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# Using a factor analysis to understand climate adaptation barriers impeding smallholder tomato farmers in the Offinso North District, Ghana

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**Abstract:** Smallholders' adaptation barriers using quantitative techniques are sparse in literature. This study focused on the barriers impeding smallholder tomato farmers' adaptation strategies in the Offinso North District (OND) of Ghana. The analysis was performed using factor analysis and Crombach's Alpha coefficient. A total of 378 smallholder tomato farmers were randomly sampled for a face-to-face interview in the OND of Ghana. Using the quantitative factor analytical approach to analyse farmers' adaptation barriers will help provide a clear direction on the strategic ways of addressing the imperative constraints that hinder tomato growers' adaptive capacity to increase tomato food security in tomato producing communities. From the factor analysis results, the study concludes that personal barriers, institutional and labour barriers, irrigation technology barriers, inadequate credit and farm inputs barriers, cost of land barriers, facility barriers and lack of political will barriers are major barriers that impede tomato farmers' adaptive strategies. Also, the study revealed that age ($P < 0.05$), gender ($P < 0.05$) and marital status ($P < 0.05$) are major determinants that influence the barriers tomato farmers encounter in their adaptive responses to climate variability. The findings point out the need for government and development partners including non-governmental organizations to enhance the adaptive capacities of farmers through the provision

Lawrence Guodaar

## ABOUT THE AUTHOR

We the authors are climate change and variability researchers with specific emphasis on impact and adaptations. We are also interested in employing quantitative methodological approach in understanding the linkages between climate change and food security in a sustained manner in Ghana and Sub-Saharan Africa. We try to understand climate variability adaptation practices aimed at improving the livelihood of rural peasant farmers.

## PUBLIC INTEREST STATEMENT

Tomato provides a good source of micro nutrients and vitamins to majority of people across the globe, especially those in sub-Saharan Africa. However, the production and supply of tomato to both local and foreign consumers have in recent times been threatened by the climate variability phenomenon. Farmers' efforts to employ sound adaptive measures in response to the impact of climate variability on tomatoes have been hampered by myriads of constraints.

In this paper, we advanced the barriers that impede tomato farmers' adaptive measures in the Offinso north district, Ghana, through a factor analysis approach. The understanding of these constraints and their concomitant factors that influence such constraints are very useful in policy implementation towards the advancement of farmers' adaptive capacities to increase tomato production.

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of adequate credit facilities and other farming logistics to build farmers' resilience to increase tomato production in the OND of Ghana.

**Subjects: Development Geography; Human Geography - Research Methods and Techniques; Rural Studies; Environmental Geography**

**Keywords: climate variability; adaptation; barriers; tomato; logistic regression; Offinso North District**

## 1. Introduction

The earth's atmosphere, biosphere, hydrosphere and cryosphere are all under the threat of climate variability (Intergovernmental Panel on Climate Change-IPCC, 2014) and adaptation efforts seem not to be providing adequate responsive solution to the problem due to adaptation constraints that impede successful adaptation of smallholders (Antwi-Agyei, Dougill, & Stringer, 2013). According to the IPCC (2014), climate variability explains the spatio–temporal variation of climatic conditions beyond individual weather events. It is also conceptualized in the context of internal variability that looks at the natural internal processes within the climate system, and the external variability which emphasizes the human-induced external forcings (Intergovernmental Panel on Climate Change-IPCC, 2012) like urbanization, population explosion, deforestation and greenhouse gas (GHG) emissions which have been extensively argued by the international community and other environmental organizations as the major driving forces (IPCC, 2014).

