Climate Risk Management 23 (2019) 124–135

Contents lists available at ScienceDirect

Climate Risk Management

journal homepage: www.elsevier.com/locate/crm

Adapting to changing climate through improving adaptive capacity at the local level – The case of smallholder horticultural producers in Ghana

Portia Adade Williams[a,b,*], Olivier Crespo[a], Mumuni Abu[c]

[a] Climate System Analysis Group, Environmental and Geographical Science Department, University of Cape Town, Rondebosch 7700, South Africa
[b] CSIR – Science and Technology Policy Research Institute, Box CT 519, Accra, Ghana
[c] Regional Institute for Population Studies, University of Ghana, Legon-Accra, Ghana

ARTICLE INFO

Keywords:
Climate variability
Adaptation
Adaptive capacity
Smallholder farmers
Horticulture
Ghana

ABSTRACT

The consequences of changing climate are often negatively impacting agricultural production, particularly vulnerable smallholder farmers. Smallholder systems heterogeneity requires local specific climate adaptation for reducing the negative impacts of changing climate in regions heavily relying on small farms agriculture. This study examined the trend in climate in Ghana, how smallholder horticultural farmers perceive this changing climate and how they are responding to its perceived effects. A survey of 480 resource-constrained horticultural producers was conducted in two municipalities of Ghana. Descriptive analysis and Weighted Average Index were employed to rank identified adaptation strategies and challenges. The results showed that farmers are already experiencing increasing temperature and declining rainfall patterns consistent with trends of observed climate changing in the last two decades. To reduce vulnerability and improve resilience of smallholders' production activities, a range of farmer driven soil, water and crop conservation measures and farm management practices are being adopted. The most important adaptation practices identified include fertilization, supplementary irrigation, crop rotation, intercropping and mixed farming. Enhancing households' climate adaptive capacity is dependent on factors such as improved access to financial resources, climate and production information, market accessibility, farm equipment, storage facilities and other institutional support. To facilitate effective and successful adaptation at the local level, government and institutional support are recommended to complement households' autonomous strategies for improved decision-making, adaptation plans and actions.

1. Introduction

Consequences of changing climate such as reduced availability of water resources, declining soil quality and increased frequency of pest and diseases have resulted in significant changes in conditions negatively affecting agricultural production (Enete and Amusa, 2016). Climate adaptation in agriculture is recognized as an essential intervention to reduce vulnerability and negative impacts from changing climate (Tambo and Abdoulaye, 2013). In the past few decades, the need for urgent actions to adapt to this changing climate and its impacts has become a subject of many climate related discussions globally, with emphasis on strengthening resilience

* Corresponding author at: Climate System Analysis Group, Environmental and Geographical Science Department, University of Cape Town, Rondebosch 7700, South Africa.
E-mail address: adadeposh@gmail.com (P.A. Williams).

https://doi.org/10.1016/j.crm.2018.12.004
Received 21 September 2018; Received in revised form 3 December 2018; Accepted 15 December 2018
Available online 17 December 2018

and adaptive capacity to climate risks and natural disasters (Holzkämper, 2017). Even though climate adaptation is a global problem, the need for adaptation is considered higher among developing countries where vulnerability is presumably higher (Adger, 2003) and also in the interest of individual farmers who rely on the revenue generated from agricultural production (Holzkämper, 2017). This is especially the case in Africa since the population is highly dependent on rain fed agriculture (the most climate-sensitive sector) and particularly for smallholder farmers as they generally have limited adaptive capacity (Morton, 2007), hence they are considered among those who will suffer most from the impacts of climate change (Easterling et al., 2007). Agricultural production is a source of livelihood for many Africans especially the resource constrained in rural communities (Bryan et al., 2009). According to Douxchamps et al. (2016), given threats posed by climate change in the future, adapting to changing climate would improve food security status of households, reduce climate vulnerability and have a positive significant impact on land productivity ensuring sustained production.

Studies have shown that various adaptation strategies exist (Boko et al., 2007) and that, farming systems in sub-Saharan Africa adapt in various ways to both short-term variations and longer-term changes in the physical, climatic and socio-economic environment (Challinor et al., 2007). However, the extent to which a system need to adapt is a function of its vulnerability to climate which is influenced by its level of exposure and sensitivity to the climate impacts (Elum et al., 2017). Furthermore, adaptation strategies are argued to be context specific and change over time, from location to location and for particular production systems (Smit and Wandel, 2006; Adger, 2003). Additionally, a study by Douxchamps et al. (2016) showed that there are no one-size-fits-all solutions and that for different smallholder farmers different adaptation strategies would be plausible. Given threats posed by changing climate in the future with an estimated 250 million people in Africa projected to be exposed to greater risk of water stress by 2020 (IPCC, 2007) as well as high confidence of agricultural production and food security in many African countries been severely compromised by climate variability and change (Boko et al., 2007), adaptation in smallholder farming systems is necessary to enhance climate adaptation practices among farmers for sustainable livelihoods. In relation to this, understanding current effects and responses to climate variability and change in specific sectors and subsectors would enable identification of effective adaptation strategies.

With growing interest in adaptation studies, most research efforts on farmers' adaptation to climate variability and change more generally have focused on major food crops such as cereals as well as root and tubers with introduction of numerous improved crop varieties which are resistant to droughts and/or early maturing varieties (Paavola, 2008). Development of similar crop varieties for other common subsectors such as horticultural crops is less developed (Malhotra, 2017) and adaptation of horticultural farmers to changing climate is under represented in literature (Williams et al., 2018b). Meanwhile, developing countries including African countries account for 98% of the production of fruit imports in developed countries and predominantly produced by smallholders (Sthapit et al., 2012). Horticultural production has the potential to grow further, as there is increased consumption of more fruits and vegetables globally rising from increasing interest in health conscious nutritional trends stemming steady demand for tropical fruits and vegetables (Sthapit et al., 2012). Small-scale producers of fruits and vegetables in Africa are however already faced with the impacts of changing climate. For instance, horticultural farmers in Uganda reported reduced yields and increased pest and disease outbreaks as a result of prolonged drought and hot temperature (Mugambwa, 2014). In Mozambique, tomato producers indicated significant impacts of climate stresses such as floods, extreme rainfall and temperatures on their livelihoods and crop growth (Vilissa, 2016). In Ghana, high rainfall variation coupled with increased temperatures were reported to lower tomato yields (Guodaar, 2015) while a study by Williams et al. (2017) revealed that climate variability impacts on the quality and quantity of pineapple production, highlighting the need for further research to explore adaptation options in response to challenging climatic conditions within the subsector.

