability level

Table 3: Frequencies and Pearson Chi-Square Test of nominal socio-economic and -demographic variables in the four districts

variable	N		frequency n	valid percent	Pearson Chi-Square
sex	302	female	116	38.4%	0.134
		male	186	61.6%	
education	275	none	75	25.1%	0.810
		basic education	201	67.2%	
		secondary	17	5.7%	
		tertiary	6	2.0%	
entitlements	295	owning	201	66.6%	<0.001***
		renting	53	17.5%	
		other	41	13.9%	
land allocated to cocoa	302	21-40	1	0.3%	0.001***
		41-60	23	7.6%	
		61-80	41	13.6%	
		81-100	237	78.5%	
share of income from cocoa	299	0-20	4	1.3%	0.076
		21-40	3	1.0%	
		41-60	33	11.0%	
		61-80	52	17.4%	
		81-100	207	69.2%	
household income	285	<6,500	202	70.9%	<0.001***
		6,500-12,600	64	22.5%	
		12,601-18,700	6	2.1%	
		18,701-25,000	6	2.1%	
		no answer	7	2.5%	

** significant at 5% probability level, *** significant at p 1% probability level

From the 302 interviewed farmers, 38.4% were female and 61.6% were male. The male dominance of the respondents was observed in all four districts. The mean age of the interviewed farmers was 50.5 (*SD*=13.2) and significantly differed among the four districts (*p*=<0.001***). The farmers in Elembelle were significantly younger than the farmers in the other three districts (EL-EJ: *p*=<0.001***; EL-OS: *p*=<0.001***; EL-SF: *p*=0.001***), and the farmers in Sefwi Wiawso were significantly younger than the farmers in Offinso South (*p*=0.001***). The mean household size was 8.8 (*SD*=6.4), being significantly smaller in Sefwi Wiaswo and Elembelle than in Ejisu-Juaben and Offinso South (*p*=<0.001***). About 75% of the interviewed farmers received some form of education, while 25% indicated that they never received any form of education. The educational level of the farmers did not significantly differ among the four districts. About 66.6% of the interviewed farmers owned the land of their cocoa farm, while 17.5% were renting the land, and 13.9% indicated to have another form of land tenure. The entitlements significantly differed among the four districts (*p*=<0.001***). The majority of the farmers in the districts Offinso South, Sefwi Wiawso and Elembelle owned the land, while the majority of farmers in Ejisu-Juaben rented the land. The mean farm size was at 5.2 ha (*SD*=4.3) and the mean area used for cocoa farming was at 4.3 ha, which corresponded to about 83% of the total farm size and hence fitted with the statement of the majority of the farmers (78.5%) that 81% to 100% of their farming land is allocated to cocoa. The farm size only significantly differed between Elembelle and Ejisu-Juaben (*p*=0.016**), where the farmers had larger farms than the ones in Elembelle. The area used for cocoa farming was also significantly higher in Ejisu-Juaben than in Elembelle (*p*=0.049**) and furthermore significantly higher than in Offinso South (*p*=0.032**). This could also be seen in the statement about the land allocated to cocoa, having significantly less farmers in Offinso South compared to the farmers of the other districts that stated that 81% to 100% of their land is allocated to cocoa (*p*=0.001**). However, the majority of the farmers in all districts had between 81% to 100% of their land allocated to cocoa. The mean number of cultivated cocoa farms per farmer was 2.1 (*SD*=1.5) and the mean age of those cocoa farms 14.2 (*SD*=10.8). Both variables significantly differed among the districts (*p*=<0.001***). The number of cultivated cocoa farms in Offinso South was significantly lower than the number of cultivated cocoa farms in the other districts (OS-EJ: *p*=<0.001***; OS-SF: *p*=0.043** and OS-EL: *p*=0.005***). The mean age of the cocoa farms was the lowest in Ejisu-Juaben, followed by Sefwi Wiawso and Elembelle and the highest in Offinso South. The majority of the farmers (69.2%) stated that between 80% to 100% of their household income is coming from cocoa farming. No significant differences were found between the districts. About 71% of the farmers had an annual household income of under 6,500 Cedi per household (6,500 Cedi = 1,358 USD[1]). The district Offinso South had compared to the farmers in the other districts significantly more farmers in the lowest income category, while the districts Sefwi Wiawso and Elembelle had significantly less farmers in the lowest category. However, most of the farmers in all districts stated to be in the lowest income category. All the post hoc tests for the socio-economic and -demographic variables can be found in Appendix V.

[1] 1 Cedi = 0.21 USD, retrieved on September 17, 2018

4.1.1 OVERALL FARMER SPECIFIC 'MOTIVATION'

Three questions of the dimension farmer specific 'motivation' were asked in a general manner and were not AM-specific. The farmers were asked if they are proud of being a cocoa farmer, if they are satisfied with the performance of their farm and if they are regularly trying out new farming practices. As can be seen in Table 4, the farmers in all regions were very proud of being a cocoa farmer (*M*=4.87, *SD*=0.48), with no significant differences between the different districts. They were ambivalent about their satisfaction with the performance of their farm and generally did not regularly try out new farming practices. However, the K-W Test showed significant differences between at least one pair of districts in the last-named variables (*p*=0.044**, respectively *p*=0.002***). Farmers in Elembelle were more satisfied with the performance of their farms than they were in Ejisu-Juaben (*p*=0.032**), and farmers in Offinso South were more often trying out new farming practices than farmers in Sefwi Wiawso (*p*= 0.001***). The post hoc pairwise comparison can be found in Appendix VI.

Table 4: Mean, std. dev and Kruskal-Wallis of the farmer specific 'motivation'

	region										
	national (N=302)		Ejisu-Juaben (n=71)		Offinso South (n=77)		Sefwi Wiawso (n=79)		Elembelle (n=75)		Kruskal-Wallis
variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	
pride	4.87	0.48	4.85	0.58	4.94	0.30	4.86	0.45	4.85	0.56	0.629
satisfaction with farm	3.15	1.34	2.79	1.33	3.17	1.29	3.22	1.31	3.39	1.37	0.044**
early adoption	2.60	1.69	2.54	1.58	3.20	1.67	2.11	1.52	2.57	1.84	0.002***

** significant at 5% probability level, *** significant at p 1% probability level

Note: 1=strongly disagree, 2=somewhat disagree, 3=neither agree nor disagree, 4=somewhat agree, 5=strongly agree

4.1.2 COCOA YIELDS IN 2015, 2016 AND 2017

Figure 5 shows the indicated cocoa yields in 2015, 2016 and 2017 in the four different districts. Both, differences among the districts and differences among the years can be seen.

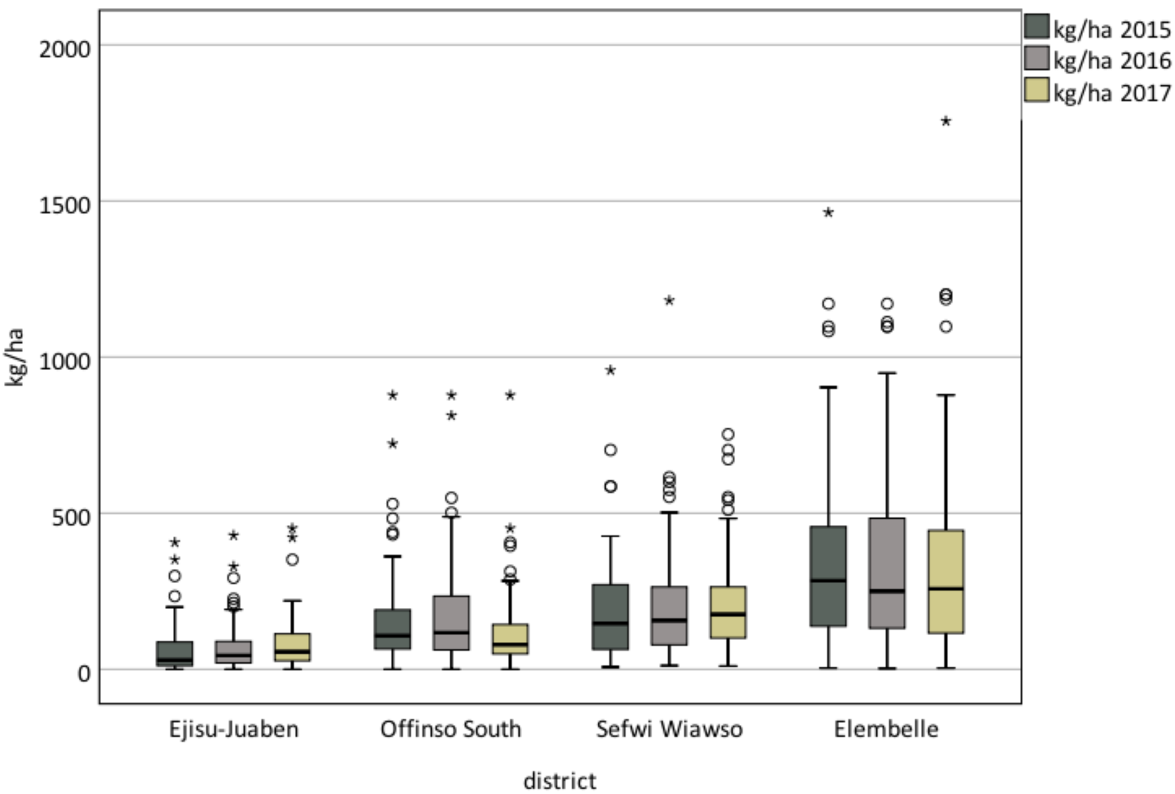

Figure 6: yield/ha/year in the four districts in 2015, 2016 and 2017

The cocoa yields significantly differed among the districts in all three years (*p*= <0.001***). In 2015 and 2016, farmers in Ejisu-Juaben had significantly lower yields than farmers in the other three districts (2015 and 2016: EJ-OS: *p*=<0.001***; EJ-SF: *p*=<0.001***; EJ-EL: *p*=<0.001***) and in 2017, significantly lower yields than Sefwi Wiawso and Elembelle (EJ-SF: *p*=<0.001***; EJ-EL: *p*=<0.001***). Elembelle had significantly higher yields than the other three districts in 2015 and 2016 (2015: EL-OS: *p*=<0.001***; EL-SF: *p*=0.016**; 2016: EL-OS: *p*=<0.001***; EL-SF: *p*=0.038**), and significantly higher yields than Ejisu-Juaben and Offinso South in 2017 (EL-OS: *p*=<0.001***). Yields in Sefwi Wiawso and Offinso South only significantly differed in the year 2017, in which Sefwi Wiawso had higher yields than Offinso South (*p*=<0.001***).

Significant yield differences among the three years could only be found in Offinso South and Ejisu-Juaben (*p*=0.033**, respectively *p*=0.039**). In Ejisu-Juaben, yields were significantly higher in 2017 compared to 2015 (*p*=0.027**), and in Offinso South, yields were significantly higher in 2016 compared to 2017 (*p*=0.047**). All the post hoc tests for the pairwise comparison of the yields among districts and years can be found in Appendix VII.

4.2 OVERVIEW 'DROUGHT EXPOSURE EXPERIENCE AND PERCEPTION', 'FEASIBILITY' AND 'MOTIVATION'

The following Table 5 shows the distribution of the responses to the statements of each dimension: 'drought exposure, experience and perception', 'feasibility' and 'motivation'.

Table 5: Responses of the statements to 'drought exposure, experience and perception', 'feasibility' and 'motivation'

variable	N	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree
damages of drought in 2015	299	3.7%	7.7%	8.0%	18.1%	62.5%
damages of drought in 2016	300	11.3%	16.3%	19.0%	29.3%	24.0%
damages of drought in 2017	301	21.3%	19.3%	19.9%	12.0%	27.6%
drought management like ancestors	301	14.3%	6.0%	7.0%	10.0%	62.8%
helplessness	300	5.3%	3.3%	2.7%	4.0%	84.7%
interest in extension	299	0.7%	0.0%	0.0%	2.3%	97.0%
drought damages in future	295	4.7%	3.1%	11.2%	9.2%	71.9%
give up cocoa farming	301	74.8%	3.7%	4.7%	3.7%	13.3%
severeness of shock	300	3.0%	3.0%	16.0%	11.7%	66.3%
money	604	29.6%	10.8%	5.6%	20.2%	33.8%
time	604	0.8%	1.0%	0.8%	13.4%	83.9%
tools	603	22.9%	10.0%	4.6%	18.4%	44.1%
knowledge and information	603	17.7%	7.5%	11.6%	20.4%	42.8%
accessibility	604	13.7%	8.1%	10.6%	24.3%	43.2%
governmental support	604	63.9%	2.8%	2.3%	7.1%	23.8%
information from extension	604	51.2%	3.1%	3.8%	8.3%	33.6%
usefulness	603	12.8%	2.2%	1.3%	21.2%	62.5%
earning more money	603	5.1%	2.0%	2.8%	14.1%	76.0%
recommendation	603	47.1%	2.2%	2.0%	10.9%	37.8%
motivation	600	2.3%	0.3%	1.5%	18.7%	77.2%
satisfaction	602	1.3%	0.7%	0.8%	14.8%	82.4%
implementation on other farms	603	29.0%	7.6%	18.6%	9.1%	35.7%

All farmers in all districts stated that they already experienced drought in their lives. Looking at the last three years, the damages of drought were perceived as most severe in the year 2015, followed by the years 2016 and 2017. The majority of the farmers (84.7%) strongly agreed on the statement that droughts make them feel helpless, and 66.3% of the farmers perceived drought as the most devastating shock event that happens to their farms. Most of the interviewed farmers (62.8%) indicated that they manage drought in the same way as their ancestors did, but after all, some 97% of the farmers recognized that they would highly appreciate information from extension services on measures that help them minimizing the adverse effects of drought. Of the interviewed farmers, 71.9% strongly believed that the damages of drought will increase in future, and 74.8% indicated that they would not switch to other crops – or give up cocoa farming – if the damages of drought increase.

The response pattern of the 'feasibility' statements showed a greater variation. The only statement that was responded very similar for all AMs was the variable of 'time'. For 83.9% of the AMs, the interviewed farmers strongly agreed that they have the time needed to optimally implement them. For 29.6% of the AMs, farmers strongly disagreed to possess the money needed for their optimal implementation, while for 33.8% of the AMs, they strongly agreed to possess the money needed for the optimal implementation. A similar response pattern could be found for the variables 'tools' and 'knowledge and information'. For about 40% of the AMs, farmers strongly agreed to possess all tools needed and all knowledge and information required for the optimal implementation and for about 20% of the AMs, they strongly disagreed to possess the tools and the required knowledge and information. For 43.2% of the AMs, farmers strongly agreed to have access to all inputs and resources needed to optimally implement the AM and only for 13.7% of the AMs, they strongly disagreed to have access to all inputs and resources. A similar response pattern could also be found for the variables 'governmental support' and 'information form extension'. For over 50% of the AMs, farmers strongly disagreed to receive governmental support and information from extension services about an optimal implementation, while they strongly agreed to receive governmental support and information form extension services for 23.8%, respectively 33.6%, of the AMs.

The response patterns for the 'motivation' statements were similar for the variables 'earning more money', 'motivation' and 'satisfaction'. For the majority of the AMs farmers strongly agreed that they can earn more money if the AMs are optimally implemented (76%), they stated to be highly motivated to implement the AMs (77.2%) and furthermore very satisfied if the AMs were implemented (82.4%). Farmers perceived 62.5% of the AMs as very useful to minimize the adverse effects of drought and only 12.8% as not useful. In 37.8% of the cases, farmers stated that they strongly recommend to other farmers to implement the respective AM, while in 47.1% of the cases, they stated that they do not recommend at all to other farmers to implement the AMs. In 35.7% of the cases, farmers strongly agreed that the AMs are implemented on other farms, while they were ambivalent in 18.6% of the cases and strongly disagreed in 29% of the cases.

The pairwise comparisons of the single questions of each dimension between the districts and between the AMs can be found in Appendix VIII. These results will not be presented here: the districts and AMs will be compared among each other using the components of each dimension that result from the PCA.

4.3 PRINCIPAL COMPONENT ANALYSIS

The following Table 6 shows the component loadings of the respective variables to each dimension of the model. No striking differences in explained variance or internal reliability (Cronbach's alpha) between the 'feasibility' and the 'motivation' component calculated based on all AMs and the components calculated for each AM separately could be found (see Appendix IX). Therefore, only the component scores[2] (calculated based on the component loadings) built on all AMs were used for the analysis. The farmer-specific 'drought exposure, experience and perception component', the AM- specific 'feasibility component' and the AM-specific 'motivation component' will from now on only be called 'drought component' 'feasibility component' and 'motivation component'. In

[2] Component scores are equal to factor scores used in EFA, but for PCA

the ‘drought component’, the variables ‘drought management like ancestors’, ‘interest in extension’ and ‘give up cocoa farming’ had to be excluded and in the ‘feasibility component’, the variable ‘time’. No variables had to be excluded from the ‘motivation component’.

Table 6: PCA for all three dimensions

drought component		feasibility component		motivation component	
variable	component loadings	variable	component loadings	variable	component loadings
damages of drought 2015	0.482	money	0.782	usefulness	0.392
damages of drought 2016	0.785	tools	0.855	earning more money	0.475
damages of drought 2017	0.630	knowledge and information	0.650	recommendation	0.528
helplessness	0.681	accessibility	0.767	motivation	0.840
drought damages in future	0.351	governmental support	0.431	satisfaction	0.833
severeness of shock	0.402	information from extension	0.545	implementation on other farms	0.392
KMO value	0.612	**KMO value**	0.691	**KMO value**	0.598
explained variance	33.3%	**explained variance**	47.3%	**explained variance**	36.8%
Cronbach’s alpha	0.591	**Cronbach’s alpha**	0.762	**Cronbach’s alpha**	0.529

Note: ‘drought component’ built with N=302; ‘feasibility component’ built with N=604; ‘motivation component’ built with N=604

4.4 COMPARING ‘DROUGHT EXPOSURE, EXPERIENCE AND PERCEPTION’

Figure 6 shows the component scores of the ‘drought component’ among the different districts. A K-W Test showed that there are significant differences in mean ranks among the districts (*Chi-Square*=287, *p*=0.001***). Post hoc tests only showed significant differences between the districts Sefwi Wiawso and Offinso South. The component scores of the ‘drought component’ were significantly lower in Offinso South compared to Sefwi Wiawso (*z*=52.78, *p*=0.001***). The post hoc pairwise comparison can be found in Appendix X.

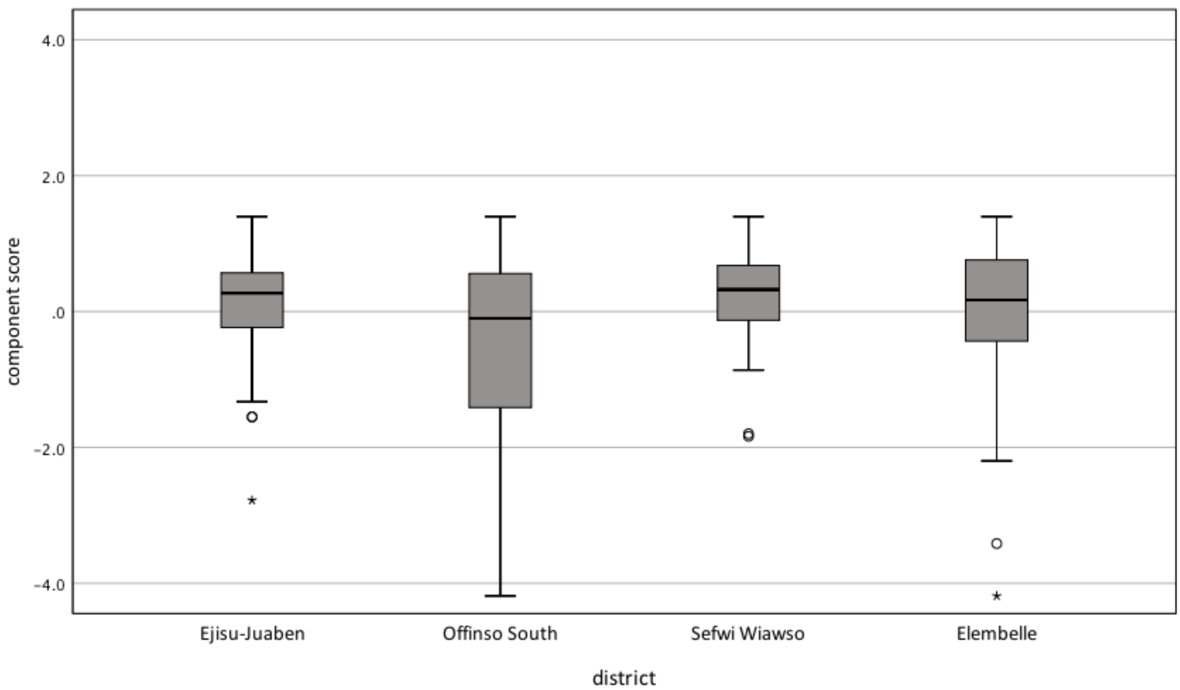

Figure 7: Component scores of the ‘drought component’ among the different districts (N=302)

4.5 COMPARING 'FEASIBILITY' AND 'MOTIVATION'

In the following section, 'feasibility' and 'motivation' will first be compared generally among the different districts and then for each AM separately. In a last part, the 'feasibility' and the 'motivation' will be compared among the different AMs.

