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Role of climate change awareness in sustainable soil nutrient management by smallholder farms in Burkina Faso

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Climate change effects are threats to the livelihood of Sub-Saharan smallholder farms. Farmers' response and readiness to take adaptive measures depend on how they perceive (perception) and moreover understand and recognize the causes (awareness) of climate change. Most studies used interchangeably perception and awareness to climate change. Taking the example of soil nutrient management, this study demonstrated the importance of distinguishing awareness from perception in climate change adaptation studies and for policy design. The study was conducted in South-western Burkina Faso. Using a semi-structured questionnaire, 360 households were surveyed. Rainfall variation and onset of the cropping season were used as climate change evidences to assess climate change perception and awareness. Descriptive statistics and Z-test were run. Results showed that beyond climate change perception, farmers largely took adaptive measures when they understand and can explain causes of climate change. Therefore, climate change adaptation studies and policy interventions should distinguish awareness from perception, and policy design should stress on raising climate change awareness of smallholder farmers.

Key words: Climate change perception, climate change awareness, sustainable soil nutrient management, smallholder farms, Burkina Faso.

INTRODUCTION

Climate change negatively impacts farming activities, aggravates crop production deficiencies, and threatens livelihoods (Jarvis et al., 2010; Lobell and Burke, 2010; Olsson et al., 2014; Porter et al., 2014). Studies (Blanc, 2012; Sultan et al., 2013) estimated that yield of main staple crops in Sub-Saharan Africa (maize, millet and

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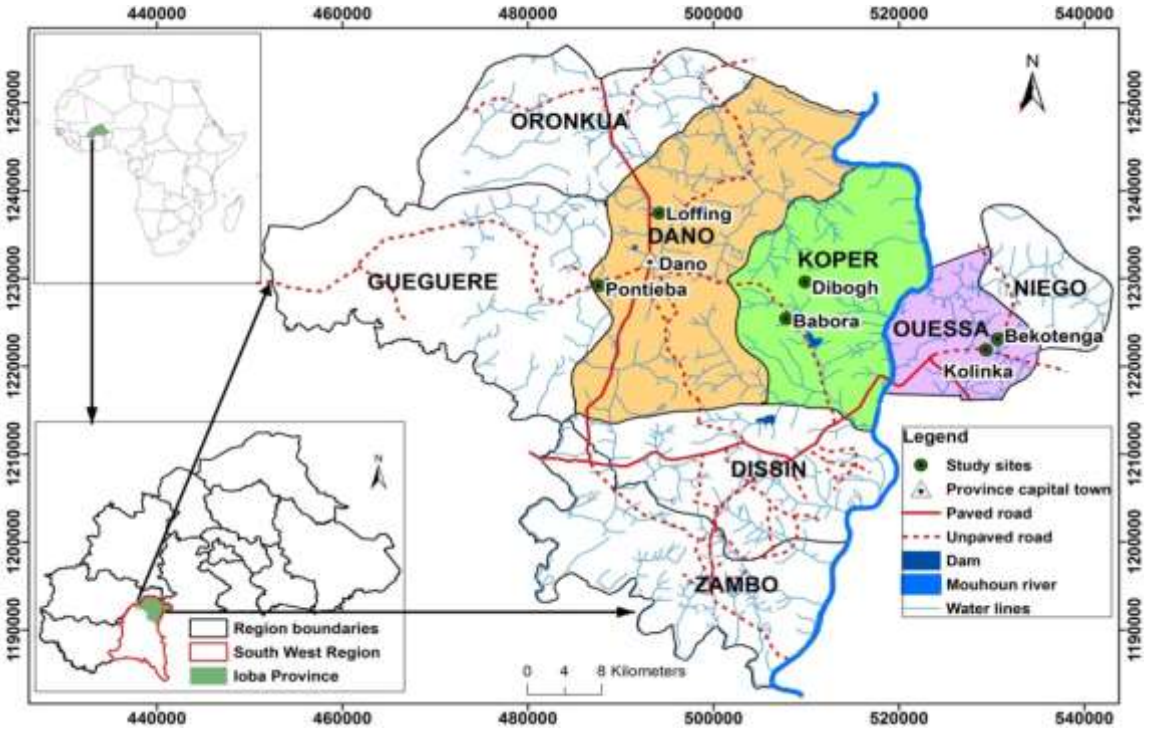

Figure 1. Study zone.

sorghum) will decrease by up to 25.5-27% under climate change during 21st century. Adapting to climate change through adoption of supplemental irrigation for instance (Sanfo et al*.,* 2017) and building farm resilience is paramount to improving food security and livelihood of smallholder farms.