Ghana like many African countries, have conducted numerous studies addressing climate adaptation strategies at different locations and within different farming systems (Westerhoff and Smit, 2009; Codjoe and Owusu, 2011; Antwi-Agyei, 2012; Asante and Amuakwa-Mensah, 2015). The country is vulnerable to the impacts of climate variability and change with evidence attesting to exposures and sensitivities on different people and places (Bawakyillenuo et al., 2014). Climatic variations resulting in increasing temperature, drought and flood events in the last four decades have also been reported (Asante et al., 2015). Cropping systems in Ghana are highly diverse and widespread (Srivastava et al., 2016) reflecting need for dynamic and context specific adaptations strategies applicable to the different cropping subsector systems and production areas especially horticultural production where studies are limited for improved implementation potential. Given that, in the Ghanaian economy, horticultural production is a significant source of income for smallholder producers by providing households with employment opportunities at the farm level (Abdulai et al., 2017), it is important to enhance resilience to adverse climatic effects and for effective adaptation policies among smallholder horticultural households. Investigation into identification of adaptation options suited to smallholder horticultural producers has also been recently recommended (Williams et al., 2018a). In relation to this, our study aims at assessing how smallholder horticultural farmers in two distinct horticultural producing areas (Keta and Nsawam Adoagyiri municipalities of Ghana) are responding to changing climate. We further explore trends in climate parameters, perceived changes and its effects on livelihoods and finally assess constraints in implementing adaptation measures to enhance smallholder climate adaptation and reduce vulnerability.

2. Theoretical overview and definition of climate adaptation

Diverse responses to the effects of climate variability and change by farmers exist in the literature. Two fundamental categorizations of these responses have been recently reviewed by (Vincent et al., 2013) and (Holzkämper, 2017). According to Vincent et al. (2013), responses to past climate variability and change are divided into coping and adaptation; while coping is used to refer to short-term mechanisms to ensure survival, adaptation refers to longer-term shifts in behavior and practices, which reduces underlying vulnerability. Holzkämper (2017) also indicated that, responses to climate variability could be distinguished into short-term incremental responses that farmers often choose autonomously in response to observed changes based on local knowledge and experiences, as well as long-term transformative responses that require strategic planning usually implemented at a larger spatial scale. While short-term responses help to improve management efficiency within existing technological, governance, and value systems, long-term responses involve alteration of the fundamental attributes of production systems to be considered transformative (Holzkämper, 2017). Vincent et al. (2013) specified that, while adaptation addresses the reduction of negative effects of changing climate, determining whether or not observed strategies are examples of coping or adaptation is dependent on context of observation and scale of interest. Importantly, farmers in preparation for upcoming seasons are observed to use both coping and adaptation strategies noting both terms are used interchangeably in adaptation studies (Nelson et al., 2008). Further emphasizing the challenge of separating the two concepts, Brockhaus, Djoudi and Locatelli (2013) indicates that, the definition of adaptation strategies is not definitively differentiated from coping strategies. Morton (2007) argued that, coping strategies could become adaptations for households or whole communities in exceptional years.

IPCC defines adaptation as “adjustments made in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC, 2014). Climate adaptation is also seen as a means of strengthening resilience of individuals and systems to climate variability and change (Elum et al., 2017). Some authors argue that, adaptation is progressive and that transformational adaptation happens when incremental adaptation is inadequate (Rickards and Howden, 2012). Smit and Wandel (2006) also view adaptation as anticipatory, concurrent or reactive based on timing in addition to degree of spontaneity be it autonomous or planned.

Multiple autonomous adaptation strategies adopted by different farming households across Africa have been identified (Deressa et al., 2009; Gbetibouo and Ringler, 2009; Below et al., 2010). Based on practices related to farm financial management, diversification of farm and off-farm activities, farm management and technology practice and knowledge management among others. Below et al. (2010) identified over one hundred adaptation practices used by farmers in Africa. Some measures such as increased water conservation and tree planting were peculiar to certain geographical regions (such as Southern Africa) and context (such as variation in temperature and precipitation) while others for instance adopting new crop varieties and livelihood diversification were observed across the whole continent (Tambo and Abdoulaye, 2013). According to Deressa, et al. (2011), adaptation at farm-level involves two stages; perceiving change in climate, and which adaptation strategy to choose implying farmers perceptions are important for the uptake of available adaptation options. Research has revealed that, farmers’ ability to adapt to changing climate depends on factors such as economic resources, infrastructure, access to information, social capital, agro-ecological settings and access to land (Bawakyillenuo et al., 2014). From sustainable livelihood and resilience literature stance, ability of households to adapt to stressors such as climate variability, influences the extent to which they are vulnerable or can be harmed (Paavola, 2008). As climate adaptation has been used to tackle developmental support issues (Ziervogel and Parnell, 2014), tracing constraints limiting the uptake of adaptation measures by smallholder farmers would broaden understanding of climate adaptation and resilient agricultural development for sustained and improved production. With the myriad of existing adaptation measures this study therefore focused on varied autonomous adaptation strategies mostly used by smallholder farmers in two horticultural producing areas to show whether the two areas differ in the application of adaptation strategies. The interest of this paper however, is to explore how farmers’ independently respond to the negative effects of past or current climatic variation. Consequently, for the context of our study (on climate vulnerability of agricultural production), we denote farmers’ reaction to effects of climate variability as autonomous adaptation strategies adopted to reduce negative climatic effect on their production activities.

3. Methodology

3.1. Study area

The study was conducted in two of the major horticultural producing areas in Ghana. These were Keta and Nsawam Adoagyiri Municipalities in the Volta and Eastern Regions of Ghana respectively (Fig. 1). Keta is a coastal area within the coastal savannah agro-ecological zone while Nsawam is inland within the forest deciduous agro-ecological zone. Both municipalities were selected because they are both considered to be undergoing changing climate. Nsawam has been experiencing decreasing precipitation pattern with increasing temperature (Williams et al., 2017) whereas Keta, as a coastal community, is particularly sensitive to changing climate associated with temperature and precipitation (GSS, 2014a). Keta’s total annual rainfall ranges from 800 mm to 1000 mm per annum and mean annual temperature ranges from 19 °C to 29 °C (GSS, 2014a). Nsawam on the other hand, receives a total annual rainfall of 1250 mm–2000 mm per annum with the mean annual temperature ranging from 26 °C to 30 °C (GSS, 2014b). Both municipalities are major horticultural crops producers, growing crops including okro, tomato, pepper, onions, spring onions, carrots, shallots cabbage, pineapple and watermelon.

