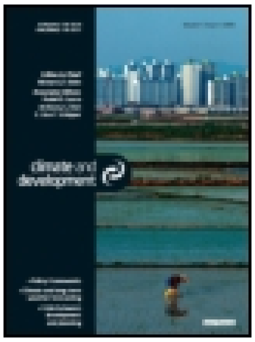

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Farmers' drought experience, risk perceptions, and behavioural intentions for adaptation: evidence from Ethiopia

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RESEARCH ARTICLE

Farmers' drought experience, risk perceptions, and behavioural intentions for adaptation: evidence from Ethiopia

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ABSTRACT
This paper examines farmers' cognitive perceptions of risk and the behavioural intentions to implement specific drought risk reduction measures using the Protection Motivation Theory (PMT) model. We follow an innovative route by extending a PMT model with a drought experience variable, which, we hypothesize, will influence risk perceptions and the take-up of adaptation measures. In order to do so, we investigated detailed historical drought patterns by looking at the spatial and temporal aspects of drought conditions during crop growing season at the village level. In our extended PMT model, drought experience, as represented by a long-term Normalized Difference Vegetation Index (NDVI), plays a significant role in predicting farmers' intention to take up adaptation measures. The result reveals that drier conditions significantly increase farmers' behavioural intention to implement adaptation measures against drought risk, which is the key finding of the study. Moreover, our findings show that perceived vulnerability and severity, self-efficacy, and response efficacy are positively and significantly associated with the number of drought risk reduction measures implemented. The findings of our empirical analysis contribute to the effect of cognitive perceptions through a new lens of farmer's personal experience with drought shocks, represented by the state of vegetation or physical environment.

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Drought; risk perception; protection motivation theory; NDVI; adaptation

1. Introduction

At continent level, food and nutrition security is Africa's most central challenge. Regardless of overall progress, sub-Saharan Africa (SSA) has still the highest incidence of undernourishment (FAO, 2014). Like most of the SSA countries, food insecurity is a persistent problem in Ethiopia although the country has been made progress in the overall economic growth in the past decade. Recent estimate indicates that there are an estimated 21.6 million people who were undernourished by 2016–2018 (FAO, IFAD, UNICEF, WFP, & WHO, 2019), showing food shortages as an on-going problem in the country.

In Ethiopia, climate variability and extreme weather events are among the central risks affecting agricultural productivity and hence rural household food security. Particularly, drought is the main significant climate-related natural hazard that frequently affects the country. In Mbow et al. (2019) the precipitation anomaly for Ethiopia is depicted for 1981–2016. Consequently, the spatial extent and frequency of droughts are causing a significant threat to rural livelihoods and food security in the country (Demeke et al., 2011; Mbow et al., 2019). A growing concern is that Ethiopia, like most of the sub-Saharan countries, is highly vulnerable to the impacts of climate variability because of its high reliance on rain-fed agriculture (Adem & Bewket, 2011; Bryan et al., 2009; Conway & Schipper, 2011; Demeke et al., 2011; Evangelista et al., 2013). Finally, a recent study by Orindi et al. (2006) reported Ethiopia as one of the country's most vulnerable to climate change with the least capacity to respond.

1.1. Food security, risk, and adaptation

In general, adaptation to climate variability, extreme events and warming trends ask for a wide range of measures. These can be incremental, transformational or allow for new enabling conditions. Incremental adaptation boils down to, inter alia, change in variety, change in plantation dates, soil management, adoption of drought-tolerant crops, or management of natural resources. Examples of transformational adaptation are early warning systems, crop and livestock insurance, food storage infrastructure, and introduction of new technologies. Examples of new enabling conditions are integrated water management, integrated water and land governance, and strengthening of local and national institutions (Mbow et al., 2019, p. 467).

In particular, climate change is affecting food security of smallholder farmers through impacts on crop production and livestock production systems (Mbow et al., 2019, p. 459). As a result, changes in climate variability will affect the well-being of rural Ethiopian people, who depend largely on farming, unless adaptation measures are extensively implemented. Developing and implementing effective adaptation measures is thus crucial so that climate-related risks and opportunities might support development objectives within local and policy

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decision-making processes (Adger et al., 2006; IPCC, 2007). However, decision-making on adaptation is decision-making under the umbrella of risk management. Not only science-based evidence but also the social and institutional contexts are to be included. With respect to social values, psychology and cultural values should have a place (Jones et al., 2014).

In this paper, smallholder farmers are judged as key to incremental adaptation through risk reduction. Farmer's adaptation is seen as vital to reduce drought vulnerability by making rural communities better able to adjust and subsequently enhance the performance of the agricultural sector. As climate change is expected to increase the frequency and severity of disaster impacts, understanding the factors that motivate farmers to make adaptation decisions, particularly the role of farmer's cognitive perception of risk and their behavioural intention to carry out specific adaptation[1] measures, is important for developing adequate policies.

There are some research studies that examined the role of behavioural factors on famers' adaptive decision-making against risk. In particular, Protection Motivation Theory (PMT) is of interest for risk evaluation as a determinant of protective behaviour against risk. Due to the development of PMT, it has been applied to a wide range of topics, for example to injury prevention, political issues, and environmental studies (Bočkarjova et al., 2009; Floyd et al., 2000; Gebrehiwot & van der Veen, 2015; Grothmann & Patt, 2005; Grothmann & Reusswg, 2006; Martin et al., 2007; Poussin et al., 2014; Truelove et al., 2015; van Duinen et al., 2015; Zaalberg et al., 2009). Previous applications to farming underscored the importance of cognitive factors on farmers' decision-making to take up adaptation measures. Literature on hazards shows that also personal experience with a risk situation is an important variable that explains risk perception and potential impact on the intention to protect oneself from the risk (Grimely et al., 2000; Slovic, 1987). However, we are not aware of studies that relate cognitive factors to the reality of drought that farmers experience.