The devastating and precarious climatic system dynamics of the earth is adversely influencing almost all sectors of the economy, especially the agricultural sector (e.g. the crop sub-sector) which provides livelihood opportunities to vast majority of the people and a tool for nation building in most developing economies including those in sub-Saharan Africa (Antwi-Agyei et al., 2013; Guodaar, Asante, & Eshun, 2017b, 2017c). Unreliable rainfall pattern and high temperatures as well as tomato diseases (e.g. tomato yellow leaf curl virus, bacterial wilt, bacterial spot, early blight and tomato mosaic viruses) and adaptive barriers (e.g. financial constraints, pest and diseases etc.) continue to be the major cause of the underproduction of tomatoes in Ghana (Asante et al., 2013; Guodaar, 2015; Guodaar et al., 2017b). Similarly, Beni, Guodaar, Segbefia, Adjei and Ganle (2016) elucidated the role of unfavourable environmental condition (such as unpredicted rainfall pattern) as a major driver of poverty among households in sub-Saharan Africa. The implication is that the persistent increase and fluctuations of climatic variables coupled with adaption barriers have the overwhelming potential to endanger food security, especially tomato which provides vitamins to the human body (Kelley & Boyhan, 2010) and reduces the risk of contracting cancer diseases such as lung, prostate, stomach, cervical, breast, oral, colorectal, oesophageal, pancreatic and many other types of cancer (Debjit, Sampath, Shravan, & Shweta, 2012).

Adaptation has become a critical development issue in most parts of sub-Saharan Africa including Ghana due to the impacts of climate variability on rain-fed agriculture coupled with farmers' low adaptive capacity (Campos, Velázquez, & McCall, 2014), and the need to achieving food security and poverty reduction. It is argued that no matter the sustained efforts to reduce GHG emissions in the atmosphere, the potential adverse effects of the changing climate cannot be avoided (Eboh, 2009). Therefore, the mitigating efforts to enhancing the sinks of GHGs will take time and can only happen to a limited extent (Le Quéré et al., 2015). It is in respect of this that adaptation has become a necessary condition in climate variability discourses. According to the IPCC (2014), adaptation refers to the process of adjustment to the actual or expected climate and its effects. It further explains that, in human systems, adaptation seeks to cause a reduction in the harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects. Common adaptation strategies employed by most smallholder farmers such as mixed cropping, crop diversification, irrigation, livestock rearing and changing planting dates are well documented (Bryan et al., 2013; Guodaar, Beni, & Benebere, 2017a; Pangapanga, Jumbe, Kanyanda, & Thangalimodzi, 2011; Zorom, Barbier, Mertz, & Servat,

2013). Even though smallholder farmers from several developing countries have resorted to the use of adaptation strategies as means of reducing the effects of the changing climate and showing resilience, a lot of barriers (e.g. finance, low adaptive capacities, high cost of input etc.) have and are still militating against their efforts, thereby rendering it ill-adaptive (Ifeanye-Obi & Issa, 2013).

However, the assessment of these barriers to climate variability adaptation measures by farmers as part of adaptive research has not been adequately explored and documented in research (Howden et al., 2007; Neisen & Reenberg, 2010), especially in Ghana. For instance, Guodaar et al. (2017b) studied the nexus between climate variability and tomato crop production in Ghana without exploring the barriers which hinder farmers' effectiveness in employing sound adaptive measures in response to the pressures of the climatic variability. Also, Arku (2013) studied the local creativity for adapting to climate change among rural farmers in the semi-arid regions of Ghana without an exploration of the barriers farmers encounter in their adaptation strategies. Moreover, Codjoe and Owusu (2011) also investigated the relationship between climate change/variability and food systems in the Afram Plains of Ghana without a critical examination of the barriers farmers encounter in their adaptation mechanisms.

Some previous studies have also explored the constraints or barriers that impede smallholder farmers' adaptation strategies to climate variability without the utilization of the factor analysis as used in this study. For instance, Antwi-Agyei et al. (2013) studied the barriers to climate change adaptation in Northern Ghana through a systematic review which failed to provide empirical evidence of the barriers farmers encounter and the factors that influence such barriers using a factor analysis. The Adaptation at Scale in Semi-Arid Regions—ASSAR (2016)—report also emphasised the barriers and enablers of climate change adaptation in semi-arid Ghana using a more descriptive statistics without employing a factor analysis to explore the major factors that can impede farmers' adaptation strategies. Ndamani and Watanabe (2015) micro-level study on farmers' perceptions about adaptation practices to climate change and barriers to adaptations in Ghana utilized the problem confrontation index in analysing the barriers to farmers' adaptation.