To improve and sustain food production, smallholders farms need to change current agricultural practices (International Food Policy Research Institute (IFPRI), 2007; Andrieu et al*.,* 2015) mostly inadequate in the context of climate change. In Burkina Faso, spots of changes were noted for the use of water harvesting techniques (Kabore-Sawadogo et al*.,* 2013) as well as for soil conservation practices (Pouya et al*.,* 2013). However, adoption of these specific techniques and practices (Bunclark et al*.,* 2015) and of other sustainable nutrient management practices (Place et al*.,* 2003; Bationo et al*.,* 2006; Anley et al*.,* 2007; Chianu et al*.,* 2012, 2012a) is still limited in Burkina Faso in particular and in Sub-Saharan Africa in general. Besides financial constraints (Koutou et al*.,* 2016) and in some extent insufficient technical know-how, lack of understanding of ongoing climate variability and its implications contributes to explaining the poor soil fertility management performances in Sub-Saharan African smallholder farms for food crops.

There is need to increase knowledge on farmers' awareness to climate change for guiding decision making on smallholder farms adaptation and resilience to climate change. The extent of climate change impact largely depends on farmers' awareness (Fosu-Mensah et al*.,* 2012). Awareness is a key determinant of adaptation to climate change (IFPRI, 2007; Ishaya and Abaje, 2008). For being proactive and taking efficient adaptation actions, smallholder farms need to understand climate change, its causes and implications. Climate change awareness enhances adaptive capacities (Marshall et al*.,* 2013).

However, most studies (Gbetibouo, 2009; Fosu-Mensah et al*.,* 2012; Nzeadibe et al*.,* 2012) did not clearly distinguish climate change perception from climate change awareness. Moreover, more studies analyzing climate change awareness in relation to sustainable nutrient management practices are still needed.

Therefore, the objective of this study is to analyze climate change perception and awareness, and the implication for sustainable soil nutrient management in smallholder farms. The specific objectives are: (i) to assess climate change perception and awareness of smallholder farmers and (ii) to analyze the effect of climate change awareness on soil nutrient management.

MATERIALS AND METHODS

Study zone

The study was conducted in Ioba province located in South-western Burkina Faso (Figure 1). Ioba province belongs to the South-Sudanian climatic zone. This climatic zone used to have average

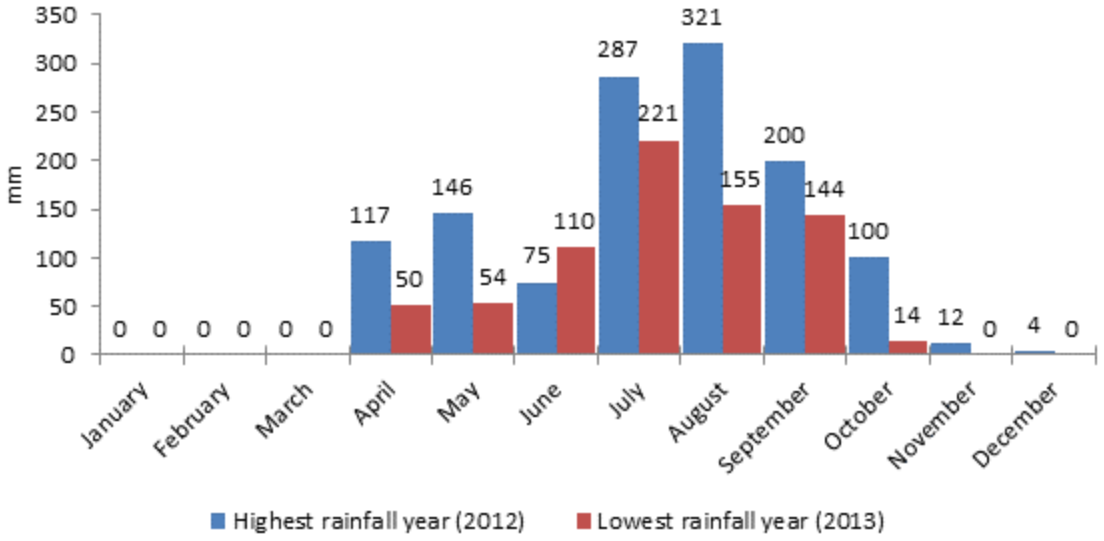

Figure 2. Monthly rainfall (mm) in Ioba province for extreme years of the decade 2004-2013.
Source: Calculated from data provided by *Direction provinciale de l'agriculture du Ioba* for the rain gauge stations of Dano, Koper and Ouessa villages.