This paper, therefore, attempts to examine farmers' cognitive perception of risk through experience with historical climate shocks and their behavioural intention to carry out specific adaptation actions using the PMT model. We follow an innovative route by extending the PMT model with biophysical parameters through the vegetation state of the farmers' local environment, which, we hypothesize, will influence drought-risk perceptions and the take-up of adaptation measures. To sum it up, we aim to test whether experience with drought conditions influences farmers' intentions to carry out risk-reduction decisions; and identify the cognitive factors that influence farmers' behavioural intentions to undertake risk reduction decisions.

The contribution of this research to the existing scant literature on cognitive barriers to adaptation against drought is twofold. First, the results contribute to the effect of cognitive perceptions through a new lens of farmers' personal experience with drought, represented by the state of vegetation or physical environment. To our knowledge, this is the first paper to extend the PMT model by including physical variables. This study will help policy makers by providing important information about the significance of how farmers perceive their local environment and how it influences their actual adaptation in the context of climate variability.

The paper is structured as follows: the next section gives a brief description of the Protective Motivation Theory. We then outline the datasets and methods and the main findings of the study. Finally, we present the discussion section followed by the conclusion.

2. Protection motivation theory

In this study, risk perception is conceptualized as the perceived likelihood of negative consequences to oneself and society from one specific environmental phenomenon: drought. PMT states that effects of fear appeal initiate a cognitive appraisal process stimulating protection motivation, the behavioural intention to protect oneself from hazard (Rogers, 1975). In the beginning, the theory was applied to health-related issues, but shortly found its way to a range of disciplines like environmental studies (Floyd et al., 2000).

Protection motivation theory (PMT) appears to be the most widely used model regarding the behaviour related to climate change (Lam, 2014). PMT has already been applied to study climate change adaptation. The PMT explicitly includes basic variables such as perceived severity, perceived vulnerability, self-efficacy, and costs of response actions as predictors, which are very relevant to climate change and climate change campaigns (Cismaru et al., 2011; Patchen, 2010). Several studies have indicated that the perception of risk threat and risk perception can predict the support of mitigation and adaptation policies (Gebrehiwot & van der Veen, 2014; Grothmann & Reusswg, 2006; O'Connor et al., 1999; Rosentrater et al., 2013). The PMT is well suited for understanding and addressing adaptation behaviour.

The revised PMT of Rogers (1983) postulates two closely related pathways, threat appraisal and coping appraisal (Rogers, 1983; Rogers & Prentice-Dunn, 1997). The theory predicts that individuals will protect themselves against a particular hazard if they perceive that the threat of the hazard that they face is high, and if coping appraisals are high (Poussin et al., 2014). Threat appraisal is basically the same as risk perception, which is the main determinant of adaptation motivation (Grothmann & Patt, 2005). Threat appraisal includes evaluating the probability of occurrence of a threat with perceived severity of consequences in the case of maladaptive response. Accordingly, threat appraisal causes fear, leading to protection motivation. Grothmann and Patt (2005) reported that perceptions of expected climate risks have shown to be significant determinants of adaptation at household level. The coping appraisal includes comparing individual's coping ability to avert a threat (perceived self-efficacy and response efficacy) with perceived response costs of adaptive measures. Thus, in the coping appraisal process, an individual must first believe that a specific risk reduction measure will be effective in reducing harm (perceived response efficacy). Then, he/she should believe that he/she has the ability to perform the specific measure (perceived self-efficacy) and finally he/she should also believe that the costs of undertaking the specific risk reduction measures are reasonable (perceived costs). The balance between the threat and coping appraisal determines the likelihood for behavioural intention to undertake risk reduction measures.

Gebrehiwot and van der Veen (2015) recently established the significance of perceived vulnerability, severity of consequences, self-efficacy, and response efficacy to influence farmers' behaviour intentions to carry out farm adaptation measures in the Ethiopia context. Gebrehiwot and van der Veen (2015) further indicated varying motivators to take up adaptation measures in agriculture across the different decision stages. However, farmers experience with drought and its influence on cognitive perceptions is missing in their study. In this study, we adopted PMT to explain farmers' adaption behaviour against drought risk. However, the innovation we bring in is that we extended the PMT model by including a variable that represents the physical characteristics of the environment of the sampled village which is hypothesized to form an important consideration in farming. Gebrehiwot and van der Veen (2013) claimed that greenness (in the form of vegetation cover) is a good surrogate for environmental conditions and can be measured in the form of a vegetation index. A long-term average Normalized Difference Vegetation Index (NVDI) formed the basis to monitor greenness of vegetation. See Mbow et al. (2019) for an application to Ethiopia. To examine farmers' adaptive decision-making, the explanatory power of PMT variables will be tested with regard to farmers' drought adaptation motivation measured as the number of specific adaptation measures implemented against drought risk.