4.5.1 'FEASIBILITY' AND 'MOTIVATION' AMONG THE DISTRICTS

Figure 7 shows the component scores of 'feasibility' and 'motivation' among the different districts. The component scores of 'feasibility' and 'motivation' within one district only significantly differed in Ejisu-Juaben, where the perceived 'motivation' was higher than the perceived 'feasibility' (Wilcoxon Signed Ranks Test: *z*=-3.38, *p*=0.001***).

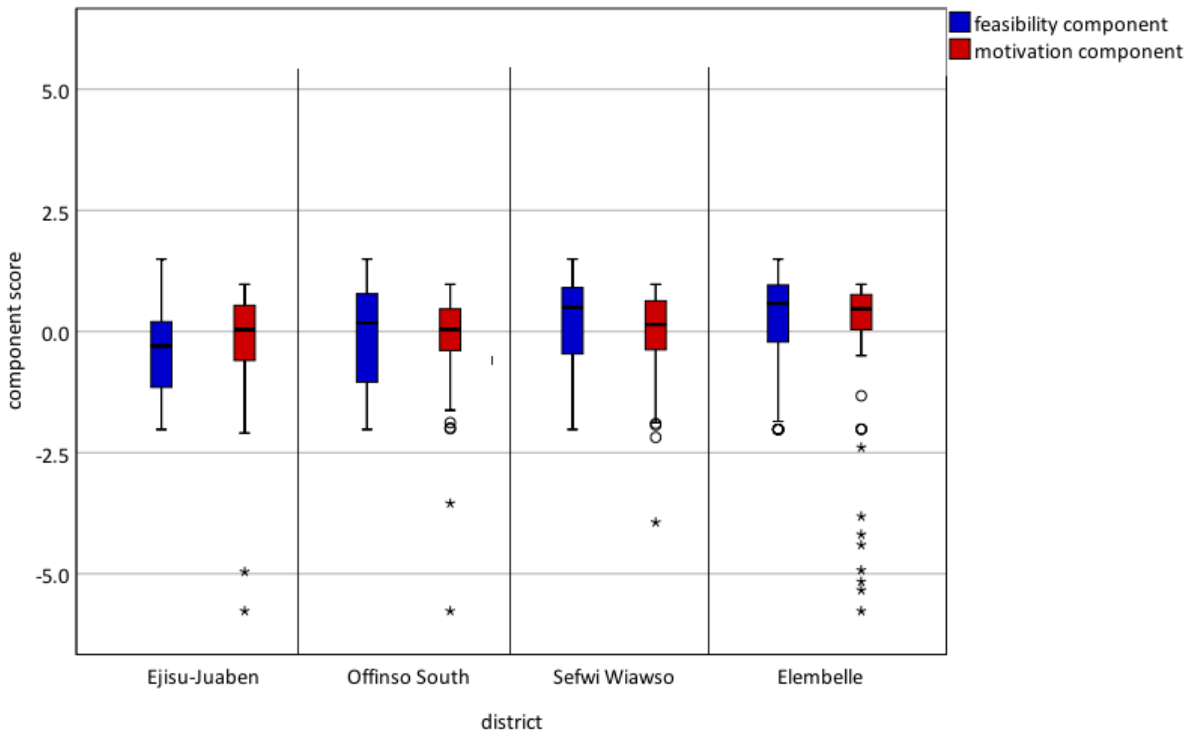

Figure 8: Component scores of 'feasibility' and 'motivation' among the districts (N=604)

A K-W Test showed that there are significant differences in the mean ranks of the component scores of 'feasibility' and 'motivation' between the different districts (*Chi-Square*=52.29, *p*=<0.001***; *Chi-Square*=31.30, *p*=<0.001***). Post hoc tests showed that the 'feasibility' in the district Ejisu- Juaben was significantly lower than in all other districts: Offinso South, Sefwi Wiawso and Elembelle (*z*=-71.86, *p*=0.002***; *z*=-115.89, *p*=<0.001***; *z*=-136.05, *p*=<0.001***). Furthermore, they showed that the district Offinso South had a lower 'feasibility' than Elembelle (*z*=64.18, *p*=0.008***).

The 'motivation' only significantly differed between the district Elembelle compared to the other three districts. Elembelle had a significantly higher 'motivation' than Ejisu-Juaben, Offinso South and Sefwi Wiawso (*z*=-103.56, *p*=<0.001***; *z*=90.11, *p*=<0.001***; *z*=63.44, *p*=0.008***). The post hoc pairwise comparison can be found in Appendix XI.

4.5.2 'FEASIBILITY' AND 'MOTIVATION' AMONG THE DISTRICTS FOR EACH AM SEPARATELY

The following part compares the component scores of 'feasibility' and 'motivation' among the districts for each of the five AMs separately.

4.5.2.1 AM1 'IRRIGATION TECHNOLOGIES'

Figure 8 shows the component scores of 'feasibility' and 'motivation' of the AM1 among the different districts. The component scores of 'feasibility' and 'motivation' differed within all districts. The perceived 'motivation' of the AM1 was significantly higher than the perceived 'feasibility' of the AM1 in Ejisu-Juaben (Wilcoxon Signed Ranks Test: z=-4.623, p=<0.001***), in Offinso South (Wilcoxon Signed Ranks Test: z=-4.511, p=<0.001***), in Sefwi Wiawso (Wilcoxon Signed Ranks Test: z=-4.843, p=<0.001***) and in Elembelle (Wilcoxon Signed Ranks Test: z=-4.228, p=<0.001***).

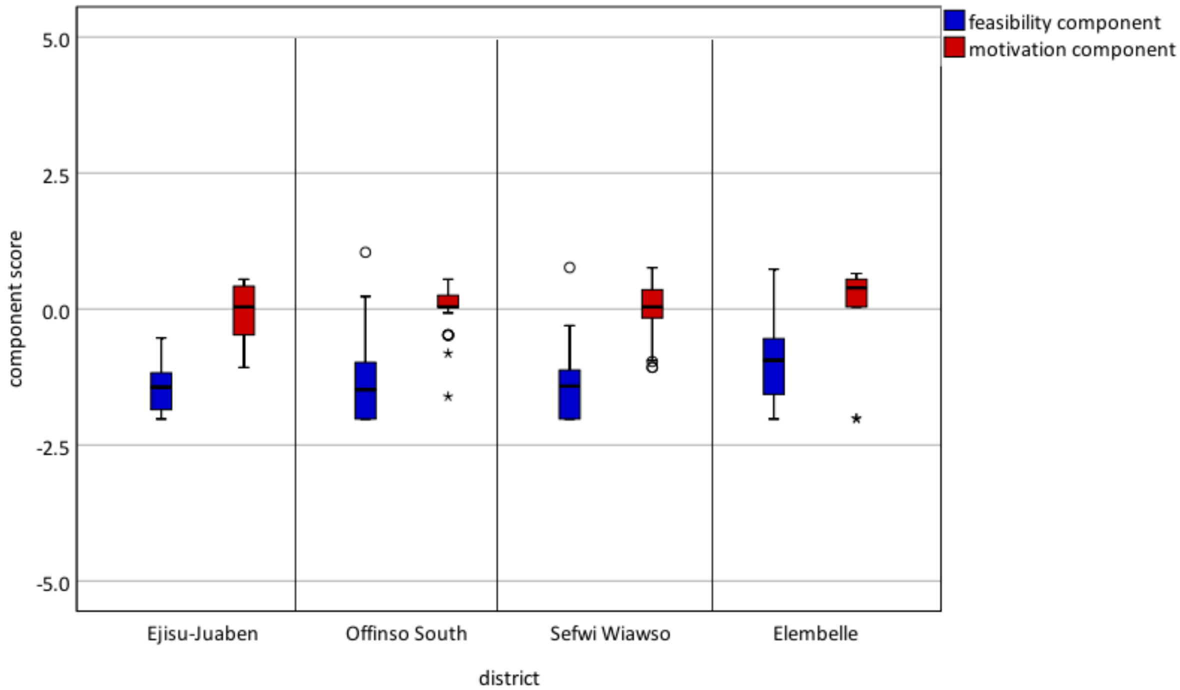

Figure 9: Component scores of 'feasibility' and 'motivation' of AM1 among the districts (n=121)

A K-W Test showed no significant differences between the districts regarding 'feasibility' component scores of AM1 but showed significant differences of the 'motivation' component scores between the different districts (*Chi-Square*=10.286, p=0.016**). In Elembelle, farmers had significantly higher 'motivation' for the AM1 compared to Ejisu-Juaben (z=-25.868, p=0.022**).

4.5.2.2 AM2 'SHADE TREES'

Figure 9 shows the component scores of 'feasibility' and 'motivation' of the AM2 among the different districts. The component scores of 'feasibility' and 'motivation' differed only within the districts Ejisu-Juaben and Offinso South. The perceived 'motivation' of the AM2 was significantly higher than the perceived 'feasibility' of the AM2 in Ejisu-Juaben (Wilcoxon Signed Ranks Test: z=-3.016, p=0.003***) and in Offinso South (Wilcoxon Signed Ranks Test: z=-2.599, p=0.009***).

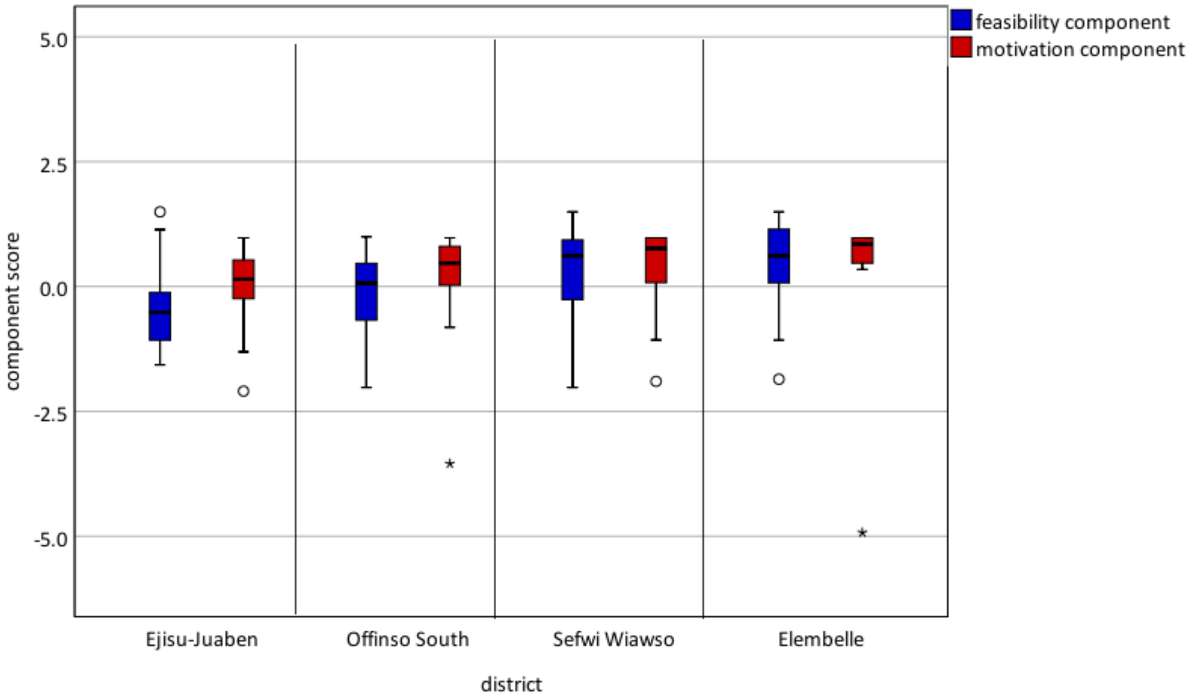

Figure 10: Component scores of 'feasibility' and 'motivation' of AM2 among the district (n=120)

A K-W Test showed significant differences between the districts regarding the 'feasibility', as well as the 'motivation' of AM2 (*Chi-Square*=23.848, p=<0.001***; *Chi-Square*=22.613, p=<0.001***). Post hoc tests showed that both, 'feasibility' and 'motivation' were significantly higher in Elembelle compared to Ejisu-Juaben and Offinso South (z=-41.617, p=<0.001***; z=24.283, p=0.042**; z=- 40.890, p=<0.001***; z=24.569, p=0.036**). Furthermore, the 'feasibility' and the 'motivation' were significantly higher in Sefwi Wiawso compared to Ejisu-Juaben (z=-32.482, p=0.002***; z=-29.780, p=0.005***).

4.5.2.3 AM3 ‘FIRE BELTS’

Figure 10 shows the component scores of ‘feasibility’ and ‘motivation’ of the AM3 among the different districts. The ‘feasibility’ and ‘motivation’ differed only within the districts Offinso South and Sefwi Wiawso. The perceived ‘feasibility’ of the AM3 was significantly higher than the perceived ‘motivation’ of the AM3 in Offinso South (Wilcoxon Signed Ranks Test: z=-2.097, p=0.036**) and in Sefwi Wiawso (Wilcoxon Signed Ranks Test: z=-3.945, p=<0.001***).

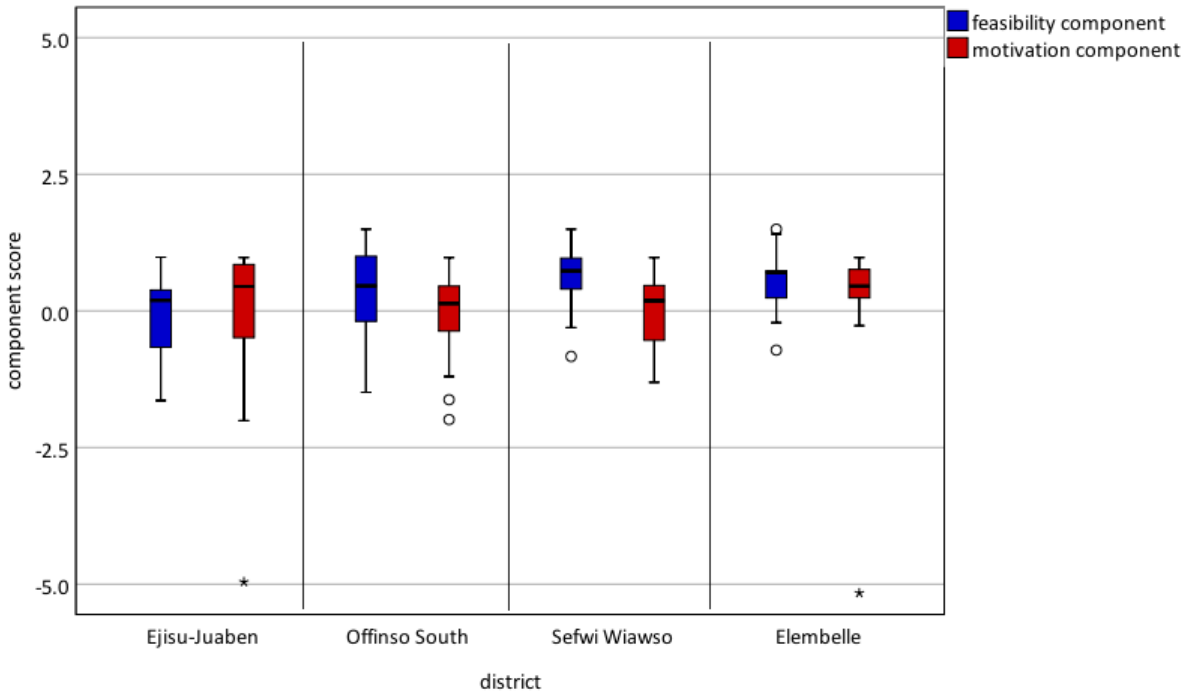

Figure 11: Component scores of ‘feasibility’ and ‘motivation’ of AM3 among the districts (n=121)

A K-W Test showed significant differences between the districts regarding the ‘feasibility’ of AM3 (*Chi-Square*=19.520, p=<0.001***) but no significant differences regarding the ‘motivation’. Post hoc tests showed that the districts Elembelle and Sefwi Wiawso had a significantly higher ‘feasibility’ compared to Ejisu-Juaben (z=-31.652, p=0.003***; z=-37.652, p=<0.001***).

4.5.2.4 AM4 'KEEPING RECORDS ON INCOME AND EXPENDITURES'

Figure 11 shows the component scores of 'feasibility' and 'motivation' of the AM4 among the different districts. The component scores of 'feasibility' and 'motivation' differed within the districts Ejisu-Juaben, Sefwi Wiawso and Elembelle. The perceived 'feasibility' of the AM4 was significantly higher than the perceived 'motivation' of the AM4 in Ejisu-Juaben (Wilcoxon Signed Ranks Test: *z*=-2.141, *p*=0.032**), in Sefwi Wiawso (Wilcoxon Signed Ranks Test: *z*=-4.488, *p*=<0.001***) and in Elembelle (Wilcoxon Signed Ranks Test: *z*=-4.547, *p*=<0.001***).

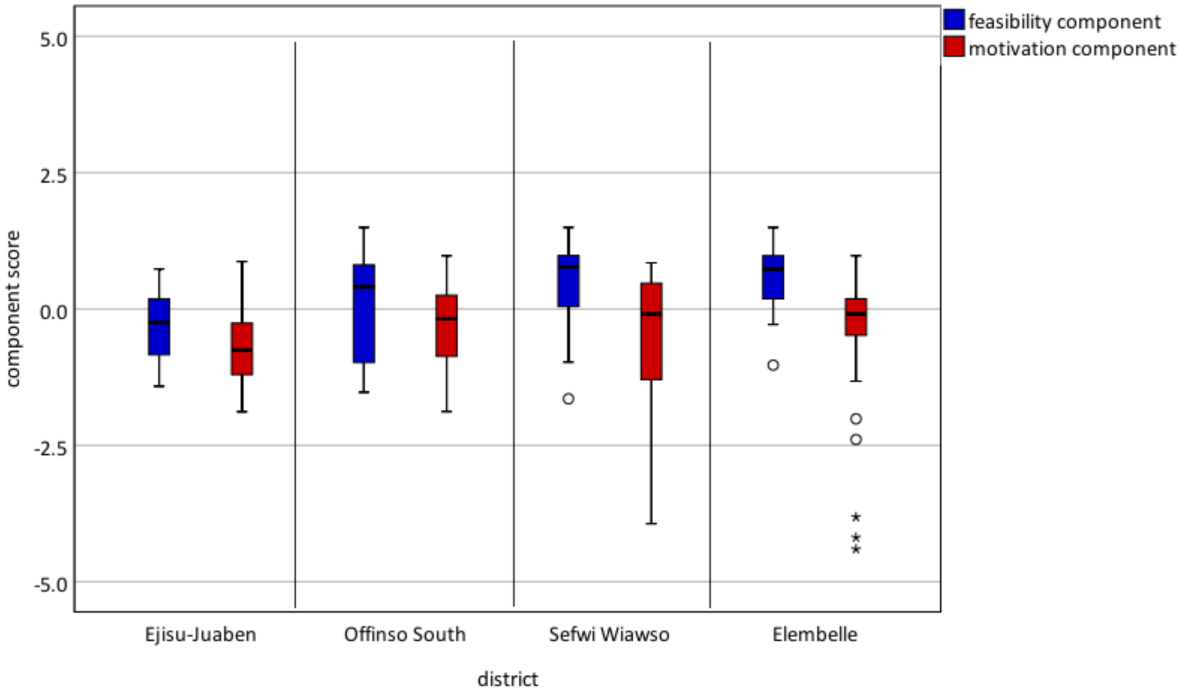

Figure 12: Component scores of 'feasibility' and 'motivation' of AM4 among the districts (n=121)

A K-W Test showed significant differences between the districts regarding 'feasibility' of AM4 (*Chi-Square*=25.289, *p*=<0.001***) but no significant differences regarding 'motivation'. Post hoc tests showed that the districts Elembelle and Sefwi Wiawso had significantly higher 'feasibility' component scores compared to Ejisu-Juaben (*z*=-41.940, *p*=<0.001***; *z*=-36.234, *p*=<0.001***).

4.5.2.5 AM5 ‘MULCHING’

Figure 12 shows the component scores of ‘feasibility’ and ‘motivation’ of the AM5 among the different districts. The component scores of ‘feasibility’ and ‘motivation’ differed only within the districts Offinso South and Sefwi Wiawso. The perceived ‘feasibility’ of the AM5 was significantly higher than the perceived ‘motivation’ of the AM5 in Offinso South (Wilcoxon Signed Ranks Test: *z*=-4.444, *p*=<0.001***) and in Sefwi Wiawso (Wilcoxon Signed Ranks Test: *z*=-2.881, *p*=0.004***).

