Beyond feasibility—the role of motivation to implement measures to enhance resilience

Evidence from drought-affected smallholder farmers in Ghana and Ethiopia

Luzian Messmer¹ · Braidia Thom¹ · Pius Kruetli² · Evans Dawoe³ · Kebebew Assefa⁴ · Johan Six¹ · Jonas Joerin⁵

Received: 24 March 2020 / Accepted: 22 April 2021 / Published online: 14 June 2021
© The Author(s) 2021

Abstract

Many regions around the world are experiencing an increase in climate-related shocks, such as drought. This poses serious threats to farming activities and has major implications for sustaining rural livelihoods and food security. Farmers' ability to respond to and withstand the increasing incidence of drought events needs to be strengthened and their resilience enhanced. Implementation of measures to enhance resilience is determined by decisions of farmers and it is important to understand the reasons behind their behavior. We assessed the viability of measures to enhance resilience of farmers to drought, by developing a general framework that covers economic-technical and psychological-cognitive aspects, here summarized under the terms (1) motivation and (2) feasibility. The conceptual framework was applied to cocoa farmers in Ghana and tef farmers in Ethiopia by using questionnaire-based surveys. A portfolio of five specific measures to build resilience (i.e., irrigation, shade trees, fire belts, bookkeeping, mulching, early mature varieties, weather forecast, reduced tillage, improved harvesting) in each country was evaluated with a closed-ended questionnaire that covered the various aspects of motivation and feasibility whereby farmers were asked to (dis)agree on a 5-point Likert scale. The results show that if the motivation mean score is increased by 0.1 units, the probability of implementation increases by 16.9% in Ghana and by 7.7% in Ethiopia. If the feasibility mean score is increased by 0.1 units, the probability of implementation increases by 24.9% in Ghana and by 11.9% in Ethiopia. We can conclude that motivation and feasibility matter, and we improve our understanding of measure implementation if we include both feasibility and motivation into viability assessments.

Keywords Vulnerability · Climate change · Sub-Saharan Africa · Cocoa · Tef

Luzian Messmer and Braidia Thom equally contributed to the study.

✉ Luzian Messmer
luzian.messmer@protonmail.com

Extended author information available on the last page of the article

1 Introduction

Farming activities have always been inherently sensitive to variability and are regularly subject to shocks and changes which often cannot be anticipated (Urruty et al. 2016). Facing these uncertainties, farmers ever since had to deal not only with short-term challenges but also with more strategic decisions driven by long-term objectives (Rodriguez et al. 2011). However, there is a consensus that change is accelerating, and shocks are becoming less predictable, more frequent, and more intense (Barrett and Constanas 2014; International Food Policy Research Institute [IFPRI] 2014) because interconnections between elements of the socioecological system that agriculture is, lead to consequences beyond the immediate context (Darnhofer et al. 2016; Sardar 2015). For example, the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) indicated that many regions around the world are experiencing an increase in extreme weather and climate-related shocks, such as drought.

Drought, among all the natural hazards, is the most important climate-related shock worldwide (Bryant 2005; Wilhite 2000). This poses serious threats to farming activities and has major implications for rural livelihoods and food security, in particular, for Sub-Saharan Africa which relies highly on rainfed smallholder agriculture (Thornton et al. 2011; Wheeler and von Braun 2013). An increase in frequency and spatial coverage of irregular rainfall patterns and drought events has been observed over the past decades, and climate change scenarios predict this trend to continue in the future. These observations and scenarios also apply for the two case study countries Ghana and Ethiopia (Deressa et al. 2011, 2009; Evangelista et al. 2013). Both, cocoa farmers in Ghana, producing a cash crop, and tef farmers in Ethiopia, cultivating a staple crop, are highly vulnerable to droughts because of the utmost importance of these crops for their livelihood. Thus, there is evidence of the vulnerability of farming activities to drought globally and notably in Ghana and Ethiopia and, therefore, a growing need for new effective strategies to minimize the adverse effects of drought.

The concept of resilience is gaining much attention in order to try dealing with shocks like drought in a more dynamic manner. According to Tendall et al. (2015, p. 18) “it [resilience] can broadly be defined as the dynamic capacity to continue to achieve goals despite disturbances and shocks.” Therefore, by definition, resilient farmers are more likely to absorb, react, restore, learn, and build robustness (International Food Policy Research Institute [IFPRI] 2014; Tendall et al. 2015). However, adaptation strategies and measures, launched by agricultural policies are encountering a number of limitations and reveal inadequacies in its capacity to meet the goal of enhancing resilience (Thompson and Scoones 2009). Thus, farmers’ ability to respond and withstand to the increasing incidence of drought events and their consequences, needs to be strengthened and their resilience enhanced (Darnhofer 2014). In addition, more attention should be paid to the viability of measures and the ability to implement them.

Implementation of measures is determined by decision-making. Therefore, it is important to understand the reasons behind farmers’ behavior when aiming at enhancing resilience (Blackstock et al. 2010). This study contributes to filling this gap in the resilience literature. We postulate that measures have to be perceived as viable in order to be implemented (Lim et al. 2004) and the drivers and constraints shaping the viability of measures have to be better understood (Niles et al. 2015). Until today, viability indicators are often defined by top-down rather than bottom-up approaches. Usually, these indicators only include economic and technical aspects. Empirical research on implementation of

Fig. 1 Conceptual framework with (1) feasibility, (2) motivation, (3) socioeconomic background, and (4) drought experience and their respective indicators determining a (non-)implementation of measures

measures has often neglected the importance of the human dimension, of measurable and alterable psychological factors like interest and motivation (Gebrehiwot and van der Veen 2015; Grothmann and Patt 2005). We expect that key indicators determining the viability of measures include both, economic-technical and psychological-cognitive aspects, here summarized under the terms (1) motivation and (2) feasibility. Subsequently, this study aimed to answer the research question; “can we better understand the implementation of measures by including both, feasibility and motivation into the viability assessment?” and attain the following objectives:

- (1) Develop a framework and define measurable indicators shaping farmers’ feasibility to implement measures and farmers’ motivation towards the implementation of those measures.
- (2) Apply this framework by means of a questionnaire-based survey to two exemplary case studies in Ghana and Ethiopia. In each case, we assessed five particular measures designed either by cocoa or tef farmers to enhance their resilience to drought.
- (3) Evaluate if and how much the two dimensions contribute in explaining the implementation of measures to enhance resilience.

2 Connecting motivation concepts with feasibility components

We propose a new framework (Fig. 1) to assess the viability of measures based on the dimensions (1) motivation, (2) feasibility, and the (3) socioeconomic background, as well as (4) farmers’ drought experience. The three dimensions are expected to contribute to the farmers’ decision-making whether or not to implement a particular measure. We postulated that it is possible to measure and explain decision-making with a holistic approach that takes various dimensions into account. Even though every human being has its own perception and opinion about specific indicators, the sum of the indicators gives us information about the dimension and thus, enables a positivist measurement and ultimately the prediction of a behavior. The development of the framework is designed around a realist

ontology (Moon and Blackman 2014). The following section explains in more detail how the stated indicators were elaborated and justified by literature reviews.