3. Materials and methods

3.1. Study area description

Administratively, the study district, *Hintalo wajirat*, is in the southern Tigray zone and is one of the districts affected by chronic food insecurity and recurrent droughts (TFSCO, 2003). Geographically the district is situated between $12^0 54'00''$ and $12^0 22'00''$ N and $39^0 17'30''$ and $39^0 46'00''$ E covering a total area of 1933.09 square kilometres (Figure 1). *Hintalo wajirat* district is sub-divided into 20 villages (locally called *Tabia*) and has an estimated population of 152,219 of which 92.2% live in rural areas (CSA, 2008).

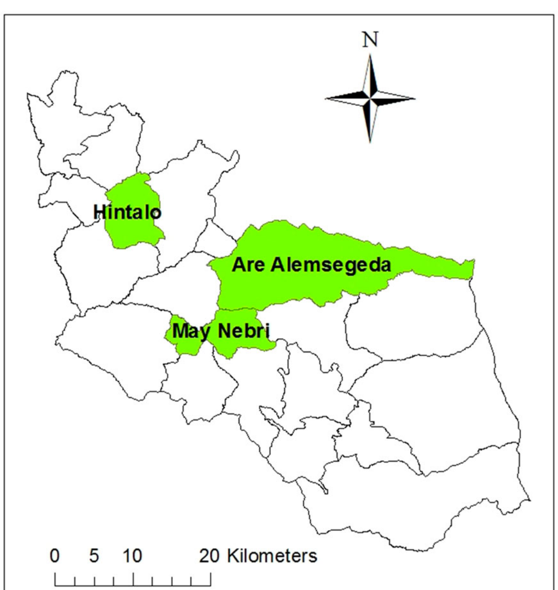

Figure 1. Map showing the study villages, in Hintalo Wajirat district, Southern Tigray zone, Ethiopia.

The district has three major agro-ecological zones, namely *Degua* (>=2300masl), *Weyna Degua* (1500–2300 masl), and *Kolla* (<1500 masl). The district experiences a uni-modal crop season locally called *Kiremti* (main) from mid-June to mid-September. The average annual rainfall usually varies between 435 and 674 mm with quite some differences across the villages.

Farming is the central source of livelihood of the people, which is largely dependent on rain-fed agriculture. Majority of the population depends on subsistence farming for survival with an average land holding size of 0.75 ha. The southern zone of Tigray has been suffering severe drought consequences. Compared to most other districts in the Tigray region, the study district has been known for its drought history and chronic food insecurity. Drought is a major problem hobbling agricultural productivity, where the overwhelming proportion of the population derives their living. Most smallholder farmers in the study district face sizeable food deficits every year which is caused by periodical drought and land degradation. As a result, crop failure is common and farmers in the district remain vulnerable to the vagaries of weather. A recent study by Gebrehiwot and van der Veen (2013) on the situation of climate vulnerability in Tigray region labelled the study district, *Hintalo Wajirat*, as the most vulnerable. Moreover, a report by FEWS NET (Famine Early Warning Systems Network) on Ethiopia Food Security Outlook, 2018, mapped the study district as one of the stressed food insecure districts in Ethiopia.

3.2. Data used

For this study, different datasets were employed. First, in order to investigate drought we analysed detailed historical drought patterns in space and time. SPOT Vegetation 10-day Normalized Difference Vegetation (NDVI) images from April 1998 to December 2013 were acquired from VGT4Africa of the DevCoCast project website. The remotely sensed SPOT Vegetation products have 1-km spatial resolution, fully cover Ethiopia and have a 10-day temporal resolution. The SPOT images were then sub-mapped to the study district.

Second, a land cover map for the study district was prepared by extracting from the ESA Global Land Cover map of 2009 in order to locate agricultural land cover type. A software package called the Software for the Processing and Interpretation of Remotely Sensed Image Time Series (SPIRITS), which was recently developed for image time series processing for agriculture monitoring, is used to process the images (Eerens et al., 2014).

Third, household-level data were collected using a survey conducted in 2014 from three villages. A multi-stage sampling technique was implemented to draw the samples. Three villages were randomly selected from the study district in the first stage. In the second stage, random sampling techniques were applied to select 340 smallholder farmers from the three villages. A structured questionnaire was administered to generate the data. The survey captured important information about farmers' drought risk perceptions; perceived drought severity; perceived ability to implement specific drought reduction measures; perceived reliance on drought reduction measures introduced; perceived cost of implementing adaptation measure; and intentions to take up adaptation measures. Respondents were asked to rate their opinion answers on a 7-point Likert scale for the majority of the questions.

3.3. Method

Two methodological approaches were employed to meet the objectives of the study. First, we applied a standard vegetation-based drought monitoring index. In recent decades, several remotely sense-based drought indices have been designed to characterize the state of vegetation and describing drought conditions (Atzberger & Eilers, 2011). Vegetation condition has been proved to be a good indicator of agricultural drought and can be quantified by the NDVI index. Consequently, NDVI-based indices have been applied to monitor vegetation state and quantify drought. It has been demonstrated that the Vegetation Condition Index (VCI) can be successfully applied for monitoring short-term agricultural droughts during the crop growing season (Brown et al., 2008; Kogan, 1995; Liu & Kogan, 1996).

