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Smallholder farmers' experiences of climate variability and change on pineapple production in Ghana: Examining adaptation strategies for improved production

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Climate variability and change presents enormous risk to agricultural production globally due to the impacts on yields. While global scholarship on climate change impacts and adaptation measures on agriculture has been well-documented, little is known about climate and pineapple production. This study examined smallholder pineapple farmers experiences of climate variability and change on production, as well as ranked adaptation options using data from both primary and secondary sources. The primary data consisted of survey and focus group discussions in four major pineapple growing districts in Ghana. The analysis revealed that pineapple farmers experience climate variability and change evidenced mainly through irregular rainfall patterns and rising temperatures. These changes cause reduction in fruit size and yield, change in colour and taste, and consequently, reduction in income from pineapple production. Although diverisification of livelihood away from pineapple cultivation emerged as the main adaptation option employed by smallholder pineapple farmers studied, it has the potential to reduce pineapple production in Ghana. For improvement and sustainability of the pineapple industry in Ghana, future studies should investigate the vulnerability of the production system to changing climate to effectively identify exposure and sensitivity of pineapple production to climatic changes. This will in effect, enhance identification of measures that will improve production as well as promote adaptation of the smallholder production systems to climate variability and change.

Key words: Climate variability, change, smallholder farmers, adaptation, pineapple production.

INTRODUCTION

Pineapple is an important crop that significantly contributes to the economy of Ghana (Badu-Gyan, 2015; Whitfield, 2016). It is estimated that in 2011, about 40,000 tons of pineapples were exported from Ghana to Europe (Kleemann et al., 2014). About 10,000 ha of farm holdings were cultivated with pineapple by both rural and

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urban households (Badu-Gyan, 2015). Pineapples produced are absorbed into both the export and local markets. The promotion of pineapple production and export has been effective in improving rural livelihoods by through improved income to farmers and reducing poverty. This is despite socio-political and economic challenges including changing regulations and the shift of international demand for pineapple from the formerly dominant 'Smooth Cayenne' variety to the MD2 variety faced by the industry over the years (Whitfield, 2016; Badu-Gyan, 2015).

The pineapple industry in Ghana is made up of small, medium and large scale producers. Pineapple small-scale producers cultivate from 1 to 20 acres of land and are distinguished in Ghana based on their relationship with large pineapple companies or exporters (Danielou and Ravry, 2005).

Climate change presents enormous risk to agricultural production globally due to the impacts on yields (Moore and Lobell, 2014; Food and Agriculture Organization [FAO], 2013; Trujilo, 2011). Projections of the nature and magnitude of these impacts on agriculture require knowledge of possible adaptation techniques (Moore and Lobell, 2014). Pineapple is more sensitive to variations as impacts from excessive heat and irregular rain results in low productivity (Iwuchukwu and Udoye, 2014; Williams et al., 2017). Though pineapple crop can withstand longer periods of drought when subjected to prolonged water stress, plants cannot obtain the desired sizes needed for flower induction and growth (Tachie-Menson et al., 2014). The major pathway through which climate variability and change affects food production is increased temperatures and water stress resulting in crop failure or decreases in crop yield (FAO, 2008). Smallholder farmers have to contend with rising levels of uncertain conditions surrounding production and limited adaptive capacity (Carr and Thompson, 2014). This uncertainty as a result of climate variability and change has resulted in a plethora of adaptation measures to tackle the potential implications of climatic changes and to help farming communities to better face extreme weather conditions associated with climate variations (Ndamani and Watanabe, 2015). Studies have indicated that, knowledge of smallholder farmers on adaptation may be used as baseline information in developing planned adaptations and inform development policy and other decision making process (Fosu-Mensah et al., 2012; Nhamo et al., 2014; Burnham and Ma, 2016). Adaptation is differentiated by the space within which it is designed. Individuals within communities design some adaptation measures while others are designed from outside the community (Burnham and Ma, 2016).