According to the IPCC (McCarthy et al. 2001, p. 982) “the practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency, and feasibility” is important. Feasibility is a dimension depending on a variety of indicators. The most important indicators are likely to be the technical feasibility, the existence of sufficient management capacity for design and implementation, and the costs and benefits of measures (Brooks et al. 2011). Thus, a wide variety of economic, social, political, and environmental conditions contribute to shaping the feasibility of measures (Burton et al. 2002). Various indicators for feasibility can be found in the literature inter alia about feasibility studies. Mesly (2017, p. 78) states in his book about “Project Feasibility” that “the goal of the feasibility expert is to evaluate methodically whether the proposed project has any chance of meeting its objectives; [...] they must set the parameters that help determine whether a project is a success or a failure.” He describes eight elements that have an influence on the success or failure of a project, namely the: financial, organizational, environmental, technological, marketing, sociocultural, legal and political contextual risk (Mesly 2017, p. 85). After all, a predefined setup for conducting a feasibility study does not exist and the format has to be adapted to the project being evaluated, taking into account the project’s goals (Mesly 2017, p. 94). In the IPCC report from 2014, the attractiveness and feasibility of adaptation measures to climate change is outlined in a hierarchical manner, where first, one needs to consider the effects of climate change, for which measures are needed in order to adapt. Then, to which extent one can adapt to the effects of climate change considering technical and physical limits, followed by what adaptation measures are desirable, considering available resources (such as money) and what is possible considering political and institutional constraints (Chambwera et al. 2014).

Below et al. (2012) highlight that the feasibility of measures to adapt to climate change depends on biophysical and economic factors like natural, physical, financial, and social capitals. Hassan and Nhemachena (2008) show that adaptation to climate change at farm level in Africa is influenced by farm assets, access to extension services, access to technology and information, and knowledge about the adaptation measure. Furthermore, the feasibility of a measure depends on how easy it is to implement, not only in terms of costs but also in terms of non-financial factors like time (Lim et al. 2004). They emphasize the importance of involving the affected stakeholders in the process of the feasibility assessment, since adaptation measures must be feasible for the stakeholders who are to implement them (Lim et al. 2004). Different measures can have different requirements in terms of capital, knowledge and time needed for their implementation. Therefore, it is important to look at the measures’ specific feasibility. These definitions of feasibility indicators and feasibility studies were the basis for developing the feasibility indicators of the framework. We used the following indicators in our framework: *money, time, tools, knowledge and information, accessibility, governmental, and information from extension*.

In contrast to feasibility, motivation can be defined as “any internal process that energizes, directs, and sustains behavior” (Reeve 2016, p. 31), or simpler as “wanting, [...] desiring some change in the self and/or the environment” (Baumeister 2016, p. 1). There are different aspects of motivation, such as needs (biological, psychological, and implicit needs), cognitions (goals, plans, expectancies, beliefs, values, attributions, and self-concept), and emotions (basic emotions, self-conscious emotions, cognitively complex emotions) (Baumeister 2016; Reeve 2016). Furthermore, the term motivation is used for everyday convenience (Kleinginna and Kleinginna 1981). Non-psychologists often use the term

motivation in an all-inclusive sense ((Kleinginna and Kleinginna 1981) and according to Maslow for the majority of human beings (except for behavioral psychologists) “the original criterion of motivation [...] is the subjective one” (Maslow 1955, p. 58). In theory, motivation is dependent on internal and external circumstances (Baumeister 2016) and is one of the fundamental drivers of humans to take action (Broussard and Garrison 2004; Guay et al. 2010). As there is no general theory of motivation (Baumeister 2016; Kleinginna and Kleinginna 1981; Reeve 2016), different and specific motivation theories such as goal theories, the expectancy-value theory, and the self-concordance model have been reviewed to serve as a basis to develop measurable indicators of motivation. These are: the *usefulness* of the measure, the *expected financial reward* of the measure, the *identification* with the measure, the *subjective motivation* towards implementing the measure, the *satisfaction* with the measure, and the *implementation of the measures by peers*.

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

The expectancy-value theory says that motivation is boosted by two main drivers, namely by the perceived outcomes of a certain action and by the value that is attributed on this outcome (Ajzen 1975; Ajzen and Fishbein 1980; Atkinson 1964). First, a belief about an object or action is developed. This belief can be modified by newly obtained information. Once the belief is developed, a value is assigned to the object or action. Based on these beliefs and values an expectation and attitude towards the outcome of the action is created (Fishbein and Ajzen 1975). According to Ajzen and Fishbein (1980) behavior intention does not only depend on the perceived outcomes and their values but also depends on subjective norms (Ajzen and Fishbein 1980). An individual is more likely to perform a certain action or behavior if they believe that important other people think the individual should do it (Ajzen and Fishbein 1980). Several studies in different countries showed subjective norms to positively influence farmers’ intentions to implement measures (Borges et al. 2014; Fielding et al. 2005; Martínez-García et al. 2013; Zeweld et al. 2017; Zubair and Garforth 2006). In this case, social pressure can be created by peers, namely other farmers in the same geographical area. Therefore, it is expected that measures that are implemented by the peers are more likely to be adopted.

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

Fig. 2 Location of the two case studies and the selected study sites in Ghana and Ethiopia

Fig. 3 Selected and assessed measures to enhance farmers' resilience to drought

external motivation and highest when based on identified and intrinsic motivation (Deci and Ryan 1985; Sheldon and Elliot 1999; Sheldon and Houser-Marko 2001).

In addition to feasibility and motivation, the framework also covers socioeconomic variables of the farmers as well as their drought experience and perception. The indicators of yield (*mean yield between 2015 and 2017*) and acreage of the respective crop (*area crop*) were used to understand and cover the socioeconomic environment of the farmers. Additionally, we included farmers' education (if they have a *basic education* and at least attended primary school) and the *household size* as well as the *age* and the *gender* of the farmers in our framework. The framework further covers the importance of, and perceived drought experience (*drought as most devastating shock* and the *expectations for an increase in future drought damages*).

3 Methodology

The theoretical framework is deductively tested in the context of two case studies with each five case specific measures (see Fig. 3) to enhance farmers' drought resilience. The following section describes the methodology we used in both case studies and explains the applied methods in the last section.

3.1 Two case studies: Ghanaian cocoa farmers and Ethiopian tef farmers

The two case studies focus on two different commodities in two countries were conducted to test the applicability of the framework and if feasibility and motivation behave similarly in both cases. Thus, the conceptual framework was applied to cocoa farmers in Ghana and tef farmers in Ethiopia. In both countries, cocoa (*Theobroma cacao* L.), and tef (*Eragrostis tef* (Zucc.) Trotter), respectively, largely dominate the agricultural sector and the economy in terms of income, employment and food security (cocoa is an indirect, while tef is a direct contributor to food security) (Kongor et al. 2017; Minten et al. 2018; Monastyrnaya et al. 2016; Stanturf et al. 2011). While cocoa can be classified as cash crop, tef is a staple crop. The research was conducted in the Ashanti and Western regions of Ghana and in the Oromia Region of Ethiopia (see Fig. 2). The former are the most important cocoa producing regions in Ghana and the latter one of the major tef-production areas in Ethiopia (Ketema 1997; Monastyrnaya et al. 2016). A detailed characterization of the study sites and the socioeconomic context of the sample can be found in Table 2 in the Supplementary material.

The case studies focus on farmers, being the least drought-resilient actors in the respective value chains (Duguma et al. 2017; Monastyrnaya et al. 2016). The increase in frequency and spatial coverage of irregular rainfall patterns and drought events in Ghana and Ethiopia over the past few decades points out the imperative of enhancing resilience. Furthermore, climate change scenarios predict this trend to continue in the future (Deressa et al. 2011, 2009; Evangelista et al. 2013).

In both case studies, a portfolio of five particular measures to enhance resilience was assessed. The measures were selected and adapted from measures elaborated by cocoa and tef farmers, which were developed within the framework of a workshop (Joerin 2018a, b). The selection process was based on the criterion that farmers should be able to implement the chosen measures on their own. In collaboration with different experts, all measures have been classified according to this criterion. The portfolio represents a great diversity in terms of requirements for implementation. The selected measures were irrigation systems, shade trees, fire belts, bookkeeping, and mulching for Ghana and irrigation, early mature varieties, weather forecast, reduced tillage, and improved harvesting technologies for Ethiopia (Fig. 3). While some of the measures are already implemented to a certain extent, others are not. Further, the portfolio covers a wide range of different measures, either reactive or anticipatory. Further details characterizing the measures can be found in Table 3 in the Supplementary material.