Given the potential of the VCI to detect and characterize agricultural drought episodes, VCI is employed in this study to identify the spatial–temporal variability of drought at village level. VCI is determined as

$$\mathrm{VCI} = \left(\frac{\mathrm{NDVI} - \mathrm{NDVI}_{\mathrm{min}}}{\mathrm{NDVI}_{\mathrm{max}} - \mathrm{NDVI}_{\mathrm{min}}}\right) * 100 \quad (1)$$

where NDVI, $\mathrm{NDVI}_{\mathrm{min}}$, and $\mathrm{NDVI}_{\mathrm{max}}$ are the smoothed 10-day NDVI, its absolute long-term minimum, and maximum NDVI values, respectively, for each pixel. VCI varies in the range of 0–100% reflecting relative changes in the vegetation condition from extremely low to high VCI (Kogan, 1995).

Besides, Absolute Difference Average (ADav) was employed to detect temporal agricultural drought episodes. ADav NDVI is a transformation of the Normalized Difference Vegetation Index, which is calculated as

$$ADav(y, p) = X(y, p) - \mathrm{Average}(p) \quad (2)$$

where y is the actual year, p is the actual time interval within year y, X(y, p) is the actual smoothed NDVI value for year y and dekad p, Average (p) is the long-term historical average for the NDVI within the same dekad p.

Second, we applied statistical methods to analyse the data collected from the sample household survey. Ideally we should have a multilevel analysis for this purpose, but we had too few observations on the village level (three), to adequately perform a multilevel analysis. Accordingly, a simple statistical analysis is performed using standard regression analysis to investigate whether behavioural intention to take up adaptation measures against drought risk is influenced by the key PMT variables and village-level physical characteristics.

4. Results

4.1. Drought conditions

As noted above, two methodological approaches were employed in this study. VCI was employed to identify the historical drought events in the study district. We follow the VCI threshold values suggested by Kogan (1995) who identified drought events during the crop growing season. Based on Kogan (1995), the VCI value varies from 0 to 100 corresponding to changes in the vegetation condition from extremely unfavourable to optimal conditions. VCI values of 35% or less are considered to be as an indicator of drought. VCI values closer to 0 are classified as extremely drought. VCI values around 50% are considered as a fair or normal vegetation condition, while VCI values between 50 and 100% are judged optimal or above normal. In a very time-consuming research trajectory, we processed 567 dekadal (10 d) images in order to produce multi-temporal VCI drought maps and to compute a vegetation change variable. Accordingly, the VCI-based drought analysis indicated a series of drought condition over the cropping period of 1998–2013 (Figure 2). Thorough inspection of the VCI-based drought maps shows the prevalence of severe drought conditions covering the whole district during the crop growing periods of 2004, 2008, and 2009. The temporal VCI maps revealed the incidence of drought episodes two years in a row covering the whole district in 2008 and 2009. A part from these district-wide droughts, the results show differences in space and time, also for our three sampled villages.

The temporal vegetation condition for the three sampled villages in *Hintalo Wajirat* district for 1983–2013 is shown in Figure 3. The vegetation condition measured by the NDVI values is expected to reach maximum from the mid of June (20th dekad) to the mid of August (25th dekad) according to Ethiopia's rainfall seasonal character.

Second, an Absolute Difference Average statistic was subsequently used to investigate the temporal pattern of drought conditions during the crop growing period. A negative NDVI shift from the historical average is usually linked to a reduction in the vigour of vegetation condition. Accordingly, drought is more likely to occur in areas where negative shifts occur more frequently and with high magnitude, making it possible to spot critical situations (Tonini et al., 2012). Against this back drop, several drought events, 2002, 2004, 2005, 2008, and 2009, could be identified in the study district based on the ADav NDVI anomalies (Figure 3). Looking at the village level, negative NDVI anomalies were observed in the sampled villages mostly during the end of crop growing season of 2004, 2005, 2008, and 2009 which resulted in crop failure (Figure 3). In contrast, most of the villages showed normal vegetation conditions during the growing season of 1999, 2005, and 2013.

4.2. Household survey

4.2.1. Descriptive results

The household survey consists of about 240 farm households from three villages. Table 1 indicates that, on average, 67% of household heads surveyed were male and the remaining 33% were female headed. As shown in Table 1, the majority of the