3.2. Data collection

The study employed both primary and secondary sources of data. Primary data was collected through a survey of 480 smallholder horticultural households (240 from each municipality) conducted in October and November 2017. Multi-stage sampling approach was employed in the selection of study respondents. In consultation with local stakeholders, the initial stage was the purposive selection of four key agricultural operational areas within each municipality. In consultation with the Agricultural Extension Agents (AEAs) three communities were selected randomly within an operational area. In each community, approximately 20 household

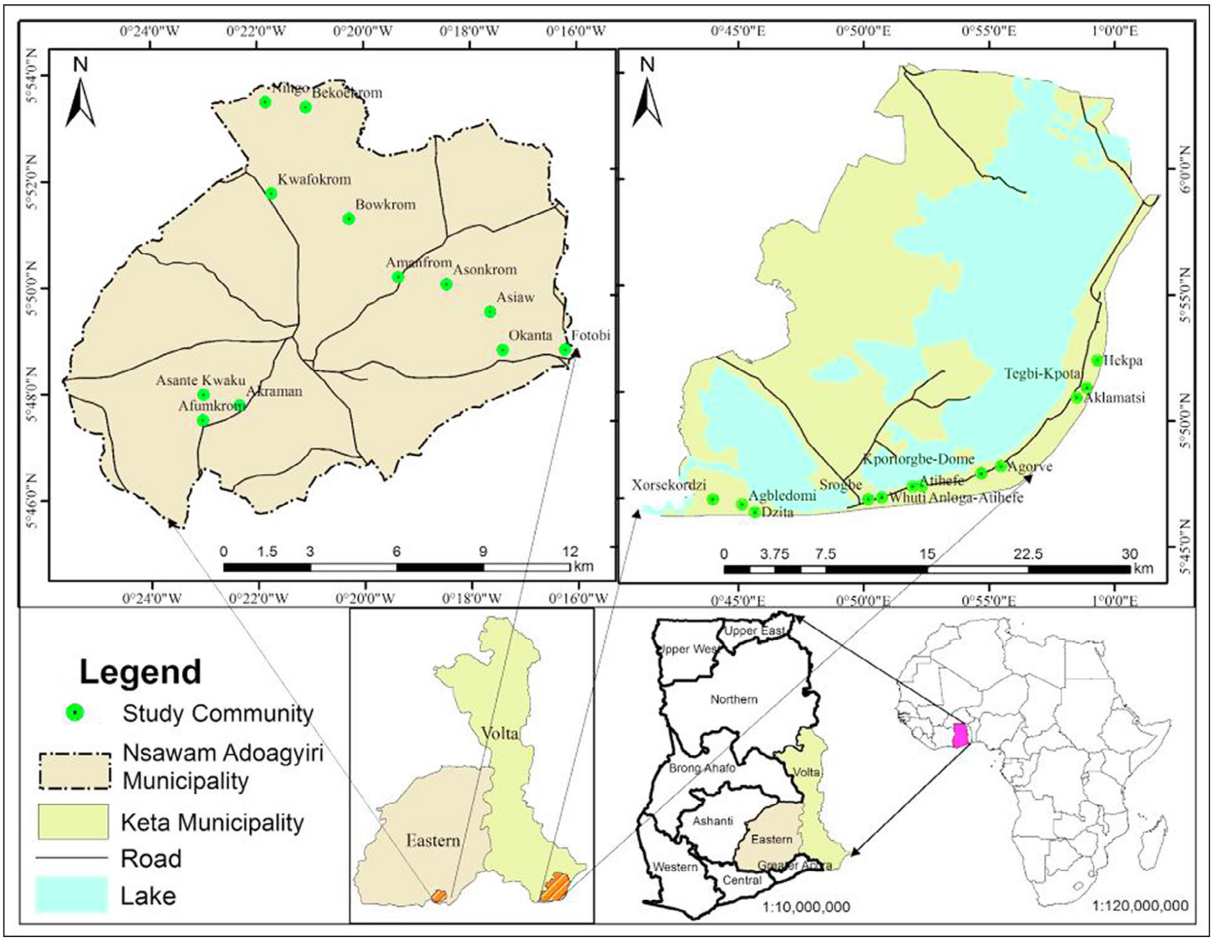

Fig. 1. Map of the study areas, Keta and Nsawam municipalities of Ghana.

heads were selected randomly and interviewed (depending on availability and willingness of household heads to respond to survey). Two Focus Group Discussions (FGDs) were conducted in each municipality. The FGD was from a maximum of ten respondents purposively selected from members of cooperative farmers association with thorough knowledge and experiences on climate and horticulture production in Ghana. Hence, the survey consisted application of structured questionnaires and Focus Group Discussions (FGDs). The questionnaire interrogated climate variability exposure and perceived related impacts on respondents' livelihoods and household, level of respondents' application of a range of adaptation strategies and challenges in implementing those strategies based on their experiences of the past 10 years. The FGDs further explored perceptions about evidences of climate variability and households' adaptive capacity for in-depth information. Literature review combined with stakeholder consultations formed the basis of identification of adaptation strategies used by smallholder farmers in responding to climate related events (mainly droughts and floods). These were then complemented with two focus group discussions at the community level from each municipality with about ten farmer representatives. Secondary data on daily rainfall and mean temperature were collected from the Ghana Meteorological Agency (Gmet) for the closest meteorological station in each municipality (1996–2016).

3.3. Data analysis

We computed total annual rainfall and mean annual temperatures from the daily rainfall and temperature data collected for each municipality. A linear model was fitted to determine the trend of change over the 20-year period (1996–2016). Descriptive analysis was done using frequencies to describe farmers' perception about changing climate and impacts on their livelihoods. Responses and views from the FGDs were analyzed employing content analysis to complement information on changing climate and households' adaptive capacity. Using a likert scale, respondents ranked their frequency of utilization of selected adaptation strategies (0 for never to 4 for often) and their degree of importance of implementation (1 for low and 5 for high). Frequency (F) and importance (W) of each adaptation strategies serve to compute a Weighted Average Index (WAI). The same process was repeated for estimating households' challenges in responding to changing climate. A Weighted Average Index (WAI) was then estimated using Eq. (1) as employed by other authors (Ndamani and Watanabe, 2015; Uddin et al., 2014) to assess farmers important adaptation strategies and challenges to

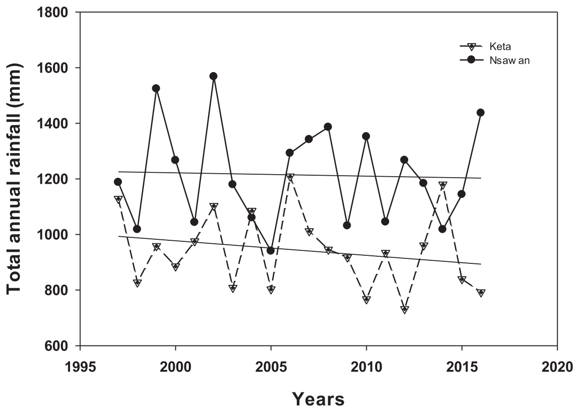

Fig. 2. Total annual rainfall for the study areas.

adaptation.

$$WAI = \frac{\Sigma FiWi}{\Sigma Fi} \quad (1)$$

where F is the frequency of adaptation response/challenge, W is the weight of each score and i is the score. We employed a non-parametric Mann-Whitney U Test to identify the differences in relation to the selection of adaptation strategies and challenges between the two municipalities. The study regarded the first five adaptation strategies ranked as the most important measures utilized by the smallholder farmers and the first two challenges ranked highest as the most crucial challenges hindering farmers response to changing climate.

