INTEGRATED SOIL FERTILITY MANAGEMENT IN GHANA

UNDERSTANDING COCOA FARMERS' MOTIVATIONS AND UNPACKING ADOPTION OF ISFM PRACTICES

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Integrated Soil Fertility Management:
Understanding cocoa farmers' motivations and unpacking adoption of ISFM practices
MSc Thesis Plant Production Systems

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Abstract

Cocoa is an important crop for the livelihoods of many Ghanaian smallholder farmers. The yields per hectare remain very low, with soil nutrient deficiency as one of the major causes. Integrated Soil Fertility Management (ISFM) has the potential to increase cocoa productivity, however, low adoption rates of ISFM practices indicate a room for improvement in matching available technology with the needs of farmers. Therefore, forty cocoa farmers were interviewed to understand their motivations to grow cocoa and decisions regarding ISFM practices. The concept of technology adoption was unpacked into different 'utilisation stages', providing insight in incentives and constraints of farmers to perform ISFM practices. The assessed practices were application of inorganic fertiliser, organic fertiliser, cocoa husk spreading, land preparation and choice of variety.

This study found motivations for growing cocoa in three categories: 'passionate', 'practical' and 'lack of alternative'. All farmers with 'passionate' motivations had higher ISFM utilisation scores than farmers with 'lack of alternative' motivations. This suggests that motivation is a driver for ISFM utilisation behaviour. Furthermore, farmers showed very diverse stages of utilisation of the ISFM practices researched in this study, as well as diverse incentives and constraints to use them. A typology based on motivations and ISFM utilisation was constructed to highlight this diversity. Five types of farmers were distinguished: 'passionate', 'high potentials', 'practical', 'stuck' and 'tired'.

It is important to acknowledge this diversity between cocoa farmers in targeting and implementing new technologies, and to take potential constraints and incentives into account. This will help improve self-selection of practices and therefore improve utilisation of ISFM and cocoa yields.

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List of abbreviations

COCOBOD	Ghana Cocoa Board
CORIP	Cocoa Rehabilitation and Intensification Programme
F	Farmer
IITA	International Institute of Tropical Agriculture
ISFM	Integrated Soil Fertility Management
PAUF	Process of Agricultural Utilisation Framework
PM	Poultry manure
SF	Soil fertility
SPD	Seed Production Division
SRQ	Sub research question
TQ	Tetteh Quarshie (cocoa tree variety)

1. Introduction

Ghana is the world's second producer of cocoa, producing about 900,000 tons of cocoa beans annually (Wessel & Quist-Wessel, 2015). Cocoa production in Ghana is the major economic activity for over 800,000 households, with over 30 percent of the total population depending on cocoa for their livelihood (COCOBOD, 2019; Gockowski et al., 2011). Most cocoa farmers in Ghana are smallholders, with farms of around two hectares (Wessel & Quist-Wessel, 2015). The cocoa production in Ghana has shown a great increase over the last decades, due to government support measures and production area expansion (Wessel & Quist-Wessel, 2015). However, the yields per hectare remain very low. The national average is around 400 kg/ha (Aneani & Ofori-Frimpong, 2013), while yields of around 3,360 kg/ha have been achieved in on-station trials in Ghana (Van Vliet et al., 2015). Despite the low productivity and associated low incomes of the cocoa sector in Ghana, the majority of farmers prioritise cocoa over other crops. In Ghana, 84% of households cite cocoa as their most important or second most important crop (Bymolt et al., 2018b).

Soil nutrient deficiency is one of the major causes of the low yield per hectare in Ghana's cocoa production sector (Van Vliet et al., 2015). Most nutrients in cocoa ecosystems are lost by the harvest of beans and husks, and the low use of fertilisers in the cocoa ecosystems results in a negative nutrient balance (Damisa & Igonoh, 2007; Hartemink, 2005). To ensure the long-term sustainability of the cocoa sector, appropriate management of soil fertility is of vital importance.

The International Institute of Tropical Agriculture (IITA) and Wageningen University and Research are the leading partners of the CocoaSoils project, a program that addresses productivity and sustainability in the cocoa sector. Two major goals of the project are developing a set of Integrated Soil Fertility Management (ISFM) recommendations for cocoa and delivering the newly generated knowledge to the farmers who can adopt the practices to increase yields (IITA, 2017). It is a contribution to sustainable intensification of Ghanaian cocoa production.

1.1 Integrated Soil Fertility Management

Integrated Soil Fertility Management (ISFM) is defined as the application of soil fertility management practices, and the knowledge to adapt these to local conditions, which maximise fertiliser and organic resource use efficiency and crop productivity (Sanginga & Woomer, 2009). ISFM consists of a set of best practices, preferably used in combination, including the use of appropriate germplasm, the appropriate use of fertilizer and of organic resources, and good agronomic practices (Vanlauwe et al., 2015). It is a means to enhance crop productivity while maximising agronomic efficiency of applied inputs (Vanlauwe et al., 2015).

The focus of ISFM is on improving biophysical factors, however it also recognises the dependence of agro-economic efficiency on social and economic realities of farmers (Bado & Bationo, 2018). Specific ISFM recommendations for cocoa are yet to be developed, however, they will include targeted fertiliser application, organic resource management, and planting trees for shade and litter fall in these recommendations (IITA, 2017).

1.2 Adoption of ISFM

Despite the promising potential of ISFM strategies in many agricultural sectors, widespread adoption is lacking (Vanlauwe et al., 2006). Low adoption rates of newly introduced technologies suggest a mismatch between the available technology to improve productivity and the needs of farmers. Lack of adequate knowledge of farmers' adoption behaviour towards new technologies is the main reason for this (Mugwe et al., 2008). Various studies point out that a deeper understanding of practices and the rationale behind farmers' behaviour is recommended in order to increase adoption and productivity (Baffoe-Asare et al., 2013; Mugwe et al., 2008; Mwangi & Kariuki, 2015). However, the majority of research on incentives and constraints for technology adoption uses structured surveys and statistical analysis methods on previously determined factors (e.g. (Anang, 2015; Baffoe-Asare et al., 2013; Damisa & Igonoh, 2007; Mugwe et al., 2008). Selecting the factors for analysis is challenging, and there is an additional risk of neglecting unknown factors in this type of research. When working with statistical distribution and regression like survey studies typically do, it is important to further probe the causality in the field with qualitative research.

Another challenge to the adoption of ISFM is the large heterogeneity in smallholder farming systems in Sub-Saharan Africa. Agricultural extension to farmers often assumes similar needs and aspirations, while there are in-fact many differences between farmers (IITA, 2019). Therefore, understanding this diversity of farmers is of vital importance for adoption of ISFM technologies.

1.3 Research objective and questions

The aim of this study is to improve our understanding of the ISFM practices of cocoa farmers. To achieve this, we look at farmers' motivations for growing cocoa and their incentives and constraints for performing past and present practices. The study has three objectives:

- To understand what motivates farmers for cultivation of cocoa;
- To understand how previous experiences and events shape current ISFM practices;
- To make a typology of farmers based on their stage of ISFM use.

An increased understanding of farmers' practices and motivations for growing cocoa can help reduce the mismatch between technology and farmers' needs. In addition, understanding previously made decisions can improve the targeting of recommendations for intensification of the cocoa production system. Vanlauwe et al. (2015) emphasise the need for region-specific knowledge on adoption so recommendations can be tailor-made. If existing ISFM practices can be locally adapted (according to the farmers' needs), they are more likely to result in yield improvement in the future.

Hence, the following research question was formulated: **what affects farmers' decisions on the application of integrated soil fertility management practices in cocoa production in Ghana?**

To achieve the research objectives, four sub-research questions (SRQs) have been formulated:

1. What are farmers' motivations to engage in cocoa production?
2. What are cocoa farmers' activities and experiences regarding soil fertility management in the past and present?
3. What is their willingness to continuously apply or start with ISFM practices in the future?
4. What patterns can be identified among cocoa farmers based on motivation and use of ISFM practices?

2. Methodology

This study used a qualitative research design to improve our understanding of the motivations and ISFM practices of cocoa farmers. This research design is explanatory and interpretive, however, based on systematically gathered and analysed data (Madden, 2017). Data collection consisted of semi-structured interviews with key informants, and with cocoa farmers using a life history approach. The life history approach has the intention to understand how the patterns of different life stories can be related to their wider historical, social, environmental and political context (Adriansen, 2012). This chapter elaborates on the research sites, the chosen research methods and participants, and the sampling strategies.

2.1 Research sites and farmer selection

Data collection was performed in five communities in two different regions in Ghana (Figure 1). The Ashanti and Western region were purposely selected because of their accessibility and because they represent old (Ashanti) and new (Western) frontiers of cocoa cultivation in Ghana (Asare & Raebild, 2015). Three districts in Ashanti Region (Abroma, Juaben and Ofoase), and two districts in Western Region (Gyedua Saamang and Ankonsia) were selected for logistical reasons: mainly based on when the communities had their "taboo days". On taboo days, ghosts of farmers' ancestors are believed to visit the farms, which means that farmers stay at home in the communities and are easier to reach.

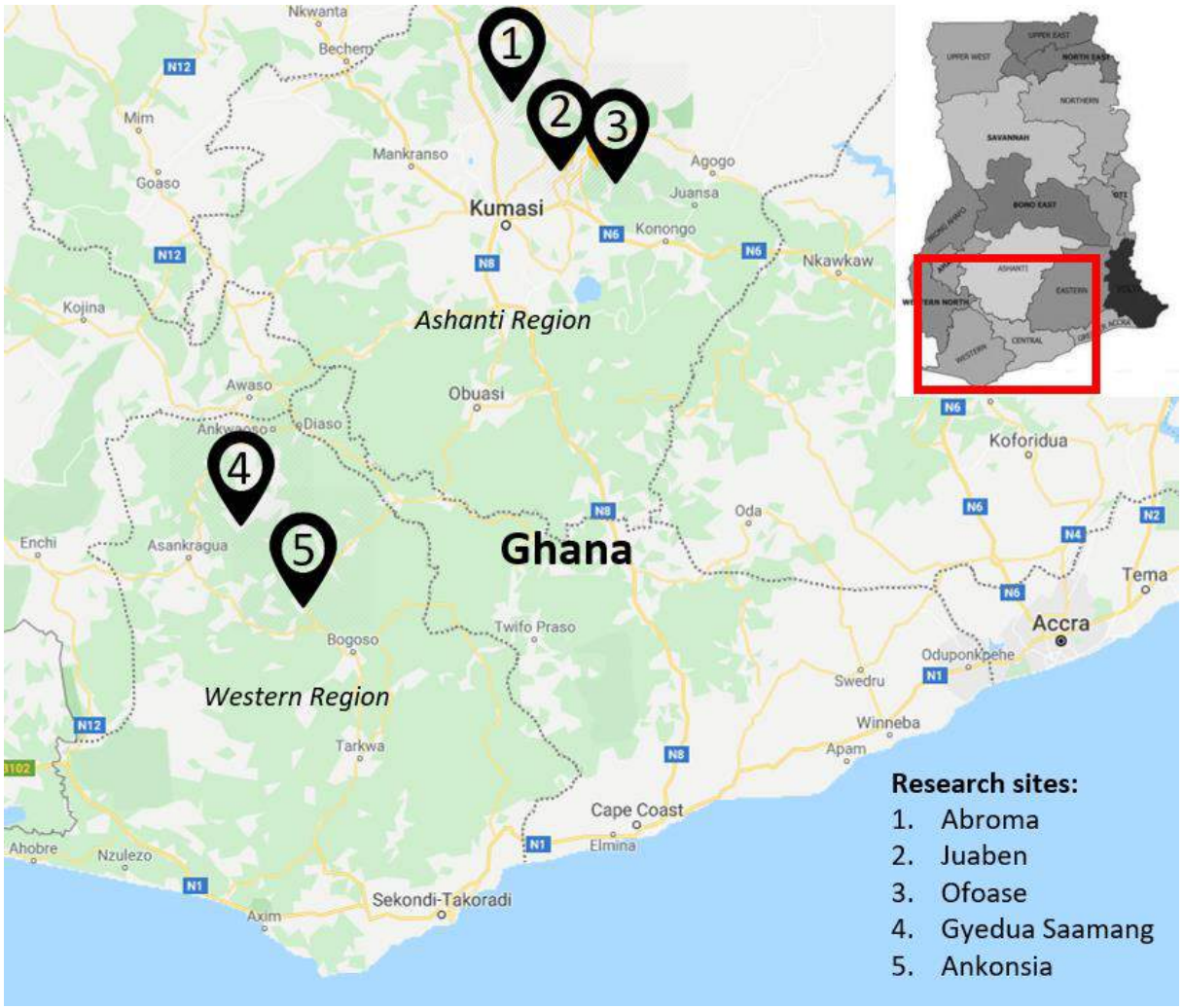


Figure 1: Locations of research sites

Going to the communities on taboo days made it easy to meet the farmers in their busy harvesting season and to have efficient field days. Prior to visiting the community, the purchasing clerk selected farmers as respondents for the interviews. There were no selection criteria other than presence in the community and availability at the day of the interview. Farmers were reached and sampled with the support of Kuapa Kokoo, a farmers organisation that provides trainings for improved practices for cocoa farmers. Not all farmers were active members, however, they were part of the extension network of the organisation.

The two regions differ in their agroecology. The three districts in Ashanti region had a tropical climate. Mean annual rainfall is 1000-1400 mm in two wet seasons, peaking in May-June and October (Logah et al., 2013). The mean annual temperature is up to 32°C in the northern parts of the region (MoFA, 2019a), where the field work was conducted. Western Region has a slightly more moderate climate with average temperature of 26°C and annual rainfall of 1400-1900 mm, also in two wet seasons (Logah et al., 2013; MoFA, 2019b).

Moreover, the communities had some socio-economic differences. Abroma is a relatively small community with cocoa farming as the major economic activity (Amon-Armah et al., 2017). The population is dominated by indigenes, with few migrants working as labourers or caretakers of local farms. In Juaben and Ofoase, currently the main agricultural land use is oil palm cultivation (Asibey et al., 2019), which increased after construction of an oil palm processing facility built in 2009 (Proforest, 2015). Five of the eighteen cocoa farmers interviewed in these two districts had an additional income from oil palm cultivation. Though the Western Region is known for its cocoa cultivation, currently small-scale surface mining for gold has emerged as the major activity in the area (Amon-Armah et al., 2017). Communities Gyedua Saamang and Ankonsia are busier compared to the other areas, with a lot of migrants from different regions purposely to mine gold. Interest of (international) mining companies has made the area even more vibrant. Illegal mining activities cause irreversible damage to the soil fertility (Obeng et al., 2019) and extension officers organise trainings to inform farmers about these risks. Additionally, both communities Gyedua Saamang and Ankonsia were part of the Cocoa Rehabilitation and Intensification Programme (CORIP) in 2015, where rural service centres provided support services for farmers to intensify production through improved planting material, ISFM, and good farm management practices with supportive financial access (Solidaridad, 2015).

For this research, the agroecological or socio-economic differences between Juaben and Ofoase as well as between Gyedua Saamang and Ankonsia are not important. For further analysis, results from these communities are combined.

2.2 Data collection

The main data was collected through semi-structured interviews: qualitative interviewing with open-ended questions. These are more likely to get a considered response than closed questions and therefore provide better access to interviewee's views, interpretations of events, understandings, experiences and opinions (Byrne, 2017). This suits the understanding nature of this research. In addition, semi-structured interviews are open to hearing respondents views in their own words, which allows for a more complex analysis than a survey based approach (Byrne, 2017). In this research, semi-structured interviews provided the possibility to come up with new topics, motivations or practices that have not already been mentioned in literature (and interview guide). For the interview participants in this research, two main groups are identified: key informants and cocoa farmers.

2.2.1 Key informant interviews

Key informants are characterised as members of a community or society who are able to provide more information and a deeper insight in what is going on around them, as a result of their personal skills or position (Marshall, 1996). In this study, key informant interviews are used as a tool to triangulate and validate information from the farmer interviews, and to acquire more knowledge about the cocoa production system.