Using a factor analysis as an analytical approach has been sparse in recent academic literature on climate adaptation research. Therefore, unpacking the barriers that militate against tomato growers' effort in response to the changing climate by utilizing a factor analytic approach will provide a methodological contribution in climate adaptation discourse, especially in Ghana and other sub-Sahara African countries.

Empirically, the study will also facilitate and strengthen farmers' adaptive capacity to help them respond appropriately to the changing climate. Sound adaptive measures will provide the platform for enhancing the resilience of communities that depend on tomato production for their livelihoods. This study utilized a total of 378 face-to-face interview samples of tomato growers in the Offinso North District (OND) of Ghana. The main objective of the study was to use a factor analysis to analyse smallholder farmers' adaptation barriers to climate variability in the OND of Ghana.

## 2. Materials and methods

### *2.1. Study profile*

This research was carried out in the OND of Southern Ghana (Figure 1). The district which experiences a double maxima rainfall regime is found in the semi-equatorial climatic zone. The major rainfall season normally starts from April and ends around June while that of the minor season starts from September to October (Guodaar, Beni, Asante, Eshun, & Adjei, 2016).

The average annual rainfall ranges between 1250 and 1800 mm. The relative humidity in the study area is also high ranging between 75% and 80% in the rainy season and 70–72% in the dry

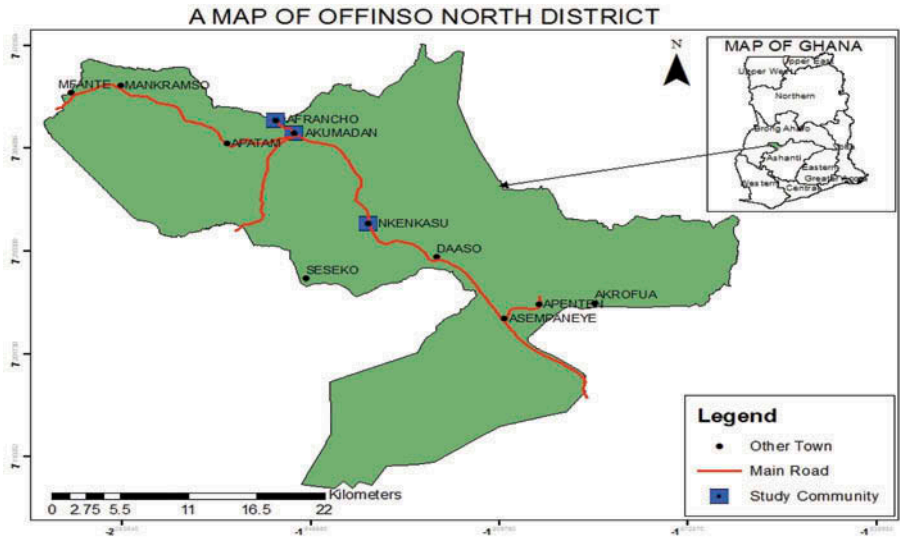


**Figure 1. The map of the study area.**

season. A maximum temperature of 30°C is experienced between March and April. The average monthly temperature is about 27°C (Guodaar et al., 2017a).

The study area is characterized by semi-deciduous forest. The availability of timber in these forests in the district serves as a good source of foreign exchange to the country. About 62.3% of the population is engaged in agriculture. This is followed by commerce which employs about 19.4%; service, 14.5%; and industry, 3.8% (Guodaar et al., 2017b). This means that agriculture is the main livelihood of majority of the population in the study area. Therefore, there is the need to protect and sustain the livelihoods of farmers through structural and institutional arrangements and interventions. Again, there is the need for extensive debate on the relevance of mitigating the impact of climate variability on agriculture in the region.