Adaptation practices used by farmers emerging internally from the communities have been mostly studied (Jones and Thornton, 2003; Ndamani and Watanabe, 2015; Misra, 2016). Until recently, development programmes were without cognizance of the effects of climate, but now climate change adaptation mainstreaming into development programmes is being practised. In addition to the 2nd sustainable development goal which seeks to "end hunger, achieve food security, improve nutrition and promote sustainable agriculture", Ghana's Nationally Determined Contribution (NDC) to the United Nation's Framework Convention on Climate Change (UNFCCC) seeks to achieve "agriculture resilience building in climate vulnerable landscapes" (United Nations, 2012; Government of Ghana, 2015). The achievement of these policy objectives requires research on the prevailing challenges that confront the food value chain as well as adaptive measures that are adopted by smallholder farmers.

Although global scholarship on climate impacts and adaptation has observed significant advances, policies and programmes to enhance planned adaptation is often constrained by limited knowledge on contextual and crop-specific practices that have reduced vulnerabilities and enhanced production (Carr and Thompson, 2014). Evidence on pineapple farmers' experiences and adaptation practices are not readily known, meanwhile knowledge of the observed effects of climate variability and change on production as well as existing adaptation strategies are imperative for building resilience in the horticultural sector.

Studies done on adaptation particularly in Ghana have not adequately targeted pineapple production (Westerhoff and Smit, 2009; Boon and Ahenkan, 2012; Nyantakyi-Frimpong and Bezner-Kerr, 2015). Although there exist few literature specific on pineapple production and climate in Africa and Ghana (Williams et al., 2017; Iwuchukwu and Udoye 2014; Mugambwa, 2014), its adaptation strategies are generally inferred from other crop production adaptation measures which is not a standard way of providing adaptation measures specifically for pineapple production. Understanding adaptation measures by smallholder pineapple farmers will provide source of knowledge on adaptation practices to a changing climate regarding cultivation. This could have direct implications for future adaptation research, policy and practices. This paper adds to the research literature by examining farmers' perceived causes of climatic variability/change, perceived effect of climate variability on pineapple production and adaptation strategies used by pineapple farmers in response to climate change/variability.

MATERIALS AND METHODS

Data and method of collection

The study employed both primary and secondary data. Primary data was obtained through a survey covering four districts from four major pineapple growing regions in Ghana. Specifically, Ga East, Akatsi North, Nsawam Adoagyiri and Gomoa West districts were selected to represent Greater Accra, Volta, Eastern and Central Regions of Ghana, respectively (Figure 1).

Figure 1. Map of the study areas.

A two-stage sampling technique was used to collect cross sectional data from four hundred smallholder pineapple farmers across the four districts in Ghana. The first stage involved a purposive sampling of the study areas and the second stage was employment of random sampling technique to select the various respondents for the survey.

A sample size of 600 was obtained from the district offices of the Ministry of Food and Agriculture (MoFA). One hundred pineapple farmers were then randomly selected as proportionate to the total sample from each district making a total of 400 respondents. Data collection was with the aid of pretested structured questionnaires to correct any inconsistencies. Data collected were mainly on socio-demographic characteristics of the respondents, climate variability and its related impacts on pineapple production as well as adaptation strategies of smallholder pineapple farmers to climate variability and change in Ghana.

Focus Group Discussions (FGDs) were also conducted with ten members of cooperative pineapple growers and marketing associations in the respective districts to get an in-depth understanding on climate and pineapple production in Ghana.

Secondary data was based on review of relevant sources such as publications, journals, books and annual reports, periodicals and through web sites in order to know strategies used by smallholder farmers in adapting to climate variability in the pineapple industry.

Data analysis

Data on socio-demographic characteristics of the respondents was analyzed using descriptive statistics. Thematic analysis using qualitative responses from the FGDs was used to analyze climate variability and its related impacts on pineapple production. The study identified and analyzed adaptation strategies of smallholder pineapple farmers to climate variability and change in Ghana. The identified factors included increased production of other crops, introduction of other crops, diversion into animal production, expansion of other farming activities, diversion into other non-farming activities, reduction/increase in pineapple farms, adoption of organic farming, change of planting dates, practice of bush fallow/crop rotation among others. Perceived strategies used by pineapple farmers were ranked by the respondents using frequency or percentage (%). The rank order was given using Garett's ranking technique. The orders of merit were transformed into units of scores by using the following formula.

Percent position = 100 (Rij – 0.50) / Nj

where Rij is the rank given for the ith factor by the jth individual and Nj is the number of factor ranked by the jth individual.

The percent position was converted into scores by referring to

the Garrett's Scale Conversion Table.