annual rainfall greater than 1000 mm in the 1960s (Robert, 2010). However, under climate change, average annual rainfall is nowadays evaluated to 900-960 mm (MAHRH and GTZ, 2004; Schmengler, 2011; DPA Ioba, 2013). The province experiences rainfall variability in time and space (MAHRH and GTZ, 2004). Based on the data provided by the Ioba Provincial Directorate of Agriculture, the years 2012 and 2013 recorded the highest and lowest rainfall of the last decade 2004-2014, respectively (Figure 2). The livelihood in the study zone is essentially farm-based. Agricultural activities rely mainly on rainfed productions. The endemic crops in the study zone are sorghum, maize, cotton, millet, rice, groundnuts and beans; whereas the main animal species are cattle, small ruminant, porcine and poultry.

The main non-farm activities consist of petty trade and traditional gold mining. As for the rest of the country, education level is low. The study sites consisted of six villages selected in three sub-districts on the basis of demographic data, soil erosion information, soil and land use maps, and normalized difference vegetation index (NDVI) data of the province.

According to *Bureau national des sols* (BUNASOL) inventory, dominants soils types encountered in the Ioba province are:

i) Leached ferruginous tropical soils: they are dominant soils in Burkina Faso and represent 85% of the country lands (Pallo and Thiombiano, 1989).Two groups of this soil type are found in Ioba province.

a) leached and hardened ferruginous tropical soils which are generally shallow and form the main soil type of the province. They cover nearly 52% of Ioba lands. Most of cultivated lands fall into this type;
b) leached ferruginous tropical soils with spots and concretions, encountered for only 2% of the lands in Ioba. These soils are poor in organic matter, macro nutrient (NPK) and have low Cationic Exchange Capacity (CEC) (Pallo and Thiombiano, 1989);

ii) Hydromorphic soils: Also characterized by low organic matter content and very low phosphorus content, they constitute the third main soil type in Burkina Faso and cover 13% of its lands (Kissou et al*.,* 2000) and around 37% of the Ioba province lands;

v) Lithosols: cover 3% of Burkina Faso territory (Kissou et al*.,* 2000) and represents 5% of lands in Ioba province;
vi) Brown eutrophic tropical soils: they form 6% of soils in Burkina and 4% of Ioba province lands. Brown eutrophic tropical soils are constrained in NPK (Kissou et al*.,* 2000).

Conceptual framework

Warming, rainfall and its unusual variability in a location are some of the most patent evidences of climate change for farmers. They can realize, feel and observe these changes without classic scientific measurements. We define this as perception of climate change. In perceiving climate change evidences, farmers can give trend over a period (e.g. increase and decrease of the amplitude of climate parameters). Beside the perception, farmers can understand changes, explain causes and implications for their activities. This allows them to take more and strong action (Figure 3), build strategies in order to cope, adapt to or mitigate these changes. We define the fact of understanding the causes of the changes as well as their implication for livelihood activities as awareness. Awareness can be raised by education capital, learning (e.g. from extension services and other developmental stakeholders), and through information (e.g. exposure to media). Because of their differences in assets endowment (education, financial resources, equipment, exposure to outside world) farmers of different socio ecological settings are expected to have different levels of climate change awareness. It appeared from literature that most of previous studies used interchangeably climate change perception and awareness (Mertz et al*.,* 2008; Gbetibouo, 2009; Fosu-Mensah et al*.,* 2012; Nzeadibe et al*.,* 2012).