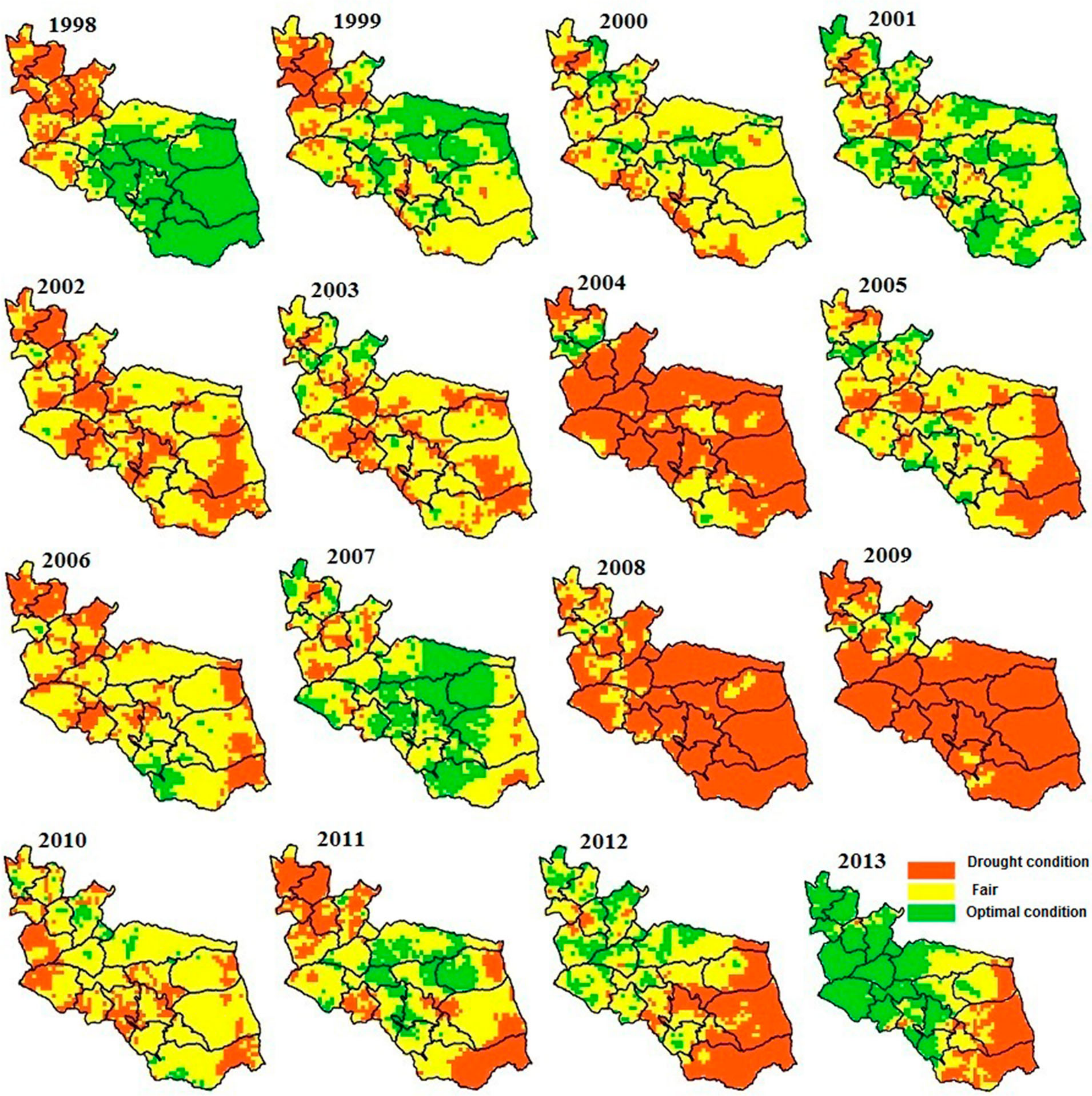

Figure 2. VCI-based agricultural drought maps for the growing season at village level for 1998–2013, Hintalo Wajirat district, Ethiopia.

respondents (36.3%) are aged between 31 and 40 years. The mean age for household heads is 41.8. With regard to educational status, the data show that majority of household heads (56.3%) do not have any formal education. Almost fifty per cent of heads of households surveyed had household size of four to six. The data further indicate that 58% of households reported owning land holding size of less than 0.5 ha (Table 2). The mean livestock holding measured in total livestock unit (TLU) is 2.7, while 20% do not own livestock and 20.5% of households had livestock of two TLU or less. Basic socio-economic characteristics of the rural households are presented in Table 1.

Furthermore, reviewing the adoption of drought-risk measures indeed reveals that different types of adaptation measures are employed by the households. As Table 2 elucidates, the five most common adaptation measures against drought risk practised among farmers, in order of descending frequency are undertaking plot-level soil conservation structures, changing cropping and planting dates, increased fertilizer and improved seeds application, adopting early maturing crop varieties, and using drought-tolerant crop.

4.2.2. Empirical results

In this study, the PMT variables were measured using different constructs of concerns about perceived risk vulnerability, perceived severity, self-efficacy, response-efficacy and perceived cost of implementing the specific adaptation measures on a 7-point Likert scale. Subsequently, a Cronbach's alpha (α) reliability coefficient was determined to indicate the levels of internal consistency by combining the different items presented to the farmer for each variable. As Table 3 depicts, all the PMT variables have acceptable levels of internal consistency with a Cronbach's alpha (α) greater than 0.6, meaning these variables can be used for further analysis.