According to Loganathan et al. (2009), for each factor, the scores of the individual rankers were added and the average score was estimated and arranged in either ascending or descending order to know the order of preference given by the respondents for the factors. Based on the mean score, the overall ranks were assigned for each. Garrett's rank scoring technique which has been developed for testing rankings was considered because this method allowed respondents to rank their preferences hence following the sequence from the most relevant factor allowed to find out the most important adaptation strategy which is the most preferred by the small holder farmers to the least preferred ones.

RESULTS AND DISCUSSION

Socio-demographic characteristics of pineapple farmers

The socio-demographic characteristics of the respondents are presented in Table 1. These characteristics impact on farmers' production activities, management and productivity. Majority (85.0%) of the pineapple farmers were male and about 90% of them were within the economic active age of 18 to 60 years. Only a tenth were above 60 years. This is encouraging, as it would ensure sustainability and continuous existence of the pineapple industry.

The pineapple farmers interviewed had varying levels of education that relates to farmer's capacity and willingness to adopt improved technologies including measures in adapting to changing climate. Education broadens one's outlook on life and helps to understand the social, political, economic and cultural issues in the society (Hasan et al., 2010). Only about 13% had no form of education at all.

As shown in Table 1, a little over a third (35.0%) of the pineapple farmers had more than 10 years of pineapple farming experience. According to the results, almost all the pineapple farmers had knowledge regarding pineapple cultivation apart from the few farmers who had less than one year experience in pineapple farming. Farmers' knowledge and skills of farming practices gained through production practices can influence their ability to adapt and cope with growing conditions including climate variation.

With regards to membership of farmer associations, the results show that, 71.0% of the pineapple farmers were members of an association; the rest did not belong to any association. Most (77.3%) of the pineapple farmers had extension contact but had less support from R&D institutions (31.0%). Majority (82.5%) of the farmers also had small farm size (less than 1.6 ha) indicating they operate on a small-scale level. Knowledge of the various land sizes operated by smallholder farmers is important since pineapple farm size influences the work intensive nature of production (Badu-Gyan, 2015). Other studies have found a significant positive relationship between farm size and income from pineapple cultivation implying the higher the farm size, the higher the income from pineapple cultivation (Hasan et al., 2010; Mondol et al., 2005).

Farmers' perception of the evidence and effects of climatic variation and change in pineapple growing areas in Ghana

Climatic variation poses great threat to farmers and their production activities. During discussions with the pineapple farmers, irregular rainfall patterns, drying up of streams, overflow of streams, rise in temperature and excessive heat which are indicators of climate variability/change were recognized in all the study areas as evident. Irregular rains and drying up of streams were particularly mentioned as the main evidence of climate variability/change.

A farmer from Gomoa West indicated that, "*since the last decade, this area receives less rains compared to the earlier periods and it does not rain at the expected time affecting our production plans*". In Akatsi, another farmer mentioned that, "*we (farmers) experience shorter raining period than before which is now approximately less than 3 months with yearly changes*". The farmers mentioned that, their growing areas had been experiencing periods of low rainfall as indicated by the drying up of streams especially during the past decade. Occasional cases of floods, which were evidenced by overflowing streams, were also reported. High temperature was also mentioned by many farmers as an indicator of changing climate.

In Ga West, a farmer indicated that, "*our forests are gone therefore sunshine has been intense with high temperature and consequently reduced rainfall*". Climate variability and change may have both positive and negative effects on farming in Ghana, though there are indications of more negative impact in the long run and may in effect challenge farmer's production efforts and affect sustainable production (Nyadzi, 2016).

Pineapple crop is more sensitive to variations in weather patterns brought about by changes and variability in the climate system. According to the pineapple farmers, some of the effects of the variation in climate on production include reduction in fruit size, reduction in yield, reduction of income from pineapple, change in colour and change in taste. This concurs with results of other studies that showed similar effects of climatic variation on pineapple production in Nigeria and Uganda (Iwuchukwu and Udoye 2014; Mugambwa, 2014). During the FGD, a farmer from Nsawam Adoagyiri remarked that, "*in January 2014, high temperatures together with low patterns during flowering stage of production resulted in small sized fruits affecting market price and reduced net income*". Regarding fruit quality, noticeable temperature effects that emerged in different farms included sunburn and black spot with resultant

Table 1. Socio-demographic characteristics of pineapple farmers.