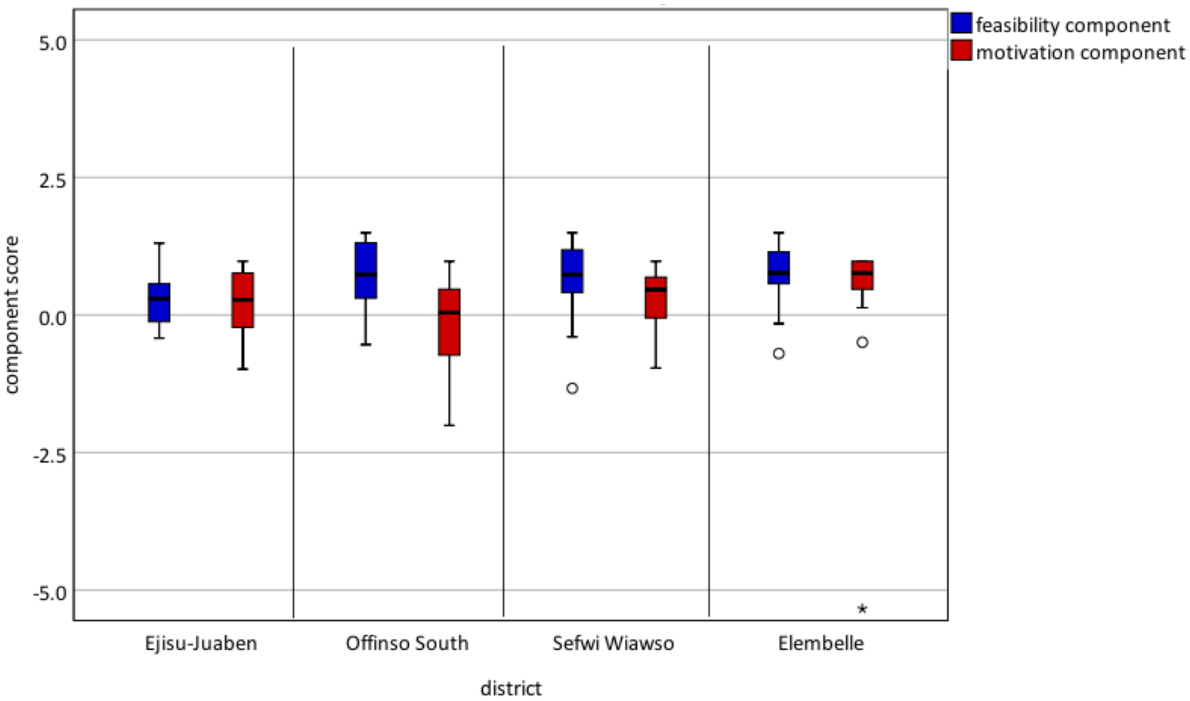

Figure 13: Component scores of ‘feasibility’ and ‘motivation’ of AM5 among the districts (n=121)

A K-W Test showed significant differences between the districts regarding the ‘feasibility’ of AM5, as well as the ‘motivation’ (*Chi-Square*=17.660, *p*=0.001***; *Chi-Square*=19.294, *p*=<0.001***). Post hoc tests showed that the ‘feasibility’ was significantly higher in Offinso South, Sefwi Wiawso and Elembelle compared to Ejisu-Juaben (*z*=-27.039, *p*=0.018**; *z*=-30.449, *p*=0.004***; *z*=-34.839, *p*=0.001***). The ‘motivation’ was significantly higher in Elembelle compared to Ejisu-Juaben and Offinso South (*z*=-23.968, *p*=0.045**; *z*=38.474, *p*=<0.001***). All post hoc pairwise comparisons can be found in Appendix XII.

4.5.3 'FEASIBILITY' AND 'MOTIVATION' AMONG THE AMs

Figure 13 shows the component scores of 'feasibility' and 'motivation' for each AM. The component scores for 'feasibility' and 'motivation' significantly differed from each other within each AM. For 'irrigation technologies' and 'shade trees', the 'motivation' was significantly higher than the 'feasibility' (Wilcoxon Signed Ranks Test: *z*=-9.08, *p*=<0.001***; *z*=-3.91, *p*=<0.001***) and for 'fire belts', 'keeping records on income and expenditures' and 'mulching' significantly lower than the 'feasibility' (Wilcoxon Signed Ranks Test: *z*=-3.48, *p*=0.001***; *z*=-6.71, *p*=<0.001***; *z*=-4.94, *p*=<0.001***).

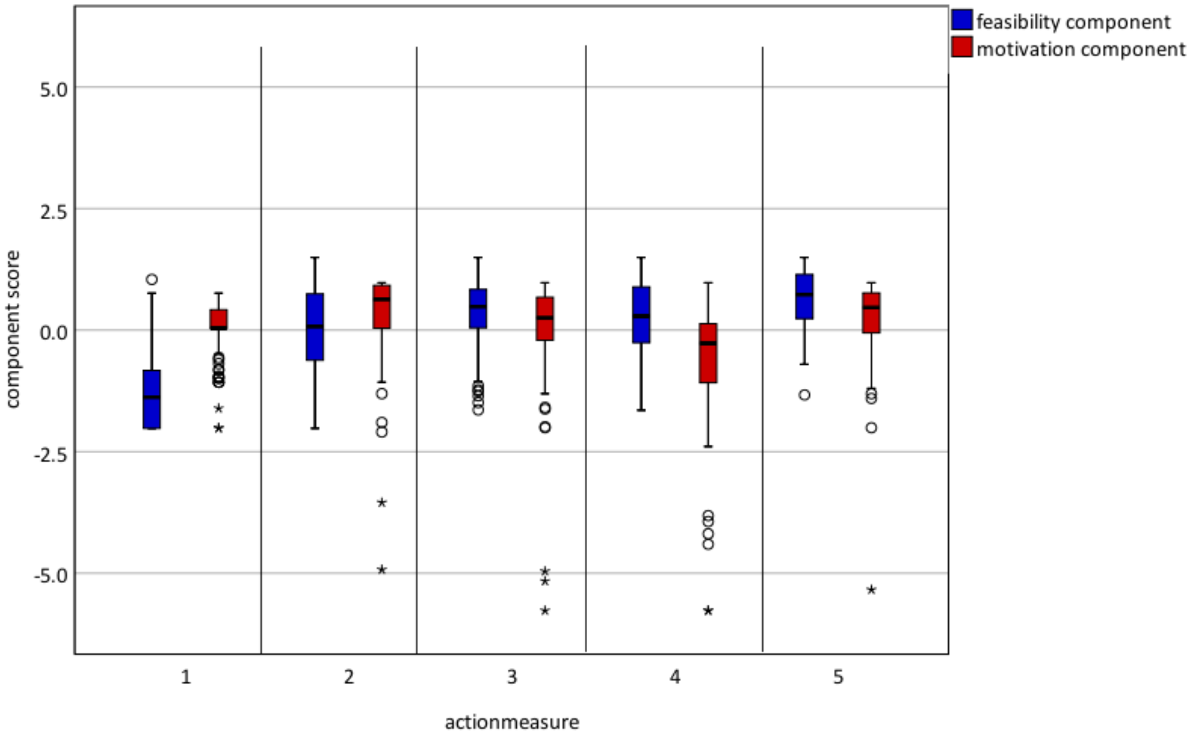

Figure 14: Component scores of 'feasibility' and 'motivation' among the AMs (N=604)

A K-W Test showed significant differences in mean ranks of the 'feasibility' and 'motivation' component scores among the different AMs (*Chi-Square*=231.0, *p*=<0.001***; *Chi-Square*=87.24, *p*=<0.001***). Post hoc tests showed that 'irrigation technologies' had a significantly lower 'feasibility' than the other four AMs (AM1-AM2: *z*=-203.70, *p*=<0.001***; AM1-AM3: *z*=-265.10, *p*=<0.001***; AM1-AM4: *z*=-241.19, *p*=<0.001***), and 'mulching' had a significantly higher 'feasibility' compared 'shade trees' and 'keeping records on income and expenditures' (AM5-AM2: *z*=-107.14, *p*=<0.001***; AM5-AM4: *z*=-69.65, *p*=<0.001***).

The 'motivation' was significantly higher for 'shade trees' compared to the 'irrigation technologies', 'fire belts' and 'keeping records on income and expenditures' (*z*=-122.18, *p*=<0.001***; *z*=70.23, *p*=0.017**; *z*=189.10, *p*=<0.001***) and significantly higher for 'mulching' compared to 'irrigation technologies' and 'keeping records on income and expenditures' (*z*=-80.34, *p*=0.003***; *z*=- 148.12, *p*=<0.001***). Furthermore, the 'motivation' was significantly higher for the 'irrigation technologies' and 'fire belts' compared to 'keeping records on income and expenditures' (*z*=67.78, *p*=0.023**; *z*=119.73, *p*=<0.001***). The post hoc pairwise comparison for the component scores of the AM specific 'motivation' and 'feasibility' can be found in Appendix XII.

4.6 IMPLEMENTATION OF AMs

Table 7 shows the frequencies of implementation of the five assessed AMs. 'Irrigation technologies' (AM1) were implemented by 6.6% of the farmers, 'shade trees' (AM2) by 97.5% of the farmers, 'fire belts' (AM3) by 90.9% of the farmers, 'keeping records on income and expenditures' (AM4) by 33.9% of the farmers and 'mulching' (AM5) by 100% of the farmers.

Table 7: Frequency of implementation of AMs

	region										
	national		Ejisu-Juaben		Offinso South		Sefwi Wiawso		Elembelle		Pearson Chi-Square
variable	frequency n	valid percent	frequency n	valid percent	frequency n	valid percent	frequency n	valid percent	frequency n	valid percent	
AM1	8/121	6.6%	1/29	3.4%	5/31	16.1%	1/31	3.2%	1/30	3.3%	0.106
AM2	117/120	97.5%	28/29	96.6%	31/32	96.9%	31/31	100%	27/28	96.4%	0.781
AM3	110/121	90.9%	26/28	92.9%	26/31	83.9%	28/32	87.5%	30/30	100%	0.142
AM4	41/121	33.9%	5/28	17.9%	13/30	43.3%	16/32	50%	7/31	22.6%	0.020**
AM5	121/121	100%	28/28	100%	30/30	100%	32/32	100%	31/31	100%	-

** significant at 5% probability level, *** significant at p 1% probability level

Significant differences in the implementation of the AMs between the districts could only be found for the AM 'keeping records on income and expenditures'. However, after the Bonferroni correction of the a level, no significant differences could be found anymore. The respective post hoc test can be found in Appendix XIV.

Every AM has been tested separately to find out if farmers who implemented a certain AM had higher 'drought component' scores (experienced more drought) than farmers who did not implement the respective AM. No significant differences in 'drought exposure, experience and perception' could be found (AM1: U=258.0, p=0.152; AM2: U=149.50, p=0.782; AM3: U=440.50, p=0.401; AM4: U=1369.50, p=0.506; AM5: 100% implemented).

4.6.1 QUALITATIVE REASONS FOR IMPLEMENTATION/NO IMPLEMENTATION OF AMs

The qualitative answers have been coded into topics to reduce the data and facilitate the evaluation. The few farmers that had 'irrigation technologies' stated that they do it to minimize the adverse effects of drought and to keep the soil moist. The main reasons for not having 'irrigation technologies' were lack of money, lack of water resources, lack of knowledge or simply that it has never occurred to them to implement an 'irrigation technology', because it is not a usual practice to irrigate cocoa.

The majority of the farmers had 'shade trees' to provide shade and protect the cocoa form excessive sunlight, minimize the adverse effects of drought and keep the soil moist. Few mentioned that they have 'shade trees' to provide food and use the timber of the mature 'shade trees' for construction purposes. The very few farmers that did not have 'shade trees' on their farms stated that they either do not have access to shade tree seedlings or do not have 'shade trees' because they are competing with the cocoa trees for nutrients and water.

The main reasons for constructing 'fire belts' were preventing fire and airing the farm. The farmers that did not construct 'fire belts' either did not share any boundaries with fellow land or did not see the necessity of constructing 'fire belts'.

The farmers that kept records of income and expenditures did it to know the costs and the profit of their farm. Furthermore, they did it for planning purposes and to compare yields and profits among the years. The main mentioned reasons for not 'keeping records on income and expenditures' were lack of knowledge, the discouraging effect of seeing losses, not seeing the necessity of 'keeping records on income and expenditures' or that it has never occurred to them to do so.

All farmers practiced 'mulching', mainly to fertilize the soil, retain soil moisture and cool the soil, prevent weeds or because they do not know what else to do with the leaves that fall on the ground.

4.6.2 PERCEIVED OPTIMAL IMPLEMENTATION OF AMs

All farmers have been asked about the perceived optimal implementation of the respective AM using closed questions. Multiple responses per block of categories were possible.

4.6.2.1 PERCEIVED OPTIMAL IMPLEMENTATION OF 'IRRIGATION TECHNOLOGIES'

Figure 14 shows the percentage of responses of the categories of each block of perceived optimal 'irrigation technology'. The perceived optimal 'irrigation technology' was sprinkler irrigation, followed by manually with buckets or gallons and others. The most mentioned other technology was a pumping machine with pipes and attached hoses or sprinkler. The indicated optimal water source was a borehole followed by rivers or lakes. Farmers with access to a nearby river or lake that does not dry out during the dry season, usually preferred that water source over a borehole. The majority of farmers perceived an irregular irrigation (only during the dry season) on the whole farm as optimal.

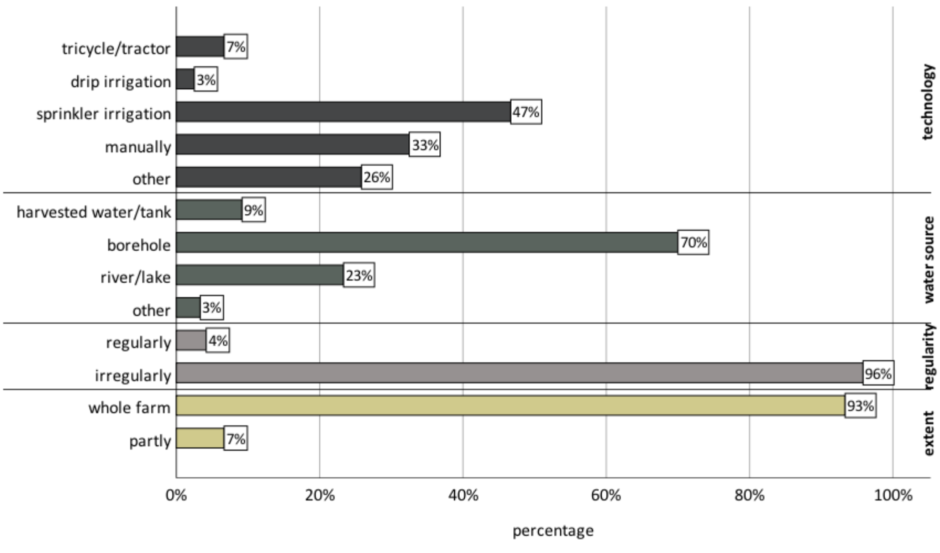

Figure 15: Perceived optimal implementation of AM1 (n=120)

4.6.2.2 PERCEIVED OPTIMAL IMPLEMENTATION OF 'SHADE TREES'

Figure 15 shows the percentage of responses of the categories of each block of perceived optimal configuration of 'shade trees'. Half of the farmers perceived over 19 shade trees/ha (>8 trees/acre) as optimal, while 30% perceived 14 to 19 shade trees/ha (6 to 8 trees/acre) as optimal. The majority saw timber trees and fruit trees as optimal or rather a multifunctional combination of at least two shade tree types. Some tree species can also fulfill different functions simultaneously, e.g. serving as medicinal trees and once mature as timber trees. More than half of the farmers (62%) thought that a combination of leaving trees during the land preparation and planting trees is the optimal establishment of 'shade trees', but after all, planting trees was perceived as better in comparison with leaving trees during the land preparation. All farmers thought that an even distribution of 'shade trees' is most beneficial.

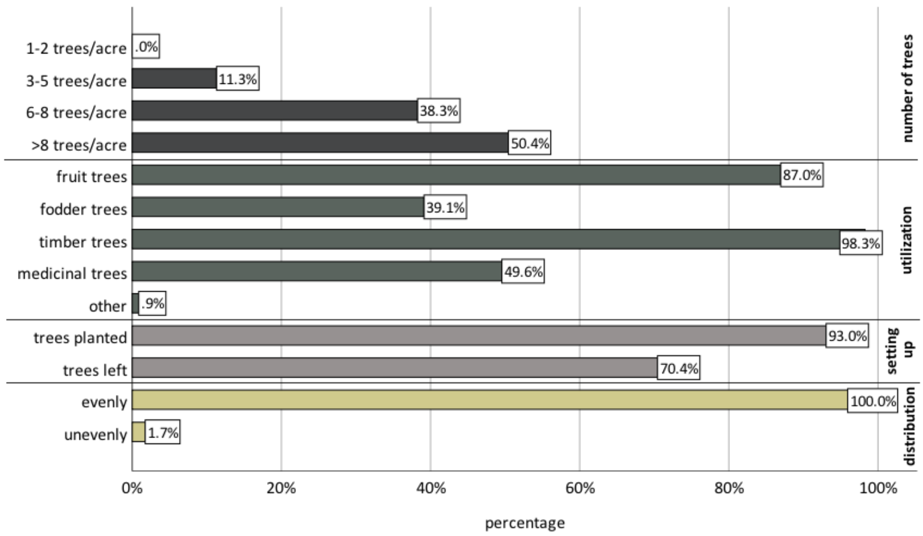

Figure 16: Perceived optimal implementation of AM2 (n=117)

4.6.2.3 PERCEIVED OPTIMAL IMPLEMENTATION OF 'FIRE BELTS'

Figure 16 shows the percentage of responses of the categories of each block of the perceived optimal 'fire belt'. 84% of the farmers indicated that an optimal 'fire belt' should encircle the whole farm. The ones that preferred a 'fire belt' only around part of the farm usually shared boundaries with other cocoa farmers, and therefore only saw the necessity of constructing 'fire belts' where their farm borders with fellow land or bush. Over 50% of the farmers perceived a 'fire belt' width of over 3 meters (>10 feet) as optimal and 24% of the farmers a width of under 1.5 meters (<5 feet). More farmers preferred constructing the 'fire belt' by themselves over a construction in collaboration with other farmers. Some did not tick anything because they stated that an optimal fire belt should be constructed by hired laborers.

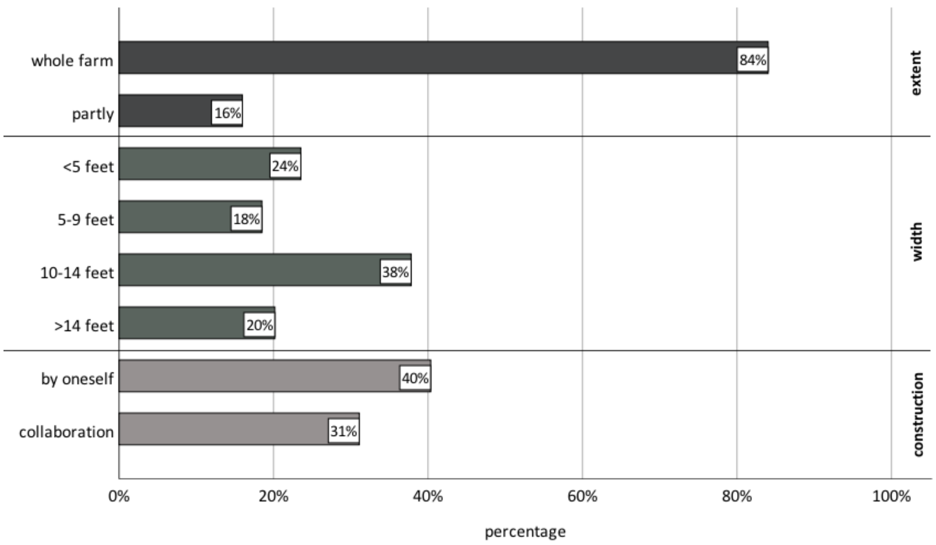

Figure 17: Perceived optimal implementation of AM3 (n=120)

4.6.2.4 PERCEIVED OPTIMAL IMPLEMENTATION OF ‘KEEPING RECORDS ON INCOME AND EXPENDITURES’

Figure 17 shows the percentage of responses of the categories of each block of the perceived optimal system to ‘keep records of income and expenditures’. About 63% of the farmers perceived keeping records on all mentioned categories (yields, revenues, input types, input amounts, input expenditures, labor costs, timing of input application, timing of harvest and calculation of profitability) as optimal. The most important categories seem to be records on yields, revenues, labor costs, timing of harvest and calculation of profitability. Almost all respondents stated that keeping records on paper/in a book is the optimal style.

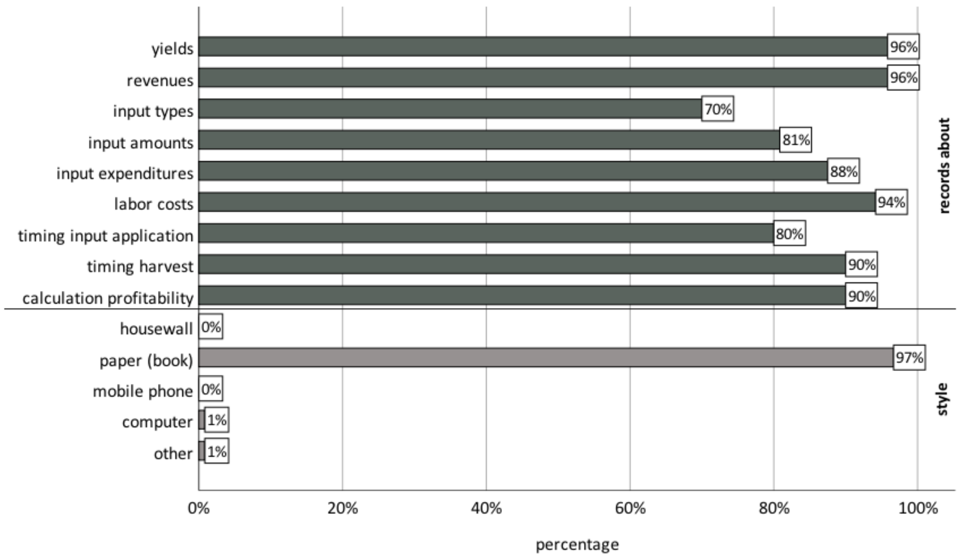

Figure 18: Perceived optimal implementation of AM4 (n=120)

4.6.2.5 PERCEIVED OPTIMAL IMPLEMENTATION OF ‘MULCHING’

Figure 18 shows the percentage of responses of the categories of each block of the perceived optimal ‘mulching’ system. 75% of the farmers stated that an optimal mulch should comprise cocoa leaves, prunings that are cut in smaller pieces and cocoa pods. In the category other mulching material poultry manure was the most mentioned material. The majority of the farmers perceived mulching on the whole farm and regularly turning the litter as optimal.