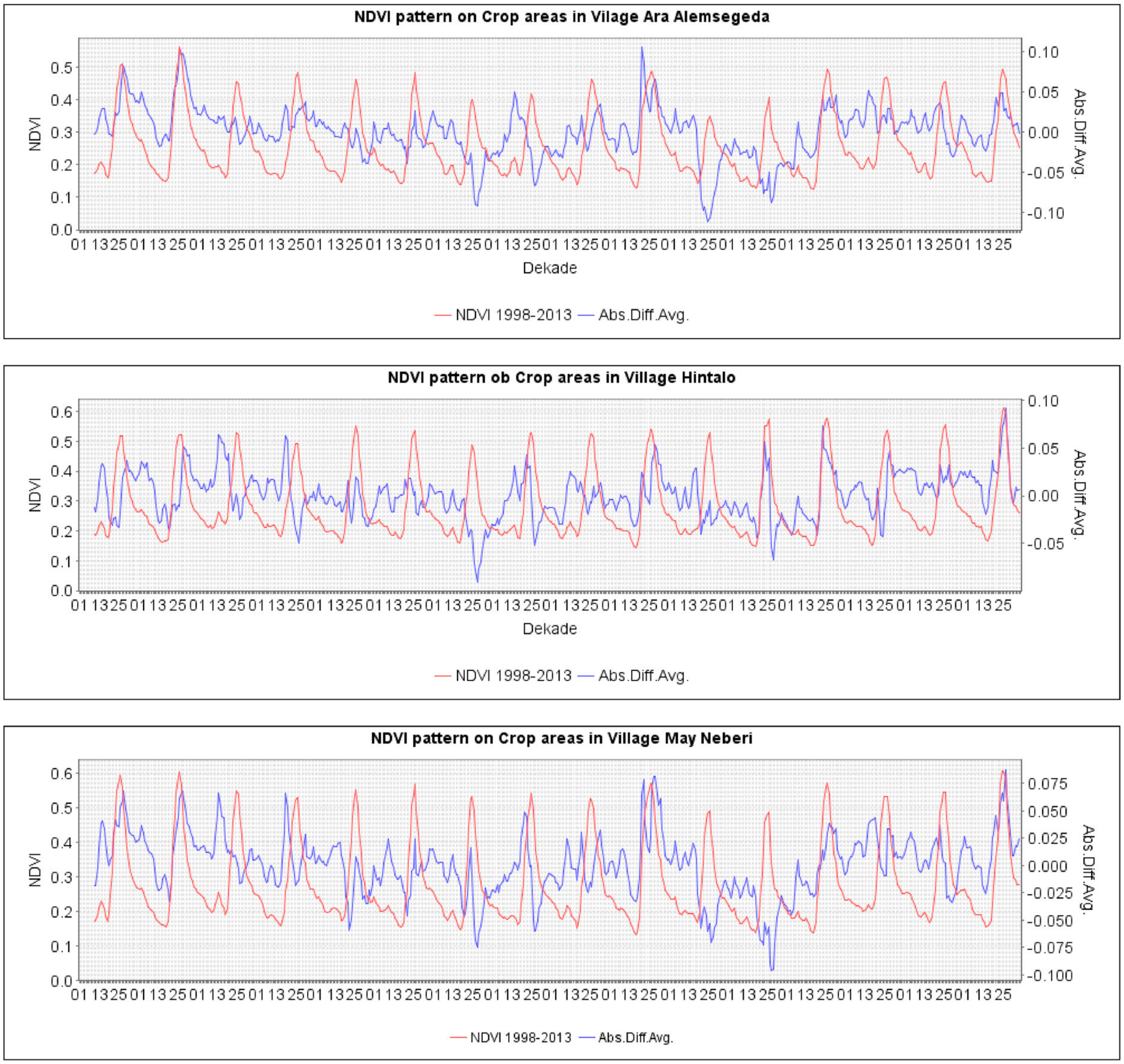

Figure 3. Temporal dekadal NDVI pattern on crop areas for the three villages of Ara Alemsegeda, Hintaloand May Neberi, Ethiopia. The dekadal NDVI anomaly is determined by subtracting the long-term historical average from the actual smoothed NDVI value; 1998–2013.

For the empirical results, we run the standard regression model by taking the composite behavioural intention as a dependent variable. As presented in Table 4, the finding revealed that all the PMT variables and long-term average NDVI have the anticipated sign, which is consistent with the concepts of PMT. The findings show that perceived vulnerability, perceived severity, perceived self-efficacy, and response efficacy associated positively with behavioural intention to undertake farm-level adaptation measures. In contrast, perceived costs of response actions and long-term average NDVI correlate negatively with adaptation measures. It is observed that healthy vegetation state, which is represented by high NDVI values, will lead to lower behavioural intention to take up plot-level specific adaptation measures against drought.

5. Discussion

This study has the objective to combine socio-psychological concepts in the handling of drought risk with a physical characterization of drought at village level. First, the study investigated the spatial and temporal characteristics of agricultural drought conditions at village level, which is, as far as we know, the first time to be applied at this level in the Ethiopian case. Rojas et al. (2011), Gebrehiwot et al. (2011), and Tonini et al. (2012) examined the spatial and temporal characteristics of drought at a continent level (Africa), regional level (Tigray, in Ethiopia), and zonal level (southern Tigray zone, Ethiopia) respectively. However, identification of drought at levels, such as zonal, national, or continent level, can conceal drought areas at the district or village within a country or region. Moreover, there are considerable spatial variations in rainfall within a country, for instance in Ethiopia. In such conditions spatial variation in agricultural drought within a district is often overlooked in analyses based on a lower aggregation levels. To the best of our knowledge, this study is the first in Ethiopia to investigate agricultural drought at village level.

Second, the study constructed a framework based on PMT variables and physical characteristics to investigate whether

Table 1. Socio-economic characteristics of the respondent households, *n*=240.