3.2 Survey: design, data collection and analysis

3.2.1 Quantitative questionnaire

We designed a quantitative survey with closed-ended questions to evaluate the feasibility and farmers' motivation towards the proposed measures. To do so, we designed a questionnaire based on our conceptual framework to assess the viability of specific measures. The questionnaire was divided into three main parts: socioeconomic and sociodemographic questions, drought-related information, and specific statements about the measures containing the aspects of feasibility and motivation. Statements have been

developed for each indicator of feasibility and motivation separately (e.g., “I have the money to implement measure x”). The answer options to (dis-)agree with the statements were set on a 5-point Likert scale with the categories “strongly disagree,” “somewhat disagree,” “neither agree nor disagree,” “somewhat agree,” and “strongly agree.” We combined the written Likert scale with a visual illustration to facilitate the choice for the respondent. The visual Likert scale can be found in Fig. 8 in the Supplementary material. The socioeconomic and sociodemographic indicators were based on adaptation measure literature and tailored to the respective countries. In order to create consistency, the statements of feasibility and motivation were formulated based on a perceived optimal level of implementation that has to be defined by the respondent. A balanced incomplete block design was used and only two of the five measures were randomly assigned to each farmer to reduce the duration of the interview and thus avoid tiredness and loss of interest by the respondent. The questionnaire can be found in Section 8.3 in the Supplementary material.

3.2.2 Data collection

The data was collected during a fieldtrip between May and July 2018. We worked with two trained facilitators in each country to conduct face-to-face interviews. Stratified Random Sampling was used to select farmers from different Agro-Ecological Zones with different rainfall patterns and therefore dissimilar experience of drought events. In Ghana, a total of 307 farmers were surveyed and in Ethiopia 275 farmers. Since each respondent was asked two randomly assigned measures, each measure was assessed at least 109 times. In order to reduce the geographical impact, each measure has been covered at least eight times per village.¹

3.2.3 Data processing and analysis

The data processing and the statistical analysis was done with IBM SPSS Statistic Version 25[®] (IBM 2017). The imported data was cleaned, controlled for reliability, and prepared for the analysis. Data analysis includes descriptive statistics, inferential tests and binary logistic regression models. The responses on the 5-point Likert scale were coded on a scale from 1 (strongly disagree) to 5 (strongly agree) while nonresponses were coded using negative values. Since indicators are seen as equally important as drivers or constraints towards the corresponding dimension (feasibility and motivation), mean scores were built using standardized means over all corresponding indicators [mean scores]. The composed dimensions feasibility and motivation were also tested for internal reliability (Cronbach’s α for motivation 0.626; and for feasibility 0.749). Statistical significance is considered for p value of <0.05 in all analyses (Ambelu et al. 2017). The predictors used in the binary logistic regression were controlled for multicollinearity and for reasons of comparability means for feasibility and motivation indicators were standardized. The confidence intervals of all the predictors in the regression are reported at 95% level. Missing values led to exclusion in the analysis and hence smaller sample sizes (n) may occur.

¹ For Ethiopia Kebele, the smallest administrative unit was used as equivalent for villages.

Fig. 4 **a** Boxplots with standardized feasibility and motivation means for each measure separately and **b** the share of implementation among the surveyed farmers for both case studies

4 Results

4.1 Feasibility and motivation for the measures and their implementation

Our results show that not all measures were implemented with equal shares. Further, also the calculated mean scores for feasibility and motivation differ for the assessed measures in both case studies (Fig. 4a). Bookkeeping in cocoa farming and reduced tillage in tef farming showed lowest motivation scores. In terms of feasibility, lowest scores were obtained for irrigation in tef and cocoa and also for improved harvesting technologies in tef—all of them high-technological measures.

Similarly, to differences in feasibility and motivation, differences were found among the share of implementation (Fig. 4b). In Ghana, the measures mulching, shade trees and fire belts were implemented by the majority of the farmers (100%, 97.5%, and 89.4%, respectively), while bookkeeping was implemented by 34.2% and irrigation systems by only very few farmers (6.5%). In Ethiopia, the measures early mature varieties, reduced tillage and weather forecast were implemented by about two thirds of the farmers (70%, 67.9%, and 62.7%, respectively), while improved harvesting was implemented by only 13.8% and irrigation technologies by nobody.

Because feasibility and motivation were found to strongly vary among the different measures and the share of implementation was not equal for all measures, we checked for correlation between motivation and the implementation (Ethiopia: $r=0.098$, $p=0.022^*$, $n=548$; Ghana: $r=0.485$, $p<0.001^{***}$, $n=609$), as well as between feasibility and implementation (Ethiopia: $r=0.329$, $p<0.001^{***}$, $n=544$; Ghana: $r=0.565$, $p<0.001^{***}$, $n=612$). All correlations were found to be positive and the effect of their strength according to Cohen (1992) mediocre, except the correlation between motivation

Fig. 5 Box-plot diagram putting of the feasibility and motivation for the (non-)implemented measures in Ghana and Ethiopia

and implementation of measures in Ethiopia; there, the effect strength was weak. This correlation is illustrated in Fig. 5 for both case studies and tested with Mann–Whitney U test for sample dependencies. Motivation means for Ghana are different for implemented and non-implemented measures ($U = 68,560.000$, $p < 0.001^{***}$, Mann–Whitney U test) and farmers are more motivated when they have the measure implemented. The same can be observed for the Ghanaian feasibility means ($U = 70,566.500$, $p < 0.001^{***}$, Mann–Whitney U test) and again farmers perceived measures more feasible to implement when having them already implemented. In the Ethiopian case study, similar motivation means for implemented and non-implemented measures were observed ($U = 40,081.500$, $p = 0.071$, Mann–Whitney U test). In contrast to this, feasibility means were found to be significantly different for implemented and for non-implemented measures, again with higher perceived feasibility for measures which are already implemented ($U = 50,588.000$, $p < 0.001^{***}$, Mann–Whitney U test).

4.2 (Non-)implementation of measures explained by feasibility and motivation

A binary logistic regression was applied to analyze possible explanatory power of feasibility and motivation as predictors determining the implementation of measures. The regression was conducted for the two case studies separately. The predictors (motivation, feasibility, drought experience, socioeconomic and sociodemographic variables, and the measures themselves) were included in the regressions in blocks; the first block comprised the drought experience, socioeconomic variables, demographic variables, and the measures, whereas the second block mean scores of feasibility and motivation. The models were improved regarding Nagelkerke's pseudo- R^2 by entering feasibility and motivation (Ghana from 0.744 to 0.826 and Ethiopia from 0.546 to 0.598). Table 1 shows the output of the two regression models:

Both models are significant (Ghana: $\chi^2(14) = 510.634$, $p < 0.001^{***}$; Ethiopia: $\chi^2(14) = 308.016$, $p < 0.001^{***}$), and the results indicate that for both, motivation and feasibility are significantly explaining the implementation of measures. The results for

Table 1 Binary logistic regression models explaining a possible implementation of measures for both case studies