Interviews with key informants were useful improve understanding of the local dynamics of the farmers which affects their decision making. They also gave insight in technological innovations in cocoa production and how the focus of extension activities changed throughout the years. The key informants for this research were an extension officer of Kuapa Kokoo, the coordinator of extension of Kuapa Kokoo, an agricultural expert and a soil scientist of CRIG, a program manager on sustainable agriculture and a purchasing clerk.

Additionally, during field work, the research attitude was open to informal conversations and field observations, which were registered in written field notes and used to validate other information. This information includes conversations and observations made while visiting:

- Various cocoa farms together with the farmers (outside the interview setting), including *n'nobua* (pod breaking) and cocoa bean drying activities in the communities;
- The office of the International Institute of Tropical Agriculture in Accra;
- Annual General Farmers Meetings of farmer organisations Kuapa Kokoo and Cocoa Abrabopa;
- COCOBOD's cocoa seedling nursery in Wassa Akropong;
- Kuapa Kokoo's Demonstration of Aged Cocoa Farm Rehabilitation in Akonsia;
- Experimental plots of the Cocoa Research Institute of Ghana in Koforidua;
- Quality control at Kuapa Kokoo's cocoa depot in Offinso.

2.2.2 Farmer interviews

Forty smallholder farmers provided the greatest source of data by means of semi-structured interviews. They were distributed between the communities as follows: 12 in Abroma, 10 in Juaben, 8 in Ofoase, 5 in Gyedua Saamang and 5 in Ankonsia. This means thirty interviews were performed in Ashanti and ten in Western Region. Two farmers spoke English, the other thirty-eight interviews were performed with a translator present. The general structure and goals of the cocoa farmer interview were as follows:

- Part 1 **the basis**: get to know the farmer and identify the perceived problems at farm level.
- Part 2 **farm development**: construct a timeline of farmer's background in cocoa and major events and changes on the farm during time.
- Part 3 **practices**: zoom in onto certain practices on the timeline, to improve understanding of why it happened at that certain time and why.
- Part 4 **aspirations**: take a look into the future of the cocoa farmer to identify future aspirations in the perspective of previous events.

Different parts of the interviews provide different parts of information necessary for answering the sub research questions. The goals (in the circle) and themes for each interview part are displayed in Figure 2 on the next page. Part 1 is related to SRQ 1, parts 2 and 3 are related to SRQ 2 and part 4 is related to SRQ 3.

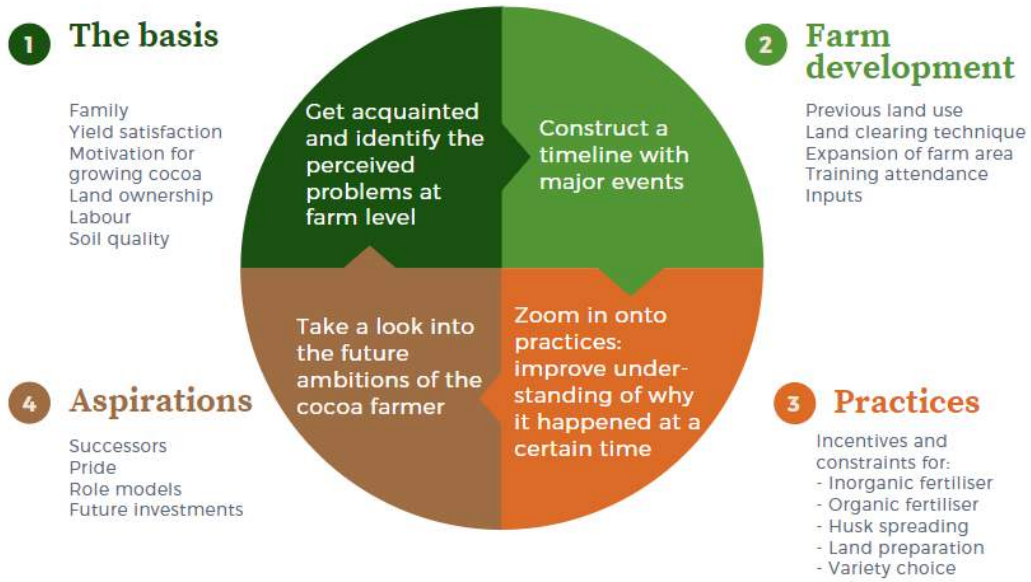


Figure 2 Farmer interviews: goals (in circle) and themes (listed)

After setting the basis of the semi-structured interview in the part 1, part 2 was specifically about life history, where a timeline was used as visual representation of the main events in the life of a farmer considering farm and field management. Part 3 involved specific ISFM practices: application of inorganic fertiliser, application of organic fertiliser (manure and compost), pod husk spreading after harvest as crop residue management, method of land preparation for cocoa cultivation and choice and origin of the planted cocoa tree variety.

2.3 Theoretical framework

This study uses a theoretical framework to order the collected data. The concept of technology adoption has been discussed briefly in the introduction. Most authors use a binary classification to understand adoption, which means farmers are classified as either adopters or non-adopters. This classification is used by different authors researching adoption of ISFM or one of its components (Anang, 2015; Baba Ali et al., 2018; Baffoe-Asare et al., 2013; Damisa & Igonoh, 2007; Mugwe et al., 2008; Wiredu et al., 2011). The binary classification provides limited insight in understanding modification of practices or the intensity of adoption. Partial adoption and modified adoption are also found in literature (Aneani et al., 2012; Lalani et al., 2016), however, the determinants of non-adoption are then not taken into account.

To assess ISFM adoption, it is necessary to use an appropriate framework that accounts for various sub-types of use and non-use of technology (Brown et al., 2017; Glover et al., 2016; Mwangi & Kariuki, 2015). Therefore, Brown et al. propose a shift in terminology from ‘adoption’ to ‘utilisation’. The authors introduce the Process of Agricultural Utilisation Framework (PAUF), which is applied to understand different types of adoption and non-adoption (see Figure 3). In this framework, the adoption process is disaggregated: four phases are distinguished (from exposure to utilisation) and connected to ten different stages towards utilisation (from unaware to total utiliser).

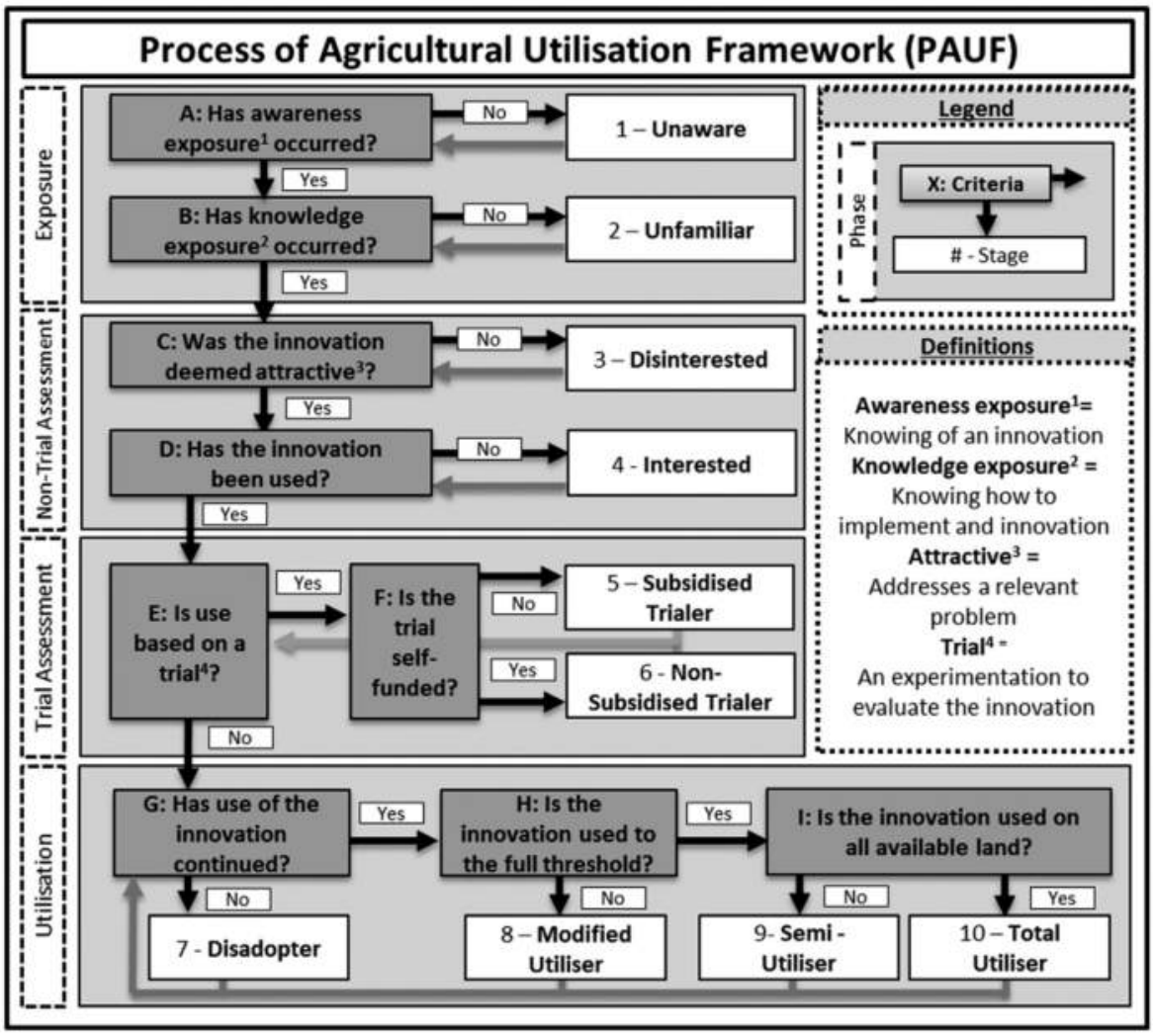


Figure 3 PAUF: Process of Agricultural Utilisation Framework (Brown et al., 2017)

To make the PAUF applicable for this study, it is simplified and specifically focused on ISFM practices, see Figure 4. The disaggregation of 'unaware' and 'unfamiliar' in the PAUF was not based on any specific information and in Brown's further analysis they have been aggregated as phase level 'unexposed' (Brown et al., 2017). Furthermore, this research does not *introduce* ISFM as a technology, but aims to find out previous experiences with ISFM practices. Therefore, the distinction between unaware and unfamiliar is not found important and they are merged together into one stage: unaware. The stages 'subsidised trialer' and 'unsubsidised trialer' are left out because the study does not involve a specific trial assessment. Additionally, the stage 'unable' is added, so resource and capital endowment (or other unabling factors) are also taken into account. Specific constraints of this 'unable' stage are explained in the results chapter, section 3.2.

The framework is suitable for unpacking adoption, however, it holds some limitations. Brown et al. (2017) note that not all stages are sequential, and a farmer is unlikely to move through from stages 1 to 8. This means that the PAUF supports in understanding different phases of adoption, however, it is not a framework for finding factors or mechanisms. Even within utilisation stages, farmers could have different reasons for their utilisation behaviour. Therefore, the stages of the framework are complemented by identifying the incentives and constraints of each decision acknowledge diversity even within the utilisation stages.

The framework distinguishes three different types of utilisers. If the technology is subsequently applied in a modified form, the farmer is classed a 'Modified Utiliser' (Brown et al., 2017). If the technology is in its original form but not applied to all applicable area, that farmer is classed by Brown et al. as a 'Partial Utiliser' (see Figure 3). However, since this study also looks at use of ISFM practices through time, the stage 'Partial Utiliser' (see Figure 4) comprises spatial utilisation (on all applicable area) as well as temporal utilisation (in all years). If the technology is currently applied in its original form and on all applicable area, that farmer is classed a 'Total Utiliser'.

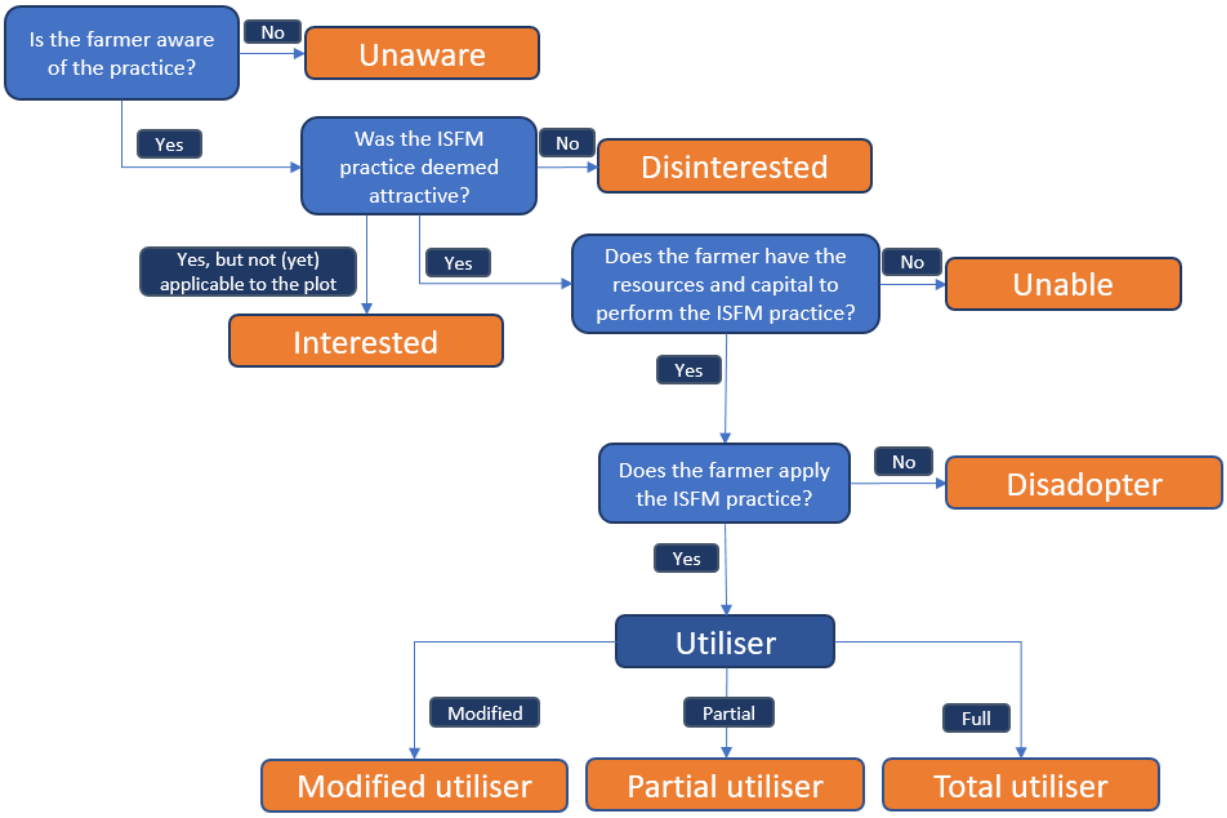


Figure 4 ISFM utilisation framework, adapted from Brown et al. (2017)

2.4 Data processing and coding

With consent of all farmers, the interviews were recorded on a voice recorder and processed into word-for-word interview transcripts in Microsoft Word. Given the personal nature of the interviews, the transcripts are anonymised and will be referred to in this report as F01 (farmer 1) to F40 (farmer 40). They were further arranged into Microsoft Excel files in a systematic order for the qualitative analysis. At first, initial coding was used as a tool to break down the data and to be able to analyse, sort and recognise patterns. Afterwards, axial coding determined which codes in the research are the dominant ones and which are the less important ones (Saldaña, 2013). In this stage, the codes were as much as possible classified and sorted according to the concepts in the research questions and theoretical framework to make them not too complicated, and pragmatic for the analysis. This resulted in the code tree in Figure 5.