4. Results

4.1. Households perceptions and trends in climate

Observed total annual rainfall and mean annual temperature for the two study municipalities of Ghana for the period 1997–2016 are shown in Fig. 2 and Fig. 3 respectively. Total annual rainfall for the two municipalities ranged from 730 mm to 1560 mm (Fig. 2). The wettest municipality was Nsawam, which recorded the highest rainfall of 1560 mm in the year 2002. The least rainfall of 730 mm during the study period was recorded in 2012 at Keta, the driest municipality. Both municipalities showed a decreasing rainfall trend of 5.4 mm/year and 1.2 mm/year trends for Keta and Nsawam respectively.

Mean annual temperature during the period 1997 to 2016 varied from 27.4 °C to 28.8 °C across the two municipalities (Fig. 3). An increasing trend showing warming was observed in both study areas at a rate of 0.03 °C/year and 0.02 °C/year for Keta and Nsawam municipalities respectively. The lowest mean annual temperature was recorded in 1997 in Nsawam Adoagyiri municipality (27.4 °C) and the highest mean annual temperature was recorded in 2016 in Keta municipality (28.8 °C).

Smallholder horticultural farmers also mainly experienced climatic changes in the past 10 years (Table 1). Almost all farmers in Keta (100.0%) and Nsawam (99.0%) perceived an increase in temperature. Majority of the farmers also perceived mainly a decrease in rainfall duration and quantity over the period. Few of the farmers perceived a moderate increase in rainfall duration (33.0%)

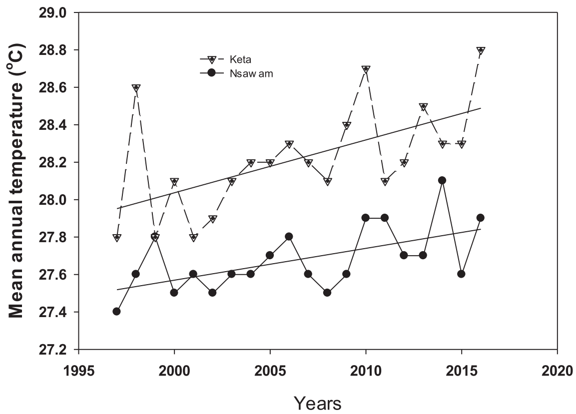

Fig. 3. Mean annual temperature for the study areas.

Table 1
Perception of changing climate parameters.

Climate parameter	Degree of increase (%)									
	Large increase		Moderate increase		Constant		Moderate decrease		Large decrease	
	K	N	K	N	K	N	K	N	K	N
Temperature	65	62	35	37	0	0	0	1	0	0
Rainfall duration	0	5	4	11	0	2	50	61	46	22
Rainfall quantity	0	4	3	22	0	1	50	54	46	20
Drought	57	55	38	38	4	5	1	2	0	0
Flood volume	2	1	35	30	13	23	49	42	2	4
Flood damage to farmlands	2	2	30	37	17	20	59	36	2	4
Availability of water sources	18	0	51	12	7	28	19	54	6	6

K = Keta; N = Nsawam.

especially for Nsawam. The perception of rainfall reduction is often related to the perceived increase in drought occurrence with 95.0% of responses in Keta and 93% in Nsawam agreeing to this. Perception of flooding in terms of volume and damage to farmlands was mostly mixed, with marginal majority perceiving decrease. Few of the farmers were indifferent (constant) about changes in flood occurrence. Two-thirds of respondents in Keta perceive that, water sources for production activities has increased, unlike farmers in Nsawam whom mostly perceived decrease. Generally, farmers perceived patterns of rainfall and temperature change shows farmers are conscious of the changing climate.

4.2. Perceived impacts and response strategies of changing climate on farmers' livelihoods

4.2.1. Perceived impacts

Smallholder horticultural farmers' production activities mainly depend on climate. Changing climate impacts on their livelihoods and as shown in Fig. 4, mostly affects the quality of horticultural farmer's produce, outputs, yield losses after harvesting and overall net revenue. Majority of the farmers in both municipalities strongly agreed to climate having such impacts on their livelihoods. Focus Group Discussions with farmers' highlighted evidences of climate variability such as erratic rainfall pattern usually unpredictable and increasing temperature affecting various crop growth stages and resulting in yield losses and poor quality produce. This subsequently increases losses after harvesting reducing farmer's revenue. According to the farmers, shorter rainfall duration, droughts, coastal erosion and floods exacerbate such impacts. The FGDs further highlighted that horticultural farmers in both study areas are already experiencing the impacts from changing climate. According to the farmers, increasing temperature and variation in rainfall quantity and duration result in dehydration, leaf scorches, increase in pest and diseases, variation in fruit maturity and abnormal fruit set with occasional fruit set failure for most horticultural crops which negatively affects productivity. Even at maturity, farmers mentioned that, water stress and high temperatures cause fruit cracking and sunburns with high post harvest losses.

Such impacts were noted to affect farmers overall productivity.

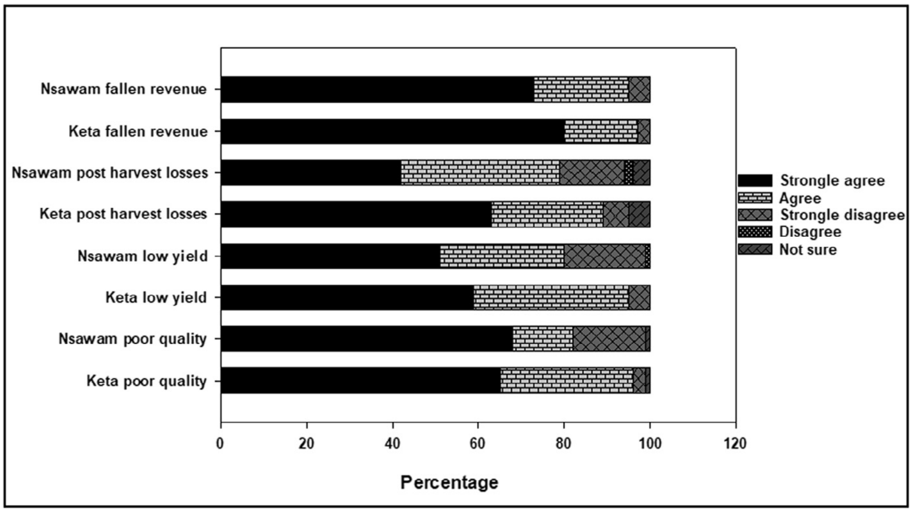

Fig. 4. Famers' perception of climate impact on livelihood.