### *2.2. Research approach and design*

The quantitative deductive approach was employed for the study. This approach was rooted in the positivist philosophical paradigm which adheres to the view that only factual knowledge gained through observation including measurement is worthwhile and trustworthy (Collins, 2010). This particular approach provides a factual and better appreciation of quantifying the variables to ensure objectivity of results with some degree of certainty and confidence for replication (Creswell, 2010). The cross-sectional survey design was used for the study. This design refers to the gathering and collection of one-time data from the field with a cursory look at the selection of the sampling unit from the study population without necessarily manipulating the study environment (Levin, 2006). This design was deemed appropriate for the study as it used the sampled views of the population to make generalizations about the target population. It is also cost-effective because of the snapshot or one-time data collection on the field.

### *2.3. Data types, sources and instrumentation*

The data types used for the study were quantitative in nature. Data and information used for the study were collected from primary and secondary sources. Primary data were collected from key informants including smallholder tomato farmers in the district. The secondary sources of information were gathered from journal articles, books, periodicals, annual reports and newspapers. A structured interview guide was used as data collection instrument for the collection of the data. The data collection exercise lasted for a period of one month (December–January). The instruments were made up of closed and open-ended questions, and they were administered face-to-face with the help of some trained researchers who have completed their first degrees with research component and with much competence in research methodology. The structured

interview was deemed appropriate because most of the respondents in the study communities could not read and write the English Language. In view of that, the questions were read out in their local dialect (Asante Twi) to facilitate a better understanding of and to respond to the questions appropriately. The interviews were conducted in the homes and in some cases on the farms of respondents where appropriate with the help of some trained research assistants. The structured interview guide centred on areas such as the socio-economic characteristics of the farmers, their adaptation practices and barriers that militate against their adaptive measures.

### *2.4. Sample and sampling method*

A total of 378 tomato farmers were used as the sample for the main study. This was determined from the sampling frame using the mathematical model expressed as $n = N/1 + N (e^2)$. The "*n*" represents the sample size; "*N*" represents the sampling frame and "*e*" represents the margin of error. Using a 5% margin of error with 95% confidence level, the sample size for the study was determined. In determining the sample sizes for the various selected communities, the proportionate sampling method was used. This method is expressed as PS = TSC × TSS/TP, where PS is the proportionate sample, TSC is total sample size for each community, TSS is the total sample size and TP is the total population of the study. Table 1 shows the representation with the respective percentages of selection per community.

The total sample size of 378 tomato farmers was systematically sampled from three populous tomato communities in the OND of Southern Ghana. The appropriateness of this particular sampling method was to give the respondents equal chance of selection and to also ensure a fair representation of the population in the communities on which generalizations were made.

### *2.5. Method of data analysis*

#### *2.5.1. A factor analytical model*

The FA analytical model was utilized for the study. The varimax-rotated factor analysis embedded in the IBM SPSS Statistics version 21 was used as a quantitative data reduction technique to unpack the barriers that hinder tomato farmers' adaptive practices to climate variability in the OND of Ghana. The FA was appropriate because it is an econometric model that has the capability of reducing large sets of measured variables to few manageable dimensions called factors (Otitoju, 2013). Also, the FA quantitative technique is preferred to other multivariate statistical analytic techniques (e.g. principal component analysis) because it seeks the least number of factors which can account for the common unique item variance shared by a set of variables as well as yielding consistent and optimal result because of its recognition of errors (Costello & Osborne, 2005). The FA provides a descriptive framework for showing the covariance relationships among the numerous explanatory variables of random quantities (factors) through weightings of the various variables into loadings which are organized into matrix of factor loadings (Hair *et al*., 1995). The typical factors used for the analysis contain unique variables with less restriction. The Kaiser–Meyer–Olkin (KMO) index and the Bartletts Test at 0.00 significant levels were used as the basis for selecting the underlying

**Table 1. Study communities and their respective total number of farmers and sample sizes**

| Study communities | No. of farmers (*N*) | Proportionate sample PS = TSC × TSS/TP |
|---|---|---|
| Akomadan | 2966 | 2966/7063*378 = 159 |
| Afrancho | 2754 | 2754/7063*378 = 147 |
| Nkenkaasu | 1343 | 1343/7063*378 = 72 |
| **Total** | **7063** | **378** |