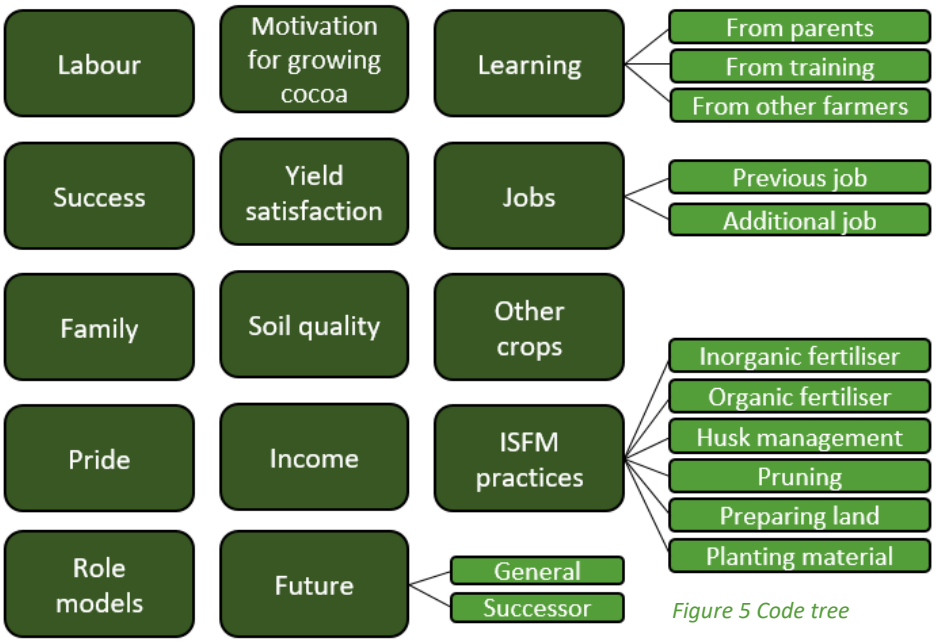


Figure 5 Code tree

2.5 Qualitative analysis

The results in chapter 3 are based on qualitative analysis of the research data. Transcribing and processing the interview data in the Excel files was a good repetition of the content, making it easier to recognise patterns and getting more acquainted with the information. The sub research questions are used as guideline to make the farmer typology, which is one of the research objectives. The data analysis steps for each sub question are briefly described below for easy understanding of the result section. The main information source for all SRQs is the data from the farmer interviews. Data from key informant interview was used additionally to validate information or to put farmer's statements into context.

SRQ 1: Motivations

What are farmers' motivations to engage in cocoa production?

After coding the farmer interview data, information on what motivates farmers to engage in cocoa production could be easily selected by sorting the data by code. Most farmers mentioned several motivations, often in different interview parts. The sorted data on motivations was re-coded into more detailed categories, carefully paying attention to the formulation and context. After re-coding, the number of mentions in each category was counted and sorted on level of frequency. Motivation subcodes are explained in Table 1 on the next page, using a typical quote of a farmer expressing that motivation.

Table 1 Motivation codes explained by farmers' quotes

Category	Motivation	Quote
Passionate	Good income	"You can compare it to gold. When you have gold first, the next thing is cocoa." (F07)
	Support Ghana	"If there was no cocoa, there would be no Ghana. I grow it to support the country." (F26)
	Be part of the cocoa farmers	"When somebody would say "where are the cocoa farmers?", then I would also be a part of it." (F06)
	Family tradition	"I am also a cocoa farmer because I have to tred, where my father's food has tred." (F14)
Practical	Support my family	"If I sell cocoa, it will allow me to take care of my wife and my children and bring them to school" (F08)
	Income provision	"Cocoa farming is an important business because it generates money" (F10)
	Enough land available	"I chose to plant cocoa, because the land was big." (F21)
	Long-lasting crop	"Cocoa is everlasting" (F23)
	Better income than oil palm	"I switched from oil palm and plantain to growing cocoa, because the income from cocoa is better compared to income from oil palm." (F29)
	Future crop	"It is a future crop. When you are old, it will take care for you." (F05)
Lack of alternative	School drop-out	"I didn't learn anything in education. So it is only the cocoa farming that I can do." (F20)
	No alternative jobs available	"There is no work here apart from cocoa farming." (F32)

Motivations are categorised into 'passionate', 'practical' and 'lack of alternative' based on expressions of farmers and researcher's interpretation of the farmers words in the context of the entire farm. They should not be applied to motivations for any other region or crop production system unrevised. For example, the category "family tradition", could be interpreted as practical ("I am doing what my parents did"), but is classified under passionate, because the farmers expressing this motivation were convinced that family tradition made cocoa farming their vocation. These qualitative choices were made to make the typology approach reality as much as possible.

SRQ 2: ISFM practices

What are farmers' activities and experiences regarding ISFM in the past and present?

The same sorting method was used to get all the information on the farmers' ISFM practices, using codes and subcodes. All the information was revised and summarised in a table where incentives for utilisation and constraints for non-utilisation were also indicated, based on the farmer interviews. With this overview, the utilisation stage was determined for the different ISFM practices of all forty farmers using the adapted Process of Agricultural Utilisation Framework (Figure 4). For every practice, the farmers were sorted on their utilisation stage to allow for seeing patterns in their incentives and constraints to utilise the practice.

After utilisation stages, incentives and constraints are assessed for each practice, the overall utilisation stage of each farmer is determined. To do this, a quantification of the utilisation stages raking from 1-5 has been made, presented in Table 2. Total utiliser was ranked the highest number (5), just as modified utiliser because the modifications are often innovative, site-specific adaptations that improve the ISFM practice. Partial utilisers were ranked with a 4, just like interested farmers, because they

often indicated to be eager to perform the practice in the future, however, their plot or trees were not yet suitable for it. This makes them 'nearly-utilisers' which gains a high ranking. Unable and unaware farmers were ranked with a 2, because they often did have the willingness to change practices but not the knowledge or means to do it. The lowest number 1 was assigned to stages disadopter and disinterested, since they even lack willingness for the ISFM practice. The average of the utilisation stages of each farmer was their personal 'ISFM utilisation score' between numbers 1 and 5. Scores under 2.5 were ranked "low", scores between 2.5 and 4 "medium", and above 4 "high". The ranking was used for constructing the typology later.

Table 2 Quantification of utilisation stages

Utilisation stage	Utiliser?	Quantification
Total utiliser	Utiliser	5
Modified utiliser	Utiliser	5
Partial utiliser	Utiliser	4
Interested	Non-utiliser	4
Unable	Non-utiliser	2
Unaware	Non-utiliser	2
Disadopter	Non-utiliser	1
Disinterested	Non-utiliser	1

SRQ 3: Future perspective

What is their willingness to continuously apply or start with ISFM practices in the future?

The future perspective of farmers is expressed by their willingness to continuously apply or start with ISFM practices in the future, which is derived from the interviews and quantified for further analysis. Farmers received a "1" for every time they declared to be planning or willing to apply the recommended practice in the future: i.e. applying inorganic fertiliser, applying organic fertiliser, spreading husks over the farm, planting the hybrid variety and no-burn land preparing. Scoring a "1" means the farmers are either interested, unable or already utilisers of the practice. When they indicated not to be willing to apply the practice in the future (i.e. disadopters or disinterested), they received a "0". The sum of these numbers resulted in a 'future ISFM score' for each farmer. Missing information is indicated by a blank box, which was counted as a "0". This especially occurs in the land preparation practice, since the farmers often had no expectation of land expansion any time soon and were not really able to express their interest. It also occurred at some specific farmers since they were simply less talkative, less future-minded or unsure about the future. In case data was missing on more than two of the practices, the future ISFM score could not justly be determined.

Additionally, the factors of planned future investments and whether they hope for their children to be cocoa farmers as well are derived from the interviews and used for the typology characteristics.

SRQ 4: Typology

Which patterns can be identified among farmers based on their motivations and ISFM utilisation?

The farmers were classified into a typology consisting of five farmer types. The typology is used to highlight the heterogeneity amongst farmers and to understand their different needs, constraints and opportunities. Segmentation between farmer types is based on their (potential) ISFM utilisation stage and their motivation for cocoa farming. On the x-axis, the low-medium-high ranking of SRQ 2 was used, and on the y-axis the lack of alternative-practical-passionate ranking of SRQ 1 (see Figure 6). After assigning the farmers to the groups, specific characteristics of those groups were determined by assessing and looking for patterns in different variables, such as tree age, farm size, farmer's age, farm labour, planned future investments, the wish for their children to become cocoa farmers, training attendance, soil fertility knowledge, etc.

The typology frame should be interpreted as a continuum on which farmers are constantly moving; within their category as well as between categories. It was constructed for the cocoa farmers in the research area, however, the concept can be applied in other areas or even other crop value chains.

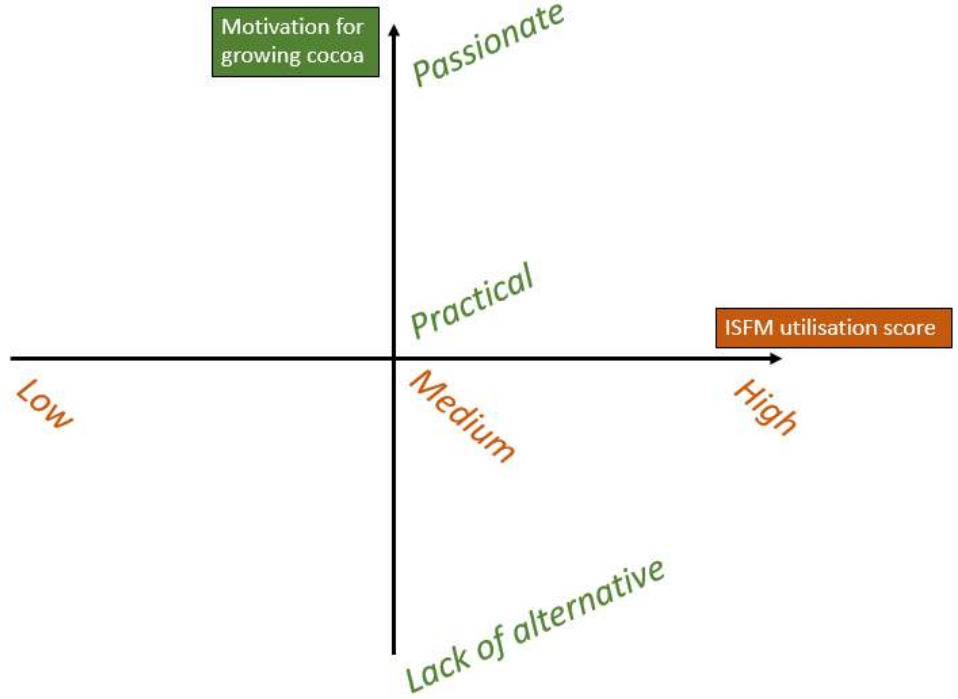


Figure 6 Visualised typology frame

3. Results

This section describes the results of the research, sorted by the four sub research questions. It should be noted that the annexes provide a simplified overview of reality and the unique situation of every farmer should be considered in interpretation of the results.

3.1 Motivations for cocoa farming

Farmers mentioned various motivations for engaging in cocoa farming. They are listed in Table 3 below and sorted in three categories. During forty interviews, a total of 95 motivations were identified, categorised into twelve groups within three categories. The last column shows the percentage of the total of forty farmers that mentioned that particular motivation. The motivation codes and categories are explained in section 2.5.1.

Table 3 Farmers' motivations for engagement in cocoa farming

Category	Motivation	# mentions	mentioned by % of farmers
Passionate	Good income	8	20
	Support Ghana	7	17.5
	Be part of the cocoa farmers	6	15
	Family tradition	6	15
Practical	Income provision	14	35
	Support my family	13	32.5
	Future crop	13	32.5
	Enough land available	7	17.5
	Long-lasting crop	5	12.5
	Better income than oil palm	4	10
Lack of alternative	School drop-out	8	20
	No alternative jobs available	4	10

Based on their motivations, each farmer was classified into the category 'Practical', 'Passionate' or 'Lack of alternative'. Results per farmer can be found in Table 5 in annex I. In case more motivations of different categories were indicated, the farmer was categorised according to their most prevalent motivation(s), e.g. F18 and F38. Eight farmers were classified 'Passionate', 24 'Practical' and eight 'Lack of alternative'.

Distribution of the motivations over the communities is displayed in Figure 7. Gyedua and Ankonsia lean towards more 'Lack of alternative' farmers, whereas Abroma has only 'Passionate' and 'Practical' farmers. Juaben and Ofoase show a more even distribution of farmers' motivations.

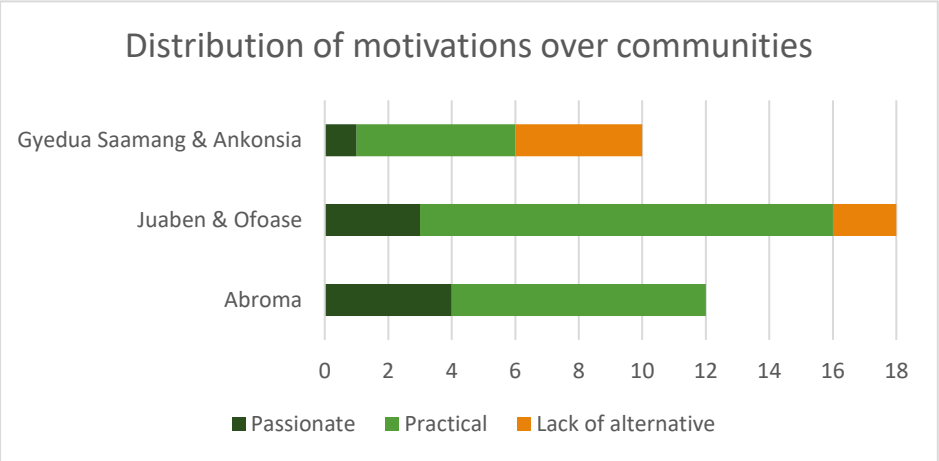


Figure 7 Distribution of motivations over the communities

3.2 ISFM utilisation stages

Annex II provides an overview of the incentives, constraints and utilisation stages of the farmers for the practices of inorganic fertiliser application, organic fertiliser application, cocoa husk management, land clearing technique and choice of variety. Tables 6 – 10 display whether the farmers have used the practice before, whether they are currently using it and their willingness to use it in the future. Farmers indicated different **incentives** to utilise the discussed practices:

- **Policy**: the practice was introduced to the farmer by a policy programme, for example COCOBOD's free fertiliser distribution or Kuapa Kokoo's input credit programmes;
- **Training**: the practice was introduced to the farmer by a training, usually organised by Kuapa Kokoo;
- **Other farmer**: the farmer was advised by a friend, family member or neighbour to do the practice, or got motivated after seeing a good effect of a practice on another farmer's farm.

Farmers who were not utilising the practices also indicated several **constraints.** The general constraints are listed below. They are related to the non-utiliser stages of the framework (*in italics*). The constraints that were specific to certain practices are explained under tables 6 – 10 in Annex II.

- **Money**: the farmer did not have the financial means to purchase or perform the practice *(unable)*;
- **Tree age**: the trees are not matured enough to perform the practice; the practice is deemed not (yet) necessary *(interested)*;
- **Soil quality**: the farmer is satisfied with their soil fertility and does not see the need of using the practice (yet) *(interested/disinterested)*;
- **Effect**: the farmer has utilised the practice, however is not happy about the effect of the practice on their yield or crop health *(disadopter)*;
- **Labour**: the practice is too tedious in doing; the farmer does not have the labour force to perform it, or the financial means to hire labour *(unable)*;
- **Availability**: the farmer indicated that it is difficult to get access to the material necessary for performing the practice *(unable)*;
- **Unawareness**: the farmer was unaware of the practice *(unaware)*;
- **Uncommon**: the practice is unusual in the perception of the farmer *(disinterested)*.