Country	B	S.E	Wald	df	Sig	Exp(B)	C.I. for Exp(B)	C.I. for Exp(B)
Ghana								
Reference measure: shade trees ^a			86.459	4	<0.001***			
Irrigation	-5.840	0.795	53.919	1	<0.001***	0.003	0.001	0.014
Fire belts ^a	-1.738	0.760	5.235	1	0.022*	0.176	0.040	0.779
Bookkeeping ^a	-5.222	0.783	44.500	1	<0.001***	0.005	0.001	0.025
Mulching ^a	16.600	3472.848	<0.001	1	0.996	16,194,113.109	<0.001	
Mean yield between 2015 and 2017 [tha ⁻¹] ^a	-2.729	0.992	7.571	1	0.006**	0.065	0.009	0.456
Area crop [ha] ^a	-0.071	0.059	1.467	1	0.226	0.931	0.830	1.045
Basic education [0=no, 1=yes] ^a	0.702	0.482	2.127	1	0.145	2.019	0.785	5.189
Household size [n] ^a	0.054	0.039	1.895	1	0.169	1.055	0.977	1.139
Age of farmer [a] ^a	0.008	0.015	0.268	1	0.605	1.008	0.979	1.037
Gender [0= male, 1= female] ^a	-0.974	0.451	4.662	1	0.031*	0.378	0.156	0.914
Drought as most devastating shock [0=no, 1=yes] ^a	0.575	0.462	1.544	1	0.214	1.776	0.718	4.396
Drought damages will increase in future [0=no, 1=yes] ^a	-0.266	0.471	0.318	1	0.573	0.767	0.305	1.930
Feasibility [mean score]	1.249	0.256	23.746	1	<0.001***	3.488	2.110	5.764
Motivation [mean score]	0.990	0.222	19.887	1	<0.001***	2.692	1.742	4.159
Constant	3.321	1.189	7.804	1	0.005**	27.678		
Summary statistics								
Hosmer and Lemeshow								
χ^2	14.214							
df	8							
p	0.076							
Model χ^2								
χ^2	510.634							
df	14							
p	<0.001***							

Table 1 (continued)

Country	B	S.E	Wald	df	Sig	Exp(B)	C.I. for Exp(B)	C.I. for Exp(B)
Nagelkerke's pseudo- R^2								
Ethiopia	0.826		57.282	4	< 0.001***			
Reference measure: early mature varieties ^a								
Irrigation ^a	-22.182	3797.595	< 0.001	1	0.995		< 0.001	
Weather forecast ^a	-0.333	0.330	1.017	1	0.313		0.717	1.369
Reduced tillage ^a	0.720	0.416	2.991	1	0.084		2.055	4.647
Improved harvesting ^a	-2.318	0.392	34.990	1	< 0.001***		0.098	0.212
Mean yield between 2015 and 2017 [tha ⁻¹] ^a	-0.296	0.149	3.937	1	0.047*		0.743	0.996
Area crop [ha] ^a	0.022	0.080	0.073	1	0.787		1.022	1.196
Basic education [0=no, 1=yes] ^a	-0.214	0.285	0.562	1	0.453		0.808	1.412
Household size [n] ^a	0.061	0.064	0.896	1	0.344		1.063	1.205
Age of farmer [a] ^a	-0.001	0.012	0.002	1	0.965		0.999	1.023
Gender [0= male, 1 = female] ^a	-0.190	0.479	0.156	1	0.692		0.827	2.117
Drought as most devastating shock [0=no, 1=yes] ^a	-1.487	0.292	25.948	1	< 0.001***		0.226	0.401
Drought damages will increase in future [0=no, 1=yes] ^a	0.201	0.406	0.245	1	0.621		1.223	2.711
Feasibility [mean score]	0.784	0.241	10.583	1	0.001**		2.191	3.515
Motivation [mean score]	0.574	0.160	12.792	1	< 0.001***		1.774	2.430
Constant	2.030	0.702	8.355	1	0.004**		7.614	
Summary statistics								
Hosmer and Lemeshow								
χ^2	5.664							
df	8							
p	0.685							

Table 1 (continued)

Country	Model χ^2	χ^2	<i>df</i>	<i>p</i>	Nagelkerke's pseudo- R^2	χ^2	<i>B</i>	S.E	Wald	<i>df</i>	Sig	Exp(B)	C.I. for Exp(B)	C.I. for Exp(B)
		308.016	14	<0.001***										
							0.598							

^aVariables entered on step 1: feasibility and motivation^bFor Ghana: $n = 559$; for Ethiopia: $n = 521$ * $0.01 \leq p < 0.05$; ** $0.001 \leq p < 0.01$; *** $p < 0.001$

both models show that the higher the motivation and the higher the feasibility, the more likely is an implementation. If the motivation mean score is increased by 0.1 units, the probability of implementation increases by 16.9% in Ghana and by 7.7% in Ethiopia. If the feasibility mean score is increased by 0.1 units, the probability of implementation increases by 24.9% in Ghana and by 11.9% in Ethiopia. This increase by 0.1 units can already be surpassed if one single indicator (e.g., money) of a dimension is responded one level higher on the Likert scale (e.g., strongly agree instead of somewhat agree).²

Further, the model for Ghana showed an association between the implementation of the measures and (1) the measure itself, (2) the mean yield between 2015 and 2017, and (3) the gender of the farmer (Table 1 (Ghana)). Compared to the reference measure (shade trees), the likelihood of implementation is significantly lower for the measures: irrigation, fire belts and bookkeeping. No significant difference was found between shade trees and mulching. If the mean yield of the farmer increases by 1 t ha⁻¹, the probability of implementation decreases by 93.5%, and if the farmer is female, the probability of implementation decreases by 62.2%.

The model for Ethiopia showed an association between the implementation of the measures and the measure itself, the mean yield between 2015 and 2017, and drought as most devastating shock (Table 1 (Ethiopia)). Compared to the reference measure early mature varieties, the likelihood of implementation is significantly lower for the measures and improved harvesting. No significant difference was found between early mature varieties, weather forecast and reduced tillage. If the mean yield of the farmer increases by 1 t ha⁻¹, the probability of implementation decreases by 25.7%. Interestingly, if farmers perceive drought as being the most devastating shock event that happens on their farm, the probability of implementation decreases by 77.4%.

4.3 Drivers and constraints of feasibility and motivation

There is a positive association between feasibility and implementation and motivation and implementation but so far it is still not clear how, and how much, the indicator contributed to shape the mean scores of feasibility and motivation. The chosen indicators show that for all measures in both countries *satisfaction* and *subjective motivation* is not constraining motivation and thus the implementation of measures (Fig. 6). The same applies for *time* as feasibility indicator. In contrast, both case studies showed that farmers perceive that *support* either *governmental* or from *extension services* is lacking. For all other indicators, the effect and its pattern are not as clear and varies strongly for each measure individually (see Fig. 9 in the Supplementary material). Therefore, these indicators cannot be clearly categorized as either constraining or non-constraining. For some, they may have a constraining effect, while for others they may not. Interestingly, farmers in Ghana agreed or disagreed clearly on the statements, where in Ethiopia the number of farmers who somewhat or neither agree or disagree is more pronounced for most statements.

² A change in one statement by one point on the 5-point Likert scale (e.g., from strongly disagree to somewhat disagree) means an increase of the mean by 0.167 units for the motivation score, respectively an increase by 0.143 for the feasibility score.

Fig. 6 Number of respondents for each indicator statement on the 5-point Likert scale from strongly disagree to strongly agree summarized for the respective five measures from each case study

5 Discussion

The literature-based framework was suitable for assessing the viability of measures within the context of two different countries and commodities. In both case studies, the executed regression models fitted very well the sampled data. Generally, it can be said that both, (1) higher motivation, as well as (2) higher feasibility increase the likelihood of implementation of measures. Our findings are in line with others stating the importance of feasibility (Chambwera et al. 2014; Hassan and Nhemachena 2008). At the same time, we can show that higher motivation—an aspect which is often neglected in adaptation and resilience research—similarly increases the likelihood of implementation of measures. The low correlation between the two dimensions shows that they are not redundant (Ghana: $r_s(607)=0.383$ $p<0.001^{***}$; Ethiopia: $r_s(545)=0.313$, $p<0.001^{***}$, Spearman correlation). Grothmann and Patt (2005) and Frank et al. (2011) emphasized that sociocognitive factors may be as or more important than socioeconomic aspects in driving individuals to adaptive actions. In this study, we did not find that motivation is more important than feasibility, but we have found a similar importance. Feasibility and motivation are different for each individual measure, which means that policy makers first have to understand which dimension is most constraining for which measure, and then design the policies accordingly. If one wants to implement irrigation systems for example, a support to increase the feasibility is necessary, while for bookkeeping, increasing the farmers' motivation is crucial. To explain these differences, one has to look at the indicators for both dimensions and how farmers perceived them for each measure.