Source: MoFA, Offinso North District, 2014.
*: Multiplication sign.

factors that explained the data. The study used only variables with factor loadings of ±0.5 for the analysis and discussions. The internal consistency of the instrument was measured using the Crombach's alpha coefficient comparing each item in the scale with all other items. A minimum score of 0.70 (Table 3) was set to ensure adequate reliability (Gillespie & Chaboyer, 2013). The criteria used in determining the factor extraction included targets for the eigenvalue >1 rule (Pallant, 2011). The FA theoretical model applied in this study according to Otitoju (2013) is expressed in the matrix:

$$\mathbf{X} = \Lambda\mathbf{f} + \mathbf{e} \quad (1)$$

where "**x**" represents the vector of *n* observable variables, "**f**" is the vector of *m* unobservable factors, "**Λ**" is the loading matrix of the order *nfm* and "**e**" representing the error vector of *nxl*.

*2.5.2. Logistic regression model*

This study employed a logistic regression model in IBM SPSS version 21 to identify whether or not tomato farmers in the OND of Ghana encounter adaptation barriers in their response to climate variability. The underlining null hypothesis ($H_0$) here was that there is no statistically significant relationship between farmers' socio-demographic characteristics and their adaptive barriers in response to climate variability. The logit regression model used was binary and dichotomous in nature where the dependent variable (adaptation barriers) is a dummy variable for encountering adaptation barriers at all (where *Yi* has only two possible values, 1 or 0, for either encountering adaptation barrier or not encountering adaptation barrier in responding to climatic changes and its concomitant pressures and risks. The *Xi* is made up of independent variables which are primarily farmers' socio-demographic characteristics (e.g. age, gender, formal education, marital status and access to credit). However, it is imperative to note that the independent variables that were statistically significant are those reported in this study. The independent variables are both categorical and continuous.

## 3. Results and discussion

### *3.1. Socio-demographic characteristics of respondents*

The study used descriptive analysis to identify responses from the respondents on their socio-economic characteristics relating to their farming activities in the OND (Table 2). From the age distribution of the respondents, the study showed that majority of the farmers 155 (41%) were between the ages of 31 and 40. This means that the farming population in the district is relatively youthful and has a relatively greater potential for sustainable tomato production.

On the sex distribution of respondents, 262 of them (69.3%) were males while 116 (30.7%) were females. Notwithstanding the gender differences in terms of number, it is important to note that both males and females continue to engage in farming activities as a source of livelihood and poverty reduction strategy. Again, since a relatively smaller number of females are represented the study, it may be misleading to advance an argument in favour of the males in terms of dominance in the tomato business.

The study also observed that 234 (61.9%) of the respondents were married, 116 (30.7%) of them were single and 28 (7.4%) were divorced. This means that the married farmers had their livelihoods dependent on the tomato business. It also implies that generally the married respondents may have used family labour (children) in their tomato business which requires a lot of labour force.

The educational level of respondents indicates that majority of them 168 (44.4%) had never been to school before. This was followed by 134 (35.5%) who had education up to the Middle school or Junior High level and 56 respondents (14.8%) who had education up to the primary school level. The