The constraints 'tree age' and 'soil quality' are related to the concept of forest rent. When planting a cocoa farm on recently cut forest, there is residual soil fertility which supports cocoa growth. When trees grow older, forest rent vanishes and weeds, pests, loss of fertility and lower yields emerge (Ruf & Zadi, 1998). Farmers mentioning the 'tree age' constraint indeed owned young trees planted on recently cut forest, and most often indicated to be interested to perform the practice in the future. Farmers mentioning the 'soil quality' constraint did not explicitly express their interest to perform the practice in the future. This constraint could therefore also be an expression of disinterest.

3.2.1 Inorganic fertiliser

Table 6 in Annex II provides an overview of the utilisation stages of all farmers with regards to using inorganic fertiliser. Results are summarised in Figure 8. Five out of forty farmers are classified as *total utilisers*: they had the financial means and knowledge to apply fertiliser every year, on their whole plot. F33 is the only *modified utiliser* of inorganic fertiliser: this farmer mixes the granular fertiliser with compost before applying it to the land. Out of the *partial utilisers*, two farmers were financially constrained to buy enough fertiliser for their whole plot (F34 and F36). Other partial utilisers often did have the financial means to buy fertiliser, however did not believe it would have a good effect on their yield or soil to apply it every year. In two cases, it was because the farmer preferred organic fertiliser over the chemical one and only used inorganic fertiliser once every two, three or four years to boost productivity.

Twelve farmers expressed that they were *interested* in using inorganic fertiliser in the future. In most cases, the reason for not applying it yet was that their trees were still young and it was not necessary yet because of forest rent. Indeed, seven of these farmers had trees under the age of ten years. The largest group, fourteen farmers, indicated that they were *unable* to buy inorganic fertiliser; all of them being constrained by money. Out of these unable farmers, ten had used inorganic fertiliser in the past at least once, and all these ten farmers were introduced to inorganic fertiliser through policy. Frequently mentioned policy programmes were inputs being sold on credit or distributed for free by the government.

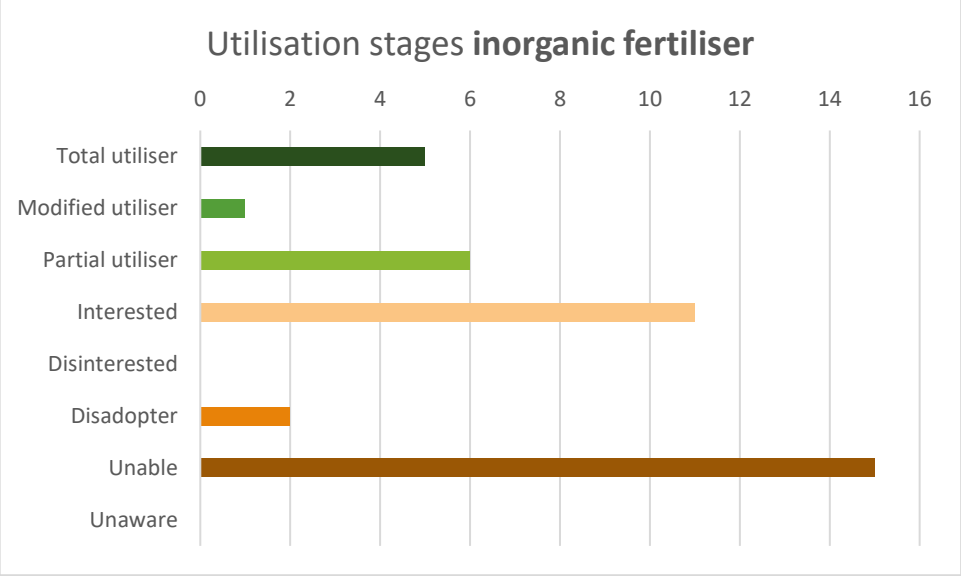


Figure 8 Utilisation stages for inorganic fertiliser application

3.2.2 Organic fertiliser

The utilisation stages, incentives and constraints of all farmers for applying organic fertiliser can be found in Table 7 in annex II. Results are summarised in Figure 9. The by far most frequently mentioned organic fertiliser type was poultry manure, other types were cow manure and compost. The results in Table 7 comprise poultry manure, unless otherwise indicated. In general, it should be noted that applying manure to a cocoa farm is a common practice which is often considered general knowledge for farmers. Because of this, farmers were less specific about the exact event that incentivised them to use organic fertiliser (such as a training or policy programme). Overall, 'learning from another farmer' was the most frequently mentioned incentive to use organic fertiliser.

Five farmers were classified as *total utilisers*: three of them applied poultry manure, one cow manure, and one compost regularly on their whole farm. The two *modified utilisers* both applied mixed combinations of fertiliser: F01 mixed poultry manure with inorganic fertiliser and F35 mixed poultry manure with ash from burned cocoa husks. The *partial utilisers* are divided into spatial partial utilisers (F04 and F11), who only applied organic fertiliser on specific parts of the farm where cocoa tree performance was low, and temporal partial utilisers (F03, F08 and F18), who only applied in years where overall cocoa tree performance on the farm was low to boost productivity for the future years.

Eight farmers are *interested* in applying organic fertiliser, but not (yet) practicing it. Corresponding with the inorganic fertiliser, four of them (F02, F06, F15, and F30) indicated that their trees are still at a young age or their soil quality is sufficient and does not need extra fertiliser yet. In every case, their trees were under ten years old and still profiting from forest rent. Two other farmers in the *interested* category were also total utilisers of inorganic fertiliser (F17 and F24). They did not have a distinct preference for inorganic, however they already provided their trees with additional nutrients in a different way. In the *disinterested* category, the four farmers preferred inorganic fertiliser. However, only one of these farmers is an actual total utiliser of inorganic fertiliser (F37); three of them are non-utilisers of inorganic fertiliser (F13, F31 and F32) but also disinterested in using organic fertiliser. Two of these farmers explained the rationale behind this: the government recommends using inorganic fertiliser, not organic, and these recommendations should be strictly followed. *Disadopters* of organic fertiliser have predominantly the same motivation as the disinterested farmers: they prefer inorganic fertiliser. Their most important reason was that they could obtain higher yields with inorganic fertiliser than with organic. One of the disadopters (F33) used to be composting, however, the effect was not good compared to the labour constraint of the practice, which made her decide to use only inorganic fertiliser in the future. Eight farmers were *unable* to apply organic fertiliser, the main reason being lack of money to buy it. When asked, only three of these six farmers knew the actual price of poultry manure. Two farmers indicated that they could not get access to manure easily due to distance of the poultry farms to their farms. Labour constraints for applying manure or other forms of organic fertiliser were not mentioned. Only one farmer was *unaware* of the use of organic fertiliser on farms, because he was only taught about the inorganic type. The utilisation stage of three farmers could not be determined based on the interview data.

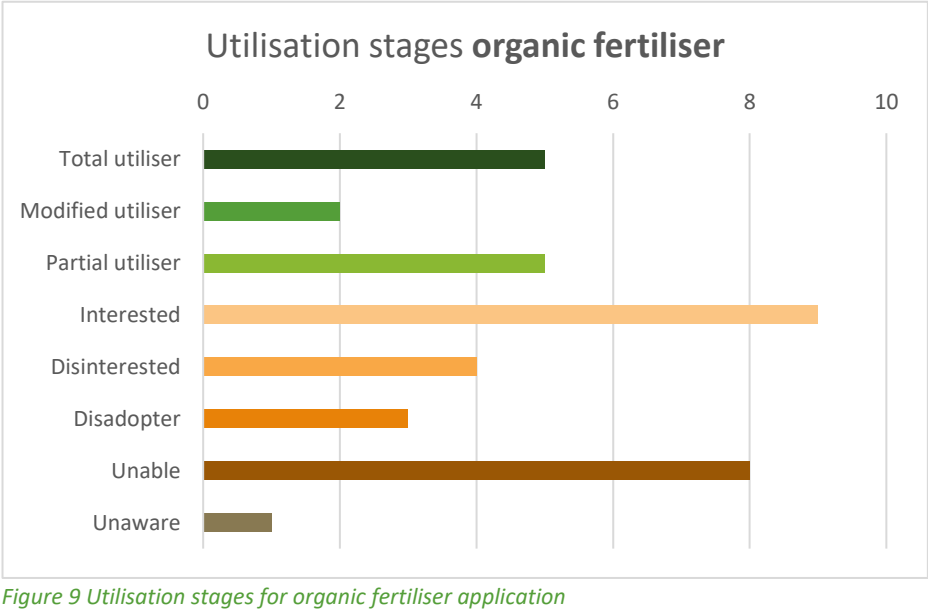


Figure 9 Utilisation stages for organic fertiliser application

3.2.3 Husk spreading

In Table 8, the utilisation stages of the husk spreading practice can be found. Results are summarised in Figure 10. Overall, fifteen farmers specifically indicated that their incentive to start with husk spreading was a training where they learned about the soil fertility benefits. Other farmers, mainly the utilisers, did not mention a specific incentive to start with husk spreading, since they consider it general knowledge. An alternative use for the cocoa husks is soap making, which five farmers are practicing. For soap making, the ash of burned cocoa husks is used. The organic material is lost by burning and additionally, it emits CO_2. Three of the soap-making farmers were unaware of the use of cocoa husks as a nutrient booster to the soil (F02, F11 and F17), and two of them deliberately chose to use some of the husks for soap instead of spreading; however only in small quantities (F01) or every other year (F12).

Seventeen farmers were classified as *total utilisers* of husk spreading. Nine of them specifically mentioned the soil fertility benefits of the practice, without initiation of the interviewer. Three out of four *modified utilisers* learned composting in training recently and use the cocoa husks in preparing the compost. The other modified utiliser (F35) had his own strategy of burning the husks to prepare potash and mixing it with poultry manure to get a fast-decomposing, organic fertiliser. All the modified utilisers indicated that they learned this technique in a training. In the *partial utiliser* category, two farmers (F15 and F37) only applied the husks to parts of the land with reduced nutrients or low crop performance. Two partial utilisers practice soap making as earlier mentioned. The last farmer (F29) indicated only to spread the cocoa husks as a substitute for inorganic fertiliser the years where he was unable to purchase it.

The *unable* farmers were all informed about the soil fertility benefits of husk spreading, yet two of them were restricted by labour constraints (F26 and F31) and prioritised other management practices on their farm. The nature of F39's farm does not allow for husk spreading because it is situated on a steep hill. Ten farmers were *unaware* about husk spreading as a soil fertility management practice. In three interviews (F36, F23 and F24), the practice was briefly explained, and the farmers expressed their interest when they heard about it.

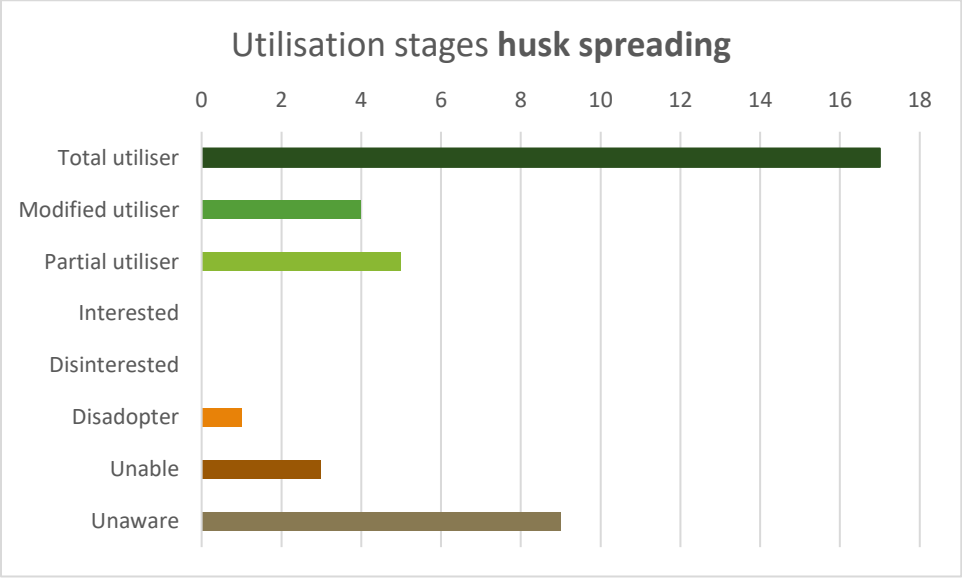


Figure 10 Utilisation stages for husk spreading

3.2.4. Land preparation

The farmers mentioned two different land preparation techniques: *slash and burn* and *proka*. Burning the entire land for cocoa cultivation is the conventional practice, but recommended improved systems suggest a shift to proka: leaving cleared weeds and biomass to mulch on prepared lands (Asare, 2013). Proka increases soil organic carbon via decomposition and improves soil fertility (Akrofi-Atitianti et al., 2018). Farmers practicing proka were classified as utilisers. Some incentives for land preparation were slightly different from incentives for other ISFM practices; they are explained in the text below. The 'present' column was only filled out when farmers recently prepared a new (second) plot for cocoa cultivation.

Table 9 displays the utilisation stages of the land preparation technique of the farmers, with their constraints and incentives. Results are summarised in Figure 11. Four farmers prepared their farm land with the proka technique and were classified as *total utilisers*. Remarkably, all these farmers have one old farm of over twenty years old, and a younger plot with trees under the age of ten years. Except for F10, the other three farmers declared they practiced proka on both plots. These three farmers learned the practice from the extension officer. Two *modified utilisers* had uncommon ways of clearing their land: F15 indicated a destructive effect of burning on the soil organisms but wanted to compromise for the ease at which land clearing is done by burning. F15 therefore does not let the weeds dry before burning, but leaves them half-wet on the farm so they will protect the soil from being damaged by the heat. F35 used a chemical product on the surface of the cut tree trunks, which makes the root system die off, so the land can be cultivated again.

Three farmers (F06, F32 and F39) were not aware of the proka technique at the time of their farm establishment, but got informed in the meanwhile and expressed their interest for future farm land preparation. These three farmers were classified as *interested*. F20 is the exception, because this farmer chose to slash and burn his farm land because he needed a smooth and level plot for maize cultivation while the cocoa was maturing. The *disinterested* farmers were aware of proka, however indicated that the practice was too tedious and did not consider doing it in the future. Two disinterested farmers (F36 and F37) also indicated proka was simply not a common practice in their region. F24 was convinced about the positive soil fertility effect of slash and burning, which made him not interested in trying proka. The *unable* category consists of six farmers who were aware of the benefits and interested in practicing proka, however, they did not have the labour force to do the tedious work of the practice. F31 and F38 specifically mentioned the nature of the weeds on their farm as a constraint for practicing proka. The motivation of the unable farmers to do slash and burn was because it is the simplest way of land clearing. Likewise, the eleven *unaware* farmers practiced slash and burn for this reason. Five of them additionally mentioned a perceived positive effect of slash and burn on their soil fertility, because of the nutrient-containing ashes. They did not mention the loss of organic matter and CO_2 emissions of burning. The exact utilisation stage of ten farmers could not be determined based on the interview data, however, half of them was surely a non-utiliser of the proka practice.