With the literature-based indicators we were able to quantify feasibility and motivation on a 5-point Likert and explain the implementation of measures. We were able to detect strong variation for indicator responses within motivation and feasibility. Bryan et al. (2009) and Tucker et al. (2010) suggest that external factors, like lack of access to credit, land, and inputs are crucial for the implementation. These “external factors” can be compared with the indicators of feasibility and motivation, both dimensions showing a positive effect on the implementation of measures. Regarding the indicators of feasibility and motivation, we found similarities and differences for both case studies. Farmers perceive in both case studies and for all measures that governmental support and information from extension is not sufficient. One might expect to find supportive literature in both case studies showing the lack of governmental support and information from extension. However, in the case of Ethiopia, Berhane et al. (2018) contradict

this assertion by claiming that Ethiopia has one of the most extensive extension services in the world in terms of its extension agent-to-farmer ratio (1:476). Thus, it may be a question of perspective and also about quality and not only quantity of support causing this result of perceived lacking support. In Ghana on the other hand, the density of extension officers is rather low, having on average one extension officer per 1500 farmers and there is room for improvement in terms of quality (Aboagye 2015; Amezah and Hesse 2002; Okorley et al. 2009). The cocoa value chain in Ghana is strongly regulated by the government and the farmers also receive support (e.g., farming inputs), but often not sufficient (Monastyrnaya et al. 2016). The indicators time, satisfaction, and subjective motivation are not constraining feasibility and motivation; these were always stated as sufficient by the respondents, even for measures that are not implemented. One reason for the sufficient satisfaction and subjective motivation might be that the measures were designed by farmers, and therefore only measures that they perceive as satisfactory and are generally motivated to implement were selected. Another reason could be that farmers give strategic answers, hoping that they receive support or something in return if they say that they have time, perceive a measure as satisfactory and are motivated to implement it. However, further research would be needed to clarify these questions.

Besides the significant influence of feasibility and motivation on implementation, the severity of drought and some socioeconomic variables were also found to significantly influence the implementation of measures. The generally held assumption that a higher perceived drought experience promotes the implementation of measures to adapt to this shock has already been debunked by various research. Adger et al. (2009, p. 339) suggest that individual adaptation to climate change depends on “whether an impact, anticipated or experienced, is perceived as a risk and whether it should (and could) be acted upon.” Bryan et al. (2009) and Tucker et al. (2010) did not find any evidence that a higher-risk perception leads to higher implementation of adaptation measures to climate change. In this research we could show that a perceived severe drought did not have any effect in Ghana while in Ethiopia a perceived severe drought impedes the implementation of measures. In contrast to Sinden and King (1990), our research shows that higher mean yield negatively influences the implementation of measures in both countries. We believe that farmers with higher yields might not feel the necessity to change their farming practices and implement measures against drought, because they are still satisfied with the status quo, or they are already resilient to drought and hence, do not need the assessed measures. The predictor gender on the other hand was only found significant in Ghana: being female decreases the probability of implementation. Findings from literature show consensus that gender matters. African female farmers are less likely than male farmers to adopt new measures (Doss 2001). There are various reasons why this might be the case: (1) female farmers simply have different preferences than men and therefore adopt different measures; (2) female farmers face different and/or often more severe constraints than male farmers, such as a lack of access to land, farming inputs, and information (Doss 2001). The non-significant effect of gender in Ethiopia may have resulted from the low percentage of interviewed female head of households (7.3%).

All in all, we can say that motivation matters, and we can better understand the implementation of measures if we include both, feasibility and motivation into the viability assessment. We were able to find relevant indicators for motivation and feasibility. Furthermore, we found that the likelihood of measures’ implementation is also influenced by the socioeconomic context. Further research should therefore pay attention to the context but also to feasibility and motivation.

6 Limitations and outlook

A farmer can have different incentives and reasons to implement a certain measure. According to Adger et al. (2009) measures can either be used to build resilience and prevent a shock or to change an existing system and recover from a shock. Further, not all measures are exclusively and equally useful in case of drought, even though the assessed measures were developed in the framework of an interdisciplinary workshop with the criterion of having the potential to enhance farmers' resilience to drought. The rewards of book-keeping for example are less tangible than they are for irrigation during the occurrence of drought. Furthermore, all measures can also be helpful (or harmful) in times where drought is not an issue. If one is interested in the holistic effects and usefulness of the measures (or the particular and exclusive usefulness in case of drought), the measures should be put in relation to their general benefits and to other shocks. This insight could lead us to a better understanding of the nature of the measure and hence, show possible positive or negative effects of a particular measure to the overall resilience of the farmers. Last but not least, the dimension time can play an important role, because measures that are implemented today "may impose negative environmental and social impacts on a future generation" (Adger et al. 2009, p. 340). Therefore, it is not only important to set system boundaries before giving advice regarding which measures should be implemented, but also to be aware of the effects that the measures can have on a wider context. Hence, as Carpenter et al. (2001) state, it is crucial to specify what system state is being considered (*resilience of what*) and what shocks are of interest (*resilience to what*).

The measure specific feasibility and motivation is not necessarily equal to the farmers' assets and overall motivation. Therefore, it would be crucial to find out whether implementation is driven by the nature of the measure or by the farmers' assets and overall motivation. Our findings suggest that the measures should be defined precisely in advance (e.g., fact sheets), so that measure specific motivation and feasibility can be asked more precisely, and farmers can better imagine what an implementation would mean. We expect that if the feasibility requirements for a particular measure exceed farmers' assets, the implementation becomes impossible. The same applies for motivation. Figure 7 shows an attempt to include the previously mentioned aspects in our framework. Drought remains the starting point of the framework. Then, the farmer's assets and overall motivation are outlined as counterpart of the measure specific feasibility and motivation. Here, we think that it is important to use the same indicators for both, the overall and the measure-specific aspect.

How farmers' assets and their overall motivation as well as the measure specific feasibility and motivation interplay is not clear. If new measures are evaluated out of a static perspective before they are implemented, the interactions are probably unidirectional, with having the assets and overall motivation influencing the specific feasibility and motivation. If measures are evaluated out of a dynamic perspective before and after implementation, then the interactions are probably bidirectional.

Furthermore, we suggest capturing the farmers' perceived need to enhance their resilience to drought as part of her or his overall motivation.

Thus, we recommend further research on the interplay between feasibility and motivation but also how implementation influences the motivation and the perceived feasibility—the vice versa of our approach (Fig. 7). It is expected that the smaller the measure-specific requirements are, compared to the farmers' assets, the higher the likelihood of implementation. Consequently, policy makers have three options or

Fig. 7 Recommended conceptual framework for further research based on our findings

a combination of them for action: Firstly, designing measures with high feasibility and triggering an elevated level of motivation; secondly enhancing farmers' overall motivation and their assets; thirdly, policy makers could nudge farmers to allocate more assets or motivation to certain measures (Fig. 7). In addition, we expect that the framework can be applied on other value chains regardless of the spatial and temporal context. Even an application on other actors than farmers could be considered. However, this assumption has to be tested by applying the framework in other case studies.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s11027-021-09952-7>.

Acknowledgements We want to thank all interviewed farmers in the study area for allowing access to their farms and for answering our survey. We also thank Akosua Pomaa Asabere and Gloria Afriyie (both from Kwame Nkrumah University of Science and Technology (KNUST), Kumasi) and Mengistu Demissie, Dejene Mekuria and Tewodros Lulseged (all from Ethiopian Institute of Agricultural Research (EIAR), Debre Zeit) for assistance with translation and fieldwork. We further acknowledge Dr. Solomon Chanyalew Kassa for institutional support provided by the EIAR Debre Zeit in Ethiopia and Dr. Ralph Hansmann of ETH for his valuable statistical assistance.