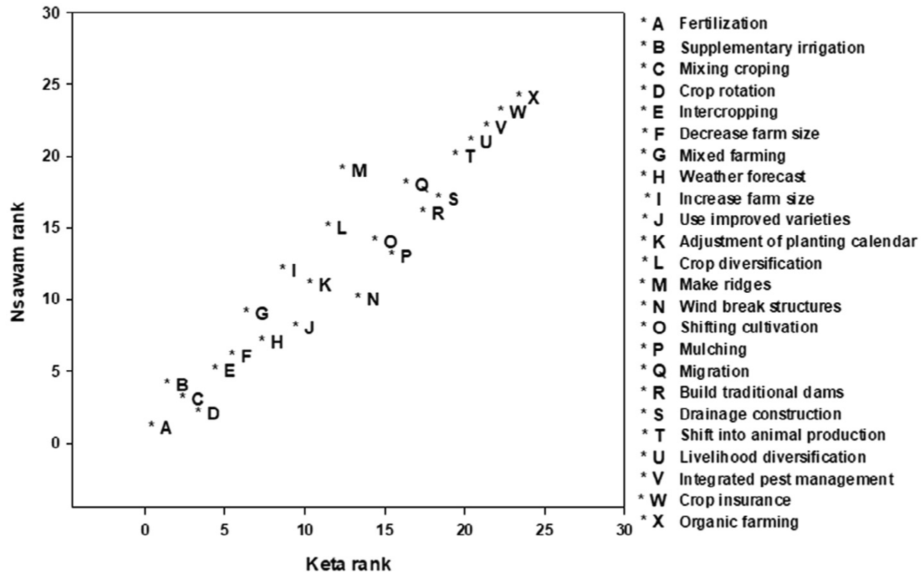

Fig. 5. Adaptation strategies of households in Keta and Nsawam Adoagyiri municipalities.

4.2.2. Households' response strategies

The study identified and ranked adaptation practices employed by farming households to reduce their vulnerability to changes in climate and increase their resilience. These measures were based on households' local knowledge and perception of changing climate. Ranking results from strategies utilized by smallholder horticultural farmers in Keta municipality revealed that, the first five most important adaptation practices at the local level included fertilization, supplementary irrigation, mixed cropping, crop rotation and intercropping (Fig. 5) in descending order of importance. The ranking results for Nsawam's practices also showed fertilization as the first highest ranked and important adaptation practices. This was same for Keta. During discussions with farmers, it was mentioned that, poor soil conditions at Keta (mostly sandy with low soil fertility) and continuous cropping on the same piece of land in Nsawam render soils infertile and resulted in both municipalities ranking fertilization as the most important adaptation strategy. Contrary to Keta, fertilization was followed by crop rotation, mixed cropping, supplementary irrigation and intercropping in descending order of importance. It was observed that, farms in Keta mostly used underground water (boreholes) sources and traditional wells on farmlands for irrigation even though they suffered from high salinity during dry periods. Farmers in Nsawam during the FGDs explained that, as much as irrigation is critical for horticultural production by conserving soil moisture and allowing for year-round production, most water sources within the municipality (small rivers and boreholes) lately dries up regularly causing water stress during crop growth hence their resort to crop rotation as second best practice. At Nsawam, rotating deep and shallow rooted crops were noted to improve soil stability and promote efficient use of soil moisture, which is highly preferable to irrigation. The least ranked and utilized practices for Keta were organic farming, crop insurance, Integrated Pest Management (IPM), livelihood diversification and animal production. Relating the least important practices in Keta to Nsawam, the same practices were also consistently ranked as the least important household practices in responding to changing climate. Other adaptation practices are shown in Fig. 5. Decreasing farm size, use of improved varieties, adjustment in planting calendar, provision of windbreaks, increasing farm size, mulching shifting cultivation and seasonal migration are moderately implemented by households. These responses constitute crop, soil, water and farm management responses to changes such as increasing temperature, and rainfall variation including droughts and coastal. Importantly, all the adaptation practices identified were autonomous and practiced at the local level. The farmers facilitated them personally by expending their own social capital and resources.

The Mann-Whitney U Test revealed no significant difference in the smallholder farmers ranking of the identified practices ($U = 273$, $Z = -1.23$, p-value = 0.234). This indicates the same level of importance given to the adaptation strategies and is common to farmers from the two municipalities. The ranks did not differ significantly for the smallholder farmers' overall rankings across the two study areas.

4.3. Households' challenges in responding to changing climate

Factors constraining the adaptive capacity of smallholder horticultural farmers in both study areas are summarized in Table 2. Using the Weighted Average Index (WAI), inadequate financial resources and high implementation cost, were ranked as the most critical challenges facing smallholder horticultural producers in adapting to changing climate in both study areas. Insufficient financial resources prevent farmers from adequately adapting to changing climate. In Keta for instance, farmers during discussions noted that, because of poor soil conditions and high salinity of water for irrigation during water stress periods, fertilization which enhances nutrient availability for plant growth would need to be modified and regularly applied but requires more capital investment

Table 2
Factors constraining adaptive capacity of smallholder horticultural farmers.

Constraints	Keta		Constraints	Nsawam	
	WAI	Rank		WAI	Rank
Inadequate financial resources	4.66	1	Inadequate financial resources	4.33	1
High implementation cost	4.23	2	High implementation cost	4.13	2
Inadequate storage facilities	3.96	3	Inadequate storage facilities	3.95	3
Inadequate access to market	3.90	4	Inadequate access to market	3.38	4
Lack of climate information	3.03	5	Lack of farm equipment	3.30	5
Inadequate production information	2.78	6	Lack of climate information	3.28	6
Lack of farm equipment	2.75	7	Inadequate production information	2.98	7
Poor institutional support	2.70	8	Poor institutional support	2.95	8
Poor extension services	2.60	9	Poor extension services	1.75	9
Land tenure issues	1.52	10	Land tenure issues	1.71	10
Socio-cultural issues	1.30	11	Socio-cultural issues	1.28	11
Mann-Whitney Test statistics					
Mann-Whitney U	58				
N	11				
Z	−0.164				
P-value	0.870				

which they do not have the capacity to do. Also, high cost of acquiring some adaptation strategies, also deter farmers from implementing them. In Nsawam municipality, even though there exist other water sources, which could still be used during water stress periods, distance of farmlands to such water sources would require high capital investment for irrigation infrastructure of which farmers are limited.

With WAI of less than 2.0, land tenure and socio-cultural issues ranked as the least constraints hindering adaptation in both municipalities. Inadequate storage facilities and market accessibility, climate and production information, lack of farm equipment and institutional support were considered moderately constraining climate adaptation of smallholders'. In terms of differences in ranking, lack of farm equipment was ranked fifth in Nsawam while it ranked seventh in Keta. Access to climate information was fifth in Keta but sixth in Nsawam. Inadequate production information was also considered sixth in Keta but seventh in Nsawam. Overall, a Mann-Whitney U Test showed no significant difference in smallholder farmers' ranking of the challenges in responding to changing climate (Table 2) implying common challenges and same level of importance found across both municipalities.

5. Discussion

5.1. Climate and horticultural crop production

Smallholder horticultural farmers in the two study municipalities of Ghana have observed climatic changes with consequences on their production activities especially with regards to temperature and rainfall parameter changes. The predominant climate related factors for crop production are temperature and rainfall (Neenu et al., 2013). Trends in observed climate data were consistent with farmers' perception about changing climate indicating a rise in temperature and declining total rainfall over the study period. Such trends overtime would have detrimental effects on horticultural production in both municipalities corroborating the fact that, risk in crop production increases as climate parameters become highly unreliable (Winkler et al., 2013).