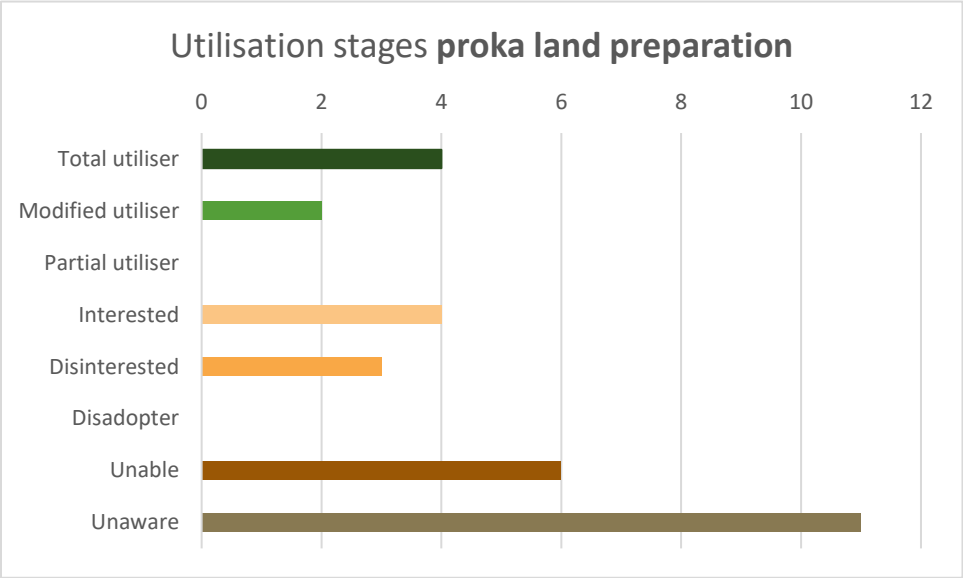


Figure 11 Utilisation stages for proka land preparation

3.2.5. Variety choice

Farmers mentioned three different varieties that they plant on their farm: Tetteh Quarshie, Amazon and hybrid. Planting hybrid seedlings increases yield as well as disease resistance (Akrofi-Atitianti et al., 2018) and is among the most important production resources that greatly influence agricultural productivity (Asare et al., 2016). Therefore, hybrid is the recommended ("utiliser") variety. Tetteh Quarshie and Amazon are less productive varieties because of their physiology (tall trees), smaller beans and longer gestation period (Prepah, 2018). Seedlings of the hybrid variety are available through seed gardens called Seed Production Divisions (SPD). For the farmers living in Abroma, Juaben and Ofoase in Ashanti Region, the SPD in Jamasi is the closest at a distance of 22 km, 26 km and 30 km respectively. This SPD was established in 1967 (Asare et al., 2010). For the farmers living in Gyedua Saamang and Ankonsia in the Western Region the SPD in Saamang is the closest at a distance of 21 km and 18 km respectively. It was established in 1990 (Asare et al., 2010). Some farms or plots were already established before establishment of the seed banks in both regions. Consequently, some farmers indicated that they got their seedlings from the SPD in Bunso, which was established earlier in 1962.

Table 10 in annex II presents the farmers' utilisation stages, sources of planting material, incentives and constraints for using the hybrid variety. Results are summarised in Figure 12. All farmers were aware of the existence of the hybrid cocoa tree variety. Sixteen farmers were classified as *total utilisers*: they planted solely hybrid variety since the beginning of their farm. Ten of them specifically mentioned the improved productivity of the hybrid type compared to the TQ or Amazon trees without being induced by the interviewer. Early maturation of the young trees was the most commonly mentioned benefit. Most of the *partial utilisers* also mentioned this benefit. All of them switched to the hybrid type for new plots and tree replanting, however, some Amazon or TQ trees are still present on their plot. Six of these farmers (F21, F24, F25, F35, F36, and F37) already planted (part of) their farm before establishment of the seed bank in their region. This means the hybrid was unavailable at the time of farm establishment.

The three *interested* farmers had various reasons for not planting hybrid on their farms before: F02 wanted to plant hybrid but does not know where to collect the seedlings; F32 is a sharecropper not replanting his trees because the land owner might re-claim the land; F34 established the farm before the hybrid variety was available and has not replanted ever since. Two farmers were *disinterested* in the hybrid type and preferred TQ because they were not convinced about the hybrid's productive features. Two other farmers classified as *disadopters* planted the hybrid variety before, but preferred to plant Amazon in the future because of the better drought resistance (F38). Even though hybrid seedlings can be collected for free at the SPDs, three farmers indicated that they were constrained by money and *unable* to plant hybrid seedlings. Two of them explained that they could not afford transport of the seedlings to their farm.

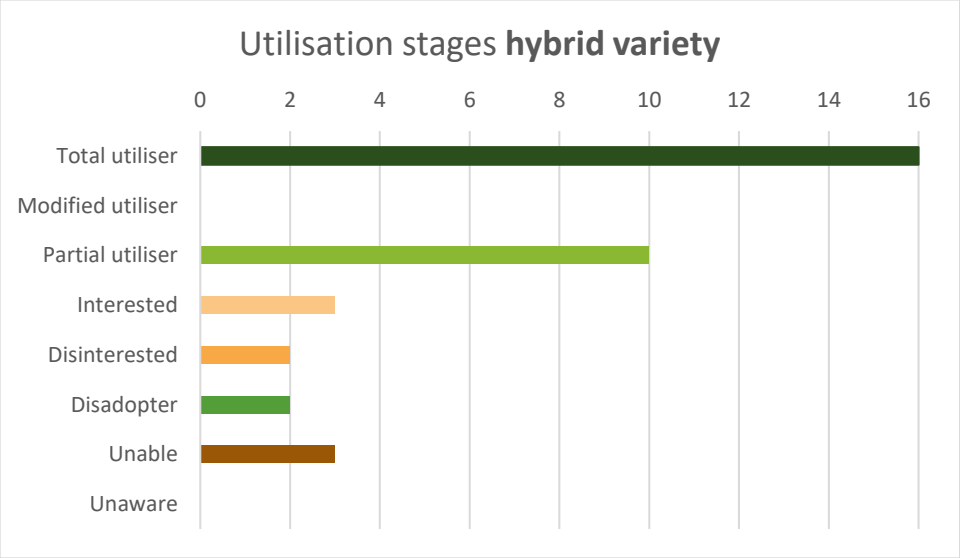


Figure 12 Utilisation stages for the hybrid variety

3.2.6 Incentives and constraints

As stated in the previous paragraphs, farmers showed different incentives to and constraints not to utilise the different ISFM practices. Tables 6 – 10 in annex II also include information on the frequency of incentives and constraints mentioned by farmers, which can provide insights for improving ISFM utilisation in general. The one or two most frequently mentioned incentives and constraints of each practice are summarised in Table 4. Examples of mentioned policy programmes were inorganic fertiliser being sold on credit or distributed for free by the government.

Table 4 Frequently mentioned incentives and constraints for utilisation of each practice

	Inorganic fertiliser	Organic fertiliser	Husk spreading	Proka land prep.	Hybrid variety
Frequently mentioned **incentives**	Policy (21)	Other farmer (11) Training (8)	Training (15)	Training (3)	Productivity (18)
Frequently mentioned **constraints**	Money (15)	Money (6) Prefer inorganic (6)	Unawareness (7) Soap making (5)	Unawareness (10) Difficult working on the land (7)	Unavailable (8)

3.2.7 ISFM utilisation scores

With the quantification of utilisation stages explained in Table 2, the current ISFM score per farmer was determined and displayed in Table 11 in annex II. Fifteen farmers were ranked with a high ISFM score, sixteen ranked “medium” and eight ranked “low”.

Moreover, Figure 13 combines the stages to provide insight in the total utilisation per practice. Shades of green indicate utilisers of the practice (either total, modified or partial) and shades of brown indicate non-utilisers. Out of the assessed practices, hybrid variety and husk spreading are most widely utilised among the participating farmers.

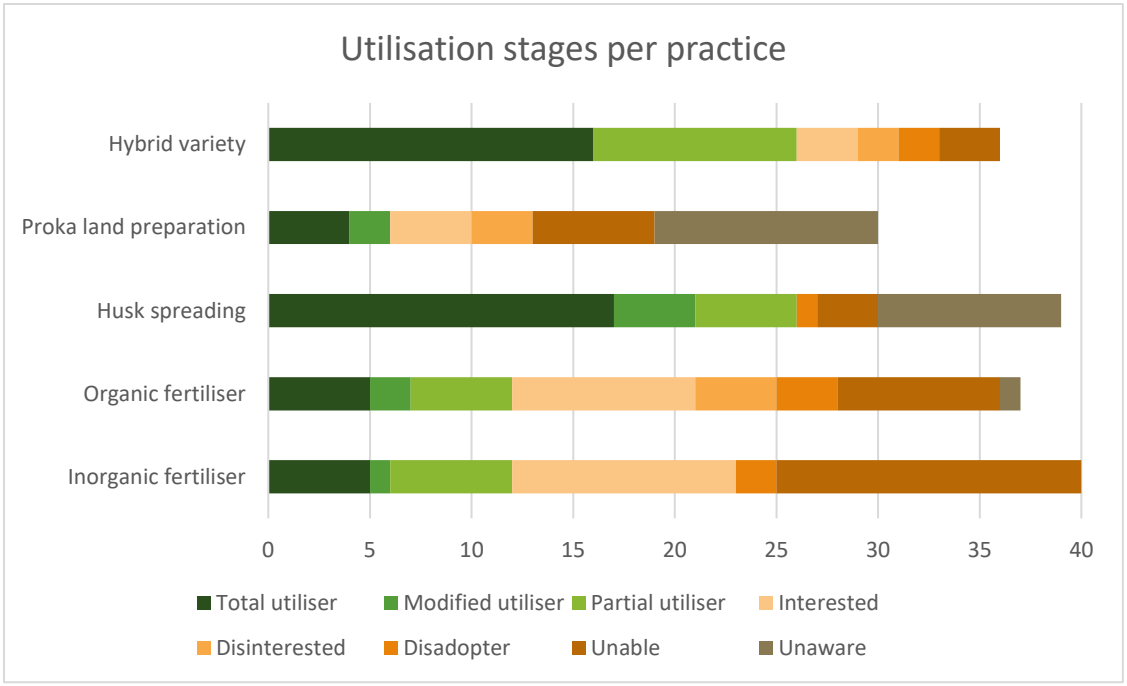


Figure 13 Combined overview of utilisation stages per practice. Note that not all practices add up to 40 farmers because of missing data.

3.3 Future perspective

The future perspective of farmers is expressed by their willingness to continuously apply or start with ISFM practices in the future. This willingness is quantified and summarised in Table 12 in annex III. Table 12 shows that nineteen farmers were planning on or willing to apply four or five of the practices, with no exceptions on inorganic fertiliser and the hybrid variety. Fourteen farmers wanted to apply three practices, and only four farmers wanted to apply only one or two of the practices.

Looking at the total willingness to apply each individual practice, inorganic fertiliser application was the most popular practice with 36 farmers being utilisers or interested. Interest in organic fertiliser, husk spreading and planting the hybrid variety were also quite frequently mentioned by 28, 28 and 29 farmers respectively. Only 11 farmers planned to do proka land preparation on a future plot.

3.4 Typology

The forty farmers were divergent in utilisation stages of the five assessed ISFM practices, showing the heterogeneity within cocoa farming. However, patterns can be identified amongst them, which are displayed in a typology (Figure 15). It is based on two indicators: motivation for cocoa farming and ISFM utilisation score. The motivation categories are also used as typology categories. All the *passionate* farmers showed a medium-high ISFM utilisation score, and all the *lack of alternative* farmers a low-medium score, indicating their position in the figure. The largest group of 'practical' farmers was distinguished into two extra categories, based on their differing ISFM utilisation scores: farmers with a low ISFM score were classified *stuck*, with a medium ISFM score remained *practical* and with a high ISFM score were classified *high potentials*.

An overview of all farmers with their type, motivation, ISFM utilisation score and stages can be found in Table 13 in annex IV. When patterns within other characteristics of the farmers could be identified, they are also listed in Figure 15. Information on how the farmer types are distributed among the different regions is displayed in Figure 14. Despite the varying number of farmers interviewed in each region, it can be observed that all farmers in Abroma are either passionate, high potential or practical, indicating an above-average level of ISFM utilisation and motivation for farming in that community. Juaben and Ofoase are more evenly distributed. Gyedua Saamang and Ankonsia show a higher occurrence of stuck and tired farmers, indicating a below-average level ISFM utilisation and motivation for cocoa farming. This relates to Figure 7, where we see more farmers with "Lack of alternative" motivation in Gyedua Saamang and Ankonsia.

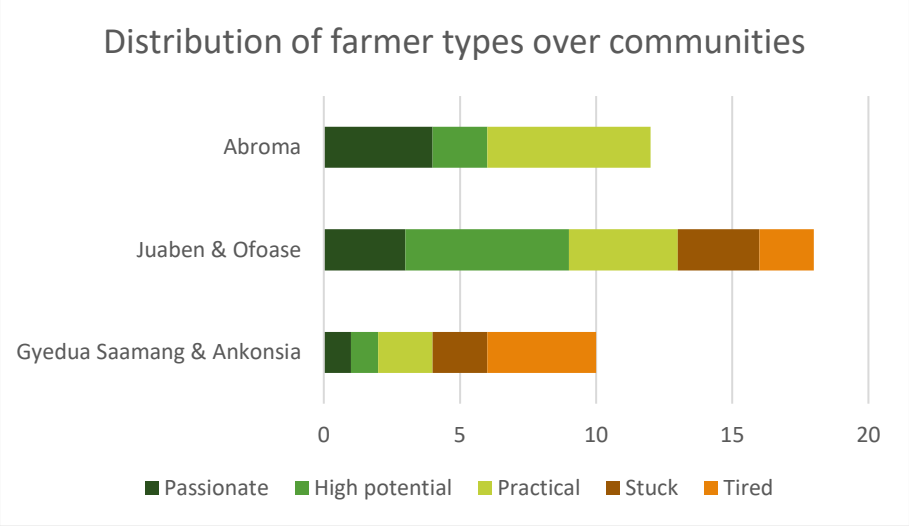
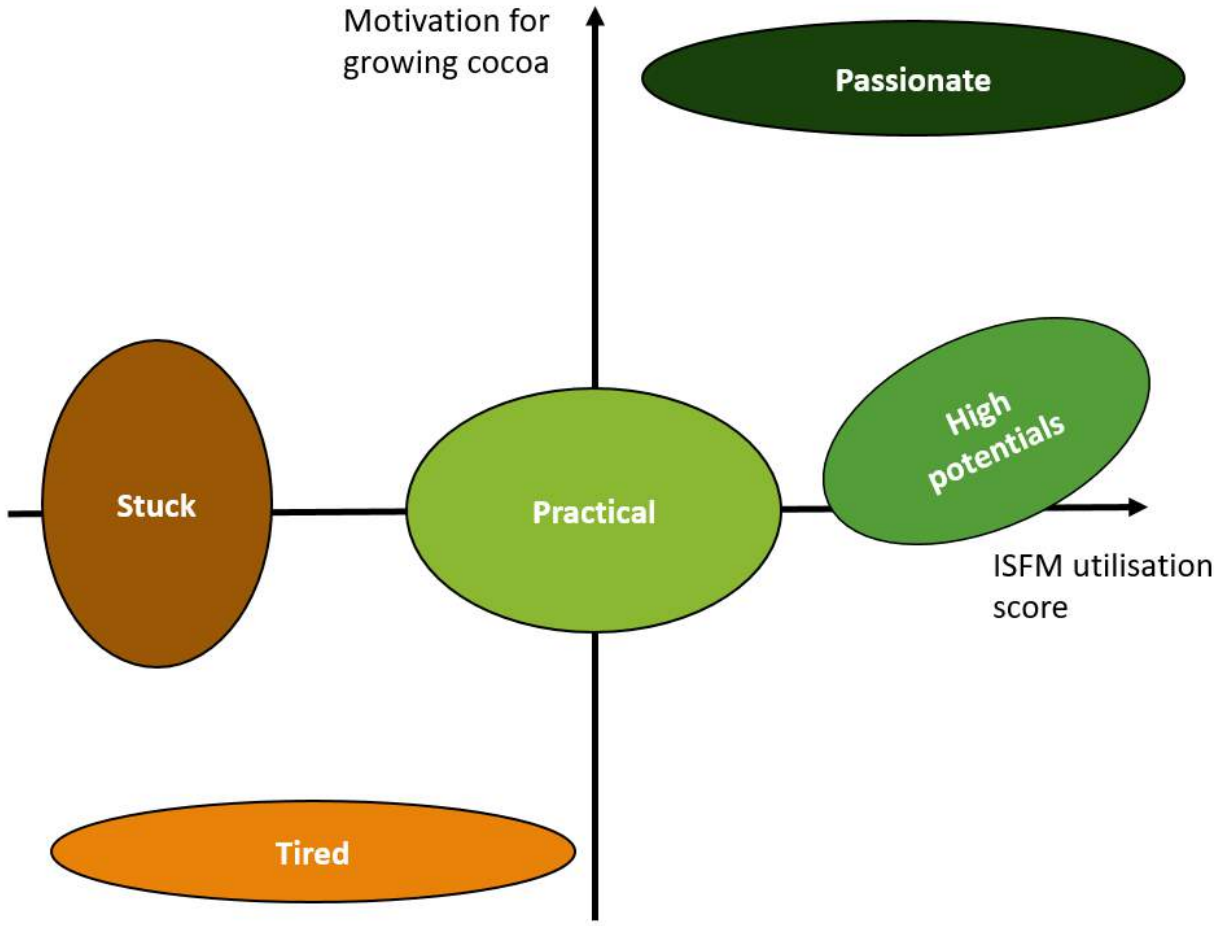