Sampling strategy and data collection

After selecting the six villages, 60 households were randomly selected per village using a list of households in the village. These lists were obtained from village leaders and updated before sampling. We obtained a sample of 360 households. The sample accounted for 29% of the total households in the six villages. The

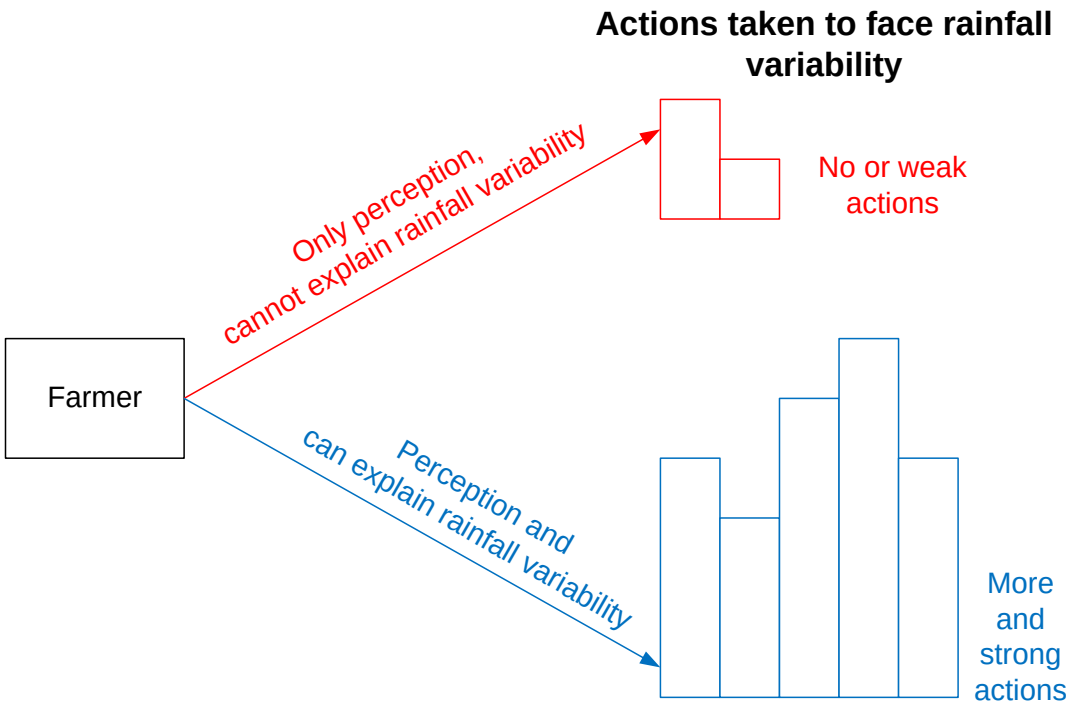

Figure 3. Conceptual framework of the study.

field surveys took place during dry season from January to March 2013. Community entry meetings were held before surveys. We were assisted during these meetings by local agricultural service personnel and local leaders. Surveys were performed through face-to-face interviews. Semi-structured questionnaires were designed and collected demographic, socio economic and geographical data as well as information on rainfall pattern. Famers were asked to give an appreciation of the rainfall pattern for the last five and to explain the causes of the pattern they observed. Ten years rainfall data was acquired from the provincial directorate of agriculture of Ioba.

Data analysis

The rainfall data was analyzed for trend detection in XLSTAT 2014 using Mann-Kendall trend test. Comparative analysis of the socio economic data was done in SPSS.20 using Z-test to test the difference between groups for the actions taken to face rainfall variability. Two groups of famers were considered: a group perceiving only rainfall variability but unable to explain, and a group perceiving rainfall variability and able to explain the reasons of this variability.

RESULTS

Farmers' perception of climate variability and change

To facilitate appreciation by farmers, they were questioned on a period of 5 years. Results showed that about 99% of the study sample perceived variability of rainfall during the last five years (2009-2013). As shown in Figure 4, almost 60% of farmers responded that the rainfall has decreased while for about 4% of farmers it has increased. A percentage of 36.33% of farmers however noted a fluctuation of the rainfall (e.g. no trend).

The perceived trends by farmers were compared to the trend of measured rainfall data using Mann-Kendall trend test (Table 1). This test revealed no trend in the rainfall for the considered period, implying fluctuating rainfall as observed by 36% of farmers. The perception of the remaining 64% of farmers did not fit the rainfall data trend. In addition to rainfall variability perception, 72.40% of farms noted a change in the onset of the cropping season. They estimated that onset of cropping season intervened late compared to the past. This calls for a change in the management of farming activities.