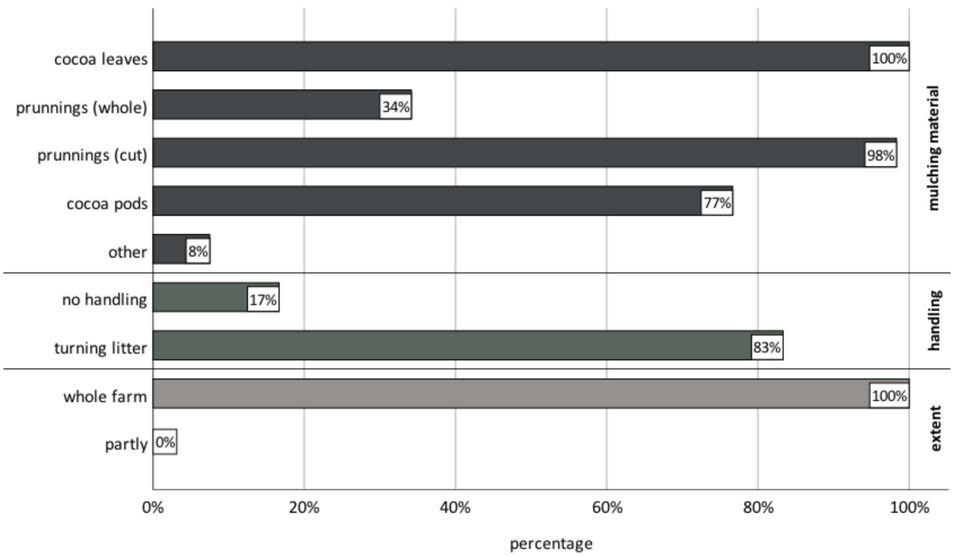

Figure 19: Perceived optimal implementation of AM5 (n=121)

4.6.3 PRIORITY OF AMs

As can be seen in Figure 19, the most prioritized AMs to minimize the adverse effects of drought were 'irrigation technologies', 'fire belts' and 'shade trees', followed by 'mulching' and the least prioritized AM was 'keeping records on income and expenditures'.

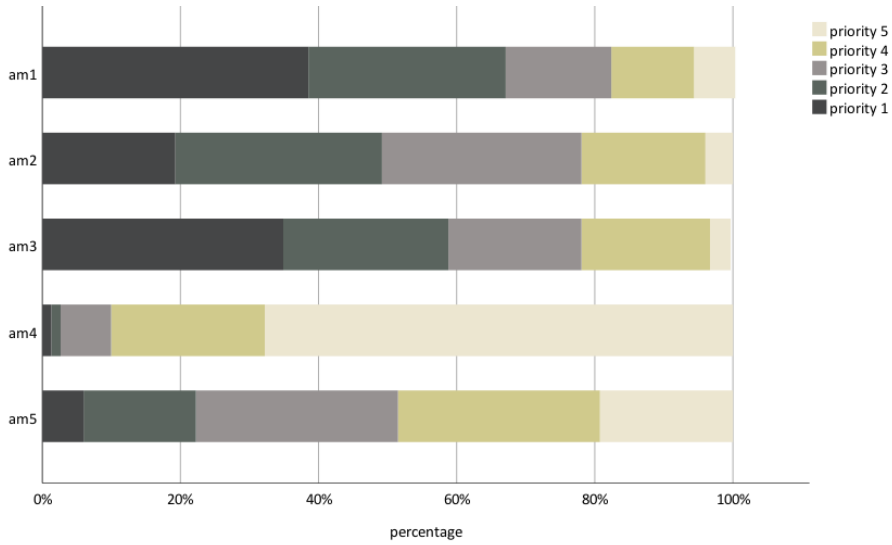

Figure 20: Priority of AMs (N=302)

4.6.4 OTHER AMs THAT ARE TAKEN TO MINIMIZE THE ADVERSE EFFECTS OF DROUGHT

Besides the AMs that were evaluated, few other measures to minimize the adverse effects of drought were taken. The following measures have been mentioned: avoid cooking on the farm in the dry season to prevent fire outbreaks; fill gallons with water to quench possible fire outbreaks; regularly visit farm in the dry season to check on possible fire outbreaks; stop weeding during the dry season; stop pruning during the dry season; weeding and pruning during the dry season to air the farm and maximize the effect of morning dew; weeding and leaving the weeds on the soil to retain water; inform other farmers when burning the farm to control the fire; reduction of bush burning.

4.7 BINARY LOGISTIC REGRESSION

The response variable of the binary regression models was the implementation of the AM, where 1=implemented and 0=not implemented. The used explanatory variables were the component scores of 'drought exposure, experience and perception', 'feasibility', 'motivation' and furthermore, socio-economic and -demographic variables. The explanatory variables were included in the regression in blocks, the first block comprised the socio-economic and -demographic variables and the second block the component scores of the three dimensions of the model. The regression was executed for each AM separately. No regression could be conducted for the AM5, since all interviewed farmers had it implemented. For the other four regression models, each variable is documented with coefficients (*B*), standard errors (*SE[B]*), the log odds (*Exp[B]*) and their 95% confidence interval, the test statistics of the Wald test (*W*), and the significance of the coefficients. Furthermore, the Lemeshow *p*-values, the Nagelkerke's pseudo-R^2 and the Omnibus Test of Model Coefficients are documented. The district Ejisu-Juaben was used as reference group to serve as the baseline category. In other words, the predictions for the other three districts were compared based on the district Ejisu- Juaben.

All the models were improved regarding Nagelkerke's pseudo-R2 by entering the 'drought component', the 'feasibility component' and the 'motivation component' as a second block (AM1: from 0.158 to 0.535; AM2: from 0.480 to 1.000; AM3: from 0.409 to 0.698; AM4: from 0.284 to 0.586). Furthermore, the Hosmer-Lemeshow goodness of fit test indicates that there is no evidence for poor fit in all the models (AM1: *p*=0.621; AM2: *p* =0.999; AM3: *p*=0.994; AM4: *p*=0.705). The models for 'shade trees', 'fire belts' and 'keeping records on income and expenditures' are significant (*Chi-Square*=27.360, *p*=0.026**; *Chi-Square*=40.772, *p*=<0.001***; *Chi-Square*=60.189, *p*=<0.001***), while the model for 'irrigation technologies' is not significant (*Chi-Square*=24.305, *p*=0.060). After all, significant variables explaining the implementation of AMs could only be found in the model for implementation of 'fire belts' and the model for implementation of 'keeping records on income and expenditures'.

Table 8 shows the regression for 'fire belts'. The regression explains 69.8% of the variance and, according to Cohen (1992), the effect size corresponds to a strong effect (*f*=0.97). The only significant predictor in explaining the implementation of 'fire belts' is the 'motivation component' (*p*=0.014**). The results show that the higher the 'motivation', the more likely is an implementation. If the 'motivation' is increased by 0.1 units, the probability of implementation of a 'fire belt' increases by 51.4%.

Table 8: Binary logistic regression for 'fire belts'

				95% confidence interval for Exp(B)			
predictor	*B*	*SE(B)*	*OR (Exp(B)*	*lower*	*upper*	*W*	*p*
area cocoa [ha]	-0.168	0.166	0.846	0.611	1.170	1.024	0.312
number farms [n]	-0.760	0.858	0.468	0.087	2.513	0.785	0.376
mean age farms [a]	-0.043	0.052	0.958	0.865	1.061	0.689	0.407
age of farmer [a]	-0.017	0.071	0.984	0.855	1.131	0.054	0.817
high education [no, yes]	16.828	14474.820	20336750.8	0.000	-	0.000	0.999
high income [no, yes]	2.756	31285.221	15.736	0.000	-	0.000	1.000
district						1.893	0.595
Elembelle	20.459	6290.367	767641445	0.000	-	0.000	0.997
Sefwi Wiawso	-3.415	2.854	0.033	0.000	8.837	1.432	0.231
Offinso South	-4.293	3.189	0.014	0.000	7.083	1.812	0.178
sex [male, female]	0.463	1.861	1.588	0.041	60.903	0.062	0.804
land ownership [no, yes]	-0.163	1.623	0.850	0.035	20.453	0.010	0.920
household size [n]	0.239	0.209	1.270	0.842	1.914	1.299	0.254
'feasibility' [score]	1.252	1.086	3.496	0.416	29.355	1.329	0.249
'motivation' [score]	1.816	0.740	6.147	1.442	26.201	6.026	0.014**
'drought' [score]	-0.183	0.665	0.833	0.226	3.067	0.076	0.783
constant	4.617	5.515	101.184			0.701	0.402
Summary statistics (block)	*chi²*	*df*	*p*				
Hosmer and Lemeshow	1.383	8	.994				
- log likelihood	24.454						
Nagelkerke's pseudo-R^2	.698						
Omnibus Test of Model	*chi²*	*df*	*p*				
Coefficients	40.772	15	<0.001***				

** significant at 5% probability level, *** significant at p 1% probability level

Note: n=101; implemented yes: n=91; implemented no: n=10

Table 9 shows the regression for 'keeping records of income and expenditures'. The regression explains 58.6% of the variance and the effect size corresponds to a strong effect (*f*=0.72). The significant predictors in explaining the implementation of 'keeping records on income and expenditures' are the 'feasibility component' and the 'motivation component' (*p*=<0.001***; *p*=0.021**). The results show that the higher the 'motivation' and the 'feasibility', the more likely is an implementation. If the 'feasibility' is increased by 0.1 units, the probability of implementation of 'keeping records on income and expenditures' increases by 95.1%, and if the 'motivation' is increased by 0.1 units, the probability of implementation increases by 17%. Thus, the likelihood of implementation is increased more by an increase in 'feasibility' than by an increase in 'motivation'.

Table 9: Binary logistic regression for 'keeping records on income and expenditures'

predictor	B	SE(B)	OR (Exp(B)	95% confidence interval for Exp(B) lower	upper	W	p
area cocoa [ha]	0.032	0.092	1.032	0.861	1.237	0.117	0.732
number farms [n]	0.214	0.373	1.239	0.597	2.572	0.330	0.566
mean age farms [a]	0.006	0.036	1.006	0.937	1.080	0.026	0.872
age of farmer [a]	0.014	0.036	1.014	0.945	1.089	0.156	0.692
high education [no, yes]	0.156	1.249	1.169	0.101	13.523	0.016	0.901
high income [no, yes]	0.567	1.285	1.762	0.142	21.864	0.194	0.659
district						5.114	0.164
Elembelle	-1.625	1.130	0.197	0.021	1.804	2.068	0.150
Sefwi Wiawso	0.063	0.959	1.065	0.163	6.974	0.004	0.948
Offinso South	0.815	1.274	2.258	0.186	27.454	0.409	0.523
sex [male, female]	-1.406	0.799	0.245	0.051	1.173	3.098	0.078
land ownership [no, yes]	-0.532	0.707	0.587	0.147	2.349	0.566	0.452
household size [n]	-0.022	0.033	0.978	0.917	1.043	0.462	0.496
'feasibility' [score]	2.352	0.667	10.511	2.842	38.869	12.430	<0.001***
'motivation' [score]	0.995	0.431	2.704	1.161	6.296	5.319	0.021**
'drought' [score]	0.188	0.381	1.207	0.572	2.546	0.244	0.621
constant	-3.540	2.592	0.029			1.866	0.172
Summary statistics (block)	*chi²*	*df*	*p*				
Hosmer and Lemeshow	5.484	8	.705				
- log likelihood	81.087						
Nagelkerke's pseudo-R^2	.586						
Omnibus Test of Model Coefficients	*chi²* 60.189	*df* 15	*p* <0.001***				

** significant at 5% probability level, *** significant at p 1% probability level

Note: n=108; implemented yes: n=39; implemented no: n=69

More details about the models with no significant predictors explaining the implementation, namely the models for 'irrigation technologies' and 'shade trees' can be found in Appendix XV.

4.8 WORKSHOPS

In the following section, a summary of the central messages of the workshops is provided. A more detailed overview of the results can be found in Appendix XVI.

4.8.1 COSTS AND BENEFITS

The indicated costs of implementation varied strongly between the AMs. 'Irrigation technologies' was considered to be by far the most expensive AM, while 'keeping records on income and expenditures' was considered to be the most cost-saving AM. The nature of the costs also varied between the AMs. While 'irrigation technologies' and 'shade trees' were considered as a one-time investment, the other AMs (AM3, AM4 and AM5) were associated with yearly recurring costs.

The farmers stated various benefits of the AMs. Farmers believed that 'irrigation technologies' increase yields and income, prevent the death of cocoa seedlings and cocoa trees, prevent or withstand possible fire outbreaks and provide food during the dry season. The benefits of 'shade trees' were believed to be the provision of shade, the prevention of soil erosion, the provision of food and medicines, the provision of additional household income and the provision of construction material. Furthermore, the farmers stated that 'shade trees' can help to cocoa to withstand drought. 'Fire belts' were stated to be beneficial in terms of preventing fire, aerating the farm, preventing black pod disease, and preventing rodents form entering the farm. 'Keeping records on income and expenditures' was stated to be beneficial to know the profit and the costs of the farm, to compare profit and costs among the years, and as motivation for the following cocoa season. 'Mulching' was believed to increase yields and furthermore to provide organic fertilizer, cool the soil, retain soil moisture, prevent soil erosion and suppress weeds. All AMs were considered to be very useful to minimize the adverse effects of drought and furthermore, to be very desirable.

4.8.2 OVERCOMING LIMITS AND BARRIERS

The discussed limits and barriers were: inadequate governmental support, inadequate information from extension services, lack of money and lack of examples where the AMs are implemented. The reasons for the existence of these limits and barriers can be summarized as follows: bureaucracy at governmental level and failure of the people in charge of distributing governmental farming inputs; lack of extension officers and low salaries for extension officers; irregular cocoa income (twice a year), lack of diversification, improper cocoa weighing scales and high household expenses; lack of money for implementation of 'irrigation technologies' and lack of knowledge for implementation of 'keeping records on income and expenditures'.

Different ideas for overcoming these limits and barriers at household and village level were mentioned, as for example: forming farmers groups and teaching each other about the implementation of AMs and hence, creating independency from government and extension officers; diversifying the income; taking out loans for the implementation of 'irrigation technologies'. Despite all these ideas, the farmers emphasized that it is very difficult to overcome these limits and barriers at household and village level, because there is a severe lack of money. The ideas what should be done at the district and governmental level to overcome the limits and barriers can be summarized as follows: providing loans with reduced interest rates; increasing governmental input supply and deliver it timely; supervision of the distribution of farming inputs; monitoring of uncertified farming inputs; training and employing more extension officers; training local farmers so they can function as local extension officers; increasing cocoa prices and subsidizing 'irrigation technologies'.

Figure 21: Workshop in Amoawi, Offinso South

5 DISCUSSION

The goal of this master thesis was to develop a model to assess the viability of action measures that enhance the resilience of a specific stakeholder to a shock, in this case the resilience of Ghanaian cocoa farmers to drought. This thesis aimed to answer the following research question:

WHAT ARE THE DIMENSIONS SHAPING THE VIABILITY OF ACTION MEASURES AND HOW DO GHANAIAN COCOA FARMERS IN DIFFERENT DISTRICTS PERCEIVE THESE DIMENSIONS FOR AMs THAT ARE DESIGNED TO ENHANCE THEIR RESILIENCE TO DROUGHT?

The following sections will discuss the main findings of the survey, starting with the perceived viability, moving on to relating the perceived viability to the implementation of the AMs, discussing the developed model and highlighting the limitations of the work. Following, the ideas to overcome limits and barriers obtained in the workshops will be discussed and in the last chapter, an outlook regarding further application of the developed model will be provided.

5.1 PERCEIVED VIABILITY

The perceived viability will be discussed starting with the dimension 'drought exposure, experience and perception' followed by the dimensions 'feasibility' and 'motivation'.

5.1.1 'DROUGHT EXPOSURE, EXPERIENCE AND PERCEPTION'

Farmers in all districts expect that the damages of drought increase in future, but do not plan in to give up cocoa farming if those damages increase. Furthermore, they all would like to receive information from extension services about measures that help to minimize the adverse effects of drought. It is interesting that Offinso South, the district that is located in the driest AEZ has lower 'drought component' scores than Sefwi Wiawso, a district located in a wetter AEZ (deciduous forest zone). This could have different reasons, as for example that the chosen villages in Offinso South were located on the border of the transitional zone with the deciduous forest zone and therefore the rainfall pattern does not differ much from the districts Ejisu-Juaben and Sefwi Wiawso (Antwi-Agyei et al., 2012, personal communication CHED [COCOBOD]). Another reason could be that drought exposure is only partly determined by the biophysical characteristics of the region where the farmer is located (van Duinen et al., 2015). Therefore, the nature of the single questions that contribute to the 'drought component' could have been decisive for the differences. The approval that droughts make you feel helpless was significantly lower in Offinso South (than Sefwi Wiawso and Elembelle) and so was the approval that drought is the most devastating shock event happening on the farm (lower than Elembelle). An explanation for this finding could be that drought events have a longer history (drier AEZ with lower rainfall) in Offinso South compared to the wetter regions Sefwi Wiawso and Elembelle and therefore farmers better know how to handle them, in other words perceive drought as more 'normal' (Dow, O'Connor, Yarnal, Carbone, & Jocoy, 2007). In Elembelle, drought probably is a rather new occurrence. Furthermore, Owusu and Waylen (2009) highlighted that the southwestern forest region is experiencing the largest proportional decrease in rainfall, which could be a reason why farmers in Elembelle feel very helpless and perceive drought as the most devastating shock event.

5.1.2 'FEASIBILITY' AND 'MOTIVATION'

The results strongly suggest that the farmers in the district Ejisu-Juaben perceive the lowest 'motivation' and 'feasibility' regarding the assessed AMs, and the farmers in the district Elembelle the highest 'motivation' and 'feasibility' regarding the assessed AMs. The districts Offinso South and Sefwi Wiawso were quite similar regarding both dimensions. These differences could have manifold reasons, like for example the socio-economic background and the farm productivity. Research shows that farm productivity in terms of yields and profit is likely to enhance the farmer's satisfaction (Gomez, Kelly, Syers, & Coughlan, 1996), which in return leads to motivation (Deci & Ryan, 1985; Sheldon & Elliot, 1999; Sheldon & Houser-Marko, 2001). The interviewed farmers in Elembelle stated to have the highest yields while farmers in Ejisu-Juaben indicated to have the lowest yields. This difference in yields was also reflected in the satisfaction with the performance of the farm, where farmers in Elembelle were more satisfied than farmers in Ejisu-Juaben. Furthermore, less farmers in Elembelle indicated to be in the lowest income category than in Ejisu-Juaben. The interviewed farmers in Elembelle were younger than the farmers in Ejisu-Juaben and more owned the land of their cocoa farms than they did in Ejisu-Juaben. This could be further factors that influence the 'motivation' as well as the 'feasibility' of AMs in the respective districts. Another aspect could be the effect of urban proximity. The selected villages in the district Ejisu-Juaben are located close to the urban centers Ejisu and Kumasi, while the selected villages in Elembelle are located in a rather remote area. In this case, it seems like if urban proximity could have a negative effect on the 'feasibility' as well as on the 'motivation' of cocoa farmers. Deichmann, Shilpi, and Vakis (2009) show in their study in Bangladesh, that farmers are more likely to pursue better-paid non-farm employment if they live closer to urban centers. Furthermore, research shows that urbanization affects the availability of agricultural land and consequently results in many farmers losing their farming land (Tacoli, 2003). Both trends can be observed in Ejisu-Juaben, where the attention is increasingly shifting away from cocoa farming to more profitable non-farm employments (personal communication CHED [COCOBOD]). However, the results of this survey showed no significant differences in share of household income coming from cocoa between Ejisu-Juaben and Elembelle. The potentially positive effects of urban/market proximity on agriculture, mainly on high-value horticulture (Danso, Drechsel, Wiafe-Antwi, & Gyiele, 2002; Tacoli, 2003) probably don't play such a key role for cocoa farming because of the strong government presence in the cocoa value chain in Ghana, the worldwide increasing cocoa demand (Kongor et al., 2017), and the consequently high acceptance guarantee in all regions. Another reason for the high 'feasibility' and 'motivation' observed in Elembelle could be the lower level of degradation and deforestation of the natural vegetation and the strong presence of NGOs in the district (personal communication CHED [COCOBOD]). Even though the district Elembelle has rather unsuitable soils for cocoa production, it is seen as an opportunity region for cocoa production (CCAFS, 2018).