Figure 14 Distribution of farmer types over communities



Passionate
- Passionate motivation for cocoa farming
- Knowledgeable about soil fertility
- Often utiliser of ISFM practices, and frontrunners on new technologies
- Only male farmers
- High training attendance, sometimes even lead farmers

Practical
- Practical motivation for cocoa farming
- Utilisers of some ISFM practices
- Medium interest in applying ISFM practices in the future
- Mostly female (9/12)
- Often owning family farms with shared family labour
- Usually attending trainings

High potentials
- Practical motivation for cocoa farming
- Interested in or utilising most ISFM practices
- Highly interested to (continue to) apply ISFM practices in the future
- Have at least one plot with trees < 10 years old
- High training attendance
- Involved in (off-farm) income diversification

Tired
- Lack of alternatives for cocoa farming
- Often unaware or disinterested in ISFM practices
- Low interest in applying ISFM practices in the future
- Often have a caretaker (4/6)

Stuck
- Practical motivation for cocoa farming
- Often unable or unaware of ISFM practices
- Only male farmers
- Owners of small plots: < 5 acres

Figure 15 Typology of five cocoa farmer types with corresponding characteristics

4. Discussion

This research identified farmers' motivations for engaging in cocoa farming (SRQ 1), and aimed to understand their decisions on utilisation of ISFM practices (SRQ 2) and future willingness to utilise them (SRQ 3). These motivations and ISFM utilisation stages were combined to construct a typology (SRQ 4) which demonstrates the heterogeneity among cocoa farmers. In this study a breakdown of different utilisation stages was used, contrary to the binary adoption or non-adoption which is used in many previous studies.

In this chapter, the farmers' motivations and their ISFM utilisation stages with a focus on incentives and constraints for utilisation are discussed in the context of existing studies. Furthermore, the typology is discussed. Finally, the methodology is reflected upon and suggestions for improvement for future studies are made.

4.1 Motivations for cocoa farming

Some studies elaborate on the importance of knowing farmers' motivations for growing cocoa, without specifically listing these motivations (e.g. (Amon-Armah et al., 2017; Darnhofer & Walder, 2014)). A review from Baah et al. (2012) showed that the objectives of cocoa farmers in Ghana include the meeting of subsistence needs of their families, provision of inheritable property to next of kin and the use of cocoa as security for old age. These objectives correspond to the motivations *support my family* and *future crop* found in this study (see Table 3).

Bymolt et al. (2018b) found *income* as the most important motivation for growing cocoa. Table 3 in section 3.1 demonstrates that in this study, *good income* and *income provision* are also the most frequently mentioned motivations in the 'Passionate' as well as the 'Practical' category respectively. Those two motivations together are mentioned by 55% of the farmers. Bymolt et al. (2018b) did not distinguish between *income provision*, *good income* and *support my family*, however they did find similar motivations. The farmers in their study mentioned for example the guaranteed price of cocoa, paying for their children's school fees, building houses, and taking care of health and household.

A different motivation found by Baah et al. (2012) is the search for capital to invest elsewhere. When asked about their planned future investments, seven farmers in this study indicated that they are interested in investing in a different business. Four of those seven farmers argued they were demotivated by cocoa farming and wanted to start something different. The other three farmers showed a practical or passionate motivation for cocoa, as well as an entrepreneurial mindset and an ambition to expand their (agricultural) business. This demonstrates that motivations of the same category can still have very different foundations.

However, this motivation of search for capital investment of Baah et al. (2012) is confirmed by Bymolt et al. (2018b) who found that farmers like the way cocoa income is received 'in bulk'. The large influx of cash is used to buy building supplies and renovate houses, pay for school fees, and buy farming equipment (Bymolt et al., 2018b). In this study, only one farmer (F13) mentioned the bulk money as a benefit of the crop compared to the monthly income from oil palm. However, twenty-two of the forty farmers had an additional source of income for their household, for example part-time jobs as baker, hairdresser, trader, or farmer of oil palm or vegetables. One farmer explained that he was a full-time cocoa farmer, however did some carpentry work in the off-season to earn some additional income

besides the 'bulk money' from cocoa. A more elaborate insight in household income from cocoa and expenditures throughout the year would be an interesting field of further research.

Additionally, *tradition and national importance* was found as an important motivation by Bymolt et al. (2018b), consistent with *support Ghana* found in this study. The last motivation the authors found was to secure long-term land rights. This is a typical motivation for sharecroppers. When they plant cocoa, they are responsible for the land with the trees on it. The agreement is often merely reconsidered when cutting down the trees. This motivation was not found in this study, which can be explained by the fact that almost all the interviewed farmers were land owners, not sharecroppers.

Furthermore, it is interesting to discuss the reasons why some farmers have a lack of alternative for growing cocoa. The two main motivations mentioned were scarcity of job opportunities and dropping out of school. The main reason for children dropping out of school is financial constraint of the parents to further their education (Baah, 2010). This may be a vicious cycle, as farmers who grow cocoa because of lack of alternative are also unlikely to utilise yield-improving technologies like ISFM (see Figure 15). With low yields and resulting low incomes, their children might face the same problem of dropping out and starting cocoa farming due to lack of alternatives. A recent study of Duflo et al. (2019) found that the latest government's promise to make senior high school free (in addition to the implemented free primary education programme) will increase the probability of tertiary education and obtaining public sector jobs and jobs with benefits. This could be an escape to the cycle of school drop-outs becoming cocoa famers. However, government jobs are in fixed supply which causes excessive entry into competing for these jobs (Duflo et al., 2019). Therefore, long term solutions for improving education and job opportunities remain important areas for further study on how to create alternatives for cocoa farmers.

4.2 ISFM utilisation stages

This paragraph explains the utilisation results of each ISFM practice and compares them with previous studies. First of all, it should be noted that ISFM in cocoa production comprises more than only the practices discussed in this study. Including more practices such as pest and disease management, weed management (Sanginga & Woomer, 2009), and placement of shade trees may give a more complete indication of the ISFM utilisation stages. Especially for inorganic fertiliser application, future research would benefit from also taking the right source, rate, time and placement of the fertiliser into account (Flis, 2017). Hence, a revision of practices is recommended when using the concept of this study for different areas or crop systems. This will allow to be able to make a more precise assessment of the utilisation stage, and more specific recommendations for targeting.

4.2.1 Inorganic fertiliser

For the application of inorganic fertiliser, ***unable*** was the most occurring utilisation stage (Figure 8) and lack of money was the only constraint mentioned (Table 6). This is consistent with results from Anang (2015), Aneani et al. (2012) and Bymolt et al. (2018a) who argue that fertiliser adoption decision is highly affected by access to credit and farmers' reliance on government subsidies.

In this study, governmental policy was found to be the most frequently mentioned incentive to start using inorganic fertiliser. However, a recent study of Baba Ali et al. (2018) relate non-adoption of inorganic fertiliser in the Western Region of Ghana to low contact with extension services and high distance from farm to community. These results are inconsistent with this study, where all farmers (including in the Western Region) were aware of inorganic fertiliser, introduced to them either by

policy or extension. Additionally, transport or accessibility difficulties were not mentioned as constraints at all. These findings could be affected by the sampling of farmers in this study, which was done through an extension network of Kuapa Kokoo. This makes analysing contact with extension difficult, since almost all the interviewed farmers were frequently involved in training programmes.

Besides, Baba Ali et al. (2018) followed a different methodology. The authors did not explicitly ask the non-adopting farmers for their constraints, but based these conclusions on significant qualitative differences in contact with extension services and farm to community distance between adopters and non-adopters.

Additionally, identification of the *interested* farmers has provided an extra insight into a new group of non-utilisers of inorganic fertiliser. The farms of this group are young, and their land is still nutrient-rich because of forest rent (Ruf & Zadi, 1998). Thus, they do not see the need of applying inorganic fertiliser yet, but are aware and interested to use it in the future. This group of famers also did not mention financial constraints. In previous studies (e.g. (Anang, 2015; Baba Ali et al., 2018; Damisa & Igonoh, 2007)), interested farmers were not distinguished and were likely classified as non-utilisers, which potentially compromises the validity of the results.

4.2.2 Organic fertiliser

Farmers had divided utilisation stages of organic fertiliser application (Figure 9). Likewise, their opinions were divided: some preferred inorganic due to the stronger effects, some preferred organic due to the low price and advantages of using non-artificial inputs. Twelve of forty farmers were utilisers of manure, and only five of them total utilisers. Other studies distinguish between manure and compost instead of considering both as organic fertiliser. Nevertheless, they find even lower results. Ruf & Bini (2011) and Bymolt et al. (2018a) found that poultry manure is applied by respectively only 3% and 6% of cocoa farmers in Ghana.

Availability of manure is a suggested constraint in literature (Mugwe et al., 2008; Vanlauwe et al., 2015), but financial constraints were mentioned more often in this study. These two constraints could however be related, since unavailability of manure in the area causes high costs for transportation to get it from elsewhere. Relatively, the Western Region had more unable and disinterested farmers than the Ashanti Region regarding organic fertiliser. This can be explained by the fact that large scale commercial poultry farms are mostly found in the Ashanti Region (Wits & Rahaman Abdulai, 2020). They bring manure to the commercial market for farmers to buy. In the Western Region, there are less poultry farms which means manure is scarcer, which was confirmed by two Western Region farmers who were constrained by availability of manure. The expected further expansion of poultry business in Ghana (FAO, 2017; Wits & Rahaman Abdulai, 2020) might increase the availability of manure for cocoa farmers in the future.

Compost is a promising component of ISFM since it increases nutrients, and also improves soil structure, increases moisture infiltration and water-holding capacity of the soil (CHED & WCF, 2016). Compost is not commercially available on the market in Ghana, and only three farmers in this study learned composting and practiced it. The standard training programme of Kuapa Kokoo does not involve composting. Currently, Kuapa Kokoo does some experiments with lead farmers to determine the effects of the practice. Labour intensity of composting was mentioned by the three composting

farmers in this study as a challenge. The future willingness of cocoa farmers to start composting (specifically, distinguished from other organic fertilisers) would be an interesting field of further study.

4.2.3 Husk spreading

Cocoa pod husks are harvest residue that can be returned to the system by spreading them on the land. Little literature is available on this recycling of harvest residues. The CocoaSoils project description states that there is currently hardly any recycling of residues from cocoa harvests, and suggests that outbreak of plant diseases as a possible reason (IITA, 2017). Figure 10 demonstrates that utilisation among the farmers in this study was high, contrary to that assumption. Possible outbreak of diseases (blackpod) as a result of husk spreading around the trees was only mentioned by one farmer (F02, disadopter). Two other farmers even mentioned a higher risk of blackpod outbreak when leaving all the husks heaped at the breaking place, because still water remains in the open pods. Still water is indeed an influential factor for reproduction of fungal diseases (ICCO, 2015). Those two farmers suggested husk spreading is a good disease prevention method. The CocoaSoils project description also hypothesises increased risk of fires as a constraint for recycling of organic inputs. The farmers in this study made no mentions of this problem at all.

In this study, the most frequently recorded constraint for husk spreading was unawareness (see Table 4). Some unaware farmers got informed about the use of husks as a natural fertiliser during the interview, and expressed their interest. This indicates that husk spreading is a practice which could be well implemented through extension.

4.2.4 Land preparation

The proka land clearing technique was largely not utilised by the farmers in this study (see Figure 11), which corresponds with findings of Codjoe et al. (2013) and Gockowski & Sonwa (2011). The main reasons for this were unawareness of the practice and difficulties in working on the land (see Table 4). The latter constraint was also determined by Prepah (2014). However, the author also found that benefits such as increased soil fertility and crop yield made proka an economically viable strategy for farmers (Prepah, 2014). This is confirmed by the absence of disadopters in this study and by the utilisers, who are positive about the results of proka.

Some literature mentions promotion of no-burn land clearing techniques in Ashanti Region (Asare, 2013), however, Kuapa Kokoo provides no training on the topic specifically. If proka land clearing is involved in mainstream extension services, utilisation (through awareness) is expected to increase.

4.2.5 Hybrid variety

In this study, the most frequently mentioned reason for planting the hybrid variety was its high productivity. However, most of the farmers heard about the hybrid for the first time during training, which was the direct incentive. Accordingly, Wiredu et al. (2011) suggest that extension serves as an important source of information on the hybrid variety. However, the authors also state that farmers have even better appreciation and confidence in their fellow farmers who expose them to the technology. In this study, learning about the hybrid variety from another farmer was only found twice (see Table 10). This could be due to more intensive focus on hybrid variety in cocoa extension since 2013, and the more recent improvement of seedling availability and accessibility through establishment of community nurseries (F. Okyere, personal communication, November 23, 2019). This

may have recently caused farmers to rely more on extension than on each other as a source of information about the hybrid variety.

Moreover, communities Gyedua Saamang and Ankonsia in the Western Region were involved in the Cocoa Rehabilitation and Intensification Programme (CORIP). Four out of ten farmers in these regions were partial utilisers of the hybrid variety and were planning on planting it on their whole land. Two other farmers were interested and also planning on replanting the hybrid variety. Due to CORIP, it is expected that the number of utilisers of the hybrid variety in the Western Region will rise in the future.

4.3 Typology

A farmer typology is often based on quantitative survey data, such as farm size and farmer characteristics such as gender, age, education, etc. (Darnhofer & Walder, 2014). This approach identifies farmer types using statistical methods, such as multivariate analysis and clustering (e.g. (Amon-Armah et al., 2017; Malawska & Topping, 2015). It provides significant correlations between factors, but does not give insight in the relationships between these factors. Since farmers' choices are affected by their personal motivations, there is a tendency to build farmer types in terms of individual motivations, intensions and interests (Darnhofer & Walder, 2014) in a qualitative approach as used in this study. This improves understanding in the relationships between factors, however, is difficult to scale up and generalise for other contexts. Larger, qualitative surveys can estimate the percentage of farmers fitting to each type.

Therefore, this study suggests a combination of qualitative and quantitative data analysis as the most appropriate way to map diversity and make recommendations for improvement. Jassogne et al. (2017) and IITA (2019) also emphasise the benefits of this approach.

Furthermore, typologies have different purposes. They are often used as entry for targeted extension, to offer farmers certain technologies that fit to their type. However, there is a large variability in farmers' use of practices throughout time, and explanatory relationships are often inconsistent (Ronner, 2018). Farmers are dynamic, and their movement through different types complicates targeted extension.

Another purpose of typologies may be to explain self-selection of practices by farmers. Some practices fit certain farmers better at a particular point in time. By offering farmers of the same type a 'basket of options' for improved technology, the most appropriate practices will be selected by the farmers themselves. This could be a more realistic approach to improve utilisation, because it acknowledges diversity and fluidity within farmer types.

The aim of the typology constructed in this study is to raise awareness for this heterogeneity among cocoa farmers in personal (motivation) as well as technical (ISFM utilisation) aspects. It emphasises the need of taking both these personal and technical mechanisms into account in research and extension. Additionally, it provides a suggestion on how to determine and map this diversity. For further research, it would be interesting to additionally look at how farmers 'move' through different stages and types over time.