**Table 2. Socio-demographic characteristics of respondents (*n* = 378)**

| Socio-economic characteristics | Frequency | Percentages (%) |
|---|---|---|
| **Age** | | |
| <20 | 14 | 3.7 |
| 20–30 | 32 | 8.5 |
| 31–40 | 155 | 41 |
| 41–50 | 150 | 39.7 |
| >50 | 27 | 7.1 |
| **Sex** | | |
| Male | 262 | 69.3 |
| Female | 116 | 30.7 |
| **Marital status** | | |
| Married | 234 | 61.9 |
| Single | 116 | 30.7 |
| Divorced | 28 | 7.4 |
| **Educational status** | | |
| Primary | 56 | 14.8 |
| Middle/Junior High | 134 | 35.5 |
| Senior High | 20 | 5.3 |
| No formal education | 168 | 44.4 |
| **Farming experience** | | |
| <10 years | 12 | 3.2 |
| >10 years | 366 | 96.8 |
| **Sources of credit** | | |
| Family support | 126 | 33 |
| Susu | 84 | 22.2 |
| Personal | 68 | 18 |
| Banks | 59 | 15.6 |
| Credit union | 35 | 9.3 |
| Friend | 6 | 1.6 |
| **Tomato variety** | | |
| Pectomech | 188 | 49.7 |
| Rano | 28 | 7.4 |
| Akoma | 36 | 9.5 |
| Rano and Pectomech | 126 | 33.3 |
| **Farm size** | | |
| 1–2 acres | 49 | 13 |
| 3–4 acres | 158 | 41.8 |
| 5–6 acres | 118 | 31.2 |
| 7–8 acres | 38 | 10 |
| 9 and above | 15 | 4.0 |

**Source**: Authors fieldwork, 2014

least number of respondents (20) were farmers who had education up to the secondary school level. They constituted 5.3%. This implies that majority of the respondents had no or little educational attainment which could influence their adaptive strategies through the adoption of traditional strategies instead of scientific techniques in responding to the impacts of the changing climate.

On farming experience, majority of the respondents 366 (96.8%) had been in the tomato business for more than 10 years while 12 (3.2%) of the respondents had less than 10 years farming experience in the tomato business. The analysis also showed that majority of the sampled respondents 354 (93.7%) indicated that they do not have access to formal credit facilities such as banks to boost their tomato business. The study saw several sources from which farmers got capital to invest in their tomato business. However, it was evident that majority of the farmers got their capital from family support (126 or 33.3%). The rest are "*susu*" or "daily savings" (84 or 22.2%), personal (68 or 18%), banks (59 or 15.6%), credit unions (35 or 9.3%) and friends (6 or 1.6%) in that order.

The study identified three main varieties of tomato (*pectomech, rano and akoma*) respondents cultivated. From the analysis, majority of the farmers (188 or 49.7%) preferred *pectomech*. A relatively large number of the respondents (126 or 33.3%) also preferred a combination of *rano* and *pectomech*. Respondents who preferred the cultivation of *akoma* (36 or 9.5%) and *rano* (28 or 7.4%) were in the minority. With regards to the farm size of farmers, in the area, the results indicated that majority of them 158 (41.8%) cultivated between 3 and 4 acres of farmland, 118 (31.2%) cultivated farm sizes of between 5 and 6 acres, 49 (13%) of the farmers cultivated between 1 and 2 acres of farmland, 38 (10.1%) farmers cultivated between 7 and 8 acres of farmland while 15 (4.0%) cultivated 9 acres and above farmland. This means that the land tenure system in the study area does not permit many farmers to own large acres of farmland. Again, the low financial capacity of most tomato farmers did not permit them to cultivate on a large scale.

### *3.2. Respondents adaptation strategies to climate variability*

Figure 2 shows the various adaptation strategies employed by the tomato farmers in the study area. The on-farm adaptation strategies include changes in the location of farms, changes in the variety of crops, diversification of crops, agro-chemicals application, irrigation and mixed cropping (Guodaar et al., 2016). Among these practices, the farmers preferred application of agro-chemicals, crop diversification and mixed cropping to the other forms of adaptation. The off-farm adaptation strategies employed by the farmers to ameliorate the harsh effects of climate variability on their tomato production included migration and diversification to non-farm activities (Guodaar et al., 2017a).

The relevance for employing these adaptation strategies by farmers is to ensure that they show resilience to reduce the cascades of effects climatic variability has on tomato productivity (Guodaar et al., 2016). However, it is important to note that sometimes some of the farmers (15%) also failed to employ any of the adaptation strategies.