Variable	Frequency	Percentage
Age		
18 - 35	124	31.0
36 - 60	236	59.0
>60	40	10.0
Educational level		
None	53	13.3
Basic	80	20.0
Secondary	257	64.2
Tertiary	10	2.5
Gender		
Male	341	85.0
Female	59	15.0
Years in pineapple farming		
<1	9	2.3
1 - 3	94	23.5
4 - 6	97	24.2
7 - 10	60	15.0
>10	140	35.0
Farmer Based Organization (FBO) membership		
Yes	284	71.0
No	116	29.0
Access to Agricultural Extension Agents(AEA)		
Yes	309	77.3
No	91	22.7
Access to Research & Development (R&D)		
Yes	124	31.0
No	276	69.0
Farm size (ha)		
<1.6	330	82.5
1.6 - 4.0	58	14.5
>4.0	12	3.0

reduction in fruit weight and size. Extended growing period that increases production cost as a consequence of drought was another effect that many farmers have observed.

In addition, farmers mentioned that, prolonged drought with unpredictable rainfall patterns mostly promote and introduce crop diseases such as heart rot and pests, which reduce crop yield and productivity. In the absence of effective adaptation measures, crop production can be severely constrained by climate variability and change (Smit and Skinner, 2002; Nyadzi, 2016). Exploring how pineapple farmers modify their farming practices in response to the changing climate is therefore very important to the development of effective policies and practices to enhance pineapple productivity in Ghana.

Adaptation strategies for pineapple production in Ghana

Smallholder pineapple farmers in Ghana have devised several practices and measures for coping with the

Table 2. Ranking of adaptation strategies by pineapple farmers (N=400).

S/N	Rank scale factors	1	2	3	4	5	Total score	Mean score	Rank
1	Increased production of crops grown earlier	63	92	104	71	68	26215	65.5375	7th
2	Production of crops not grown before	67	111	83	89	45	26368	65.92	6th
3	Movement into animal production	112	116	94	42	29	27480	68.7	4th
4	Expansion of animal farm	118	116	94	46	23	27884	69.71	3rd
5	Movement into non-farm occupations	166	115	55	48	10	28669	71.6725	2nd
6	Reduction of pineapple farm size	174	89	74	40	19	28709	71.7725	1st
7	Changing date of planting and other operations concerned with pineapple production	78	83	103	95	36	26430	66.075	5th
8	Adoption of organic farming in my pineapple production	22	118	110	35	109	25173	62.9325	11th
9	Increase pineapple production farm size	21	90	105	47	134	24841	62.1025	12th
10	Practice of bush fallow	45	111	70	64	106	25551	63.8775	9th
11	Practice of crop rotation	41	110	66	30	150	25266	63.165	10th
12	Other measures	63	92	104	71	68	26215	65.5375	7th

effects of climate variability and change in order to adapt to this phenomenon. Using Garrett's Ranking Technique, ranking results of measures used by the farmers as adaptation strategies during pineapple production are shown in Table 2. Out of the 12 factors examined, reduction in pineapple farm size (with a mean score of 71.8) was considered as the main adaptation strategy used by farmers in adapting to climate variability and change (Table 2). Movement into non-farm occupations, expansion of animal farm as well as movement into animal production were the next top three measures ranked after reduction in farm size by the farmers in the study areas (Table 2). The measure ranked as the least effective adaptation strategy used was increasing pineapple production farm size. As depicted in Table 2, other measures such as changing date of planting and other operations concerned with pineapple production, production of crops not grown before and increased production of crops grown earlier are adaptation strategies also found to be used by smallholder pineapple farmers in adapting to the effects of climate change and variability.

Smallholder pineapple farmers' most important adaptation strategies

Results from the adaptation strategies examined indicates that, the five most important climate adaptation measures employed by pineapple farmers in Ghana include reduction of pineapple farm size, movement into non-farm occupations, expansion of animal farm, movement into animal production and changing date of planting and other operations concerned with pineapple production (Table 2). Apart from changing the growing period, the other factors fall under the broad theme of crop and livelihood diversification, which is a combination of practices that seek to stabilize production and to a large extent income of farmers.