When looking at the assessed AMs, the results show, that 'irrigation technologies' are perceived as having the lowest 'feasibility' and 'keeping records of income and expenditures' as having the lowest 'motivation'. This finding could clearly be observed in all the districts. The highest feasibility was perceived for the AM 'mulching' and the highest 'motivation' for the AMs 'shade trees' and 'mulching'. In the literature, irrigation technologies are acknowledged as possible measures for cocoa farmers to adapt to climate change, but in line with the findings of this thesis it is emphasized that there is a lack of money to adopt them (Stanturf et al., 2011). According to Carr and Lockwood (2011), irrigation technologies are a luxury that is not feasible for many farmers and will probably only be considered when other constraints and limiting factors in cocoa farming have already been addressed. This 'luxury' is though perceived by the interviewed farmers as having the highest priority to tackle the challenge of minimizing the adverse effects of drought. 'Keeping records on income and expenditures' on the other hand are perceived as having the lowest priority in terms of minimizing the adverse effects of drought. Muchira (2012) shows in a study about record keeping of micro and small enterprises in Kenya that the entrepreneurs are not motivated enough to do it, even though some are willing to learn about recordkeeping. In line with the qualitative findings of this thesis, the main reasons for not keeping records are: lack of knowledge, fear of discouragement in case of loss and not seeing the necessity of keeping records. These reasons could explain the low 'motivation' for 'keeping records on income and expenditures'. The high 'feasibility' and 'motivation' for 'mulching' can probably be attributed to the nature of the AM. Once the cocoa trees are mature, mulching can be done without much effort because mulching material is easily available in form of leaves and prunings. Unfortunately, this study didn't assess the perceived 'feasibility' and 'motivation' of bringing mulch to the young cocoa trees, the phase where mulching would be particularly beneficial but also most expensive (Carr & Lockwood, 2011; CCAFS, 2018).

5.2 IMPLEMENTATION AND VIABILITY OF AMs

Despite the differences in 'drought exposure, experience and perception', 'feasibility' and 'motivation' among the four districts, the AMs were not implemented significantly more often in one district compared to another, but some AMs were everywhere implemented more than at others. Furthermore, farmers who implemented a certain AM – irrespective of the district – did not have a higher 'drought exposure, experience and perception' than farmers who did not implement the AM. These findings suggest that the implementation of AMs is more a function of the nature of the respective AM (in terms of 'motivation' and 'feasibility') than a function of socio-economic and -demographic variables.

In all districts, the lowest implementation level was seen for 'irrigation technologies', followed by 'keeping records on income and expenditures'. 'Fire belts' and 'shade trees' were implemented with high frequencies and 'mulching' was implemented by all farmers. The implementation of AMs was used as a proxy to measure the perceived viability of AMs and thus, based on the findings of this thesis, it can be assumed that farmers perceive the AM 'mulching' as the most viable AM, followed by 'shade trees' and 'fire belts'. 'Irrigation technologies' and 'keeping records of income and expenditures' have a lower viability, which could be attributed to the low 'feasibility' for 'irrigation technologies' and the low 'motivation' for 'keeping records of income and expenditures'. The author thinks that external support would be needed in order to increase 'feasibility' and 'motivation' of the two previously mentioned AMs and hence, overcome limits and barriers of implementation.

5.3 VALIDATION OF THE DEVELOPED MODEL

The binary logistic regression was used to find out whether the three defined variables ('feasibility', 'motivation' and 'shock exposure, experience and perception') can be used to explain the implementation of AMs. In summary, it can be said that although not all AM regression models are significant, the dimensions 'feasibility' and 'motivation' show some significance and hence feature explanatory power. However, no direct effect of 'drought exposure, experience and perception' on the implementation of AMs could be found in this thesis and no conclusions can be drawn whether shock experience promotes or impedes the implementation of AMs. This finding is in line with Bryan et al. (2009) and Tucker, Eakin, and Castellanos (2010) who could neither find effects of a higher risk perception on the implementation of adaption measures to climate change. Both suggest that external factors, like lack of access to credit and land, are more crucial for the implementation.

In accordance with research about adaptation to climate change in Africa, this thesis found that 'feasibility' increases the likelihood of implementation of one AM ('keeping records on income and expenditures') (Below et al., 2012; Chambwera et al., 2014; Hassan & Nhemachena, 2008). 'Motivation' was found to increase the likelihood of implementation of two AMs ('fire belts' and 'keeping records on income and expenditures'). This finding regarding the importance of 'motivation' is in line with posits of literature, that socio-cognitive factors may be as or more important than socio- economic aspects in driving individuals to adaptive actions (Frank et al., 2011; Grothmann & Patt, 2005). However, it is interesting that the likelihood of implementation of the AM ‘keeping records on income and expenditures’ is increased more by ‘feasibility’ than ‘motivation’. The ‘motivation’ for ‘keeping records on income and expenditures’ is lower than its ‘feasibility’ and furthermore lower if compared to the other AMs. After all, ‘feasibility’ seems to be more crucial for determining if a farmer implements ‘keeping records on income and expenditures’ or not. One reason for this finding could be the importance of ‘knowledge and information’ as a prerequisite for ‘keeping records on income and expenditures’ (Muchira, 2012).

Coming to the limitations of this work, it is debatable if implementation is a good proxy for the viability of a certain AM to enhance resilience to a shock. It cannot be excluded that there are also other reasons leading to the implementation of a certain AM than enhancing resilience to a certain shock only. Furthermore, the used indicators to measure ‘motivation’ were developed based on western motivation theories and world views. More tailored indicators could possibly improve the quality of the survey. Convergence problems while trying to fit all the models into one, explaining the overall implementation, were another limitation of this work. For the single models, it was difficult to obtain significant results because of the small sample size and the distribution of the response variable. This research tried to reduce country-specific obstacles of language and translation by using visual scales for answering the questions. Nevertheless, differences in obtained responses for some variables could be found between the interpreters, which is a major limit of this research and could eventually have led to a bias of the results obtained in Elembelle, because one of the interpreters was only present there.

With lessons learnt from data analysis and empirical experiences in Ghana and in Ethiopia but also based on conceptual contexts, we[3] believe that the model should be adjusted for further research. Shock experience is not AM-related, thus it should be on the same level as socio-economic and - demographic indicators. In contrast, we recommend to emphasize more on the ‘usefulness’ aspect (in the model included in the dimension ‘motivation’). Deressa, Hassan, and Ringler (2011) emphasized the importance of perceived usefulness and profit for adoption of new farming practices. One proposes to use the four components of Tendall et al. (2015) which are (1) robustness, (2) redundancy, (3) flexibility & rapidity and (4) resourcefulness and adaptability as a starting point to design indicators for assessing the usefulness of AMs to enhance resilience to a certain shock. Given the circumstances, it is also believed that ‘motivation’ is the final essential element determining the behavior that leads to adaptation (Broussard & Garrison, 2004; Frank et al., 2011; Guay et al., 2010) and that ‘motivation’ in turn is premised on ‘feasibility’, ‘usefulness’ and ‘desirability’ of the respective AM (Geen, 1995; Gollwitzer, 1990; Sheeran, 2002). Therefore, the adjusted conceptual model is outlined in in Figure 20 as follows:

[3] Me and Luzian Messmer

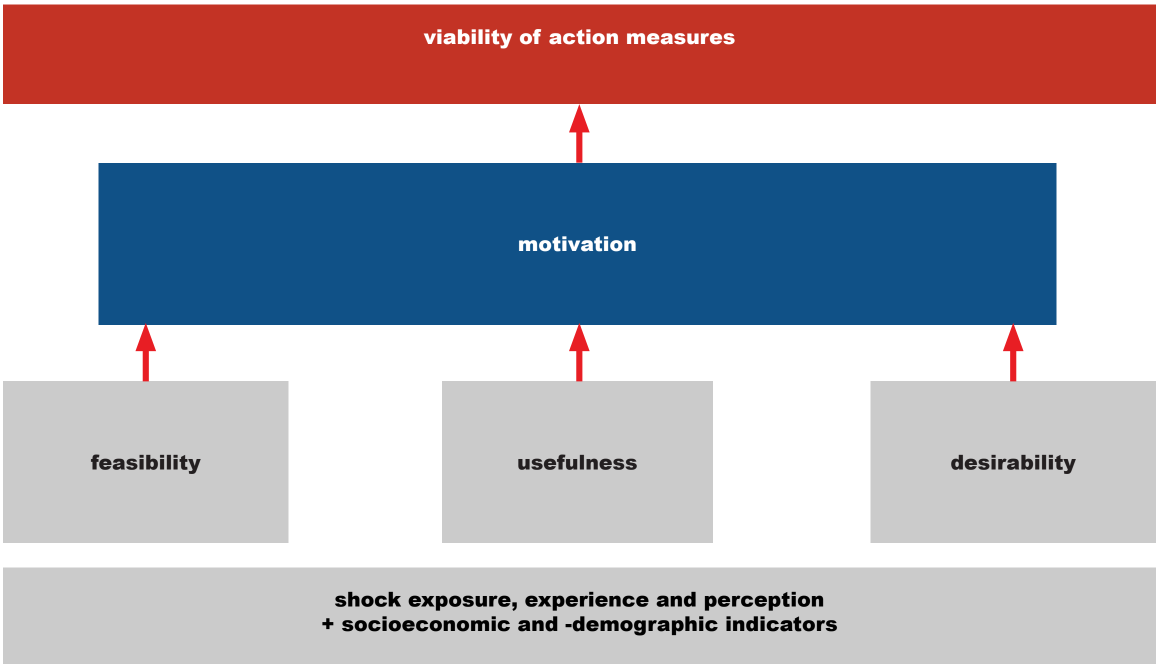

Figure 22: Adjusted conceptual model

5.4 OVERCOMING LIMITS AND BARRIERS OF IMPLEMENTATION

The main limits and barriers for the implementation of the assessed AMs were lack of 'money', lack of 'governmental support', lack of 'information from extension services' and lack of 'implementation on other farms', in other words, lack of peer pressure.

The ideas to overcome these limits and barriers of implementation that farmers came up with in the workshops are in line with several policy recommendations, like Nhemachena and Rashid (2008), who recommend that affordable access to credits and free access to sufficient extension services increase the likelihood that adaptation measures to climate change are adopted. Furthermore, they suggest that governments should disseminate and promote appropriate technologies, like irrigation technologies (Nhemachena & Rashid, 2008). Another suggested way to overcome the limits and barriers was building farmer groups and promoting a stronger collaboration between farmers. Källström and Ljung (2005) show that the motivation to implement farming practices is reinforced by social interactions and collaboration and highlight the importance that authorities foster collaborative learning. Last but not least, farmers mentioned that diversifying their income would help to overcome lack of money for the implementation of some AMs. Monastyrnaya et al. (2016) showed that the low diversification within the whole cocoa value chain in Ghana is one of the major issues that should be tackled to increase resilience.

5.5 OUTLOOK

Based on the findings of this master thesis, the author recommends that further research should be conducted on the drivers of behavioral change of stakeholders (e.g. farmers) within a food system and on the interactions between 'feasibility', 'usefulness' and 'desirability' in shaping the viability of AMs to enhance resilience. Furthermore, research should be conducted on how to measure viability beyond the economic viability in a more comprehensive way where the human dimension is put in the center of the attention. It was realized that it is not only difficult to measure resilience but also difficult to assess AMs designed to enhance resilience to a specific shock. The system boundaries are quite vague in terms of attributing a specific AM to a specific shock. It is hard to measure the effect of a specific shock on the decision-making of the stakeholder, because a stakeholder can have different incentives and reasons to implement a certain AM. The 'action measure assessment model' was developed in such a way that it could be applied for different food systems, different stakeholders and different shocks. Further studies need to gain deeper understanding regarding the applicability of the model to other food systems, other stakeholders and other shocks.

Figure 23: Cocoa beans in Ayawora, Elembelle

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7 APPENDICES

APPENDIX I

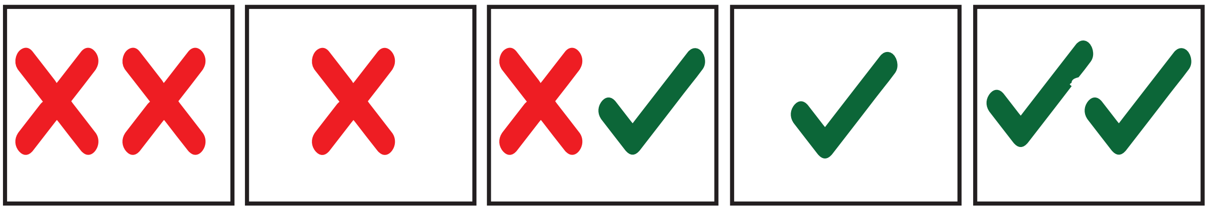

Figure 24: Visual Likert scale

APPENDIX II

Table 10: Balanced incomplete block design

block with 'feasibility' related questions first											block with 'motivation' related questions first									
12F	13F	14F	15F	23F	24F	25F	34F	35F	45F		12M	13M	14M	15M	23M	24M	25M	34M	35M	45M
AM1F	AM1F	AM1F	AM1F								AM1M	AM1M	AM1F	AM1M						
AM2F				AM2F	AM2F	AM2F					AM2M				AM2M	AM2M	AM2M			
	AM3F			AM3F			AM3F	AM3F				AM3M			AM3M			AM3M	AM3M	
		AM4F			AM4F		AM4F		AM4F				AM4M			AM4M		AM4M		AM4M
			AM5F			AM5F		AM5F	AM5F					AM5M			AM5M		AM5M	AM5M
#1	#2	#3	#4	#5	#6	#7	#8	#9	#10		#11	#12	#13	#14	15	16	17	18	19	20

The order of all the versions (1 to 20) has been randomized twice for the survey. Firstly, each version was brought into a random order forming a version block. This procedure was repeated 16 times and the generated blocks were then again ordered randomly. To make sure that every version (one questionnaire block) was used at least once in every village, a new randomized block of versions was started in every village.

Farmer_ID: Version_ S_{mno}: Date:

Assessing the perception of the viability of action measures to enhance the resilience of cocoa production

I'm a Swiss agronomy student working with the Kwame Nkrumah University of Science and Technology. We would like to talk with you about your farm and learn about your experiences with droughts. We would be very grateful if you could answer some questions and tell us your valuable opinion.
All your answers and your personality will be treated confidentially, and the results will not contain any information that can be used to identify you. However, if you agree we will write down your contact information in case some responses are unclear and also to invite you for a workshop in July. If you have any hesitations with regard to the interview you can contact my via email or phone.
Thank you very much, in advance, for your kind cooperation and patience.

Socioeconomic and Sociodemographic Questions

Age ______________ [years] [age]

Household size ______________ [#people] [hh_size]

Gender ☐ f ☐ m [sex]

What level of schooling did you complete? [edu]
- ☐ None
- ☐ Basic Education
- ☐ MSLC
- ☐ Secondary
- ☐ Tertiary
- ☐ No answer

Main form of land tenure [entit]
- ☐ Owning, I'm the caretaker
- ☐ Owning, I have a caretaker (abuna)
- ☐ Owning, I have a caretaker (abusa)
- ☐ Not owning, I'm the caretaker (abuna)
- ☐ Not owning, I'm the caretaker (abusa)

Number of cocoa farms ______________ [#farms]

Age of cocoa farms ______________ [years]
______________ [years]
______________ [years]

Total farm size (cocoa AND other crops) ______________ [acre] [f_size]

	0%-20%	21%-40%	40%-60%	61%-80%	81%-100%	
Land allocated to cocoa	☐	☐	☐	☐	☐	[crop]
Share of household income from cocoa farm	☐	☐	☐	☐	☐	[off_inc]

Label/Program ☐ yes, name ______________ ☐ no [label]

	<6'500	6'500-12'600	12'601-18'700	18'701-25'000	>25'000	no answer	
Level of household income [Cedi/year/household]	☐	☐	☐	☐	☐	☐	[hh_inc]

Farmer_ID:

Overall questions drought and motivation

		very bad	somewhat bad	neither good nor bad	somewhat good	very good		kg/total farm (1 bag=64kg)	
How was the yield compared to average years in...	2017	☐	☐	☐	☐	☐	[y_17]	______	[kg_17]
	2016	☐	☐	☐	☐	☐	[y_16]	______	[kg_16]
	2015	☐	☐	☐	☐	☐	[y_15]	______	[kg_15]

	yes	no	
Did you already experience droughts in your life?	☐	☐	[d_exp]

			strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
If yes	The damage of droughts on my farm was severe in...	in 2017	☐	☐	☐	☐	☐	[d_17]
		in 2016	☐	☐	☐	☐	☐	[d_16]
		in 2015	☐	☐	☐	☐	☐	[d_15]
	I manage droughts in the same way as my ancestors did.		☐	☐	☐	☐	☐	[anc]
	Droughts make me feel helpless.		☐	☐	☐	☐	☐	[help]
	I want to receive information from extension services about measures that help to minimize the adverse effects of droughts.		☐	☐	☐	☐	☐	[ext]

		strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I'm proud of being a cocoa farmer.		☐	☐	☐	☐	☐	[pr]
I'm satisfied with the performance of my farm.		☐	☐	☐	☐	☐	[per]
I'm regularly trying out new things (farming practices) on my farm.		☐	☐	☐	☐	☐	[adop]
The damages of droughts on my farm will increase in the next ten years.		☐	☐	☐	☐	☐	[dd_f]
If damages of droughts increase, I will switch from cocoa to other crops or give up farm.		☐	☐	☐	☐	☐	[give]
I think droughts are the most devastating shock events happening on my farm.		☐	☐	☐	☐	☐	[d_se]
The following attributes influence drought events...	Government failure	☐	☐	☐	☐	☐	[gov]
	Climate change	☐	☐	☐	☐	☐	[cc]
	Will of God	☐	☐	☐	☐	☐	[god]
	Coincidence	☐	☐	☐	☐	☐	[coin]

The farm measures that we will present you now, have been recommended from cocoa farmers of the regions Ejisu, Offinso, Wiawso and Juaboso. The result were 25 different measures and now we randomly picked two of them and would like to find out what you think about them.

Farmer_ID:

AM 1: Irrigation technologies

Present and explain the AM1 to the farmer, according to the card.

Do you irrigate/water your cocoa farm? yes ☐ no ☐ [imp1]

If yes

Why and since when do you irrigate/water your cocoa farm? [why1]

How does the irrigation/watering look like on your cocoa farm? [how1]

Technology:
- ☐ Tricycle/tractor with mounted tank
- ☐ Drip irrigation
- ☐ Sprinkler irrigation
- ☐ Manually (buckets/ gallons)
- ☐ other: ____________

Water source:
- ☐ Harvested water/ storage tank
- ☐ Borehole
- ☐ River/lake
- ☐ Other: __________

Extent:
- ☐ Whole farm
- ☐ Only partly

Which part? ______________

Regularity:
- ☐ Regularly during whole year
- ☐ Irregularly, only when rain doesn't fall

If you have the option, how would a perfect irrigation system look like on your cocoa farm? [opt_i1]

Technology:
- ☐ Tricycle/tractor with mounted tank
- ☐ Drip irrigation
- ☐ Sprinkler irrigation
- ☐ Manually (buckets/ gallons)
- ☐ other: ____________

Water source:
- ☐ Harvested water/ storage tank
- ☐ Borehole
- ☐ River/lake
- ☐ Other: __________

Extent:
- ☐ Whole farm
- ☐ Only partly

Which part? ______________

Regularity:
- ☐ Regularly during whole year
- ☐ Irregularly, only when rain doesn't fall

If no

Why don't you irrigate/water your cocoa farm? [whynot1]

If you have the option, how would a perfect irrigation system look like on your cocoa farm? [opt_ni1]

Technology:
- ☐ Tricycle/tractor with mounted tank
- ☐ Drip irrigation
- ☐ Sprinkler irrigation
- ☐ Manually (buckets/ gallons)
- ☐ other: ____________

Water source:
- ☐ Harvested water/ storage tank
- ☐ Borehole
- ☐ River/lake
- ☐ Other: __________

Extent:
- ☐ Whole farm
- ☐ Only partly

Which part? ______________

Regularity:
- ☐ Regularly during whole year
- ☐ Irregularly, only when rain doesn't fall

Farmer_ID:

All the following questions refer to the perfect irrigation system that you mentioned before.

Motivation

	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I think a perfect irrigation system is useful to minimize the adverse effects of droughts on my cocoa farm.	☐	☐	☐	☐	☐	[m1_1]
I can earn more money if a perfect irrigation system is implemented on my cocoa farm.	☐	☐	☐	☐	☐	[m1_2]
I often recommend to other cocoa farmers to implement a perfect irrigation system on their cocoa farms.	☐	☐	☐	☐	☐	[m1_3]
I'm motivated to implement a perfect irrigation system on my cocoa farm.	☐	☐	☐	☐	☐	[m1_4]
To see a perfect irrigation system on my cocoa farm gives me satisfaction.	☐	☐	☐	☐	☐	[m1_5]
Most cocoa farmers in my community have a perfect irrigation system on their cocoa farms.	☐	☐	☐	☐	☐	[m1_6]

Feasibility

	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I possess the money needed to implement a perfect irrigation system on my cocoa farm.	☐	☐	☐	☐	☐	[f1_1]
I have the time needed to implement a perfect irrigation system on my cocoa farm.	☐	☐	☐	☐	☐	[f1_2]
I possess all tools needed to implement a perfect irrigation system on my cocoa farm.	☐	☐	☐	☐	☐	[f1_3]
I have all the knowledge & information required to implement a perfect irrigation system on my cocoa farm.	☐	☐	☐	☐	☐	[f1_4]
I have access to all inputs & resources needed to implement a perfect irrigation system on my cocoa farm (e.g. water, land, energy, farming inputs, writing material). [Accessability not Affordability!!]	☐	☐	☐	☐	☐	[f1_5]
I receive support from the government to implement a perfect irrigation system on my cocoa farm (e.g. farming inputs, credits, tools).	☐	☐	☐	☐	☐	[f1_6]
I receive information from an extension officer about perfect irrigation systems for cocoa farms.	☐	☐	☐	☐	☐	[f1_7]

Farmer_ID:

AM 2: Shade trees

Present and explain the AM2 to the farmer, according to the card.