Increasing temperature coupled with decreasing rainfall trend observed in both municipalities could further result in increased evapotranspiration and water stress affecting soil water and irrigation water availability. Additionally, water stress increases salt concentration in the soil affecting loss of water from plant cells (Pena and Hughes, 2007). Such conditions lead to increased water loss in plant cells and inhibition of processes such as photosynthesis and respiration thereby reducing productivity of most horticultural crops (Pena and Hughes, 2007; Abewoy, 2018). This is especially critical for households in Keta, which is a coastal area where elevated soil salinity during dry periods is already a general concern. Reports of reduction in crop growth, wilting and poor quality fruits were particular. However, even though farming situations for Nsawam Municipality (an in-land area) seem relatively more favorable (receives relatively higher rainfall, lower temperature and more fertile soils) than Keta, it is equally faced with increasing temperature trend and decreasing trend in total rainfall which would aggravate in future. This could challenge sustainable and increased production among smallholders. As a result, measures to sustain farmers' livelihoods in both municipalities are important as they are already faced with negative climatic impacts. While households are conscious about occurrence of climatic variation and changes, efforts on adaptation need to be enhanced to build resilient farming communities and minimize the adverse impacts of climate. Farmers consider horticultural production as a capital-intensive agricultural activity. Horticulture generally is in a development phase and requires initiatives for sustainable development (Malhotra, 2017). With climate variation having consequences on water availability and soil quality and subsequently influencing year-to-year agricultural production, there is need for improved adaptation actions. Adoption of effective adaptation practices would reduce vulnerability and improve resilience of households to adverse effects from climatic changes.

5.2. Households' adaptation responses

Agricultural crop production is primarily determined by factors such as soil moisture, temperature and soil fertility (Malhotra, 2017) which changing climate is expected to alter and subsequently influence productivity. Adoption of efficient and effective practices would therefore improve farmer's resilience to sustain and improve production. All practices identified in this study as adaptive responses utilized to respond to changing climate, reflect autonomous practices, which are independently farmer-led strategies (based on their experience, climate perception and local knowledge) and intended to reduce climate vulnerability and increase resilience of farmers. Practicing fertilization (both organic and inorganic), which enhances nutrient availability and improves soil fertility was the most important to horticultural household for both study municipalities. Changing climatic conditions reduces soil fertility which resulted in fertilization been the most important adaptation measure to the farmers. As a soil conservation practice, fertilization has also been observed as an important practice across studies in other African countries such as Ethiopia (Abewoy, 2018), Senegal (Mertz et al., 2009) and other parts of Ghana (Fosu-Mensah et al., 2012). The top crop management practices that is, crop rotation, mixed cropping and intercropping identified are mainly to improve soil and water use efficiency, enhance nutrient uptake and buffer against losses in an unfavorable season.

Even though other farm production strategies such as crop diversification and changing planting date are common practices observed among other food crop producers in Africa (Belay et al., 2017; Ndamani and Watanabe, 2015, Farauta et al., 2011), market availability for crops produced is an important factor that informed farmers' choice of crops grown in a season together with irrigation facilities hence not promptly considered as critical adaptation measures for horticultural production. In cases of extreme variability at the beginning of the production season, farmers rather relied on weather forecast and this practice was observed to be improving in both municipalities. This is due to a mobile weather forecast services introduced by a telecommunication agency where regular forecast updates are sent directly to farmers on their mobile phones. With the interest shown by farmers on the usefulness of this service, improved awareness should be created for greater adoption. Other adaptation practices such as decreasing farm size, use of improved varieties, adjustment in planting calendar, provision of wind breaks, increasing farm size, mulching, shifting cultivation and seasonal migration were sometimes reportedly utilized in both municipalities to respond to climatic variation. These measures are mainly soil, water and crop conservation techniques as well as farm management practices that provide efficient use of natural resources and make farmers less sensitive to climatic changes. Unlike the horticultural producers context, these practices has been reported in findings of other studies as the highest ranked and utilized adaption strategy in food crop productions (Alam et al., 2017; Belay et al., 2017; Ndamani and Watanabe, 2015) concurring to the context specificity of adaptation studies in climate adaptation scholarship. Ridges and drainage construction, seasonal migration, building farm dams, crop diversification and shifting cultivation were seldom utilized to reduce impacts of climate variability especially excessive weather conditions such as instances of heavy rainfall. These practices are not proactively utilized as they are also considered capital, technology and other resources intensive. Technological adaptations for example are generally developed through research programs undertaken or government sponsored and also through Research and Development programs (Smit and Skinner, 2002) hence it is not surprising such practices are currently not common among horticultural smallholders and the rate of utilization is consistently low in both municipalities. This indicates the need for government programmes and policies as well as other institutional responses to adequately support smallholder farmers improve their responses to climate adaptation.

5.3. Enhancing households' adaptive capacity

Despite diverse climate adaptation measures existing in the study areas, it was revealed that, horticultural smallholders' were constrained and limited in their capacity to practice the identified adaptation strategies to its full potential. Generally, smallholder farmers are financially constrained which farmers considered as a major limitation to their implementation potential. Limited financial resources together with high implementation cost amidst capital-intensive horticultural production among resource constrained smallholder farmers therefore are critical and associated with thwarting sustainable and increased production. To this end and at the local level, assessing the effectiveness of identified practices to guide and enhance farmers' decision making on likely options to invest in and implement given their limited resources is essential. Addai (2013), notes that, farm businesses devote their resources toward the more pressing appropriate response to climate and market opportunities. Also, adaptation at the local level is considered as the result of individual decisions influenced by forces, particularly internal to the farm household, for example, risk of income loss (Smit and Skinner, 2002). Since adaptation comes with some costs and benefits, economic analysis which aims to understand and inform financial trade-offs in the efficient allocation of scarce resources amongst competing demands (Wise and Capon, 2016) would therefore improve decision support and enhance adaptation of smallholder production systems to changing climate. Additionally, support for improved access to sufficient financial resources through government subsidies and services to enable smallholder farmers' adequately obtain both production and adaptation facilities is needed. Furthermore, identifying more affordable and cost effective techniques for implementation could improve financial challenges faced by farmers. This resonates the need to economically assess adaptation strategies to guide decision making for implementation.