As indicated by Altieri and Koohafkan (2008) and Hassan and Nhemachena (2008), livelihood diversification as response to changing climate is related to reduction in risk associated with crop production. Deressa et al. (2009) also refers to this as risk-mitigating strategies. The pineapple farmers reported that, pineapple production is highly capital intensive, hence, effects such as reduction in fruit size and yield which result in poor economic returns due to varying climatic conditions may have contributed to some of the farmers diversifying from pineapple production. This is however not encouraging as it would affect sustainability of the pineapple industry in Ghana. Reduction in pineapple farm size, which ranked as the topmost climate adaption measure equally contributes to this future threat to the industry. Varying area cultivated as an adaptation strategy concurs with other studies (Gbetibouo, 2009; Molua and Lambi, 2006). Total area of pineapple farming has been identified by most studies as a critical factor that significantly contributes and has direct effect on the income of pineapple farmers (Badu-Gyan 2015; Hasan et al., 2010). As noted by Badu-Gyan (2015), the larger the farm size, the more difficult it is for pineapple farmers to manage production activities and as such increases the likelihood of the farmers' choice of production practices. Smaller farms were noted in the study to have greater propensity for adopting work intensive production while larger farm size is expected to have a negative influence on farmers' choices of advanced production systems. The size of land influences the level of input used and also the quantity of output produced from it which could

imply that, increasing planting area would increase production cost and subsequently reduce income due to climatic changes.

To sustain pineapple production, reduction in pineapple farm size and diversification into other livelihood activities such as production of food and vegetable crops as practiced by the pineapple farmers are response to climatic variation and change that needs to be effectively addressed. A major concern to production raised by farmers during discussions was inadequate government support to address climate related challenges during production. Almost all adaptation strategies identified were farmer initiated bottom-up practices. This type of approach depends on the farmers' own characteristics (Fujisawa et al., 2015). FAO classifies top-down adaptation strategies as government supported strategies and has even been classified as introduced adaptation strategies (Kuwornu et al., 2013). These strategies are found to enhance smallholder farmers resilience to climate change and variability and such practices include modernized irrigation system (Hassan and Nhemachena, 2008), improved meteorological forecast (Easterling et al., 2007), farm insurance (FAO, 2009) as well as good agricultural practices (Easterling et al., 2007).

A combination of farmers initiated bottom-up and institution led top-down approaches would facilitate more flexible and widely accepted adaptations practices as it involves diversity of actors that could make adaptation more dynamic and innovative (Fujisawa et al., 2015). According to the pineapple farmers, beyond their capacities, distinct measures such as introduction to irrigation systems, afforestation in pineapple producing areas, provision of modern technologies such as plastic mulching and capacity building to enhance knowledge to improve production practices would greatly enable them to deal with climate variability and change. This needs to be appropriately considered in adaptation policy for government and research institutions to intervene in the development and promotion of strategies perceived to be effective in improving production.

Smallholder pineapple farmers' least important adaptation strategies

Results of the analysis further show the least ranked measure that could also be considered as the least effective adaptation strategy for pineapple farmers (Table 2). The least ranked adaptation measure was increasing pineapple production farm size. This could be explained by the fact that, farmers reported difficulty in predicting weather pattern, particularly rainfall, affecting planning of operations during production cycle. Rainfall and temperature variation were reported to produce delay in pineapple growth stages that results in increasing cost of production and consequently significant reduction of crop revenue. For instance, it was mentioned that, production is planned such that, flower induction coincides with the minor season rains to avoid delays in production schedules and marketing arrangements as well as secure yield. Delays and variation in climate therefore negatively affects fruit quality and quantity as well as production schedules and market. The resultant effect is farmers reducing production area, which as earlier noted will not be sustainable for the sector.

Among the other least effective strategies used in adapting to the effects of climate change and variability by the smallholder farmers were practice of bush fallow, practice of crop rotation and adoption of organic farming in pineapple production. Farmers complained that, there are drawbacks in practising crop rotation and bush fallow, as more time is required in preparing the soil for new crops as well as scarcity of land to support these practices. Also, despite the importance and advantages associated with organic farming and the environmental friendliness related to it, pineapple farmers ranked it among the least effective measure against climatic changes as it is considered to be capital and labour intensive and risky. The formal organic sector in Ghana currently occupies only 0.2% of agricultural land (Badu-Gyan, 2015) implying minimal adoption of the practice. Overall, other measures such as changing date of planting and other operations concerned with pineapple production, production of crops not grown before and increased production of crops grown earlier were also found to be used by smallholder pineapple farmers in adapting to the effects of climate change and variability.