Funding Open Access funding provided by ETH Zurich. The writing of this study was funded by the Sustainable Agroecosystems Group and the TdLab at ETH Zurich and the fieldwork supported with a grant from the Hochstrasser Foundation.

Declarations

Conflict of interest The authors declare no conflict of interest.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Aboagye PY (2015) Promise and reality of decentralization: the case of farmers' access to agricultural advisory services in the Sunyani Municipality of Ghana. Master's thesis, Lunds Universitet
- Abraha MT, Hussein S, Laing M, Assefa K (2015) Genetic management of drought in tef: current status and future research directions. *Glob J Crop Soil Sci Plant Breed* 3:156–161
- Adger WN et al (2009) Are there social limits to adaptation to climate change? *Clim Change* 93:335–354
- Ahmed MM, Sanders JH, Nell WT (2000) New sorghum and millet cultivar introduction in Sub-Saharan Africa: impacts and research agenda. *Agric Syst* 64:55–65. [https://doi.org/10.1016/S0308-521x\(00\)00013-5](https://doi.org/10.1016/S0308-521x(00)00013-5)
- Ajzen I (1975) Belief, attitude, intention and behaviour: an introduction to theory and research
- Ajzen I, Fishbein M (1980) Understanding attitudes and predicting social behaviour, 1st edn. Prentice-Hall, Englewood Cliffs
- Ambelu A et al (2017) Intervention pathways towards improving the resilience of pastoralists: a study from Borana communities, southern Ethiopia. *Weather Clim Extreme* 17:7–16. <https://doi.org/10.1016/j.wace.2017.06.001>
- Amezah K, Hesse J (2002) Reforms in the Ghanaian extension system. World Bank and USAID, Washington DC
- Amissah L, Kyereh B, Agyeman VK (2010) Wildfire incidence and management in the forest transition zone of Ghana: Farmers' perspectives Ghana. *J Forest* 26:61–73
- Anim-Kwapong G, Frimpong EB (2006) Vulnerability and adaptation assessment under the Netherlands climate change studies assistance programme phase 2 (NCCSAP2), Vulnerability of agriculture to climate change-impact of climate change on cocoa production. Cocoa Research Institute of Ghana, NEW TAFO AKIM 1–30
- Antwi-Agyei P, Fraser EDG, Dougill AJ, Stringer LC, Simelton E (2012) Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. *Appl Geogr* 32:324–334. <https://doi.org/10.1016/j.apgeog.2011.06.010>
- Appiah M, Damnyag L, Blay D, Pappinen A (2010) Forest and agroecosystem fire management in Ghana. *Mitig Adapt Strat Glob Change* 15:551–570. <https://doi.org/10.1007/s11027-010-9236-z>
- Atkinson JW (1964) An introduction to motivation. Van Nostrand, Oxford
- Balemie K, Singh RK (2012) Conservation of socioculturally important local crop biodiversity in the Oromia Region of Ethiopia: a case study. *Environ Manage* 50:352–364. <https://doi.org/10.1007/s00267-012-9883-9>
- Barrett CB, Constan MA (2014) Toward a theory of resilience for international development applications. *P Natl Acad Sci USA* 111:14625–14630. <https://doi.org/10.1073/pnas.1320880111>
- Baumeister RF (2016) Toward a general theory of motivation: problems, challenges, opportunities, and the big picture. *Motiv Emot* 40:1–10. <https://doi.org/10.1007/s11031-015-9521-y>
- Beer J (1987) Advantages, disadvantages and desirable characteristics of shade trees for coffee, cacao and tea. *Agrofor Syst* 5:3–13. <https://doi.org/10.1007/BF00046410>
- Below TB, Mutabazi KD, Kirschke D, Franke C, Sieber S, Siebert R, Tscherning K (2012) Can farmers' adaptation to climate change be explained by socio-economic household-level variables? *Glob Environ Chang* 22:223–235. <https://doi.org/10.1016/j.gloenvcha.2011.11.012>
- Berhane G, Ragasa C, Tadesse Abate G, Woldu Assefa T (2018) The state of agricultural extension services in Ethiopia and their contribution to agricultural productivity. Washington, DC, USA and Addis Ababa, Ethiopia
- Blackstock KL, Ingram J, Burton R, Brown KM, Slee B (2010) Understanding and influencing behaviour change by farmers to improve water quality. *Sci Total Environ* 408:5631–5638. <https://doi.org/10.1016/j.scitotenv.2009.04.029>

- Blaser WJ, Oppong J, Hart SP, Landolt J, Yeboah E, Six J (2018) Climate-smart sustainable agriculture in low-to-intermediate shade agroforests. *Nat Sustain* 1:234–239. <https://doi.org/10.1038/s41893-018-0062-8>
- Borges JAR, Lansink AGO, Ribeiro CM, Lutke V (2014) Understanding farmers' intention to adopt improved natural grassland using the theory of planned behavior. *Livest Sci* 169:163–174. <https://doi.org/10.1016/j.livsci.2014.09.014>
- Brooks N, Anderson S, Ayers J, Burton I, Tellam I (2011) Tracking adaptation and measuring development. International Institute for Environment and Development (IIED), London
- Broussard SC, Garrison MEB (2004) The relationship between classroom motivation and academic achievement in elementary-school-aged children. *Fam Consum Sci Res J* 33:106–120. <https://doi.org/10.1177/1077727X04269573>
- Bryan E, Deressa TT, Gbetibouo GA, Ringler C (2009) Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environ Sci Policy* 12:413–426. <https://doi.org/10.1016/j.envsci.2008.11.002>
- Bryant E (2005) Natural hazard second edition. Chapter 5 Drought as a hazard. Cambridge University Press. <https://doi.org/10.1017/CBO9780511811845>
- Burton I, Huq S, Lim B, Pilifosova O, Schipper EL (2002) From impacts assessment to adaptation priorities: the shaping of adaptation policy. *Clim Policy* 2:145–159. <https://doi.org/10.3763/cpol.2002.0217>
- Byerlee D, Spielman D, Alemu D, Gautam M (2007) Policies to promote cereal intensification in Ethiopia: a review of evidence and experience. International Food Policy Research Institute [IFPRI], Washington DC
- Carpenter S, Walker B, Anderies JM, Abel N (2001) From metaphor to measurement: resilience of what to what? *Ecosystems* 4:765–781
- Carr MKV, Lockwood G (2011) The water relations and irrigation requirements of cocoa (*Theobroma cacao* L.): a review. *Exp Agr* 47:653–676. <https://doi.org/10.1017/S00014479711000421>
- Ghana Cocoa Board (2018) Manual for cocoa extension in Ghana. CCAFS Manual. Ghana Cacao Board (COCOBOD). <https://hdl.handle.net/10568/93355>
- Chambwera M et al. (2014) Economics of adaptation. Part A: global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge, UK and New York, USA
- Cohen J (1992) A power primer. *Psychol Bull* 112:155–159. <https://doi.org/10.1037/0033-2909.112.1.155>
- Darnhofer I (2014) Resilience and why it matters for farm management. *Eur Rev Agric Econ* 41:461–484. <https://doi.org/10.1093/erae/jbu012>
- Darnhofer I, Lamine C, Strauss A, Navarrete M (2016) The resilience of family farms: towards a relational approach. *J Rural Stud* 44:111–122. <https://doi.org/10.1016/j.jrurstud.2016.01.013>
- Deci E, Ryan RM (1985) Intrinsic motivation and self-determination in human behavior. New York: Plenum Press. <https://doi.org/10.1007/978-1-4899-2271-7>
- Deressa TT, Hassan RM, Ringler C, Alemu T, Yesuf M (2009) Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environ Chang* 19:248–255. <https://doi.org/10.1016/j.gloenvcha.2009.01.002>
- Deressa TT, Hassan RM, Ringler C (2011) Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *J Agr Sci* 149:23–31. <https://doi.org/10.1017/S0021859610000687>
- Dohmen MM, Noponen M, Enomoto R, Mensah C, Muilerman S (2018) Climate-smart agriculture in cocoa: a training manual for field officers. World Cocoa Foundation and The Rainforest Alliance, Accra. <https://hdl.handle.net/10568/93360>
- Doss CR (2001) Designing agricultural technology for African women farmers: lessons from 25 years of experience. *World Dev* 29:2075–2092. [https://doi.org/10.1016/S0305-750X\(01\)00088-2](https://doi.org/10.1016/S0305-750X(01)00088-2)
- Duguma MK, Brüntrup M, Tsegai D (2017) Policy options for improving drought resilience and its implication for food security: the cases of Ethiopia and Kenya. German Development Institute, Bonn
- Erenstein O (2003) Smallholder conservation farming in the tropics and sub-tropics: a guide to the development and dissemination of mulching with crop residues and cover crops. *Agric Ecosyst Environ* 100:17–37. [https://doi.org/10.1016/S0167-8809\(03\)00150-6](https://doi.org/10.1016/S0167-8809(03)00150-6)
- Evangelista P, Young N, Burnett J (2013) How will climate change spatially affect agriculture production in Ethiopia? Case studies of important cereal crops. *Clim Change* 119:855–873. <https://doi.org/10.1007/s10584-013-0776-6>
- Fielding KS, Terry DJ, Masser BM, Bordia P, Hogg MA (2005) Explaining landholders' decisions about riparian zone management: the role of behavioural, normative, and control beliefs. *J Environ Manage* 77:12–21. <https://doi.org/10.1016/j.jenvman.2005.03.002>
- Fishbein M, Ajzen I (1975) Belief, attitude, intention and behaviour: an introduction to theory and research. Reading, MA: Addison-Wesley