Do you have shade trees on your cocoa farm?	yes ☐ no ☐	[imp2]
If yes	Why and since when do you have shade trees on your cocoa farm?	[why2]
	How does the configuration (arrangement, number) of shade trees look like on your cocoa farm? Number of trees/acre: ☐ 1-2 trees/acre ☐ 3-5 trees/acre ☐ 6-8 trees/acre ☐ >8 trees/acre Distribution: ☐ Evenly ☐ Unevenly Establishment of shade trees: ☐ Plant trees ☐ Leave trees during land preparation Tree types: ☐ Fruit trees ☐ Fodder trees ☐ Timber trees ☐ Medicinal trees ☐ Other: ______________	[how2]
	If you have the option, how would a perfect configuration (arrangement, number) of shade trees look like on your cocoa farm? Number of trees/acre: ☐ 1-2 trees/acre ☐ 3-5 trees/acre ☐ 6-8 trees/acre ☐ >8 trees/acre Distribution: ☐ Evenly ☐ Unevenly Establishment of shade trees: ☐ Plant trees ☐ Leave trees during land preparation Tree types: ☐ Fruit trees ☐ Fodder trees ☐ Timber trees ☐ Medicinal trees ☐ Other: ______________	[opt_i2]
If no	Why don't you have shade trees on your cocoa farm?	[whynot2]
	If you have the option, how would a perfect configuration (arrangement, number) of shade trees look like on your cocoa farm? Number of trees/acre: ☐ 1-2 trees/acre ☐ 3-5 trees/acre ☐ 6-8 trees/acre ☐ >8 trees/acre Distribution: ☐ Evenly ☐ Unevenly Establishment of shade trees: ☐ Plant trees ☐ Leave trees during land preparation Tree types: ☐ Fruit trees ☐ Fodder trees ☐ Timber trees ☐ Medicinal trees ☐ Other: ______________	[opt_ni2]

Farmer_ID:

All the following questions refer to the perfect configuration of shade trees that you mentioned before.

Motivation

	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I think a perfect configuration of shade trees is useful to minimize the adverse effects of droughts on my cocoa farm.	☐	☐	☐	☐	☐	[m2_1]
I can earn more money if a perfect configuration of shade trees is implemented on my cocoa farm.	☐	☐	☐	☐	☐	[m2_2]
I often recommend to other cocoa farmers to implement a perfect configuration of shade trees on their cocoa farms.	☐	☐	☐	☐	☐	[m2_3]
I'm motivated to implement a perfect configuration of shade trees on my cocoa farm.	☐	☐	☐	☐	☐	[m2_4]
To see a perfect configuration of shade trees on my cocoa farm gives me satisfaction.	☐	☐	☐	☐	☐	[m2_5]
Most cocoa farmers in my community have a perfect configuration of shade trees implemented on their cocoa farms.	☐	☐	☐	☐	☐	[m2_6]

Feasibility

	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I possess the money needed to implement a perfect configuration of shade trees on my cocoa farm.	☐	☐	☐	☐	☐	[f2_1]
I have the time needed to implement a perfect configuration of shade trees on my cocoa farm.	☐	☐	☐	☐	☐	[f2_2]
I possess all tools needed to implement a perfect configuration of shade trees on my cocoa farm.	☐	☐	☐	☐	☐	[f2_3]
I have all the knowledge & information required to implement a perfect configuration of shade trees on my cocoa farm.	☐	☐	☐	☐	☐	[f2_4]
I have access to all inputs & resources needed to implement a perfect configuration of shade trees on my cocoa farm (e.g. water, land, energy, farming inputs, writing material). [Accessability not Affordability!!]	☐	☐	☐	☐	☐	[f2_5]
I receive support from the government to implement a perfect configuration of shade trees on my cocoa farm (e.g. farming inputs, credits, tools).	☐	☐	☐	☐	☐	[f2_6]
I receive information from an extension officer about perfect configurations of shade trees for cocoa farms.	☐	☐	☐	☐	☐	[f2_7]

Farmer_ID:

AM 3: Fire belts

Present and explain the AM3 to the farmer, according to the card.

Do you have a fire belt around your cocoa farm?	yes ☐ no ☐	[imp3]
If yes	Why and since when do you have the fire belt around your cocoa farm?	[why3]
	How does the fire belt look like on your cocoa farm? Length: ☐ Around whole farm ☐ Only partly — Which part? ______ Width: ☐ <5 feet ☐ 5-9 feet ☐ 10-14 feet ☐ >14 feet Construction: ☐ Oneself ☐ Collaboration with other farmers	[how3]
	If you have the option, how would a perfect fire belt look like on your cocoa farm? Length: ☐ Around whole farm ☐ Only partly — Which part? ______ Width: ☐ <5 feet ☐ 5-9 feet ☐ 10-14 feet ☐ >14 feet Construction: ☐ Oneself ☐ Collaboration with other farmers	[opt_i3]
If no	Why don’t you have a fire belt around your cocoa farm?	[whynot3]
	If you have the option, how would a perfect fire belt look like on your cocoa farm? Length: ☐ Around whole farm ☐ Only partly — Which part? ______ Width: ☐ <5 feet ☐ 5-9 feet ☐ 10-14 feet ☐ >14 feet Construction: ☐ Oneself ☐ Collaboration with other farmers	[opt_ni3]

Farmer_ID:

All the following questions refer to the perfect fire belt that you mentioned before.

Motivation

	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I think a perfect fire belt is useful to minimize the adverse effects of droughts on my cocoa farm.	☐	☐	☐	☐	☐	[m3_1]
I can earn more money if I have a perfect fire belt around my cocoa farm.	☐	☐	☐	☐	☐	[m3_2]
I often recommend to other cocoa farmers to construct a perfect fire belt around their cocoa farms.	☐	☐	☐	☐	☐	[m3_3]
I'm motivated to construct a perfect fire belt around my cocoa farm.	☐	☐	☐	☐	☐	[m3_4]
To see a perfect fire belt around my cocoa farm gives me satisfaction.	☐	☐	☐	☐	☐	[m3_5]
Most cocoa farmers in my community have a perfect fire belt around their cocoa farms.	☐	☐	☐	☐	☐	[m3_6]

Feasibility

	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I possess the money needed to construct a perfect fire belt around my cocoa farm.	☐	☐	☐	☐	☐	[f3_1]
I have the time needed to construct a perfect fire belt around my cocoa farm.	☐	☐	☐	☐	☐	[f3_2]
I possess all tools needed to construct a perfect fire belt around my cocoa farm.	☐	☐	☐	☐	☐	[f3_3]
I have all the knowledge & information required to construct a perfect fire belt around my cocoa farm.	☐	☐	☐	☐	☐	[f3_4]
I have access to all inputs & resources needed to construct a perfect fire belt around my cocoa farm (e.g. water, land, energy, farming inputs, writing material). [Accessability not Affordability!!]	☐	☐	☐	☐	☐	[f3_5]
I receive support from the government to construct a perfect fire belt around my cocoa farm (e.g. farming inputs, credits, tools).	☐	☐	☐	☐	☐	[f3_6]
I receive information from an extension officer about perfect fire belts for cocoa farms.	☐	☐	☐	☐	☐	[f3_7]

Farmer_ID:

AM 4: Keeping records on income and expenditures

Present and explain the AM4 to the farmer, according to the card.

Do you keep records on income and expenditures of your cocoa farm?	yes ☐ no ☐	[imp4]
If yes	Why and since when do you keep records on income and expenditures of your cocoa farm?	[why4]
	What records on income and expenditures do you take of your cocoa farm? Records on: ☐ Yield ☐ Revenues ☐ Input types ☐ Input amounts ☐ Input expenditures ☐ Labor costs ☐ Timing of input application ☐ Timing of harvest ☐ Calculation of profitability Type: ☐ On house wall ☐ On paper (book) ☐ On mobile phone ☐ On computer ☐ Other: ____________	[how4]
	If you have the option, how would a perfect system to keep records on income and expenditures of your cocoa farm look like? Records on: ☐ Yield ☐ Revenues ☐ Input types ☐ Input amounts ☐ Input expenditures ☐ Labor costs ☐ Timing of input application ☐ Timing of harvest ☐ Calculation of profitability Type: ☐ On house wall ☐ On paper (book) ☐ On mobile phone ☐ On computer ☐ Other: ____________	[opt_i4]
If no	Why don't you keep records on income and expenditures of your cocoa farm?	[whynot4]
	If you have the option, how would a perfect system to keep records on income and expenditures of your cocoa farm look like? Records on: ☐ Yield ☐ Revenues ☐ Input types ☐ Input amounts ☐ Input expenditures ☐ Labor costs ☐ Timing of input application ☐ Timing of harvest ☐ Calculation of profitability Type: ☐ On house wall ☐ On paper (book) ☐ On mobile phone ☐ On computer ☐ Other: ____________	[opt_ni4]

Farmer_ID:

All the following questions refer to the perfect system to keep records on income and expenditures that you mentioned before.

Motivation

	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I think a perfect system to keep records on income and expenditures is useful to minimize the adverse effects of droughts on my cocoa farm.	☐	☐	☐	☐	☐	[m4_1]
I can earn more money if I have a perfect system to keep records on income and expenditures of my cocoa farm.	☐	☐	☐	☐	☐	[m4_2]
I often recommend to other cocoa farmers to implement a perfect system to keep records on income and expenditures of their cocoa farms.	☐	☐	☐	☐	☐	[m4_3]
I'm motivated to implement a perfect system to keep records on income and expenditures of my cocoa farm.	☐	☐	☐	☐	☐	[m4_4]
To see a perfect system to keep records on income and expenditures of my cocoa farm gives me satisfaction.	☐	☐	☐	☐	☐	[m4_5]
Most cocoa farmers in my community have a perfect system to keep records on income and expenditures of their cocoa farms.	☐	☐	☐	☐	☐	[m4_6]

Feasibility

	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I possess the money needed to implement a perfect system to keep records on income and expenditures of my cocoa farm.	☐	☐	☐	☐	☐	[f4_1]
I have the time needed to implement a perfect system to keep records on income and expenditures of my cocoa farm.	☐	☐	☐	☐	☐	[f4_2]
I possess all tools needed to implement a perfect system to keep records on income and expenditures of my cocoa farm.	☐	☐	☐	☐	☐	[f4_3]
I have all the knowledge & information required to implement a perfect system to keep records on income and expenditures of my cocoa farm.	☐	☐	☐	☐	☐	[f4_4]
I have access to all inputs & resources needed to implement a perfect system to keep records on income and expenditures of my cocoa farm (e.g. water, land, energy, farming inputs, writing material). [Accessability not Affordability!!]	☐	☐	☐	☐	☐	[f4_5]
I receive support from the government to implement a perfect system to keep records on income and expenditures of my cocoa farm (e.g. farming inputs, credits, tools).	☐	☐	☐	☐	☐	[f4_6]
I receive information from an extension officer about perfect systems to keep records on income and expenditures for cocoa farms.	☐	☐	☐	☐	☐	[f4_7]

Farmer_ID:

AM 5: Mulching

Present and explain the AM5 to the farmer, according to the card.

Do you mulch on your cocoa farm?		yes ☐ no ☐ [imp5]
If yes	Why and since when do mulch on your cocoa farm?	[why5]
	How does the mulching look like on your cocoa farm? Mulching material: ☐ Cocoa leaves ☐ Prunings (whole branches) ☐ Prunings (cut in pieces) ☐ Cocoa pods ☐ Material from outside cocoa farm (e.g. banana leaves) Handling: ☐ No handling ☐ Regularly turning litter Extent: ☐ Whole farm ☐ Only partly Which part? ______	[how5]
	If you have the option, how would a perfect mulching system look like on your cocoa farm? Mulching material: ☐ Cocoa leaves ☐ Prunings (whole branches) ☐ Prunings (cut in pieces) ☐ Cocoa pods ☐ Material from outside cocoa farm (e.g. banana leaves) Handling: ☐ No handling ☐ Regularly turning litter Extent: ☐ Whole farm ☐ Only partly Which part? ______	[opt_i5]
If no	Why don't you mulch on your cocoa farm?	[whynot5]
	If you have the option, how would a perfect mulching system look like on your cocoa farm? Mulching material: ☐ Cocoa leaves ☐ Prunings (whole branches) ☐ Prunings (cut in pieces) ☐ Cocoa pods ☐ Material from outside cocoa farm (e.g. banana leaves) Handling: ☐ No handling ☐ Regularly turning litter Extent: ☐ Whole farm ☐ Only partly Which part? ______	[opt_ni5]

Farmer_ID:

All the following questions refer to the perfect mulching system that you mentioned before.

Motivation

	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I think a perfect mulching system is useful to minimize the adverse effects of droughts on my cocoa farm.	☐	☐	☐	☐	☐	[m5_1]
I can earn more money if a perfect mulching system is implemented on my cocoa farm.	☐	☐	☐	☐	☐	[m5_2]
I often recommend to other cocoa farmers to implement a perfect mulching system on their cocoa farms.	☐	☐	☐	☐	☐	[m5_3]
I'm motivated to implement a perfect mulching system on my cocoa farm.	☐	☐	☐	☐	☐	[m5_4]
To see a perfect mulching system on my cocoa farm gives me satisfaction.	☐	☐	☐	☐	☐	[m5_5]
Most cocoa farmers in my community have a perfect mulching system on their cocoa farms.	☐	☐	☐	☐	☐	[m5_6]

Feasibility

	strongly disagree	somewhat disagree	neither agree nor disagree	somewhat agree	strongly agree	
I possess the money needed to implement a perfect mulching system on my cocoa farm.	☐	☐	☐	☐	☐	[f5_1]
I have the time needed to implement a perfect mulching system on my cocoa farm.	☐	☐	☐	☐	☐	[f5_2]
I possess all tools needed to implement a perfect mulching system on my cocoa farm.	☐	☐	☐	☐	☐	[f5_3]
I have all the knowledge & information required to implement a perfect mulching system on my cocoa farm.	☐	☐	☐	☐	☐	[f5_4]
I have access to all inputs & resources needed to implement a perfect mulching system on my cocoa farm (e.g. water, land, energy, farming inputs, writing material). [Accessability not Affordability!!]	☐	☐	☐	☐	☐	[f5_5]
I receive support from the government to implement a perfect mulching system on my cocoa farm (e.g. farming inputs, credits, tools).	☐	☐	☐	☐	☐	[f5_6]
I receive information from an extension officer about perfect mulching systems for cocoa farms.	☐	☐	☐	☐	☐	[f5_7]

Farmer_ID:

Priority and other AMs

Are you taking other measures to minimize the adverse effects of droughts that were not mentioned on the cards?	[am]

What is your priority of the 5 AMs to minimize the adverse effects of droughts?

[AM1, AM2, AM3,AM4, AM5, AM6]

1. Priority ____________ [p_1] [highest priority]
2. Priority ____________ [p_2]
3. Priority ____________ [p_3]
4. Priority ____________ [p_4]
5. Priority ____________ [p_5] lowest prority]

GPS Coordinates	____________	[latitude, longitude in ° ' "]	[gps]
Region	____________		[reg]
Village	____________		[village]
Contact data of farmer	____________	[name, surname]	[cont]
	____________	[phone, e-mail]	
Name of the interpreter	____________	[name, surname]	[inter]

Other notes, observations:

APPENDIX IV

STATISTICAL TESTS

Before conducting the statistical analysis, the data was tested for normal distribution using the Kolmogorov-Smirnov and the Shapiro-Wilk test. The response variables are not normally distributed and therefore non-parametric tests that do not assume normal distribution were used to test for differences between the four districts.

MANN WHITNEY-U TEST

A Mann Whitney-U Test was used to test for side effects, like the order of the questions and the influence of the interpreter. The Mann Whitney-U Test is a non-parametric test for two independent samples (University of Zurich [UZH], 2018c).

KRUSKAL-WALLIS H TEST AND POST HOC ANALYSIS

The K-W Test was used to test for differences in responses in the different sampled districts. The K-W Test is a non-parametric test for k-independent samples and is based on ranked data. The null hypothesis "H0: all mean ranks of the groups are equal" is tested (Liu, 2015). A significant K-W Test indicates that at least one district significantly differs from another district. A post hoc Dunn- Bonferroni Test was conducted for all variables that showed significant p-values in the K-W Test to examine the particular pairs that significantly differ from each other (UZH, 2018b). The post hoc Dunn- Bonferroni Test adjusts the a level by the Bonferroni correction for multiple testing to avoid a "Type I" error (Abdi, 2007). The K-W Test can only be applied on continuous or ordinal data (not on nominal data) and therefore, some variables had to be tested with a Pearson Chi-Square Test (UZH, 2018b).

PEARSON CHI-SQUARE TEST AND POST HOC ANALYSIS

For the variables 'gender, 'education', 'entitlements, 'land allocated to cocoa', 'share of household income coming from cocoa', 'household income', implementation 'irrigation technologies', implementation 'shade trees', implementation 'fire belts', implementation 'keeping records on income and expenditures' and implementation 'mulching' differences between the districts were tested with a Pearson Chi-Square Test. The Pearson Chi-Square Test analyses if there is a difference between two nominal variables (UZH, 2018d). In this thesis all Chi-Square tests are associated with more than one degree of freedom, because differences are tested among four different districts. A significant p-value indicates that there are differences between at least one pair of variable expressions but does not give information about which pairs differ. Therefore, a post hoc test was conducted to determine which districts show significant differences in the variance of a variable compared to the variance of the whole sample (Cox & Key, 1993; Sharpe, 2015). To avoid a "Type I" error the a level was adjusted by the Bonferroni correction for multiple testing (Abdi, 2007).

EXPLORATIVE FACTOR ANALYSIS: PRINCIPAL COMPONENTS ANALYSIS

An explorative factor analysis (EFA) was conducted for each AM separately and over all AMs to find an underlying component in the variables of the three different dimensions of the model, namely: 'motivation', 'feasibility' and 'drought exposure, experience and perception'. In order to reduce the number of variables for each dimension to one component, a PCA has been conducted. The PCA was done, such as only one component represents the respective dimension of the different AMs and for all AMs.

Since all farmers indicated that they have already experienced drought, this variable has been excluded from the EFA, because it doesn't show any variance and therefore no possible influence of having experienced drought or not can be shown in this thesis. The first step was testing the suitability of the variables for an EFA with the Kaiser-Meyer-Olkin (KMO) Test of Sampling Adequacy. A KMO value >0.5 indicates that the variables are acceptable to conduct an EFA (UZH, 2018a). The only variables that did not meet this requirement were the variables of the dimension 'motivation' of the AM1. Since all the other variables met the requirement the EFA was conducted anyway.

During the analysis, the component loadings and the Cronbach's alpha were used as guidance to eliminate variables and hence, improve the representation of the components. All variables with component loadings under 0.25 were excluded from the analysis and the PCA was conducted again without those variables (UZH, 2018a). After the PCA, the internal reliability of the components was tested with the Cronbach's Alpha. Variables were excluded again if their exclusion led to a higher Cronbach's Alpha value (Cronbach's Alpha >0.5).

BINARY LOGISTIC REGRESSION

To examine what influences the implementation of AMs (binary dependent variable), a binary logistic regression has been conducted. The independent variables used for the regression were socio- economic and -demographic variables and the constructed 'feasibility', the 'motivation' and the 'drought exposure, experience and perception' components. For the variables 'entitlements', 'education' and 'household income' dummy variables were created. The variable 'entitlements' was recoded into two categories, namely: owning the land and not owning the land. The 'education' and the 'household income' were recoded into 'higher education' and 'higher household income', were the cutoff points were set at education higher than basic education, respectively household income higher than 12'600 Cedi per household per year. All variables were tested for multicollinearity and were only included in the regression if no strong correlations could be found (Spearman's rho: r< 0.5) (Cohen, Manion, & Morrison, 2007). The farm size was not considered in the regression of all AMs, because of its strong correlation with the area of cocoa (AM1: r=0.964, p=<0.001***; AM2: r=0.956, p=<0.001***; AM3: r=0.963, p=<0.001***; AM4: r=0.969, p=<0.001***; AM5: r=0.963, p=<0.001***). For the regression of the AM3 the variable 'number of cocoa farms' was also excluded, because of its strong correlation with the area of cocoa (r=0.501, p=<0.001***). The first block of the regression included all socio-economic and -demographic variables and the second block the three previously mentioned components (Dettling, 2017).