Characteristics	Frequency (%)
Household headship	
Male	67
Female	33
Total	100.0
Household size	
3 and less	20.0
4–6	49.6
7–9	27.9
10 and above	2.5
Total	100.0
Mean size of households	5.4
Age	
Under 30	18.3
31–40	36.3
41–50	25.4
51–60	13.3
Above 60	6.7
Total	100.0
Mean age of households	41,8
Literacy	
Illiterate	56.3
1–6 Years of schooling	31.3
7–8 years of schooling	6.3
9–10 years of schooling	5.0
Above 10 years of schooling	1.3
Total	100.0
Land holding	
0.25 ha and less	26.3
0.26–0.5 ha	32.1
0.51–0.75 ha	15.0
0.76–1.00 ha	18.3
Above 1 ha	8.3
Total	100.0
Mean land holding size	0.48
Livestock holding	
Without livestock	20.0
2 TLU and less	20.5
2.1–4 TLU	29.6
4.1–6 TLU	21.7
Above 6 TLU	7.9
Total	100.0
Mean livestock holding	2.74

important cognitive factors and farmer's drought experience are reliable indicators of adaptive behaviours towards the implementation of farm level drought-risk reduction measures. The PMT model is extended by including a bio-physical variable, in particular, long-term vegetation conditions, which is believed to have had influence on farmers' intentions to take up of adaptation measures. With the extended PMT framework, we aspired to test whether the key PMT variables and village level physical parameters help to explain farmers' adaptive behavioural intentions. Specifically, it is hypothesized that perceived vulnerability, severity, self-efficacy, and response efficacy will show a positive association with the higher number of adaptive measures implemented, while perception of high costs of response actions and long-term average NDVI will show a negative association with the number of adaptive measures implemented and predict more maladaptive intentions.

Table 2. Adaptation measures practised against drought risk, *n*=240.

Measures	Proportion of farmers adopted (%)
Plot level soil conservation structures	99.6
Changing cropping and planting dates	98.3
Increased fertilizer and improved seeds application	95.4
Adopt early maturing crop varieties	92.5
Using drought-tolerant crop	82.5
Use self-insurance through saving	54.2
Using irrigation (run-off diversion)	43.1
Building productive assets	36.8
Diversify income sources	31.3
Adopting water harvesting schemes	7.9
Participate in voluntary resettlement	0.8
Having more drought-resistant livestock breeds	0.4
Crop insurance	0

Table 3. Descriptive statistics.

	Cronbach alpha (α)	Mean	Standard deviation
Composite behavioural intention	–	2.742	0.447
Perceived vulnerability	0.68	4.584	0.464
Perceived severity	0.811	3.882	0.541
Perceived response	0.94	4.922	0.684
Perceived self-efficacy	0.93	4.706	0.785
Cost response	0.74	4.909	0.681
Long-term average NDVI	–	0.273	0.012

The spatial–temporal aspect of drought in the *Hintalo* district during the crop growing season was investigated by using the vegetation condition index. In the study region, drought is considered to be a meteorological phenomenon characterized by extended periods of precipitation deficit. We follow the VCI threshold values suggested by Kogan (1995) who identified drought events during the crop growing season. The VCI-based drought analysis, during the crop growing season, reveals continuous localized drought conditions in different villages due to the failure of timely rainfall at the start or towards the end or during the cropping growing season. District-wide severe drought conditions were observed during the crop growing periods of 2004, 2008, and 2009. The VCI-based analysis revealed the incidence of drought episodes of two years in a row covering the whole districts in 2008 and 2009. Subsequently, agricultural activities in the district were severely impacting household food security and rural livelihoods. Shiferawa et al. (2014) claimed that drought directly affects production, lives, health, livelihoods, and assets that contribute to food insecurity and poverty. Recent studies reveal that the southern zone of Tigray shows a short- and long-range tendency for drought risk and is most likely to suffer from drought (Gebrehiwot et al., 2011; Tonini et al., 2012). Sewonet (2002) reported that a delay in rainfall in the onset of *Kermti* rains has led to severe consequences such as shortage of pasture for livestock and a shift in planting with subsequent reduction of the growing period in which soil moisture was available for crop growth.

Table 4. OLS model estimates' coefficients.

Variables	B	Std. Error
Perceived Vulnerability	0.090*	0.039
Perceived Severity	0.128**	0.035
Perceived Self-efficacy	0.176**	0.031
Perceived response-efficacy	0.212**	0.036
Perceived cost	0.070**	0.024
Long-term average NDVI	−13.061**	1.389
Constant	1.614**	0.434
F	91.276 (6)**	

Note: * and **significant at probability levels of 5 and 1%, respectively.

In contrast, healthy vegetation conditions were observed over the cropping seasons of 2007 and 2010, indicating relatively good crop harvest. The normal conditions, during these cropping periods, are associated with adequate rainfall conditions during the main rainy season leading to healthy vegetation condition. Moreover, agricultural activity in the study district mainly depends on seasonal rainfall and is usually affected by the failure of timely rainfall beginning or a failure towards the end of the crop growing period.

In the study district, drought mainly indicates the deficiency of rainfall compared to normal rainfall conditions. During the crop season, the temporal vegetation condition was assessed using Absolute Difference Average NDVI anomalies to detect drought episodes, which resulted in crop failure. Subsequently, drought episodes in 2004, 2005, 2008, and 2009 were detected in the whole study district, and two additional drought events (2001 and 2002) were detected in the sample villages where the household survey was conducted. The findings further show that there is spatial heterogeneity in drought conditions even within one district.

Our empirical analysis showed that perceived vulnerability and severity, self-efficacy, and response efficacy are significantly and positively associated with the number of adaptation measures implemented. This result is consistent with the concept of protection motivation theory that both threat and coping appraisal influence individual's protection motivation to implement risk reducing measures. It is also found that long-term average NDVI has a significant effect on behavioural intention, indicating that the farmers, who live in a better physical environment represented by good state of vegetation, are less motivated to take up adaptation measures against drought risk, which is one of the key findings of the study.