- Frank E, Eakin H, López-Carr D (2011) Social identity, perception and motivation in adaptation to climate risk in the coffee sector of Chiapas, Mexico. *Glob Environ Chang* 21:66–76. <https://doi.org/10.1016/j.gloenvcha.2010.11.001>
- Gebrehiwot T, van der Veen A (2015) Farmers prone to drought risk: why some farmers undertake farm-level risk-reduction measures while others not? *Environ Manage* 55:588–602. <https://doi.org/10.1007/s00267-014-0415-7>
- Geen RG (1995) Human motivation: a social psychological approach. Brooks/Cole Publishing Company, Belmont
- Government of Ghana [GoG] (2015) Ghana's third national communication report to the UNFCCC
- Government of Ghana [GoG] (2017a) Physical characteristics, Ejisu Municipal. <http://www.ghanadistricts.com/Home/LinkDataDistrict/6337>. Accessed 23 Aug 2018
- Government of Ghana [GoG] (2017b) Physical characteristics, Ellembele. <http://www.ghanadistricts.com/Home/LinkDataDistrict/3138>. Accessed 27 Aug 2018
- Government of Ghana [GoG] (2017c) Physical characteristics, Offinso Municipal. <http://www.ghanadistricts.com/Home/LinkDataDistrict/6444>. Accessed 23 Aug 2018
- Government of Ghana [GoG] (2017d) Physical characteristics, Sefwi Wiawso. <http://www.ghanadistricts.com/Home/LinkDataDistrict/3429>. Accessed 27 Aug 2018
- Grothmann T, Patt A (2005) Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Glob Environ Chang* 15:199–213. <https://doi.org/10.1016/j.gloenvcha.2005.01.002>
- Guay F, Chanal J, Ratelle CF, Marsh HW, Larose S, Boivin M (2010) Intrinsic, identified, and controlled types of motivation for school subjects in young elementary school children. *Br J Educ Psychol* 80:711–735. <https://doi.org/10.1348/000709910X499084>
- Habtegebrial K, Sing BR, Haile M (2007) Impact of tillage and nitrogen fertilization on yield, nitrogen use efficiency of tef (*Eragrostis tef* (Zucc.) Trotter) and soil properties. *Soil Till Res* 94:55–63. <https://doi.org/10.1016/j.still.2006.07.002>
- Hassan R, Nhemachena C (2008) Determinants of African farmers' strategies for adapting to climate change: multinomial choice analysis. *Afr J Agric Resour E* 2:83–104
- Hilemical K, Alamirew T (2017) Water productivity of teff under semi-arid climates. *J Environ Earth Sci* 7:8
- IBM (2017) IBM SPSS Statistics for Mac, 25.0 edn. IBM, Armonk
- International Food Policy Research Institute [IFPRI] (2014) Resilience for food and nutrition security vol 1. International Food Policy Research Institute, Washington DC. <https://doi.org/10.2499/9780896296787>
- IPMS (2007) Ada'a Woreda, Oromiya. IPMS, Addis Ababa
- Issaka RN, Buri MM, Tobita S, Nakamura S, Owusu-Adjei E (2012) Indigenous fertilizing materials to enhance soil productivity in Ghana. *Soil Fertility Improvement and Integrated Nutrient Management - A Global Perspective*, Whalen, JK, pp 119–134
- Joerin J et al. (2018a) Resilience of the Tef Value Chain in Ethiopia - final report. ETH Zurich, Department of Environmental Systems Science, Zurich
- Joerin J et al. (2018b) Resilience of the Cocoa Value Chain in Ghana - final report. ETH Zurich, Department of Environmental Systems Science, Zurich
- Kassie BT, Hengsdijk H, Rotter R, Kahiluoto H, Asseng S, Van Ittersum M (2013) Adapting to climate variability and change: experiences from cereal-based farming in the Central Rift and Kobo Valleys, Ethiopia. *Environ Manage* 52:1115–1131. <https://doi.org/10.1007/s00267-013-0145-2>
- Ketema S (ed) (1997) *Eragrostis tef* (Zucc.) Trotter vol 12. Promoting the conservation and use of underutilized and neglected crops. International Plant Genetic Resources Institute, Rome
- Kleinginna PR, Kleinginna AM (1981) A categorized list of motivation definitions, with a suggestion for a consensual definition. *Motiv Emot* 5:263–291. <https://doi.org/10.1007/BF00993889>
- Kongor JE, De Steur H, Van de Walle D, Gellynck X, Afoakwa EO, Boeckx P, Dewettinck K (2017) Constraints for future cocoa production in Ghana. *Agrofor Syst* 92:1273–1385. <https://doi.org/10.1007/s10457-017-0082-9>
- Legesse G, Suryabagavan KV (2014) Remote sensing and GIS based agricultural drought assessment in East Shewa Zone, Ethiopia. *Trop Ecol* 55:349–363
- Lim B, Spanger-Siegfried E, Burton I, Malone EL, Huq S (2004) Adaptation policy frameworks for climate change: developing strategies, policies and measures. Cambridge University Press
- Manu M, Tetteh JK (1987) A guide to cocoa cultivation. Cocoa Research Institute of Ghana (COCOBOD)
- Martínez-García CG, Dorward P, Rehman T (2013) Factors influencing adoption of improved grassland management by small-scale dairy farmers in central Mexico and the implications for future research on smallholder adoption in developing countries. *Livest Sci* 152:228–238. <https://doi.org/10.1016/j.livsci.2012.10.007>