Besides financial capacity related challenges, inadequate storage facilities and limited market accessibility were major constraints in responding to climate variability. Horticultural crops are highly perishable and farmers during discussions noted that, increasing their production outputs as a result of adapting to changing climate would subsequently result in high post harvest losses because of limited storage facilities and market accessibility. This implies that, market accessibility and storage facilities could either trigger or hinder successful adaptation at the local level and needs to be improved. Other challenges identified such as inadequate climate and production information, farm equipment, institutional services including extension services, land tenure and sociocultural issues are in line with past studies in Africa where similar factors inhibited adaptation of smallholders to changing climate (Bryan et al., 2009; Deressa et al., 2009). Climate and production information as well as extension services increase awareness on vital adaptation information that would enhance households' production and climate adaptive capacity. Regular access to adequate climate information enables decision makers including farmers and even policy makers determine their intent, timing and direction for any climate adaptation plans and actions to be implemented as indicated by other scholars (Elum et al., 2017; Alam et al., 2017). Therefore up-to-date information should be improved for more informed decision-making on adaptation actions. Lack of farm equipment for example irrigation facilities is associated with limited technological development. Farm equipment was considered as a higher factor in Nsawam compared to Keta. Keta as a coastal area has a relatively higher water table. However, majority of irrigation water sources especially in Nsawam is from dug shallow (about 10 to15 meters deep) ponds and wells and with declining water tables hence reduced water accessibility. There is need for much deeper reach of underground water to maintain irrigation for production activities, which requires technological advancement. Lack of equipment to address this problem limits farmers from realizing the full potential from irrigation. Government intervention is required to support farmers to improve such measure at the local level. Finally, since adaptation strategies such as shifting cultivation and increasing farm size that requires more farmland were seldom practiced in both study areas, shortage of farmland and its associated land tenure and ownership agreement issues as well as other related sociocultural issues were considered least constraints in limiting climate adaptation in the study areas. This finding is contrary to studies in other contexts such as horticultural farmers in South Africa (Elum et al., 2017) and food crops in Northern Ghana (Ndamani and Watanabe, 2015) where such factors were considered crucial to climate adaptation.

6. Conclusion

This study presented climate adaptation strategies practiced at the local level using evidence from smallholder horticultural farmers in two municipalities of Ghana. The study revealed an increasing temperature and decreasing rainfall trends in the past two decades for observed climate data in the study areas. The observed data concurred farmers' perceptions and experiences about climatic trends, which has consequences for production activities. As a market-oriented horticultural production activity, households' perceived impacts such as poor quality produce, yield losses, post harvest losses and declined net revenue from climatic stress on their livelihoods. In the local context studied, the increasing temperature and decreasing rainfall trends guided the adoption of practices such as fertilization, supplementary irrigation, crop rotation, mixed cropping and intercropping as the most important and common adaptation strategies subsequently employed in response to the changing climate. Additionally, farmers also utilized a range of other soil, water and crop conservation measures as well as farm management practices in minimizing the effects of climate variability during production. With critical challenges related to finances, market, technological and institutional services identified to hinder adaptation, there is need for support to enhance implementation of adaptation strategies at the local level.

To enhance resilience of horticultural producers to climate variability and also sustain and improve production, it is important for smallholders' local level knowledge and actions to be augmented with government and other institutional support for effective and successful adaptation. Despite the various climate response strategies identified based on our findings, this study argues that, climate adaptation with respect to market oriented and capital-intensive horticultural production and particularly resource constrained smallholder farmers need to be improved with adequate policy, institutional, technological and research support. This is based on the scholarship that agricultural adaptation is context specific and requires all climatic, economic, technological, social, and political forces for successful implementation. Particularly for smallholder farmers, we assert that, improving their implementation potential is dependent on their economic resources for financial investment hence assessing the economic effectiveness of identified adaptation strategies is imperative for enhancing adaptation for vulnerable smallholder production systems. Hence research needs to explore the effectiveness of identified adaptation practices to support decision-making by relevant stakeholders (including farmers and policy makers) on efficient allocation of scarce resources. Specifically, economic analysis of strategies identified needs to be conducted to guide decision on adaptation actions. This is important to also enable identification of more affordable and cost effective techniques for implementation to improve financial challenges faced by farmers. Also, with a challenging climate, development of climate resilient horticultural crop varieties for adapting to conditions such as hot and dry environments and tolerance of salt could be emphasized in further research.

Declarations of interest

None.

Acknowledgement

The Organisation of Women in Science for the Developing World (OWSD) Fellowship Programme and Swedish International Development Cooperation Agency (Sida) supported this research study. Interpretation of the findings and conclusion drawn from the study however are the responsibilities of the authors and not on any part of OWSD/Sida.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.crm.2018.12.004.