Within the typology, all farmers with a "lack of alternative" motivation for growing cocoa scored relatively low on ISFM utilisation (i.e. the tired farmers in the typology). This can be explained by their high levels of disinterest and disadoption, combined with a low training attendance. On the other

hand, all the passionately motivated farmers scored above average on ISFM utilisation (i.e. the "passionate" farmers in the typology). Therefore, motivation for growing cocoa and farmers' willingness and likelihood to utilise ISFM practices seem to be highly related. This finding indicates that farmers with different motivations should be approached and informed differently about technical practices.

The distribution of farmer types over the communities (Figure 14) can largely be explained by the community characteristics in section 2.1. Gyedua Saamang and Ankonsia had more stuck and tired farmers than other communities. This can be explained by the growing opportunities for small-scale mining and associated worries for pollution of agricultural resources such as soil and water. A similar conclusion is found by Obeng et al. (2019). In Juaben and Ofoase, oil palm and food crop are the main land use instead of cocoa. No specific pattern can be identified regarding the distribution of farmer types over these two communities. This finding indicates that the apparent crop alternatives did not influence the motivations or ISFM utilisation of farmers substantially.

The results of Figure 14 show the importance of taking local characteristics into account when targeting extension programmes. The presence of only utilisers in Abroma cannot be related to the known local characteristics. This remarkable distribution might be a result of sampling bias. The selection of participant farmers was performed by the purchasing clerk of each community. The only criteria were presence in the village and availability on the day of the field trip. The sampling strategy does not guarantee a representative sample of gender, age, resource and capital endowment, training involvement, etc., nor is it random. Potential selection bias might have occurred if the purchasing clerk purposely selected 'lead farmers' to represent his community in front of a foreign researcher.

4.4 Methodological reflections

This study used diverse tools and methods to answer the research questions, which will be briefly reflected upon. Moreover, this paragraph gives some suggestions for improvement of data collection for similar studies in the future.

Using the adapted framework of Brown et al. (2017) was an interesting method to unpack adoption. It gave insights in layers of adoption or utilisation that would have remained unknown if the binary adoption approach was used. Identifying the incentives and constraints of each decision was useful to acknowledge diversity even within the utilisation stages. This is important because even under similar circumstances, farmers make different choices (Darnhofer & Walder, 2014).

Furthermore, it was challenging to identify the farmers' willingness to use ISFM practices in the future. For future research, it would be good to have clear-cut indicators, such as a potential successor for the farm, exact planned investments, and expansion plans. More specific information on these topics would allow to paint a better picture on the farmers future, and eventually possibly use it to polish the typology.

Moreover, some improvements can be made regarding data collection. For instance, the translation of the interviews may interfere with the quality of the answers. Interpretation of meanings is one of the most important assets of qualitative research (van Nes et al., 2010). This interpretation was challenged by the fact that people commonly use language-specific narratives and metaphors in order to capture the richness of the experience (Polkinghorne, 2005). Translation of this can lead to misunderstanding, which is one of the biggest challenges for the validity of the data. The most

important implication of this language barrier was that the many translation interruptions hindered the use of life history method (co-construction of a timeline). This method was therefore not used to its fullest potential. Language barriers should not be overlooked or trivialised in future qualitative studies abroad with personal interviews as the main data source.

Researcher positionality also may have influenced the quality of the interview data. Differences in culture, age, race, educational background and (in more than half of the cases) gender caused a very evident outsider perspective. Outsiders may be unable to understand or accurately represent the experiences of their participants (Hayfield & Huxley, 2015). Likewise, it cannot be guaranteed that all the information presented in this study was interpreted correctly. Nevertheless, the interviews were performed with the best possible cultural sensitivity and understanding of the local context, with help of the key informants. Results are presented in the most ethical way to do justice to the unique situations of the farmers. Potentially wrong or missing interpretations were reduced as much as possible by regularly discussing the interviews with the translator and by validation of the data with the staff of IITA Accra.

On the other hand, the outsider perspective may enable the researcher to make observations and draw conclusions that insiders might overlook (Hellawell, 2006). At the start of the interviews, the farmers were asked to be the 'teacher' and explain their individual choices and practices to the interviewer. A lot of farmers enjoyed this position and were very explanatory and elaborate. Especially in case of the modified practices, the outsider perspective revealed some interesting adaptations farmers made to the technology that an insider would have easily overlooked.

5. Conclusion

Low adoption rates of ISFM practices indicate room for improvement in matching available technology with farmers' needs. Therefore, understanding farmers' motivations and decisions on ISFM practices is important in cocoa research and extension.

The aim of this study was to improve our understanding of the ISFM practices of cocoa farmers. We looked at farmers' motivations for growing cocoa and their incentives and constraints for performing past and present practices. The study has three objectives:

- To understand what motivates farmers for cultivation of cocoa;
- To understand how previous experiences and events shape current ISFM practices;
- To make a typology of farmers based on their stage of ISFM use.

This study found three groups of motivations: 'passionate', 'practical' and 'lack of alternative'. All farmers with 'passionate' motivations had higher ISFM utilisation scores than farmers with 'lack of alternative' motivations. This suggests that motivation is an important driver for ISFM utilisation behaviour. By incorporating motivational aspects in extension programmes, farmers can be approached more effectively.

Furthermore, farmers showed very diverse stages of utilisation of the ISFM practices researched in this study, as well as diverse incentives and constraints to use them. It is important to acknowledge this diversity in targeting and implementing new technologies, and to consider the suggested potential constraints and incentives. This will help improve self-selection of ISFM practices by cocoa farmers.

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Annex I – Farmers' motivations for growing cocoa

Table 5 Category and motivation(s) per farmer

Farmer	Category	Farmer's motivations for cocoa cultivation
F01	Practical	Income; long-lasting crop; future crop
F02	Practical	Support family; good income
F03	Passionate	Support Ghana; be part of the cocoa farmers
F04	Practical	Income; support family
F05	Practical	Future crop; support family
F06	Passionate	Be part of the cocoa farmers; family tradition
F07	Passionate	Future crop; good income; family tradition
F08	Passionate	Support family; support Ghana; future crop
F09	Practical	Support family; income provision
F10	Practical	Support family
F11	Practical	Income; be part of the cocoa farmers
F12	Practical	Better income than oil palm; income; future crop
F13	Practical	Support Ghana; income; enough land available
F14	Passionate*	Family tradition; support family
F15	Practical	Support family
F16	Lack of alternative	School drop-out; future crop
F17	Lack of alternative	School drop-out; future crop
F18	Practical	Future crop; income; school drop-out
F19	Practical	Future crop
F20	Practical	Family tradition; support family; school drop-out
F21	Practical	Better income than oil palm; enough land available
F22	Practical	Future crop; support family; better income than oil palm
F23	Practical	Income; future crop; be part of the cocoa farmers; support family; long-lasting crop
F24	Practical	Long-lasting crop; future crop
F25	Practical	Long-lasting crop
F26	Passionate	Support Ghana
F27	Practical	Good income; long-lasting crop; enough land available; be part of the cocoa farmers
F28	Practical	Future crop
F29	Practical	Good income; better income than oil palm
F30	Passionate	Income; support Ghana; school drop-out
F31	Lack of alternative	Family tradition; school drop-out; enough land available
F32	Lack of alternative	School drop-out; income provision; no alternative job available; good income
F33	Practical	Good income; enough land available; be part of the cocoa farmers
F34	Passionate	Support Ghana; enough land available; good income
F35	Practical	Good income
F36	Lack of alternative	School drop-out
F37	Lack of alternative	No alternative job available; enough land available; income provision
F38	Lack of alternative	No alternative job available; support Ghana
F39	Practical	No alternative job available; support family
F40	Practical	Family tradition; support family

*Despite scoring on practical motivations, F14 was categorised as passionate because of his fervent and heartfelt way of expressing himself about cocoa.

Annex II – Farmers' utilisation stages of ISFM practices

Table 6 Utilisation stages of inorganic fertiliser use with incentives and constraints

Inorganic fertiliser						
Farmer	**Utilisation stage**	**Past**	**Present**	**Future**	**Incentive to apply**	**Constraint not to apply**
F14	Total utiliser	✔	✔	✔	Policy	-
F17	Total utiliser	✔	✔	✔	Training	-
F19	Total utiliser	✔	✔	✔	Policy	-
F24	Total utiliser	✔	✔	✔	Other farmer	-
F37	Total utiliser	✔	✔	✔	Policy	-
F33	Modified utiliser	✔	Mod.	Mod.	Training	-
F03	Partial utiliser	✔	2nd yr.	✔	Policy	
F07	Partial utiliser	✔	✘	✔	Policy	Effect
F18	Partial utiliser	✘	4th yr.	✔	Training	-
F20	Partial utiliser	✔	3rd yr.	✔	Policy	-
F34	Partial utiliser*	✔	2nd yr.	✔	Policy	Money
F36	Partial utiliser	✔	✔	✔	Radio	Money
F02	Interested	✘	✘	✔	-	Soil quality
F04	Interested	✘	✘	✔	-	Tree age
F08	Interested	✘	✘	✔	-	Tree age
F11	Interested	✘	✘	✔	-	Tree age
F12	Interested	✘	✘	✔	-	Tree age
F16	Interested	✘	✘	✔	Policy	Tree age
F25	Interested	✘	✘	✔	-	Tree age
F29	Interested	✔	✘	✔	Policy	
F30	Interested	✘	✘	✔	-	Tree age
F31	Interested	✔	✘	✔		Soil quality
F35	Interested	✔	✘	✔	Policy	Tree age
F10	Disadopter	✔	✘	✘	Policy	Effect
F40	Disadopter	✔	✘	✘		Effect
F01	Unable	✔	✘	✔	Policy	Money
F05	Unable	✔	✘		Policy	Money
F06	Unable	✔	✘	✔	Policy	Money
F09	Unable	✘	✘		-	Money
F13	Unable	✔	✘	✔	Policy	Money
F15	Unable	✔	✘	✔	Policy	Money
F21	Unable	✔	✘	✔	Other farmer	Money
F22	Unable	✘	✘	✔	-	Money
F23	Unable	✔	✘	✔	Policy	Money
F26	Unable	✔	✘	✔	Policy	Money
F27	Unable	✘	✘	✔	-	Money
F28	Unable	✘	✘	✔	-	Money
F32	Unable	✔	✘	✔	Policy	Money
F38	Unable	✔	3rd yr.	✔	Policy	Money
F39	Unable	✔	✘	✔	Policy	Money

*F34 applies inorganic fertiliser every other year, initially because he cannot afford it every year. However, he is satisfied with the results and does not want to apply yearly in the future.

Table 7 Utilisation stages of organic fertiliser use with incentives and constraints

Organic fertiliser						
Farmer	**Utilisation stage**	**Past**	**Present**	**Future**	**Incentive to apply**	**Constraint not to apply**
F07	Total utiliser	✔ Cow manure	✔ Cow manure	✔ Cow manure		-
F12	Total utiliser	✔	✔	✔	Other farmer	-
F14	Total utiliser	✔	✔	✔		-
F26	Total utiliser	✔	✔	✔	Training	
F40	Total utiliser	✔ Compost	✔	✔	Training	-
F01	Modified utiliser	✔	✔ Mod.	✔		-
F35	Modified utiliser	✔ Compost	✔ Mod.	✔	Training	-
F03	Partial utiliser	✔	2nd yr.			
F04	Partial utiliser	✔	Where necessary	✔		-
F08	Partial utiliser	✔	When necessary	✔	Other farmer	Soil quality
F11	Partial utiliser	✔	Where necessary	✔		-
F18	Partial utiliser	✔	3 yrs. PM, 1 yr. fert	✔	Training	-
F02	Interested	✘	✘	✔	-	Tree age
F06	Interested	✘	✘	✔	Training	Tree age
F15	Interested	✘	✘	✔		Soil quality
F17	Interested	✘	✘	✔	Other farmer	
F23	Interested	✘	✘	✔	Other farmer	
F24	Interested	✘	✘	✔		
F25	Interested	✘	✘	✔	Other farmer	
F30	Interested	✔	✘	✔ Compost	Experimenting	Tree age
F39	Interested	✘	✘	✔	Other farmer	
F13	Disinterested	✘	✘	✘	-	Prefers inorg.
F31	Disinterested	✘	✘	✘	-	Prefers inorg.
F32	Disinterested	✘	✘	✘	-	Prefers inorg.
F37	Disinterested	✘	✘	✘	-	Prefers inorg.
F16	Disadopter	✔	✔	✘		Prefers inorg.
F20	Disadopter	✔	✘	✘	Other farmer	Prefers inorg.
F33	Disadopter	✔ Compost	✔ Compost	✘	Training	Effect
F10	Unable	✘	✘	✔	-	Money
F21	Unable	✘	✘	✔	-	Money
F27	Unable	✔	✘	✔	Other farmer	Money
F28	Unable	✔	✘	✔	Training	Money
F29	Unable	✔	✘	✔	Training	Money
F34	Unable	✘	✘	✔	Other farmer	Availability
F36	Unable	✘	✘	✔	Other farmer	Availability
F38	Unable	✘	✘	✔	Other farmer	Money
F19	Unaware	✘	✘	✘	-	Unawareness
F05		✔				
F09		✘	✘			
F22		✘	✘			

Table 8 Utilisation stages of husk spreading with incentives and constraints

Husk spreading						
Farmer	**Utilisation stage**	**Past**	**Present**	**Future**	**Incentive to apply**	**Constraint not to apply**
F03	Total utiliser	✔	✔	✔	Training	-
F05	Total utiliser	✔	✔		Training	-
F06	Total utiliser	✔	✔	✔		-
F07	Total utiliser	✔	✔	✔	Training	-
F08	Total utiliser	✔	✔	✔	Other farmer	-
F09	Total utiliser	✔	✔	✔	Training	-
F10	Total utiliser	✔	✔	✔		-
F13	Total utiliser	✘	✔	✔		-
F14	Total utiliser	✘	✔	✔	Training	-
F16	Total utiliser	✔	✔	✔	Training	-
F18	Total utiliser	✔	✔	✔		-
F20	Total utiliser	✔	✔	✔		-
F25	Total utiliser	✘	✔	✔	Training	-
F27	Total utiliser	✔	✔	✔	Training	-
F28	Total utiliser	✔	✔	✔		-
F34	Total utiliser	✔	✔	✔		-
F38	Total utiliser	✔	✔	✔	Training	-
F30	Modified utiliser	Compost	Compost	Compost	Training	-
F33	Modified utiliser	Compost	Compost		Training	-
F35	Modified utiliser	Mix with PM	Mix with PM	Mix with PM	Training	-
F40	Modified utiliser	Compost	Compost	Compost	Training	-
F01	Partial utiliser	✔	✔	✔	Training	Soap making
F12	Partial utiliser	2nd yr.	2nd yr.	2nd yr.		Soap making
F15	Partial utiliser	✔	Where necessary	✔		
F29	Partial utiliser	✔	Some yrs.	✔		
F37	Partial utiliser	✔	Where necessary	✔	Other farmer	-
F02	Disadopter	✔	✘	✘	-	Effect**
F26	Unable	✘	✘	✔	-	Labour
F31	Unable	✘	✘	✘	-	Labour
F39	Unable	✘	✘	✘	Training	Slope
F04	Unaware	✘	✘		-	Unaware
F11	Unaware	✘	✘	✘	-	Soap making
F17	Unaware	✘	✘	✘	-	Soap making
F19	Unaware	✘	✘	✘	-	Unawareness
F21	Unaware	✘	✘		-	Unawareness
F23*	Unaware	✘	✘	✔	-	Unawareness
F24*	Unaware	✘	✘	✔	Other farmer	Unawareness
F32	Unaware	✘	✘		-	Unawareness
F36*	Unaware	✘	✘	✔	-	Unawareness
F22						

*These unaware farmers were informed about it during the interview, and immediately expressed their interest to do it in the future. | **Farmer was afraid husk spreading would increase risk on disease (blackpod) outbreak.