Farmers' awareness of climate variability and change

Figure 5 shows responses given by farmers on the question regarding causes of the observed rainfall pattern. As much as 50% of farmers were unable to explain the causes of the rainfall variation (Don't know). A percentage of about 26% of farmers explain rainfall variation by beliefs. For these farmers, rainfall variation is due to people's misbehaviors, abandonment of customs (e.g. sacrifices to ancestors) or punishment of humans by God. Only 4.10% referred to causes we interpreted as climate change and 19.20% cited deforestation as a cause of rainfall variation. We considered these two groups (Farmers who responded climate change and

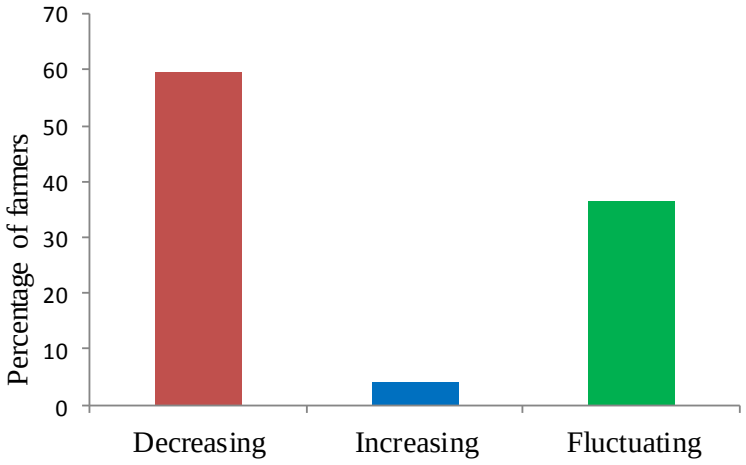

Figure 4. Perception of rainfall trend over last five years by farmers.

Table 1. Mann-Kendall trend test.

Kendall's tau	0.156
S	7.000
Var(S)	0.000
p-value (Two-tailed)	0.601
Alpha (α)	0.05

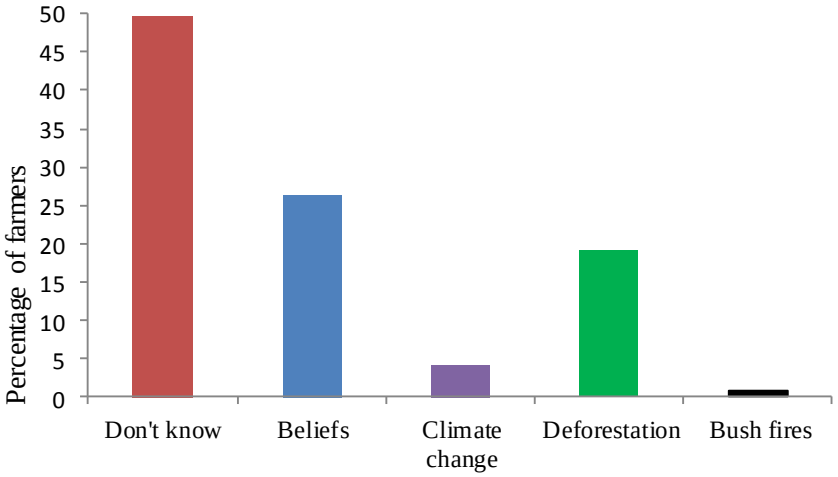

Figure 5. The causes of rainfall variation according to farmers.

deforestation) as farmers that have climate change awareness.

Farmers' responsiveness to climate change and variability in terms of soil nutrient management

We analyzed measures undertaken by farmers in response to rainfall variation. The main identified measures are presented in Figure 6. Farmers' responses in terms of sustainable soil nutrient management consisted mainly in the use of fertilizer alone (mineral or organic), the use of soil conservation measures alone (e.g. stone bunds), and the combination of fertilizer and soil conservation measures. As expected, a large proportion of farmers who have no climate change