References

Abdulai, J., Nimoh, F., Darko-Koomson, S., Kassoh, K.F.S., 2017. Performance of vegetable production and marketing in peri-urban Kumasi, Ghana. J. Agric. Sci. 9 (3), 202–218.
Abewoy, D., 2018. Review on impacts of climate change on vegetable production and its management practices. Adv. Crop Sci. Technol. 6 (1), 1–7.
Addai, D., 2013, The economics of adaptation to climate change by broadacre farmers in western Australia, no. January.
Adger, W.N., 2003. Social capital, collective action, and adaptation to climate change. Econ. Geogr. 79 (4), 387–404.
Alam, G.M.M., Alam, K., Mushtaq, S., 2017. Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. Clim. Risk Manage. 17, 52–63.
Antwi-agyei, P., 2012, Vulnerability and adaptation of Ghana' s food production systems and rural livelihoods to climate variability.
Asante, F.A., Amuakwa-Mensah, F., 2015. Climate change and variability in ghana: stocktaking. Climate 3, 78–99.
Bawakyillenuo, S., Yaro, J.A., Teye, J., 2014. Exploring the autonomous adaptation strategies to climate change and climate variability in selected villages in the rural northern savannah zone of Ghana. Local Environ. (October), 1–22.
Belay, A., Recha, J.W., Woldeamanuel, T., Morton, J.F., 2017. Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agric. Food Secur. 6 (1), 24.
Below, T., Artner, A., Siebert, R., Siebert, S., 2010, Microlevel practices to adapt to climate change for African Small-Scale Farmes. IFPRI Discussion Paper 00953, no. February.
Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, R., Yanda, P., 2007. Africa, Climate change 2007: Impacts, adaptation and vulnerability. In: Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., Hanson, C.E. (Eds.), Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Contribution of Working Group II, Cambridge University Press, Cambridge, UK, pp. 433–467.
Brockhaus, M., Djoudi, H., Locatelli, B., 2013. Envisioning the future and learning from the past: adapting to a changing environment in northern Mali. Environ. Sci. Policy 25, 94–106.
Bryan, E., Deressa, T.T., Gbetibouo, G.A., Ringler, C., 2009. Adaptation to climate change in Ethiopia and South Africa: options and constraints. Environ. Sci. Policy 12 (4), 413–426.
Challinor, A., Wheeler, T., Garforth, C., Craufurd, P., Kassam, A., 2007. Assessing the vulnerability of food crop systems in Africa to climate change. Clim. Change 83, 381–399.
Codjoe, S., Owusu, G., 2011. Climate change/variability and food systems: evidence from the Afram Plains, Ghana. Reg. Environ. Change 11 (2), 1113–1130.
Deressa, T.T., Hassan, R.M., Ringler, C., 2011. Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. J. Agric. Sci. 149 (1), 23–31.
Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T., Yesuf, M., 2009. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environ. Change 19 (2), 248–255.
Douxchamps, S., Van Wijk, M.T., Silvestri, S., Moussa, A.S., Quiros, C., Ndour, N.Y.B., Buah, S., Somé, L., Herrero, M., Kristjanson, P., Ouedraogo, M., Thornton, P.K., Van Asten, P., Zougmoré, R., Rufino, M.C., 2016. Linking agricultural adaptation strategies, food security and vulnerability: evidence from West Africa. Reg. Environ. Change 16 (5), 1305–1317.
Easterling, W., Aggarwal, P., Batima, P., Brander, K., Earda, L., Howden, S., 2007. Food, Fibre, and Forest Products. In: Parry, M., Canziani, O., Palutikof, J., van der Linden, P., Hanson, C. (Eds.), Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 273–313.
Elum, Z.A., Modise, D.M., Marr, A., 2017. Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. Clim. Risk Manage. 16, 246–257.
Enete, A.A., Amusa, T.A., 2016. Challenges of Agricultural Adaptation to Climate Change in Nigeria : a Synthesis from the Literature Challenges of Agricultural Adaptation to Climate Change in Nigeria : a Synthesis from the Literature 1, vol. 4, no. December 2010, pp. 0–11.
Farauta, B.K., Idrisa, Y.L., Egbule, C.L. & Agu, V.C., 2011, Farmers' perceptions of climate change and adaptation strategies in Northern Nigeria: an empirical assessment, African Technology Policy Studies Network.
Fosu-Mensah, B., Vlek, P.L.G., MacCarthy, D.S., 2012. Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. Environ. Dev. 14 (4), 495–505.
Gbetibouo, G.A., Ringler, C., 2009, Mapping South African Farming Sector Vulnerability to Climate Change and Variability : A Subnational Assessment, no. December, pp. 2–4.
GSS 2014a, 2010 Population and housing census: Keta municipality-District Analytical Report, Accra-Ghana.
GSS 2014b, 2010 Population and housing census: Nsawam Adoagyiri municipality-District Analytical Report, Accra-Ghana.
Guodaar, L., 2015. Effects of Climate Variability on Tomato Crop Production in the Offinso North District of Ashanti Region. Kwame Nkrumah University of Science and Technology, Kumasi.
Holzkämper, A., 2017. Adapting agricultural production systems to climate change—What's the use of models? Agriculture 7 (10), 86.
IPCC, 2007. Climate change 2007: impacts, adaptation and vulnerability. In: Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., Hanson, C.E. (Eds.), The IPCC's Fourth Assessment Report. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
IPCC, 2014. Working Group II Fact Sheet, Climate Change 2014 : Impacts, Adaptation, and Vulnerability. Climate Change 2014: Impacts, Adaptation, and Vulnerability, vol. 5, no. September 2013, p. 94305.
Malhotra, S.K., 2017. Horticultural crops and climate change: a review. Indian J. Agric. Sci. 87 (1), 12–22.
Mertz, O., Mbow, C., Reenberg, A., Diouf, A., 2009. Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. Environ. Manage. 43 (5), 804–816.
Morton, J.F., 2007. The impact of climate change on smallholder and subsistence agriculture.
Mugambwa, E., 2014. Effects of Climatic Variability on Pineapple Growing in Uganda: A Case Study of Pineapple Growers in Kangulumira Sub-County, Kayunga District. LAP Lambert Academic Publishing, OmniScriptum GmbH & Co. KG.
Ndamani, F., Watanabe, T., 2015. Farmers' perceptions about adaptation practices to climate change and barriers to adaptation: a micro-level study in Ghana. Water (Switzerland) 7 (9), 4593–4604.
Neenu, S., Biswas, A.K., Subba Rao, A., 2013. Impact of climatic factors on crop production – a review. Agric. Rev. 34 (2), 97–106.
Nelson, V., Lamboll, R., Arendse, A., 2008. Climate change adaptation, adaptive capacity and development, DSA-DFID Policy Forum.
Paavola, J., 2008. Livelihoods, vulnerability and adaptation to climate change in Morogoro. Tanzania 11, 642–654.
Pena, R., Hughes, J., 2007. Improving vegetable productivity in a variable changing climate. J. SAT Agric. Res. 4 (1), 1–22.
Rickards, L., Howden, S.M., 2012. Transformational adaptation: agriculture and climate change. Crop Pasture Sci. 63 (3), 240–250.
Smit, B., Skinner, M.W., 2002. Adaptation options in agriculture to climate change: a typology. Mitigation Adapt. Global Change 71992 (UNFCCC), 85–114.
Smit, B., Wandel, J., 2006. Adaptation, adaptive capacity and vulnerability. Global Environ. Change 16, 282–292.
Srivastava, A.K., Mboh, C.M., Zhao, G., Gaiser, T., Ewert, F., 2016. Climate change impact under alternate realizations of climate scenarios on maize yield and biomass in Ghana. Agric. Syst.(March) 0–1.
Sthapit, B., Rao, V.R., Sthapit, S., 2012. Tropical Fruit Tree Species and Climate Change. Bioversity International, New Delhi, India.
Tambo, J.A., Abdoulaye, T., 2013. Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. Reg. Environ. Change 13 (2), 375–388.
Uddin, M., Bokelmann, W., Entsminger, J., 2014. Factors affecting farmers' adaptation strategies to environmental degradation and climate change effects: a farm level study in Bangladesh. Climate 2 (4), 223–241.
Vilissa, D.J., 2016. Vulnerability of Horticulture Producers to Climate Variability. University of Cape Town, South Africa.
Vincent, K., Cull, T., Chanika, D., Hamazakaza, P., Joubert, A., Macome, E., Mutonhodza-Davies, C., 2013. Farmers' responses to climate variability and change in

southern Africa – is it coping or adaptation? Clim. Dev. 5 (3), 194–205.
Westerhoff, L., Smit, B., 2009. The rains are disappointing us: dynamic vulnerability and adaptation to multiple stressors in the Afram Plains, Ghana. Mitig. Adapt. Strat. Glob. Change 14 (4), 317–337.
Williams, P.A., Crespo, O., Abu, M., 2018a. Assessing vulnerability of horticultural smallholders' to climate variability in Ghana: applying the livelihood vulnerability approach. Environ. Dev. Sustain.
Williams, P.A., Crespo, O., Abu, M., Simpson, N.P., 2018b. A systematic review of how vulnerability of smallholder agricultural systems to changing climate is assessed in Africa. Environ. Res. Lett. 13 (10), 103004.
Williams, P.A., Crespo, O., Atkinson, C.J., Essegbey, G.O., 2017. Impact of climate variability on pineapple production in Ghana. Agric. Food Secur. 6 (1).
Winkler, J.A., Cinderich, A.B., Ddumba, S.D., Doubler, D., Nikolic, J., Perdinan, Pollyea, A.M., Al, E., 2013. Understanding the impacts of climate on perennial crops. Clim. Vulnerability 2, 37–49.
Wise, R.M., Capon, T., 2016. Assessing the costs and benefits of coastal climate adaptation, Gold Coast.
Ziervogel, G., Parnell, S., 2014. Tackling Barriers to Climate Change Adaptation in South African Coastal Cities, pp. 57–73.