Table 9 Utilisation stages of land clearing technique with incentives and constraints

Land preparation technique						
Farmer	**Utilisation stage**	**Past**	**Present**	**Future**	**Incentive for current technique**	**Constraint for proka**
F10	Total utiliser	Slash & burn	Proka	Proka	Other farmer	-
F25	Total utiliser	Proka	Proka	Proka	Training	-
F26	Total utiliser	Proka	Proka	Proka	Training	-
F27	Total utiliser	Proka	-	Proka	Training	-
F15	Modified utiliser	Slash & burn	-	Burn half-dry		
F35	Modified utiliser		Chemical	Chemical		
F06	Interested	Slash & burn	-	Proka	Easy	Unaware*
F20	Interested	Slash & burn	-	Proka	SF effect	Maize cultivation**
F32	Interested	Slash & burn	-	Proka	Easy	Unaware*
F39	Interested	Slash & burn	-	Proka	Easy; common	Unaware*
F24	Disinterested	Slash & burn	-	Slash & burn	SF effect	Difficult***
F36	Disinterested	Slash & burn	-	Slash & burn	Easy	Difficult; uncommon
F37	Disinterested	Slash & burn	-	Slash & burn	Easy	Difficult; uncommon
F28	Unable	Slash & burn	-	Proka	Easy	Difficult
F31	Unable	Slash & burn	-	Proka	Easy	Weed type****
F33	Unable	Slash & burn	-	Proka	Easy	Difficult
F34	Unable	Slash & burn	-	Proka	Easy	Difficult
F38	Unable	Slash & burn	-	Proka	Easy	Weed type*****
F40	Unable	Slash & burn	-	Proka	Easy	Difficult
F01	Unaware	Slash & burn	-		Easy; effect	Unaware
F02	Unaware	Slash & burn	-		Easy	Unaware
F04	Unaware	Slash & burn	-	Slash & burn	SF effect	Unaware
F13	Unaware	Slash & burn	Slash & burn	Slash & burn	SF effect; easy	Unaware
F14	Unaware	Slash & burn	Slash & burn	Slash & burn	SF effect; easy; common	Unaware
F16	Unaware	Slash & burn	-	Slash & burn	Easy	Unaware
F18	Unaware	Slash & burn	-	Slash & burn	Easy	Unaware
F21	Unaware	Slash & burn	-	Slash & burn	Easy	Unaware
F22	Unaware	Slash & burn	-	Slash & burn	Effect	Unaware
F23	Unaware	Slash & burn	-	Slash & burn	Easy; effect	Unaware
F30	Unaware	Slash & burn	-	Slash & burn	Easy	Unaware
F03						
F05		Slash & burn				
F07						
F08		Slash & burn			Easy	
F09		Slash & burn			Easy	
F11		Slash & burn			Easy	
F12						
F17		Slash & burn				
F19						
F29						

*Unaware of proka at the time of farm establishment, informed about proka in the meantime
**For maize cultivation, F20 needed to have very clear and level land to work on
***"Difficult" means that the farmer indicated that debris from proka makes planting of crops and weeding on the farm extra difficult
****Thorny weeds that complicate cultivation and access to the farm
*****Quickly re-occurring bamboo vegetation

Table 10 Utilisation stages of tree variety with incentives and constraints

Variety							
Farmer	**Utilisation stage**	**Past**	**Present**	**Future**	**Source of current planting material**	**Incentive(s) for using hybrid**	**Constraint for not using hybrid**
F03	Total utiliser	Hybrid	Hybrid		SPD	Productivity	-
F08	Total utiliser	Hybrid	Hybrid	Hybrid	SPD	Training; productivity	-
F09	Total utiliser	Hybrid	Hybrid		SPD	Radio	-
F12	Total utiliser		Hybrid	Hybrid	Other farm + SPD		-
F13	Total utiliser	Hybrid	Hybrid	Hybrid	SPD Bunso	Training	-
F15	Total utiliser		Hybrid	Hybrid	SPD Bunso	Productivity	-
F16	Total utiliser	Hybrid	Hybrid	Hybrid	SPD	Productivity	-
F18	Total utiliser		Hybrid	Hybrid	SPD	Training; productivity	-
F20	Total utiliser	Hybrid	Hybrid	Hybrid	SPD	Other farmer*	-
F22	Total utiliser		Hybrid		SPD		
F23	Total utiliser	Hybrid	Hybrid	Hybrid	SPD	Productivity	-
F26	Total utiliser	TQ	Hybrid	Hybrid	SPD	Common; productivity	-
F27	Total utiliser	Hybrid	Hybrid	Hybrid	SPD	Policy; training; productivity	-
F29	Total utiliser	Hybrid	Hybrid	Hybrid	SPD	Other farmer; productivity	-
F30	Total utiliser	Hybrid	Hybrid	Hybrid	SPD	Training; productivity	-
F33	Total utiliser	Hybrid	Hybrid	Hybrid	Family farm + SPD	Availability	-
F06	Partial utiliser	TQ	TQ + hybrid	Hybrid	Family farm + SPD	Easier to manage	
F07	Partial utiliser	Amazon	Amazon + hybrid	Hybrid	Family farm + SPD	Training; productivity	Accessibility
F11	Partial utiliser	TQ	TQ + hybrid	Hybrid	Family farm + SPD	Productivity	Poor drought resistance
F21	Partial utiliser	TQ	TQ + hybrid	Hybrid		Productivity	Unavailable
F24	Partial utiliser	TQ	TQ + hybrid	Hybrid	Other farm	Productivity	Unavailable
F25	Partial utiliser	TQ	TQ + hybrid	Hybrid	SPD Bunso	Training; productivity	Unavailable
F35	Partial utiliser	TQ	TQ + hybrid	Hybrid	SPD	Training; productivity	Unavailable
F36	Partial utiliser	Amazon	Amazon + hybrid	Hybrid	Family farm + SPD	Common	Unavailable
F37	Partial utiliser	Amazon	Amazon + hybrid	Hybrid	Other farm + SPD	Training; productivity	Unavailable
F40	Partial utiliser	Amazon	Amazon + hybrid	Hybrid	Other farm + SPD	Productivity	
F02	Interested			Hybrid	Mother's farm	Productivity	Knowledge
F32	Interested	Amazon	Amazon	Hybrid	Other farms	Training; common	Not replanting**
F34	Interested	TQ	TQ	Hybrid	Other farms	Productivity	Unavailable
F17	Disinterested	TQ	TQ	TQ	Other farm	-	Unavailable; prefers TQ
F19	Disinterested	TQ	TQ	TQ	Own farm	-	Uncommon; prefers TQ
F14	Disadopter	Amazon	Hybrid	Amazon	SPD	Training	Prefers Amazon
F38	Disadopter	Hybrid	Hybrid	Amazon	SPD Bunso	-	Effect***
F01	Unable	Amazon	Amazon	Hybrid	Other farmer		Money
F31	Unable	Anywhere	Amazon + Hybrid	Hybrid	Other farms	Training; disease resistance	Money
F39	Unable	Amazon	Amazon	Hybrid	Family farm		Money
F04							
F05							
F10							
F28							

*Father works at the SPD | **Farmer is a sharecropper and the land owner might re-claim the land when he cuts down current trees for replanting | *** Farmer was not satisfied with hybrid's poor drought resistance

Table 11 Quantified utilisation stages and current ISFM scores of farmers

Farmer	Inorganic fertiliser	Organic fertiliser	Husk spreading	Land preparation	Variety	Current ISFM score	Ranking
F01	2	5	4	2	2	**3**	Medium
F02	4	4	2	2	4	**3.2**	Medium
F03	4	4	5		5	**4.5**	High
F04	4	4	2	2		**3**	Medium
F05	2		5				
F06	2	4	5	4	4	**3.8**	High
F07	4	5	5		4	**4.5**	High
F08	4	4	5		5	**4.5**	High
F09	2		5		5	**4**	High
F10	1	2	5	5		**3.25**	Medium
F11	4	4	2		4	**3.5**	Medium
F12	4	5	4		5	**4.5**	High
F13	2	1	5	2	5	**3**	Medium
F14	5	5	5	2	1	**3.6**	Medium
F15	2	4	4	5	5	**4**	High
F16	4	1	5	2	5	**3.4**	Medium
F17	5	4	2		1	**3**	Medium
F18	4	4	5	2	5	**4**	High
F19	5	2	2		1	**2.5**	Low
F20	4	1	5	4	5	**3.8**	High
F21	2	2	2	2	4	**2.4**	Low
F22	2			2	5	**3**	Medium
F23	2	4	2	2	5	**3**	Medium
F24	5	4	2	1	4	**3.2**	Medium
F25	4	4	5	5	4	**4.4**	High
F26	2	5	2	5	5	**3.8**	High
F27	2	2	5	5	5	**3.8**	High
F28	2	2	5	2		**2.75**	Low
F29	4	2	4		5	**3.75**	High
F30	4	4	5	2	5	**4**	High
F31	4	1	2	2	2	**2.2**	Low
F32	2	1	2	4	4	**2.6**	Low
F33	5	1	5	2	5	**3.6**	Medium
F34	4	2	5	2	4	**3.4**	Medium
F35	4	5	5	5	4	**4.6**	High
F36	4	2	2	1	4	**2.6**	Low
F37	5	1	4	1	4	**3**	Medium
F38	2	2	5	2	1	**2.4**	Low
F39	2	4	2	4	2	**2.8**	Low
F40	1	5	5	2	4	**3.4**	Medium

Annex III – Farmers' future willingness for ISFM practices

Table 12 Quantified future willingness of farmers to apply or practice the ISFM practices

Future willingness to apply or practice...							
Farmer	Inorganic fertiliser	Organic fertiliser	Husk spreading	Hybrid variety	Proka land preparation	Future ISFM score	Ranking
F06	1	1	1	1	1	5	High
F25	1	1	1	1	1	5	High
F26	1	1	1	1	1	5	High
F27	1	1	1	1	1	5	High
F34	1	1	1	1	1	5	High
F01	1	1	1	1		4	High
F07	1	1	1	1		4	High
F08	1	1	1	1		4	High
F12	1	1	1	1		4	High
F15	1	1	1	1	0	4	High
F18	1	1	1	1	0	4	High
F20	1	0	1	1	1	4	High
F23	1	1	1	1	0	4	High
F24	1	1	1	1	0	4	High
F29	1	1	1	1		4	High
F30	1	1	1	1	0	4	High
F35	1	1	1	1	0	4	High
F36	1	1	1	1	0	4	High
F39	1	1	0	1	1	4	High
F02	1	1	0	1		3	Medium
F10	0	1	1		1	3	Medium
F11	1	1	0	1		3	Medium
F13	1	0	1	1	0	3	Medium
F14	1	1	1	0	0	3	Medium
F16	1	0	1	1	0	3	Medium
F21	1	1		1	0	3	Medium
F28	1	1	1		0	3	Medium
F31	1	0	0	1	1	3	Medium
F32	1	0		1	1	3	Medium
F33	1	0		1	1	3	Medium
F37	1	0	1	1	0	3	Medium
F38	1	1	1	0	0	3	Medium
F40	0	1	1	1		3	Medium
F03	1		1				
F04	1	1			0	2	Low
F17	1	1	0	0		2	Low
F09			1				
F19	1	0	0	0		1	Low
F22	1				0		
F05							

Annex IV – Typology overview table

Table 13 Typology overview table - farmers sorted by type. Types are based on motivation and ISFM score; the utilisation stages are given for context

Farmer	Type	Motivation	ISFM score	Inorganic fertiliser	Organic fertiliser	Husk spreading	Land preparation	Variety
F03	**Passionate**	Passionate	High	Partial utiliser	Partial utiliser	Total utiliser		Total utiliser
F06	**Passionate**	Passionate	High	Unable	Interested	Total utiliser	Interested	Partial utiliser
F07	**Passionate**	Passionate	High	Partial utiliser	Total utiliser	Total utiliser		Partial utiliser
F08	**Passionate**	Passionate	High	Interested	Partial utiliser	Total utiliser		Total utiliser
F14	**Passionate**	Passionate	Medium	Total utiliser	Total utiliser	Total utiliser	Unaware	Disadopter
F26	**Passionate**	Passionate	High	Unable	Total utiliser	Unable	Total utiliser	Total utiliser
F30	**Passionate**	Passionate	High	Interested	Interested	Modified utiliser	Unaware	Total utiliser
F34	**Passionate**	Passionate	Medium	Partial utiliser	Interested	Total utiliser	Unable	Interested
F09	**High potential**	Practical	High	Unable		Total utiliser		Total utiliser
F12	**High potential**	Practical	High	Interested	Total utiliser	Partial utiliser		Total utiliser
F15	**High potential**	Practical	High	Unable	Interested	Partial utiliser	Modified utiliser	Total utiliser
F18	**High potential**	Practical	High	Partial utiliser	Partial utiliser	Total utiliser	Unaware	Total utiliser
F20	**High potential**	Practical	High	Partial utiliser	Disadopter	Total utiliser	Interested	Total utiliser
F25	**High potential**	Practical	High	Interested	Interested	Total utiliser	Total utiliser	Partial utiliser
F27	**High potential**	Practical	High	Unable	Unable	Total utiliser	Total utiliser	Total utiliser
F29	**High potential**	Practical	High	Interested	Unable	Partial utiliser		Total utiliser
F35	**High potential**	Practical	High	Interested	Modified utiliser	Modified utiliser	Modified utiliser	Partial utiliser
F01	**Practical**	Practical	Medium	Unable	Modified utiliser	Partial utiliser	Unaware	Unable
F02	**Practical**	Practical	Medium	Interested	Interested	Disadopter	Unaware	Interested
F04	**Practical**	Practical	Medium	Interested	Partial utiliser	Unaware	Unaware	
F05	**Practical**	Practical	Medium	Unable		Total utiliser		
F10	**Practical**	Practical	Medium	Disadopter	Unable	Total utiliser	Total utiliser	
F11	**Practical**	Practical	Medium	Interested	Partial utiliser	Unaware		Partial utiliser
F13	**Practical**	Practical	Medium	Unable	Disinterested	Total utiliser	Unaware	Total utiliser
F22	**Practical**	Practical	Medium	Unable			Unaware	Total utiliser
F23	**Practical**	Practical	Medium	Unable	Interested	Unaware	Unaware	Total utiliser
F24	**Practical**	Practical	Medium	Total utiliser	Interested	Unaware	Disinterested	Partial utiliser
F33	**Practical**	Practical	Medium	Modified utiliser	Disadopter	Modified utiliser	Unable	Total utiliser
F40	**Practical**	Practical	Medium	Disadopter	Total utiliser	Modified utiliser	Unable	Partial utiliser
F19	**Stuck**	Practical	Low	Total utiliser	Unaware	Unaware		Disinterested
F21	**Stuck**	Practical	Low	Unable	Unable	Unaware	Unaware	Partial utiliser
F28	**Stuck**	Practical	Low	Unable	Unable	Total utiliser	Unable	
F38	**Stuck**	Practical	Low	Unable	Unable	Total utiliser	Unable	Disadopter
F39	**Stuck**	Practical	Low	Unable	Interested	Unable	Interested	Unable
F16	**Lack of alternative**	Lack of alternative	Medium	Interested	Disadopter	Total utiliser	Unaware	Total utiliser
F17	**Lack of alternative**	Lack of alternative	Medium	Total utiliser	Interested	Unaware		Disinterested
F31	**Lack of alternative**	Lack of alternative	Low	Interested	Disinterested	Unable	Unable	Unable
F32	**Lack of alternative**	Lack of alternative	Low	Unable	Disinterested	Unaware	Interested	Interested
F36	**Lack of alternative**	Lack of alternative	Low	Partial utiliser	Unable	Unaware	Disinterested	Partial utiliser
F37	**Lack of alternative**	Lack of alternative	Medium	Total utiliser	Disinterested	Partial utiliser	Disinterested	Partial utiliser