- Maslow A (1955) Deficiency motivation and growth motivation. In: Jones MR (ed) Nebraska symposium on motivation. University of Nebraska Press
- Matthess A (2015) Farmer Business School, training notebook and workbook, cocoa production systems. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn
- McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS (2001) Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change, vol 2. Cambridge University Press, Cambridge
- Mesly O (2017) Project feasibility: tools for uncovering points of vulnerability. 1 edn. CRC Press, Boca Raton. <https://doi.org/10.1201/9781315295251>
- Minten B, Taffesse AS, Brown P (eds) (2018) The economics of teff: exploring Ethiopia's biggest cash crop. International Food Policy Research Institute [IFPRI], Washington DC. <https://doi.org/10.2499/9780896292833>
- Monastyrnaya E, Joerin J, Dawoe E, Six J (2016) Assessing the resilience of the cocoa value chain in Ghana, case study report. Swiss Federal Institute of Technology Zurich, Switzerland and Kwame Nkrumah University of Science & Technology, Kumasi
- Moon K, Blackman D (2014) A guide to understanding social science research for natural scientists. *Conserv Biol* 28:1167–1177. <https://doi.org/10.1111/cobi.12326>
- Muchira BW (2012) Record keeping and growth of micro and small enterprises: A case study of Tika Municipality in Kenya. School of Business of Kenyatta
- Muhie T (2001) Agro-ecological map of Ethiopia. Natural Resources Management and Regulatory Department, Ministry of Agriculture, Addis Ababa
- Mutua JM (2015) Effect of bookkeeping on the growth of small and medium enterprises in Chuka Town. *Eur J Bus Soc Sci* 4:102–112
- Niles MT, Lubell M, Brown M (2015) How limiting factors drive agricultural adaptation to climate change. *Agric Ecosyst Environ* 200:178–185. <https://doi.org/10.1016/j.agee.2014.11.010>
- Ofori-Frimpong K, Afrifa A, Acquaye S (2010) Impact of shade and cocoa plant densities on soil organic carbon sequestration rates in a cocoa growing soil of Ghana. *Afr J Environ Sci Technol* 4:621–624
- Okorley EL, Gray DI, Reid JI (2009) Improving agricultural extension human resource capacity in a decentralized policy context: a Ghanaian case study. *J Int Agric Extension Educ* 16:35–46
- Reeve J (2016) A grand theory of motivation: why not? *Motiv Emot* 40:31–35. <https://doi.org/10.1007/s11031-015-9538-2>
- Rodriguez D, deVoil P, Power B, Cox H, Crimp S, Meinke H (2011) The intrinsic plasticity of farm businesses and their resilience to change An Australian example. *Field Crop Res* 124:157–170. <https://doi.org/10.1016/j.fcr.2011.02.012>
- Sardar Z (2015) Postnormal times revisited. *Futures* 67:26–39. <https://doi.org/10.1016/j.futures.2015.02.003>
- Sheldon KM, Elliot AJ (1999) Goal striving, need satisfaction, and longitudinal well-being: the self-concordance model. *J Pers Soc Psychol* 76:482–497. <https://doi.org/10.1037/0022-3514.76.3.482>
- Sheldon KM, Houser-Marko L (2001) Self-concordance, goal attainment, and the pursuit of happiness: can there be an upward spiral? *J Pers Soc Psychol* 80:152–165. <https://doi.org/10.1037/0022-3514.80.1.152>
- Sinden JA, King DA (1990) Adoption of soil conservation measures in Manilla shire, New South Wales. *Rev Mark Agric Econ* 58:179–192
- Stanturf JA, Warren ML, Charnley S, Polasky SC, Goodrick SL, Armah F, Nyako YA (2011) Ghana climate change vulnerability and adaptation assessment. United States Agency for International Development, Washington DC
- Tendall DM et al (2015) Food system resilience: defining the concept. *Glob Food Sec* 6:17–23. <https://doi.org/10.1016/j.gfs.2015.08.001>
- Thompson J, Scoones I (2009) Addressing the dynamics of agri-food systems: an emerging agenda for social science research. *Environ Sci Policy* 12:386–397. <https://doi.org/10.1016/j.envsci.2009.03.001>
- Thornton PK, Jones PG, Ericksen PJ, Challinor AJ (2011) Agriculture and food systems in sub-Saharan Africa in a 4 degrees C+ world. *Philos T R Soc A* 369:117–136. <https://doi.org/10.1098/rsta.2010.0246>
- Tsegay A et al (2012) Unravelling crop water productivity of tef (*Eragrostis Tef* (Zucc.) Trotter) through aquacrop in Northern Ethiopia. *Exp Agr* 48:222–237. <https://doi.org/10.1017/S0014479711001153>
- Tucker CM, Eakin H, Castellanos EJ (2010) Perceptions of risk and adaptation: coffee producers, market shocks, and extreme weather in Central America and Mexico. *Glob Environ Chang* 20:23–32. <https://doi.org/10.1016/j.gloenvcha.2009.07.006>

- Tulema B, Aune JB, Johnsen FH, Vanlauwe B (2008) The prospects of reduced tillage in tef (*Eragrostis tef* Zucca) in Gare Arera, West Shawa Zone of Oromiya, Ethiopia. *Soil Till Res* 99:58–65. <https://doi.org/10.1016/j.still.2007.12.001>
- Urruty N, Tailliez-Lefebvre D, Huyghe C (2016) Stability, robustness, vulnerability and resilience of agricultural systems. a review. *Agron Sustain Dev* 36. <https://doi.org/10.1007/s13593-015-0347-5>
- Wheeler T, von Braun J (2013) Climate change impacts on global food security. *Science* 341:508–513. <https://doi.org/10.1126/science.1239402>
- Wilhite DA (2000) Drought as a natural hazard: Concepts and definitions. Drought Mitigation Center Faculty Publications 69
- Woldemariam Z (2017) Ethiopia: Teff gets mechanization solution. *The ethiopian herald*, all Africa Global Media
- Wood SA, Jina AS, Jain M, Kristjanson P, DeFries RS (2014) Smallholder farmer cropping decisions related to climate variability across multiple regions. *Global Environ Chang* 25:163–172. <https://doi.org/10.1016/j.gloenvcha.2013.12.011>
- World Vision Ethiopia (2000) Food security monitoring report of november 1999. Grants division February 2020. Addis Ababa
- Yihun YM, Haile AM, Schultz B, Erkossa T (2013) Crop water productivity of irrigated teff in a water stressed region. *Water Resour Manage* 27. <https://doi.org/10.1007/s11269-013-0336-x>
- Zeweld W, Van Huylenbroeck G, Tesfay G, Speelman S (2017) Smallholder farmers' behavioural intentions towards sustainable agricultural practices. *J Environ Manage* 187:71–81. <https://doi.org/10.1016/j.jenvman.2016.11.014>
- Zubair M, Garforth C (2006) Farm level tree planting in Pakistan: the role of farmers' perceptions and attitudes. *Agrofor Syst* 66:217–229. <https://doi.org/10.1007/s10457-005-8846-z>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Authors and Affiliations

Luzian Messmer¹ · Braida Thom¹ · Pius Kruetli² · Evans Dawoe³ · Kebebew Assefa⁴ · Johan Six¹ · Jonas Joerin⁵

Braida Thom
bthom@ethz.ch

Pius Kruetli
pius.kruetli@usys.ethz.ch

Evans Dawoe
edawoe@gmail.com

Kebebew Assefa
kebebew.assefa@yahoo.com

Johan Six
jsix@ethz.ch

Jonas Joerin
jonas.joerin@frs.ethz.ch

¹ Department of Environmental Systems Science, Institute of Agricultural Science, Sustainable Agroecosystems Group, ETH Zurich, Zurich, Switzerland

² Department of Environmental Systems Science, Institute for Environmental Decisions, Transdisciplinarity Lab (TdLab), ETH Zürich, Zurich, Switzerland

³ Faculty of Renewable Natural Resources, Department of Agroforestry, Kwame Nkrumah University of Science and Technology, Kumasi-Ashanti, Ghana

⁴ Ethiopian Institute of Agricultural Research, Debre Zeit, Ethiopia

⁵ Singapore-ETH Center, Future Resilient Systems, Singapore, Singapore