APPENDIX V

Table 11: Pairwise comparison socio-economic and -demographic variables among the four districts

variable		Ejisu-Juaben	Offinso South	Sefwi Wiawso
age	Ejisu-Juaben			
	Offinso South	-		
	Sefwi Wiawso	-	< 0.001***	
	Elembelle	< <0.001***	< <0.001***	< 0.001***
hh_size	Ejisu-Juaben			
	Offinso South	-		
	Sefwi Wiawso	< 0.026**	< <0.001***	
	Elembelle	< 0.003***	< <0.001***	-
f_size	Ejisu-Juaben			
	Offinso South	-		
	Sefwi Wiawso	-	-	
	Elembelle	< 0.016**	-	-
area_cocoa	Ejisu-Juaben			
	Offinso South	< 0.032**		
	Sefwi Wiawso	-	-	
	Elembelle	< 0.049**	-	-
n_farms	Ejisu-Juaben			
	Offinso South	< <0.001***		
	Sefwi Wiawso	-	> 0.043**	
	Elembelle	-	> 0.005***	-
age_farm_mean	Ejisu-Juaben			
	Offinso South	> <0.001***		
	Sefwi Wiawso	> 0.002***	< 0.033**	
	Elembelle	> 0.017**	< 0.013**	-

** significant at 5% probability level, *** significant at p 1% probability level
Note: Ejisu-Juaben (n=71); Offinso South (n=77); Sefwi Wiawso (n=79); Elembelle (n=75)

Table 12: Post hoc test for the variable ‚entitlements'

entitlements (N=295)		Ejisu-Juaben	Offinso South	Sefwi Wiawso	Elembelle
owning	count	25	62	49	65
	adj. z-score	-5.99	2.92	-1.36	4.20
	p-value	<0.0001**	0.0035**	0.1738	<0.0001**
	adj. α	0.0042	0.0042	0.0042	0.0042
renting	count	28	7	14	4
	adj. z-score	5.87	-2.31	-0.07	-3.25
	p-value	<0.0001**	0.0209	0.9442	0.0012**
	adj. α	0.0042	0.0042	0.0042	0.0042
other	count	13	7	16	5
	adj. z-score	1.55	-1.37	1.91	-2.05
	p-value	0.1211	0.1707	0.0561	0.0404
	adj. α	0.0042	0.0042	0.0042	0.0042

** significant at 5% probability level, *** significant at p 1% probability level

Table 13: Post hoc test for the variable ‚land allocated to cocoa'

land allocated to cocoa (N=302)		Ejisu-Juaben	Offinso South	Sefwi Wiawso	Elembelle
21%-40%	count	1	0	0	0
	adj. z-score	1.81	-0.59	-0.60	-0.58
	p-value	0.0703	0.5552	0.5485	0.5619
	adj. α	0.0031	0.0031	0.0031	0.0031
41%-60%	count	4	14	4	1
	adj. z-score	-0.72	4.05	-1.00	-2.37
	p-value	0.4715	0.0001**	0.3173	0.0178
	adj. α	0.0031	0.0031	0.0031	0.0031
61%-80%	count	8	15	12	6
	adj. z-score	-0.65	1.75	0.49	-1.63
	p-value	0.5157	0.0801	0.6241	0.1031
	adj. α	0.0031	0.0031	0.0031	0.0031
81%-100%	count	58	48	63	68
	adj. z-score	0.75	-3.99	0.32	2.96
	p-value	0.4533	0.0001**	0.7490	0.0031
	adj. α	0.0031	0.0031	0.0031	0.0031

** significant at 5% probability level, *** significant at p 1% probability level

Table 14: Post hoc test for the variable ‚household income‘

household income [cedi/household/year] (N=285)		Ejisu-Juaben	Offinso South	Sefwi Wiawso	Elembelle
<6,500	count	60	66	45	31
	adj. z-score	2.92	3.35	-3.20	-3.27
	p-value	0.0035	0.0008**	0.0014**	0.0011**
	adj. α	0.0025	0.0025	0.0025	0.0025
6,500-12,600	count	9	9	32	14
	adj. z-score	-2.28	-2.65	4.52	0.34
	p-value	0.0226	0.0080	<0.0001**	0.7339
	adj. α	0.0025	0.0025	0.0025	0.0025
12,601-18,700	count	1	1	2	2
	adj. z-score	-0.47	-0.58	0.31	0.80
	p-value	0.6384	0.5619	0.7566	0.4237
	adj. α	0.0025	0.0025	0.0025	0.0025
18,701-25,000	count	1	1	0	4
	adj. z-score	-0.47	-0.58	-1.53	2.85
	p-value	0.6384	0.5619	0.1260	0.0044
	adj. α	0.0025	0.0025	0.0025	0.0025
no answer	count	0	0	0	7
	adj. z-score	-1.54	-1.63	-1.66	5.30
	p-value	0.1236	0.1031	0.0969	<0.0001**
	adj. α	0.0025	0.0025	0.0025	0.0025

** significant at 5% probability level, *** significant at p 1% probability level

APPENDIX VI

Table 15: Pairwise comparison overall ‘motivation’ among the four districts

	variable		Ejisu-Juaben		Offinso South		Sefwi Wiawso	
farmer specific motivation	pr	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	-		-		-	
	per	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	>	0.032**	-		-	
	adop	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		<	0.001***		
		Elembelle	-		-		-	

** significant at 5% probability level, *** significant at p 1% probability level

Note: ‘overall motivation’ (N=302); Ejisu-Juaben (n=71); Offinso South (n=77); Sefwi Wiawso (n=79); Elembelle (n=75)

APPENDIX VII

Table 16: Mean and SD of yield/ha/year

	region										
	national (N=291)		Offinso South (n=76)		Ejisu-Juaben (n=66)		Sefwi Wiawso (n=78)		Elembelle (n=71)		Kruskal-Wallis
variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	
cocoa yield 2015 [kg/ha]	191.9	220.0	160.8	157.8	63.7	85.0	192.5	171.3	356.9	310.9	<0.001***
cocoa yield 2016 [kg/ha]	203.7	220.2	171.4	164.0	73.7	84.2	208.3	186.5	354.5	297.2	<0.001***
cocoa yield 2017 [kg/ha]	193.7	222.2	122.0	128.9	85.7	91.1	328.0	162.0	350.9	328.9	<0.001***
Kruskal-Wallis	0.529		0.033**		0.039**		0.541		0.953		

** significant at 5% probability level, *** significant at p 1% probability level

Table 17: Comparison of yield/ha/year among the four districts

variable		Ejisu-Juaben	Offinso South	Sefwi Wiawso
yield_ha_15	Ejisu-Juaben			
	Offinso South	> <0.001***		
	Sefwi Wiawso	> <0.001***	-	
	Elembelle	> <0.001***	> <0.001***	> 0.016
yield_ha_16	Ejisu-Juaben			
	Offinso South	> <0.001***		
	Sefwi Wiawso	> <0.001***	-	
	Elembelle	> <0.001***	> <0.001***	> 0.038
yield_ha_17	Ejisu-Juaben			
	Offinso South	-		
	Sefwi Wiawso	> <0.001***	> <0.001***	
	Elembelle	> <0.001***	> <0.001***	-

** significant at 5% probability level, *** significant at p 1% probability level

Table 18: Pairwise comparison of yield among the years in Ejisu-Juaben

variable		2015	2016	2017
yield_ha Ejisu-Juaben	2015			
	2016	-		
	2017	> 0.027**	-	

** significant at 5% probability level, *** significant at p 1% probability level

Table 19: Pairwise comparison of yield among the years in Offinso South

variable		2015	2016	2017
yield_ha Offinso South	2015			
	2016	-		
	2017	-	< 0.047**	

** significant at 5% probability level, *** significant at p 1% probability level

APPENDIX VIII

Table 20: Mean, SD and Kruskal-Wallis of ‘drought exposure, experience and perception’ among the districts

	region										
	national (N=302)		Ejisu-Juaben (n=71)		Offinso South (n=77)		Sefwi Wiawso (n=79)		Elembelle (n=75)		Kruskal-Wallis
variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	
dd_15	4.28	1.13	4.55	1.03	4.18	1.16	4.28	1.08	4.12	3.24	0.020**
dd_16	3.38	1.32	3.56	1.08	2.92	1.50	3.81	1.13	3.24	1.34	0.001***
dd_17	3.05	1.51	2.60	1.16	2.62	1.67	3.68	1.24	3.25	1.62	<0.001***
anc	4.01	1.49	4.25	1.23	4.17	1.44	4.20	1.31	3.41	1.80	0.015**
help	4.59	1.07	4.87	0.56	4.05	1.51	4.70	0.84	4.77	0.92	<0.001***
ext	4.95	0.36	4.92	0.50	4.95	0.23	4.99	0.11	4.95	0.47	0.374
dd_f	4.40	1.11	4.33	1.20	4.27	1.21	4.62	0.80	4.38	1.16	0.259
give	1.77	1.45	1.83	1.39	1.45	1.19	1.75	1.47	2.07	1.66	0.041**
d_se	4.35	1.05	4.44	1.13	4.10	1.10	4.17	1.00	4.72	0.85	<0.001***

** significant at 5% probability level, *** significant at p 1% probability level

Note: 1=strongly disagree, 2=somewhat disagree, 3=neither agree nor disagree, 4=somewhat agree, 5=strongly agree

Table 21: Pairwise comparison of single ‘drought exposure, experience and perception’ questions among the districts

	variable		Ejisu-Juaben		Offinso South		Sefwi Wiawso	
farmer specific drought exposure, experience and perception	dd_15	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	<	0.030**	-		-	
	dd_16	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		>	0.001***		
		Elembelle	-		-		-	
	dd_17	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	>	<0.001***	>	<0.001***		
		Elembelle	-		-		-	
	anc	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	-		<	0.032**	-	
	help	Ejisu-Juaben						
		Offinso South	<	<0.001***				
		Sefwi Wiawso			>	0.014**		
		Elembelle			>	<0.001***		
	ext	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	-		-		-	
	dd_f	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	-		-		-	
	give	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	-		-		-	
	d_se	Ejisu-Juaben						
		Offinso South	<	0.031**				
		Sefwi Wiawso	-		-			
		Elembelle	-		>	<0.001***	>	<0.001***

** significant at 5% probability level, *** significant at p 1% probability level

Note: total N=302; Ejisu-Juaben (n=71); Offinso South (n=77); Sefwi Wiawso (n=79); Elembelle (n=75)

Table 22: K-W Test, M and SD of single 'motivation' and 'feasibility' questions among the districts

	region										
	national (N=604)		Ejisu-Juaben (n=142)		Offinso South (n=154)		Sefwi Wiawso (n=158)		Elembelle (n=150)		Kruskal-Wallis
variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	
f_q1	3.18	1.68	2.90	1.63	2.97	1.60	3.22	1.69	3.60	1.72	<0.001***
f_q2	4.79	0.59	4.70	0.66	4.84	0.58	4.77	0.45	4.83	0.64	0.001***
f_q3	3.51	1.65	3.14	1.57	3.20	1.62	3.71	1.59	3.96	1.67	<0.001***
f_q4	3.63	1.52	3.68	1.37	3.36	1.59	3.54	1.55	3.95	1.50	0.001***
f_q5	3.75	1.43	3.32	1.29	3.63	1.45	3.62	1.45	4.42	1.29	<0.001***
f_q6	2.24	1.74	1.24	0.89	2.50	1.80	3.22	1.81	1.89	1.61	<0.001***
f_q7	2.70	1.85	1.35	1.02	3.21	1.80	3.37	1.80	2.75	1.90	<0.001***
m_q1	4.19	1.36	4.26	1.26	3.95	1.48	4.25	1.24	4.29	1.42	<0.015**
m_q2	4.54	1.02	4.40	0.97	4.36	1.24	4.60	0.94	4.79	0.84	<0.001***
m_q3	2.90	1.88	2.79	1.79	2.59	1.86	2.99	1.89	3.23	1.91	<0.010**
m_q4	4.68	0.74	4.56	0.72	4.74	0.55	4.69	0.63	4.71	0.99	<0.001***
m_q5	4.76	0.63	4.74	0.57	4.75	0.58	4.76	0.50	4.79	0.84	<0.003***
m_q6	3.15	1.65	2.74	1.68	3.31	1.51	3.28	1.64	3.22	1.74	<0.011**

** significant at 5% probability level, *** significant at p 1% probability level

Note: 1=strongly disagree, 2=somewhat disagree, 3=neither agree nor disagree, 4=somewhat agree, 5=strongly agree

Table 23: Pairwise comparison of single ‘feasibility’ and ‘motivation’ questions among the districts

	variable			Ejisu-Juaben		Offinso South		Sefwi Wiawso
AM specific feasibility	f_q1	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	>	<0.001***	>	<0.001***	-	
	f_q2	Ejisu-Juaben						
		Offinso South	>	0.046**				
		Sefwi Wiawso	-		-			
		Elembelle	>	0.011**	-		>	0.015**
	f_q3	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	>	0.002***	>	0.008***		
		Elembelle	>	<0.001***	>	<0.001***	-	
	f_q4	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	-		>	0.001***	>	<0.001***
	f_q5	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	>	0.044**	-			
		Elembelle	>	<0.001***	>	<0.001***	>	<0.001***
	f_q6	Ejisu-Juaben						
		Offinso South	>	<0.001***				
		Sefwi Wiawso	>	<0.001***	>	0.004***		
		Elembelle	>	0.009***	<	0.004***	<	<0.001***
	f_q7	Ejisu-Juaben						
		Offinso South	>	<0.001***				
		Sefwi Wiawso	>	<0.001***	-			
		Elembelle	>	<0.001***	-		<	<0.001***
AM specific motivation	m_q1	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	-		>	0.007***	-	
	m_q2	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	>	0.007***	-			
		Elembelle	>	<0.001***	>	<0.001***	>	<0.001***
	m_q3	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	-		>	0.010**	-	
	m_q4	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	>	<0.001***	-		>	0.012**
	m_q5	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	-		-			
		Elembelle	>	0.009***	>	0.025**	>	0.010**
	m_q6	Ejisu-Juaben						
		Offinso South	-					
		Sefwi Wiawso	>	0.024**	-			
		Elembelle	>	0.029**	-		-	

** significant at 5% probability level, *** significant at p 1% probability level

Note: total AMs (N=604); total AMs Ejisu-Juaben (n=142); total AMs Offinso South (n=154); total AMs Sefwi Wiawso (n=158); total AMs Elembelle (n=150)

Table 24: K-W Test, M and SD of single ‘motivation’ and ‘feasibility’ questions among the AMs

	region										
	AM1 (n=121)		AM2 (n=120)		AM3 (n=121)		AM4 (n=121)		AM5 (n=121)		Kruskal-Wallis
variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	
f_q1	1.35	0.96	2.76	1.55	3.39	1.48	3.97	1.46	4.42	0.86	<0.001***
f_q2	4.78	0.63	4.88	0.33	4.82	0.55	4.63	0.86	4.83	0.40	0.201
f_q3	1.33	0.86	3.67	1.45	4.33	1.08	3.73	1.54	4.48	0.87	<0.001***
f_q4	2.44	1.56	3.77	1.34	4.42	0.96	3.23	1.65	4.30	1.02	<0.001***
f_q5	2.53	1.58	3.33	1.52	4.19	1.07	4.31	1.01	4.39	0.85	<0.001***
f_q6	1.40	1.10	2.92	1.88	2.22	1.79	2.36	1.78	2.31	1.74	<0.001***
f_q7	1.68	1.37	3.38	1.82	2.68	1.88	2.83	1.86	2.95	1.86	<0.001***
m_q1	4.90	0.44	4.72	0.76	3.46	1.70	3.45	1.53	4.40	1.16	<0.001***
m_q2	4.97	0.18	4.62	0.84	4.26	1.33	4.50	0.97	4.34	1.23	<0.001***
m_q3	2.11	1.68	3.54	1.76	3.45	1.84	2.17	1.76	3.25	1.82	<0.001***
m_q4	4.72	0.67	4.75	0.63	4.73	0.72	4.45	1.02	4.75	0.54	0.017**
m_q5	4.93	0.25	4.83	0.51	4.77	0.66	4.54	0.90	4.74	0.60	<0.001***
m_q6	1.36	0.79	4.01	1.23	3.96	1.18	2.07	1.37	4.36	1.03	<0.001***

** significant at 5% probability level, *** significant at p 1% probability level

Note: 1=strongly disagree, 2=somewhat disagree, 3=neither agree nor disagree, 4=somewhat agree, 5=strongly agree

Table 25: Pairwise comparison of single ‘feasibility’ and ‘motivation’ questions among the AMs

	variable			AM1		AM2		AM3		AM4
AM specific feasibility	f_q1	AM1								
		AM2	>	<0.001***						
		AM3	>	<0.001***	>	0.025**				
		AM4	>	<0.001***	>	<0.001***	>	0.014**		
		AM5	>	<0.001***	>	<0.001***	>	<0.001***	-	
	f_q2	AM1								
		AM2	-							
		AM3	-		-					
		AM4	-		-		-			
		AM5	-		-		-		-	
	f_q3	AM1								
		AM2	>	<0.001***						
		AM3	>	<0.001***	>	0.005***				
		AM4	>	<0.001***	-		-			
		AM5	>	<0.001***	>	0.001***	-		>	0.019**
	f_q4	AM1								
		AM2	>	<0.001***						
		AM3	>	<0.001***	>	0.002***				
		AM4	>	0.001***	-		<	<0.001***		
		AM5	>	<0.001***	>	0.029**	-		>	<0.001***
	f_q5	AM1								
		AM2	>	0.002***						
		AM3	>	<0.001***	>	<0.001***				
		AM4	>	<0.001***	>	<0.001***	-			
		AM5	>	<0.001***	>	<0.001***	-		-	
	f_q6	AM1								
		AM2	>	<0.001***						
		AM3	>	0.006***	<	0.024**				
		AM4	>	<0.001***	-		-			
		AM5	>	<0.001***	-		-		-	
	f_q7	AM1								
		AM2	>	<0.001***						
		AM3	>	<0.001***	-					
		AM4	>	<0.001***	-		-			
		AM5	>	<0.001***	-		-		-	
AM specific motivation	m_q1	AM1								
		AM2	-							
		AM3	<	<0.001***	<	<0.001***				
		AM4	<	<0.001***	<	<0.001***	-			
		AM5	<	0.002***	-		>	<0.001***	>	<0.001***
	m_q2	AM1								
		AM2	<	0.002***						
		AM3	<	<0.001***	-					
		AM4	<	<0.001***	-		-			
		AM5	<	<0.001***	-		-			
	m_q3	AM1								
		AM2	>	<0.001***						
		AM3	>	<0.001***	-					
		AM4	-		<	<0.001***	<	<0.001***		
		AM5	>	<0.001***	-		-		>	<0.001***
	m_q4	AM1								
		AM2	-							
		AM3	-		-					
		AM4	-		<	0.035**	<	0.034**		
		AM5	-		-		-		-	
	m_q5	AM1								
		AM2	-							
		AM3	-		-					
		AM4	<	<0.001***	<	0.003***	<	0.023**		
		AM5	<	0.025**	-		-		-	
	m_q6	AM1								
		AM2	>	<0.001***						
		AM3	>	<0.001***	-					
		AM4	>	0.010**	<	<0.001***	<	<0.001***		
		AM5	>	<0.001***	-		-		>	<0.001***

** significant at 5% probability level, *** significant at p 1% probability level

Note: total AMs (N=604); ‘irrigation technologies’ (n=121); ‘shade trees’ (n=120); ‘fire belts’ (n=121); ‘keeping records’ (n=121); ‘mulching’ (n=121)

APPENDIX IX

Table 26: AM specific PCA for all dimensions and overall PCA for all dimensions

	variable	variable label	component loadings					
			AM1	AM2	AM3	AM4	AM5	all AMs
AM specific motivation	m_i_1	usefulness	0.446	0.703	-	-	0.544	0.392
	m_i_2	earning more money	0.357	0.456	0.584	0.385	0.550	0.475
	m_i_3	recommendation	0.473	-	0.478	0.672	-	0.528
	m_i_4	motivation	0.685	0.833	0.909	0.790	0.815	0.840
	m_i_5	satisfaction	0.497	0.829	0.896	0.799	0.847	0.833
	m_i_6	implementation on other farms	-	0.628	0.579	0.602	-	0.392
farmer specific motivation	pr	pride	0.431	-	-	-	0.509	
	per	satisfaction with farm	0.352	-	-	0.427	0.384	
	adop	early adoption	-	-	-	-	-	
		KMO value	0.495	0.620	0.680	0.740	0.656	0.598
		explained variance	22.5%	49.6%	50.7%	40.1%	39.8%	36.8%
		Cronbach's alpha	0.296	0.671	0.614	0.661	0.613	0.529
AM specific feasibility	f_i_1	money	0.716	0.657	0.568	0.863	0.736	0.782
	f_i_2	time	-	-	0.489	0.493	0.447	-
	f_i_3	tools	0.697	0.778	0.849	0.863	0.765	0.855
	f_i_4	knowledge and information	0.704	0.526	0.548	0.395	0.558	0.650
	f_i_5	accessibility	0.655	0.761	0.773	0.770	0.723	0.767
	f_i_6	governmental support	-	0.415	0.438	-	0.401	0.431
	f_i_7	information from extension	0.398	0.577	0.475	-	0.366	0.545
		KMO value	0.639	0.605	0.654	0.740	0.656	0.691
		explained variance	41.7%	40.0%	37.1%	49.0%	35.1%	47.3%
		Cronbach's alpha	0.620	0.682	0.667	0.700	0.621	0.762
farmer specific drought exposure, experience and perception	dd_16	damages of drought in 2016						0.785
	help	helplessness						0.681
	dd_17	damages of drought in 2017						0.630
	dd_15	damages of drought in 2015						0.482
	d_se	severeness of shock						0.402
	dd_f	drought damages in future						0.351
		KMO value						0.612
		explained variance						33.3%
		Cronbach's alpha						0.591

Note: AMi with i=1 to 5; 'feasibility component' all AMs built with N=604; 'motivation component' all AMs built with N=604, 'feasibility component' component AM1 built with n=121; 'motivation component' component AM1 built with n=121; 'feasibility component' component AM2 built with n=120; 'motivation component' component AM2 built with n=120; 'feasibility component' component AM3 built with n=121; 'motivation component' component AM3 built with n=121; 'feasibility component' component AM4 built with n=121; 'motivation component' component AM4 built with n=121; 'feasibility component' component AM5 built with n=121; 'motivation component' component AM5 built with n=121; 'drought component' built with N=302

APPENDIX X

Table 27: Kruskal-Wallis and pairwise comparison for the component scores of the 'drought component' among the districts

variable		Ejisu-Juaben	Offinso South	Sefwi Wiawso	Kruskal-Wallis
component score 'drought exposure, experience and perception'	Ejisu-Juaben				0.001***
	Offinso South	-			
	Sefwi Wiawso	-	> 0.001***		
	Elembelle	-	-	-	