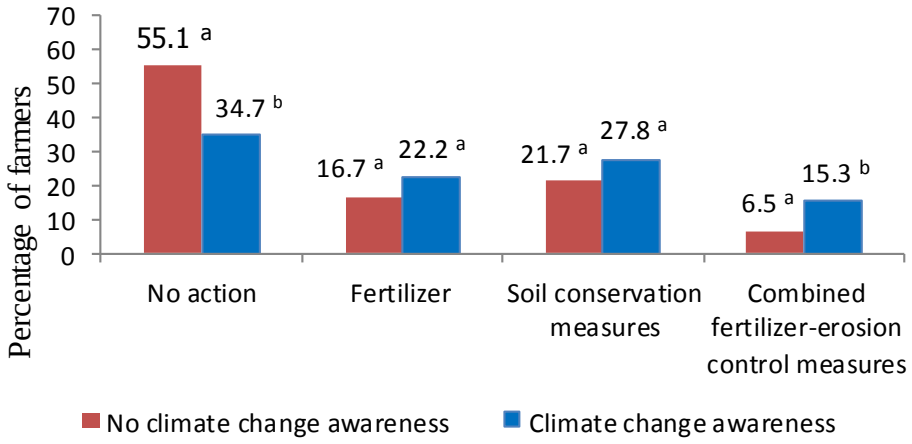

Figure 6. Actions taken by farmers in response to rainfall variability. Bars chart with same letter per action are not significantly different at 5% ($p<0.05$).

awareness (55.13%) took no action in response to rainfall variability. A proportion of 34.72% of farmers who have climate change awareness took no action. These two percentages were significantly different at 5%.

No significant difference was however found between the two groups (with and without climate change awareness) for fertilizer use alone and soil conservation measures alone. But significant difference at 5% was found between farmers group with no climate change awareness and farmers group with climate change awareness for combined use of fertilizer and erosion control measures (integrated response).

DISCUSION

Awareness generating stronger responsiveness of famers to climate variability and change than perception

The findings of this study demonstrates that farmers largely perceive ongoing climate variability and change in the region as previously found by a nationwide study (Ouédraogo et al., 2010). However the perception by up to 64% of farmers did not fit the rainfall data trend. This illustrates the difficulties for farmers to keep an accurate track of inter-annual rainfall variations. This fact may negatively effect on their response capacity to climate variability and change. The issue could be address by building farmers' capacities in agro meteorology through extension services and media. Indeed, a network of raingages set by agricultural extension office exists in the study area that could contribute to a better management of farming activities and efficient response to climate change. The approach however requires a better collaboration between famers and extension agents who can provide farmers with accurate time series rainfall information and help better address rainfall variability effects on farm activities.

The findings of this study further highlight that farmers' capability of understanding and explaining the underlying causes of rainfall variability is key for taking sound adaptive measures. Comprehension based on sole beliefs (lack of awareness) more likely leads to weak or not strong response in terms of soil nutrient management, in response to rainfall variability. The percentage of farmers with climate change awareness who combined the use of fertilizer and soil conservation measures was significantly higher than the percentage of farmers with no climate change awareness who took the same action. This combination is a stronger response and can have better effect compared to individual use of fertilizer or soil conservation measure alone. Farmers are more likely to take action against rainfall variability when they have climate change awareness. All farmers with climate change awareness may not take action as other factors (e.g. labor, financial resources and education) may affect sustainable soil nutrient management (Anley et al., 2007; Kassie et al., 2013; Lambrecht et al., 2014; Martey et al., 2014). Likewise without awareness, farmers will still adopt efficient measures based only on their perception of climate change. Farmers may adopt soil fertility management measures because of growing land scarcity and new market opportunities rather than the perceived climate change (Barbier et al., 2008).

Implications for policy intervention and research

Climate change is a growing issue worldwide in general and in particular for sub-Saharan African countries which are agricultural based economies. They will likely be more vulnerable due to the poverty of the populations, the rainfed agriculture and its current low performance. Building adaptive capacities and resilience to climate change effects in agriculture sector will depend on

available resources and a sound understanding of farmers' behaviour in the face of the phenomenon. Perception and awareness to climate change are often used interchangeably. However our study demonstrates the needs for distinguishing the two as with awareness farmers are more likely to undertake strong adaptive measures. Therefore, policy intervention should aim at building and improving awareness among farmers. Research should as well distinguish between the two for providing suitable information and for better guiding decision making.

Conclusion

This study investigates the role of climate change awareness in sustainable soil nutrient management by smallholder farms. Farmers overwhelmingly perceived climate change. It was shown that perceiving climate change only is not enough for farmers to take adaptive measures. It is crucial for them to understand what is causing this change. On methodological level, the study showed the need for clearly distinguishing climate change perception from climate change awareness in sustainable land management studies. At policy level, policy intervention should focus on raising farmers' climate awareness through education and training. The findings of the present study should guide further research in the study zone and in similar settings to support building smallholder farms' adaptiveness and resilience to climate change.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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