As Table 4 clearly elucidates from the threat appraisal variables, perceived vulnerability, and perceived severity of consequences are positively related with the number of adaptation measures implemented. This indicates that farmers, who perceive to be more vulnerable to drought and will suffer a significant damage or foresee severe consequences, are more likely to implement adaptation measures. Similar results are found by Blennow and Persson (2009) and Milne et al. (2000) who reported a positive association between the farmers' adaptation measures implemented and high perceived threat. Furthermore, this finding echoes the findings of Mankad et al. (2013), Martin et al. (2007), Bočkarjova et al. (2009) and Gebrehiwot and van der Veen (2015) concerning urban water shortage, wild fires in the US, flooding in the Netherlands, and drought in Ethiopia, respectively.

Concerning the coping appraisal, perceived self-efficacy, and perceived response-efficacy variables are positively associated with the number of adaptation measures implemented by the sampled smallholder farmers. This indicates that farmers' ability to carry out specific adaptation measures and their perception on the effectiveness of these measures significantly enhance farmers' intentions to take up adaptation measures, which is consistent with the findings of the literature. Floyd et al. (2000) similarly reported that self-efficacy will increase the likelihood of undertaking adaptation measures. Mankad et al. (2013) reported that high individual perceptions on the effectiveness of rainwater tanks to protect individual from water shortages would lead individuals to install rainwater tanks. Poussin et al. (2014), in contrast, reported that perceived response-efficacy does not influence actual flood preparedness, but is an important aspect of influence on households' intentions to carryout extra-mitigation measures.

On the other hand, high perceived costs associated with adaptation measures significantly reduce farmers' intention to implement adaptation measures. In this respect, Botzen et al. (2009) reported that perceived response cost of measures and, in particular, the expected time required to carry out emergency preparedness measures plays an important role in the decision to implement such measures. In Greece, in a study on flood protection, Koerth et al. (2013) similarly reported that perceived costs of response actions were negatively associated with the number of flood protection measures implemented. Interestingly, in our study, the result indicates that a higher long-term average NDVI, which signifies a healthy state of vegetation condition in a village, significantly reduces farmers' intention to implement adaptation measures against drought risk. The result further indicates that farmers' perception of their physical environment and state of vegetation condition influences farmer's adaptation behaviours. On this point, Grimely (2000) and Slovic (1987) claimed that individuals' personal experience with risk can have a significant impact on the recognition of risk and may potentially affect individuals' decision-making within the risk-reduction continuum.

By and large, the findings showed that like earlier applications of the PMT framework in the field of other natural hazards, coping appraisal makes a significant contribution to the explanation of individual's adaptive behaviour (Bubeck et al., 2013; Koerth et al., 2013).

6. Conclusions

The study investigates farmer's cognitive perception of risk and their behavioural intention to carry out adaptation measures by adopting the PMT model using multilevel analysis. We extend this PMT model by including bio-physical parameters through the vegetation state of the environment of the villages of the farmers. Accordingly, we investigated detailed historical drought patterns by looking at the spatial and temporal aspects of drought during crop growing season at village level, which is, as far as we know, the first time to be applied at this level in the Ethiopian case. A standard vegetation-based drought monitoring index, in particular the Vegetation Condition Index, was applied for this purpose. Kogan's (1995) VCI classification threshold was employed for the identification of agricultural drought events. We applied an innovative new software package to process the SPOT images and subsequently two spatial datasets, a land cover map and the study districts, were integrated to extract the NDVI values over crop areas and examined agricultural drought over space.

The study provides useful information on the major historical drought events and the villages exposed to recurrent cycle of drought in the study district over the period April 1998 to December 2013. Accordingly, 567 dekadal images were administered in order to produce the multi-temporal VCI-based drought maps. The analysis indicated a district-wide severe drought condition during the crop growing seasons of 2004, 2008, and 2009. The finding further revealed incidence of drought episodes of two years in a row covering the whole district in 2008 and 2009. Consequently, agricultural activities in the district were severely impacting household food security and rural livelihoods. On the contrary, a healthy vegetation condition was observed over the crop growing seasons of 2007 and 2010, indicating relatively good crop harvest. By and large, the VCI-based analysis provides policymakers with important information on the existence of spatial heterogeneity in drought conditions even within one district, which is vital for the execution of localized programmes that aid to improve rural household food security conditions in the affected villages.

The findings of our empirical analysis indicated that the extended PMT model, which includes long-term NDVI variables, plays a significant role in predicting farmers' intention to take up adaptation measures against drought. The study revealed that perceived vulnerability and severity, self-efficacy, and response efficacy are positively associated with the number of adaptation measures implemented. On the other hand, high perceived costs associated with adaptation measures significantly reduce farmers' intention to implement adaptation measures. Remarkably, the result indicates that a higher long-term average NDVI, which signifies a healthy state of vegetation condition in a village, significantly reduces farmers' behavioural intention to implement adaptation measures. This indicates that farmers, who experience recurrent drought conditions, are more willing to implement adaptation measures against drought risk, which is the key finding of the study. High perception of farmer's vulnerability to drought coupled with high perception of consequences of damage motivates farmers to act against drought risk. In general, the empirical study provided important information that the extended PMT model can be applied as the framework for explaining farmers' adaptation behaviour against drought risk.

Note

1. This study used one of the most widely recognized definitions of adaptation by Adger & co-authors, where adaptation is defined as a process of deliberate change in response to external stimuli and changes that affect people's lives (Adger et al., 2006)

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