** significant at 5% probability level, *** significant at p 1% probability level

Note: total N=302; Ejisu-Juaben (n=71); Offinso South (n=77); Sefwi Wiawso (n=79); Elembelle (n=75)

APPENDIX XI

Table 28: Differences in 'feasibility' and 'motivation' within one district

				Wilcoxon Signed Ranks Test
Ejisu-Juaben	component score 'feasibility'	<	component score 'motivation'	0.001***
Offinso South	component score 'feasibility'	=	component score 'motivation'	0.720
Sefwi Wiawso	component score 'feasibility'	=	component score 'motivation'	0.127
Elembelle	component score 'feasibility'	=	component score 'motivation'	0.664

** significant at 5% probability level, *** significant at p 1% probability level

Note: total AMs Ejisu-Juaben (n=142); total AMs Offinso South (n=154); total AMs Sefwi Wiawso (n=158); total AMs Elembelle (n=150)

Table 29: Pairwise comparison of the component scores of 'feasibility' and 'motivation' among the districts

variable		Ejisu-Juaben	Offinso South	Sefwi Wiawso	Kruskal-Wallis
component score 'feasibility'	Ejisu-Juaben				<0.001***
	Offinso South	> 0.002***			
	Sefwi Wiawso	> <0.001***	-		
	Elembelle	> <0.001***	> 0.008***	-	
component score 'motivation'	Ejisu-Juaben				<0.001***
	Offinso South	-			
	Sefwi Wiawso	-	-		
	Elembelle	> <0.001***	> <0.001***	> <0.008***	

** significant at 5% probability level, *** significant at p 1% probability level

Note: total AMs (N=604); total AMs Ejisu-Juaben (n=142); total AMs Offinso South (n=154); total AMs Sefwi Wiawso (n=158); total AMs Elembelle (n=150)

APPENDIX XII

Table 30: Differences in 'feasibility' and 'motivation' within one district for each AM

					Wilcoxon Signed Ranks Test
AM1	Ejisu-Juaben	component score 'feasibility'	<	component score 'motivation'	<0.001***
	Offinso South	component score 'feasibility'	<	component score 'motivation'	<0.001***
	Sefwi Wiawso	component score 'feasibility'	<	component score 'motivation'	<0.001***
	Elembelle	component score 'feasibility'	<	component score 'motivation'	<0.001***
AM2	Ejisu-Juaben	component score 'feasibility'	<	component score 'motivation'	0.003***
	Offinso South	component score 'feasibility'	<	component score 'motivation'	0.009***
	Sefwi Wiawso	component score 'feasibility'	=	component score 'motivation'	0.399
	Elembelle	component score 'feasibility'	=	component score 'motivation'	0.255
AM3	Ejisu-Juaben	component score 'feasibility'	=	component score 'motivation'	0.517
	Offinso South	component score 'feasibility'	>	component score 'motivation'	0.036**
	Sefwi Wiawso	component score 'feasibility'	>	component score 'motivation'	<0.001***
	Elembelle	component score 'feasibility'	=	component score 'motivation'	0.178
AM4	Ejisu-Juaben	component score 'feasibility'	>	component score 'motivation'	0.032**
	Offinso South	component score 'feasibility'	=	component score 'motivation'	0.063
	Sefwi Wiawso	component score 'feasibility'	>	component score 'motivation'	<0.001***
	Elembelle	component score 'feasibility'	>	component score 'motivation'	<0.001***
AM5	Ejisu-Juaben	component score 'feasibility'	=	component score 'motivation'	0.820
	Offinso South	component score 'feasibility'	>	component score 'motivation'	<0.001***
	Sefwi Wiawso	component score 'feasibility'	>	component score 'motivation'	0.004***
	Elembelle	component score 'feasibility'	=	component score 'motivation'	0.094

** significant at 5% probability level, *** significant at p 1% probability level

Note: 'Irrigation technologies' (n=121); 'shade trees' (n=120); 'fire belts' (n=121); 'keeping records on income and expenditures' (n=121); 'mulching' (n=121); 'irrigation technologies' Offinso South (n=31); 'irrigation technologies' Ejisu-Juaben (n=29); 'irrigation technologies' Sefwi Wiawso (n=31); 'irrigation technologies' Elembelle (n=30); 'shade trees' Offinso South (n=32); 'shade trees' Ejisu-Juaben (n=29); 'shade trees' Sefwi Wiawso (n=31); 'shade trees' Elembelle (n=28); 'fire belts' Offinso South (n =31); 'fire belts' Ejisu-Juaben (n=28); 'fire belts' Sefwi Wiawso (n =32); 'fire belts' Elembelle (n=30); 'keeping records on income and expenditures' Offinso South (n=30); 'keeping records on income and expenditures' Ejisu-Juaben (n=28); 'keeping records on income and expenditures' Sefwi Wiawso (n=32); 'keeping records on income and expenditures' Elembelle (n=31); 'mulching' Offinso South (n=30); 'mulching' Ejisu-Juaben (n=28); 'mulching' Sefwi Wiawso (n=32); 'mulching Elembelle' (n=31)

Table 31: Pairwise comparison of the conent scores of ‘feasibility’ and ‘motivation’ among the districompts for each AM

variable			Ejisu-Juaben		Offinso South		Sefwi Wiawso	Kruskal-Wallis
AM1	Ejisu-Juaben							0.055
component scores	Offinso South	-						
‘feasibility’	Sefwi Wiawso	-		-				
	Elembelle	-		-		-		
AM1	Ejisu-Juaben							0.016**
component scores	Offinso South	-						
‘motivation’	Sefwi Wiawso	-						
	Elembelle	>	0.022**			-		
AM2	Ejisu-Juaben							<0.001***
component scores	Offinso South	-						
‘feasibility’	Sefwi Wiawso	>	0.002***	-				
	Elembelle	>	<0.001***	>	0..036**	-		
AM2	Ejisu-Juaben							<0.001***
component scores	Offinso South							
‘motivation’	Sefwi Wiawso	>	0.005***					
	Elembelle	>	<0.001***	>	0.045**			
AM3	Ejisu-Juaben							<0.001***
component scores	Offinso South	-						
‘feasibility’	Sefwi Wiawso	>	<0.001***	-				
	Elembelle	>	<0.003***	-		-		
AM3	Ejisu-Juaben							0.073
component scores	Offinso South	-						
‘motivation’	Sefwi Wiawso	-		-				
	Elembelle	-		-		-		
AM4	Ejisu-Juaben							<0.001***
component scores	Offinso South	-						
‘feasibility’	Sefwi Wiawso	>	<0.001***	-				
	Elembelle	>	<0.001***	-		-		
AM4	Ejisu-Juaben							0.121
component scores	Offinso South	-						
‘motivation’	Sefwi Wiawso	-		-				
	Elembelle	-		-		-		
AM5	Ejisu-Juaben							0.001***
component scores	Offinso South	>	0.018**					
‘feasibility’	Sefwi Wiawso	>	0.004***					
	Elembelle	>	0.001***					
AM5	Ejisu-Juaben							<0.001***
component scores	Offinso South	-						
‘motivation’	Sefwi Wiawso	-		-				
	Elembelle	>	0.045**	>	<0.001***	-		

** significant at 5% probability level, *** significant at p 1% probability level

Note: ‘Irrigation technologies’ (n=121); ‘shade trees’ (n=120); ‘fire belts’ (n=121); ‘keeping records on income and expenditures’ (n=121); ‘mulching’ (n=121); ‘irrigation technologies’ Offinso South (n=31); ‘irrigation technologies’ Ejisu-Juaben (n=29); ‘irrigation technologies’ Sefwi Wiawso (n=31); ‘irrigation technologies’ Elembelle (n=30); ‘shade trees’ Offinso South (n=32); ‘shade trees’ Ejisu-Juaben (n=29); ‘shade trees’ Sefwi Wiawso (n=31); ‘shade trees’ Elembelle (n=28); ‘fire belts’ Offinso South (n =31); ‘fire belts’ Ejisu-Juaben (n=28); ‘fire belts’ Sefwi Wiawso (n =32); ‘fire belts’ Elembelle (n=30); ‘keeping records on income and expenditures’ Offinso South (n=30); ‘keeping records on income and expenditures’ Ejisu-Juaben (n=28); ‘keeping records on income and expenditures’ Sefwi Wiawso (n=32); ‘keeping records on income and expenditures’ Elembelle (n=31); ‘mulching’ Offinso South (n=30); ‘mulching’ Ejisu-Juaben (n=28); ‘mulching’ Sefwi Wiawso (n=32); ‘mulching’ Elembelle (n=31)

APPENDIX XIII

Table 32: Differences in ‘feasibility’ and ‘motivation’ within one AM

				Wilcoxon Signed Ranks Test
AM1	component score ‘feasibility’	<	component score ‘motivation’	<0.001***
AM2	component score ‘feasibility’	<	component score ‘motivation’	<0.001***
AM3	component score ‘feasibility’	>	component score ‘motivation’	0.001***
AM4	component score ‘feasibility’	>	component score ‘motivation’	<0.001***
AM5	component score ‘feasibility’	>	component score ‘motivation’	<0.001***

** significant at 5% probability level, *** significant at p 1% probability level

Note:’ Irrigation technologies’ (n=121); ‘shade trees’ (n=120); ‘fire belts’ (n=121); ‘keeping records on income and expenditures’ (n=121); ‘mulching’ (n=121)

Table 33: Pairwise comparison of the component scores of ‘feasibility’ and ‘motivation’ among the AMs

variable			AM1		AM2		AM3		AM4	Kruskal-Wallis
component score ‘feasibility’	AM1									<0.001***
	AM2	>	<0.001***							
	AM3	>	<0.001***	-						
	AM4	>	<0.001***	-		-				
	AM5	>	<0.001***	>	<0.001***	-		>	<0.001***	
component score ‘motivation’	AM1									<0.001***
	AM2	>	<0.001***							
	AM3	-		<	0.017**					
	AM4	<	0.023**	<	<0.001***	<	<0.001***			
	AM5	>	0.003***	-		-		>	<0.001***	

** significant at 5% probability level, *** significant at p 1% probability level

Note:’ Irrigation technologies’ (n=121); ‘shade trees’ (n=120); ‘fire belts’ (n=121); ‘keeping records on income and expenditures’ (n=121); ‘mulching’ (n=121)

APPENDIX XIV

Table 34: Post hoc test for implementation ‘keeping records on income and expenditures’

imp4 (n=121)		Ejisu-Juaben	Offinso South	Sefwi Wiawso	Elembelle
no	count	23	17	16	24
	adj. z-score	2.04	-1.26	-2.25	1.54
	p-value	0.0414	0.2077	0.0244	0.1236
	adj. α	0.0063	0.0063	0.0063	0.0063
yes	count	5	13	16	7
	adj. z-score	-2.04	1.26	2.25	-1.54
	p-value	0.0414	0.2077	0.0244	0.1236
	adj. α	0.0063	0.0063	0.0063	0.0063

** significant at 5% probability level, *** significant at p 1% probability level

APPENDIX XV

Table 35: Binary logistic regression for ‘irrigation technologies’

				95% confidence interval for Exp(B)			
predictor	*B*	*SE(B)*	*OR (Exp(B)*	*lower*	*upper*	*W*	*p*
area cocoa [ha]	-0.103	0.237	0.902	0.567	1.435	0.188	0.664
number farms [n]	-0.120	0.804	0.887	0.184	4.286	0.022	0.881
mean age farms [a]	0.11	0.071	1.011	0.879	1.163	0.025	0.876
age of farmer [a]	-0.29	0.067	0.971	0.852	1.106	0.195	0.658
high education [no, yes]	-1.750	2.649	0.174	0.001	31.258	0.436	0.509
high income [no, yes]	-16.899	12271.892	0.000	0.000	-	0.000	0.999
district						3.851	0.278
Elembelle	-1.513	1.949	0.220	0.005	10.040	0.603	0.437
Sefwi Wiawso	-1.845	1.915	0.158	0.004	6.747	0.928	0.335
Offinso South	4.993	3.047	147.326	0.376	57802.683	2.685	0.101
sex [male, female]	-0.807	1.384	0.446	0.030	6.723	0.340	0.560
land ownership [no, yes]	-1.124	1.544	0.325	0.016	6.694	0.530	0.466
household size [n]	-0.113	0.166	0.893	0.645	1.238	0.460	0.498
‘feasibility’ [score]	1.184	0.828	3.268	0.644	16.573	2.043	0.153
‘motivation’ [score]	9.186	6.235	9762.286	0048	1.979E+9	2.171	0.141
‘drought’ [score]	1.039	0.835	2.827	0.550	14.525	1.550	0.213
constant	1.633	0.835	5.117			0.115	0.735
Summary statistics (block)	*chi²*	*df*	*p*				
Hosmer and Lemeshow	6.231	8	0.621				
- log likelihood	26.992						
Nagelkerke’s pseudo-R^2	0.535						
Omnibus Test of Model	*chi²*	*df*	*p*				
Coefficients	24.305	15	0.060				

** significant at 5% probability level, *** significant at p 1% probability level

Note: n=104; implemented yes: n=7; implemented no: n=97

Table 36: Binary logistic regression for ‘shade trees’

				95% confidence interval for Exp(B)			
predictor	*B*	*SE(B)*	*OR (Exp(B)*	*lower*	*upper*	*W*	*p*
area cocoa [ha]	-126.295	1249.847	0.000	0.000	-	0.010	0.920
number farms [n]	170.008	1744.676	6.816E+73	0.000	-	0.009	0.922
mean age farms [a]	-0.861	27.640	0.423	0.000	1.424E+23	0.001	0.975
age of farmer [a]	-25.121	249.788	0.000	0.000	5.128E+201	0.010	0.920
high education [no, yes]	2072.257	22709.154	-	0.000	-	0.008	0.927
high income [no, yes]	216.395	11552.817	9.532E+93	0.000	-	0.000	0.985
district						0.011	1.000
Elembelle	38.769	2031.670	6.873E+16	0.000	-	0.000	0.985
Sefwi Wiawso	1233.137	13263.723	-	0.000	-	0.009	0.926
Offinso South	268.087	3044.603	2.684E+116	0.000	-	0.008	0.930
sex [male, female]	250.668	2507.593	7.308E+108	0.000	-	0.010	0.920
land ownership [no, yes]	21.533	1909.663	2.247E+64	0.000	-	0.000	0.991
household size [n]	148.875	1431.399	4.523E+64	0.000	-	0.011	0.917
‘feasibility’ [score]	128.875	1412.625	7.7070E+55	0.000	-	0.008	0.927
‘motivation’ [score]	22.371	1114.415	5.195E+9	0.000	-	0.000	0.984
‘drought’ [score]	-44.596	1137.581	0.000	0.000	-	0.002	0.969
constant	1461.672	14692.940	-			0.010	0.921
Summary statistics (block)	*chi²*	*df*	*p*				
Hosmer and Lemeshow	0.000	1	.999				
- log likelihood	0.000[b]						
Nagelkerke’s pseudo-R^2	1.000						
Omnibus Test of Model	*chi²*	*df*	*p*				
Coefficients	27.360	15	0.026**				

** significant at 5% probability level, *** significant at p 1% probability level

Note: n=107; implemented yes: n=104; implemented no: n=3)

APPENDIX XVI

Table 37: Costs and benefits Offinso South

	AM1	AM2	AM3	AM4	AM5
costs	borehole + pipes that serve a whole community: 150,000 GHC pumping machine for one farmer: 1,500 GHC hoses + sprinklers for one farmer: 1,000 GHC	for one acre (8 trees/acre): one shade tree seedling: 1.50 GHC = 12 GHC/acre transport of seedlings: 50 GHC 0.7 bags of ammonia: 45.50 GHC	construction of a fire belt of 10-14 feet by laborers around 1 acre: 44-80 GHC (costs of laborer: 22 GHC/day)	book and pencils for one year: 3-5 GHC	costs of optimal mulching of 1 acre: 3 bags of fertilizer: 300 GHC 5 bags of poultry manure: 20 GHC transport costs of fertilizer and poultry manure: 50 GHC mulching by laborers: 50 GHC/month
benefits	more yield prevent, stop or withstand fire outbreak food supply during dry season prevent death of seedlings and trees	provision of shade provision of food medicinal purposes provision of household income provision of construction material	prevent fire aerate farm prevent rodents from entering farm	know profit and loss/costs motivation for the next season	increase yields cool the soil organic fertilizer pruning allows air to circulate on the farm
usefulness	10	10	10	10	10
desirability	10	10	10	10	10

Table 38: Overcoming limits and barriers Offinso South

		overcoming barriers			
limits/barriers	reasons for barriers	household level	village level	district level	governmental level (COCOBOD)
inadequate governmental support	-the people in charge of distributing farming inputs	-money, so they can buy their own farming inputs and overcome the problem of insufficient and untimely governmental support -create independency from government (they don't think that the government will listen to them)	-meet as a group and appoint a leader who sends their plight and negotiates with the district planning level -contribute money to farmers group and buy own farming inputs	-loans with reduced interest rates for farmers -district chief executives should make the Agric officers nurse seedlings and distribute it to the farmers	-sufficient and timely input supply -allow the Agric officers to nurse cocoa seedlings and distribute it to the farmers
inadequate information from extension services	-low salaries for extension officers -poor service conditions -few extension officers available	-teach each other in the community -create independency from extension officers	-meet as a group, teach each other and solve issues with different ideas	-train local farmers to extend the knowledge learnt	-train and employ more extension officers
lack of money	-competition -cocoa income comes only twice a year -household expenses -no help from the district level	-diversify income	-diversify income	-loans with reduced interest rates for farmers -provisions of seeds	-increase cocoa prices -loans with reduced interest rates
lack of examples where AMs are implemented	-lack of money for the implementation of irrigation technologies -lack of knowledge and motivation for keeping records (because profits are low)	-take out loans for the implementation of irrigation technologies -buy books and pens to start keeping records	-collect money as a group -form farmers groups and teach each other how to keep records	-subsidize irrigation technologies	-provide money

Table 39: Costs and benefits Elembelle

	AM1	AM2	AM3	AM4	AM5
costs	irrigation technology for 5 farms: borehole: 15,000-20,000 GHC pumping machine: 1,800 GHC pipes: 12,000 GHC hoses + sprinklers: 1,000 GHC	for one acre (8 trees/acre): one shade tree seedling: 7-10 GHC = 56-80 GHC/acre transport of seedlings: 50 GHC costs for planting: 10 GHC	construction of a fire belt of <5 feet by laborers around 1 acre: 60-150 GHC (construction of fire belt: 1-3 times/year)	book and pencils for one year: 13-14 GHC	hiring a laborer for pruning (one a year): 160-600 GHC hiring a laborer for spreading cocoa pods: 30 GHC
benefits	more yield increase income stronger cocoa trees healthy cocoa seedlings prevent yellowing of smaller pods more food crops (plantain)	provision of shade help cocoa withstanding drought prevent soil erosion medicinal purposes provision of food provision of construction material leaves provide organic fertilizer	prevent fire aerate farm prevent rodents from entering farm prevent black pod disease	calculate income and expenditures know profit or loss compare profits and expenditures among the years know the progress of the work	prevent soil erosion organic fertilizer retain soil moisture cool the soil source of feed for poultry suppress weeds
usefulness	10	10	10	10	10
desirability	10	10	10	10	10

Table 40: Overcoming limits and barriers Elembelle

		overcoming barriers			
limits/barriers	reasons for barriers	household level	village level	district level	governmental level (COCOBOD)
inadequate governmental support	-bureaucracy -lack of respect for farmers -differences in problems -government didn't know that cocoa was grown in that region -no farmer groups	-visit government officials and complain to them -individual savings -take out loans	-form farmer groups/cooperatives, contribute money and buy the things needed for cocoa farming -construct good roads (as community)	-form cooperatives and appoint a leader who sends their plight and negotiates with the district planning level -supervision of farm inputs from the district officers	-open an agrochemical shop and sell farm inputs -subsidized farming inputs -supply inputs on time -continuous supervision -conduct census of farmers in Elembelle to better plan the amount of provided inputs
inadequate information from extension services	-no farmer groups -lack of communication between farmers and extension officers -few extension officers available	- visit an extension officer, ask him/her to help and pay him/her afterwards -teach each other in the community	-form farmer groups -teach each other in the community -help each other with extension services (pruning)	-form cooperatives and registered groups and appoint a leader who informs the district chief executives about the inadequate extension services in the community -employ more extension officers	-train local people so they can provide extension services to other farmers in the community -train and employ more extension officers
lack of money	-little money form cocoa farming is spent on farming again -school fees, domestic inputs -income is mainly coming from cocoa farming -improper weighing scales -climate change -lack of diversification	-diversify income -open a bank account -cut expenses on other things (e.g. funerals, clothes) -save some of the little money generated from cocoa -prioritize things, plan well how money is spent	-take out loans as a village group -help each other to reduce the costs of hiring laborers	-loans with reduced interest for farmers -centralize one certified source of input supply	-loans with reduced interest for farmers -distribute farm inputs at reduced prices -increased supply of farming inputs -improve monitoring of uncertified farming inputs
lack of examples where AMs are implemented	-lack of knowledge on keeping records on income and expenditures and irrigation -lack of money to implement irrigation technologies	-purchase books and pens and start record keeping -use gallons to irrigate the farm	-come together, contribute and buy the things needed for keeping records on income and expenditures -come together and use gallons to start irrigating their farms	-district chief executives should employ people who teach record keeping in the villages -district chief executives should provide funds for the implementation of irrigation technologies -provide loans	-provide book and pens -train farmers on record keeping -introduce informal education -provide funds for the implementation of irrigation technologies