Implications for improved adaptation strategies for pineapple production in Ghana

There are varying ways pineapple farmers are using to adapt or cope with changing climate to reduce the effects of its consequences based on their own experiences. It is been generally noted that, not all observed adaptation practices by farmers are deliberately planned as adaptive actions against the climate but that, some are by-products or secondary benefits from activities unrelated to changing climate (Fujisawa et al., 2015). The strategies identified in this study therefore are not a comprehensive list of measures that may all be relevant especially for local specific adaptation decisions in addressing anticipated current and future threats resulting from changing climate to the pineapple production industry in Ghana. Climate projections in Ghana indicate that, there would be more variable weather conditions and extended periods of drought with potentially devastating implications (Allison et al., 2009).

A very recent study by Williams et al. (2017) confirms that, climate variability impacts on pineapple production in Ghana and has consequences for both fruit quality and quantity produced. Adapting to climate projections therefore will require a new paradigm, as the adaptation

actions taken so far by farmers are likely not to sustain and improve the pineapple production industry in Ghana. Adapting to impacts from projected climatic changes may even require structural changes such as irrigation facilities, which would demand government intervention. More so, adaptation strategies are becoming increasingly important issues for promoting development (Clement et al., 2011). Therefore, since the identified alternatives are not likely to be appropriate in all circumstances in Ghana, a better understanding of local awareness of climate vulnerabilities to help communities understand their sensitivity to climate will be important in informing policy for future successful adaptation strategies for pineapple production.

Fujisawa et al. (2015) argue that a combination of the farmers-initiated bottom-up and the institution-led top-down approaches would facilitate more flexible and widely accepted practices to climatic changes with the involvement of a diversity of actors making the entire adaptation process more dynamic and innovative. Importantly, there is no 'one-size fits all' approach for communities to anticipate, plan, and adapt to the changing climate (Hinkel et al., 2010). According to Ndamani and Watanabe (2017), an effective analysis of climate vulnerability in agriculture is fundamental to developing viable adaptation options to manage future anticipated climatic risks and to support adaptation planning.

Conclusion

Pineapple production is both a major contributor to the economic development of Ghana and also promiment livelihood activity for smallholder farmers. However, in addition to the constraints from the political economy of the global market, climate variability and change presents considerable challenge to farmers. Discussions with the farmers revealed that, erratic weather patterns through floods, droughts and increase in temperature affect pineapple production and yield. In response to the effects of climatic changes on pineapple production experienced by farmers, acess to weather information needs to be timely and prioritized to help farmers in their decision making processes (e.g., planting date options for farmers). The Ghana Meteorlogical Agency has agro stations across the country that can provide the necessary information to smallholder farmers.

The three most important adaptation measures employed by the pineapple farmers included reduction in pineapple farm size, movement into non-farm occupations and expansion of animal farm mainly under diversification of livelihoods. These adaptation measures can negatively impact and reduce pineapple production in Ghana.

Further drifts from pineapple production could completely annihilate pineapple as a major source of income in Ghana. This will not only affect the macroeconomy that pineapple production supports, but also the livelihoods of the individual farmers involved. Given that, the adaptation measures identified were bottom up practices initiated by farmers, intervention from other actors and institutions such as policy makers, agricultural extension services through the Ministry of Food and Agriculture and national research intstitutes support farmers. Policy strategies should be directed toward mainstreaming climate adaptation of smallholder production systems into agricultural development strategies. Agricultural extension services should ensure the sensitization and promotion of effective adaptation practices that will enhance farmer's knowledge about pineapple production.

Additionally, there will be the need for further research into development and identification of appropriate and effective technologies for climate adaptation and improvement of pineapple production in Ghana. This will require a holistic approach of incorporating policy makers, pineapple farmers and other stakeholders in developing a sustainable adaptation strategy to climate change with focus on technological innovations, socio-economic and ecological ramifications. For identifying adaptation measures that will improve pineapple production, assessment of the vulnerability of the pineapple production system to changing climate in future studies will serve as an effective approach to improve adaption of smallholder production systems to climate variability and change.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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