### *3.3. FA of barriers that impede tomato farmers' adaptive strategies to climate variability*

Table 3 shows the varimax-rotated FA of barriers that hinder tomato farmers' effort in adapting to the changing climate in the OND of Ghana. The data indicate that seven factors were responsible for the challenges tomato farmers were confronted with in adapting to the changing climate. The KMO index and the Bartletts test at 0.00 significant levels formed the basis for selecting the underlying factors that explained the data. As far as this study is concerned, only variables with factor loadings of ±0.5 and above were considered and used in naming the factors. The principal factors include personal barriers (Factor 1), institutional and labour barriers (Factor 2), irrigation technology barriers (Factor 3), inadequate credit and farm inputs barriers (Factor 4), cost of land barriers (Factor 5), facility barriers (Factor 6) and lack of political will barriers (Factor 7).

#### *3.3.1. Personal barriers*

Under factor 1 (personal barriers), the specific issues that loaded high were inadequate financial assistance to farmers in coping with climate variability (0.696), inadequate knowledge of farmers in coping with climate variability (0.623), high cost of agro-chemicals (0.564) and inadequate knowledge of farmers on climate variability (0.564). These personal factors have

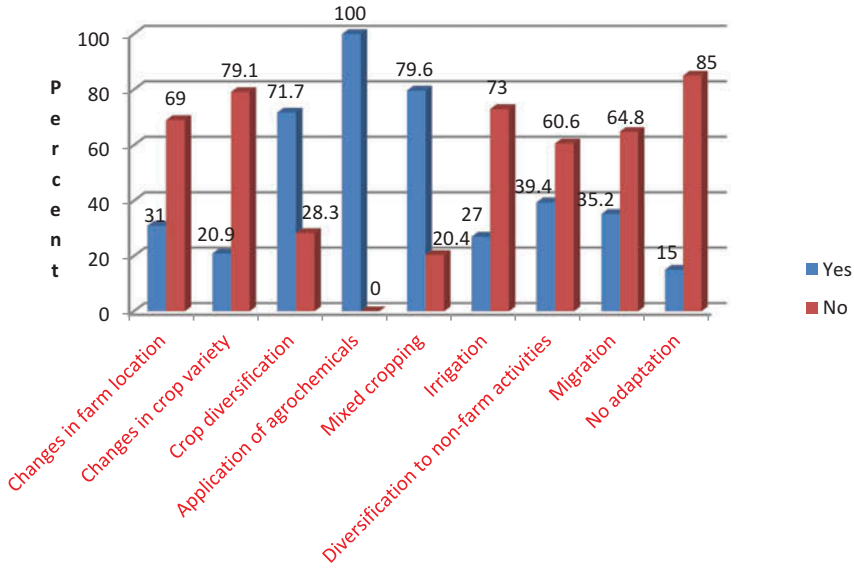


**Figure 2. Tomato farmers' adaptation strategies to climate variability (*n* = 378).**

**Source: Authors field work (2014)**

serious effects on farmers, especially on their general level of output. The enormity of these barriers to farmers affects their livelihoods and their poverty situations. The sustainability of tomato production in the district is also threatened by some of these personal factors, especially the high cost of agro-chemicals. This finding supports the study of Satishkumar, Tevari and Singh (2013) who observed that personal barriers have far-reaching effects on farmers in sustaining their livelihoods.

*3.3.2. Institutional and labour barriers*

The variables that were most amplified under factor 2 (institutional and labour barriers) include untimely education of farmers on right adaptation strategies by extension personnel (0.895), poor extension services (0.820), inability of extension officers to build farmers' adaptive capacity (0.791), high cost of farm labour (0.709), unavailability of tomato processing facility by government (0.580) and lack of access to climate or weather information (0.727). Institutions are recognized as important agencies that facilitate the building of adaptive capacities of local communities in coping with the pressures of environmental stimuli. Information dissemination on weather titbits and application of right extension technologies are very vital in providing early warning signals and reorienting the mindset of farmers towards sound adaptive capacities. This corroborates the findings of Antwi-Agyei et al. (2013) who identified lack of climate risk information and early warning systems due to poor meteorological facilities and equipment as having detrimental effects on farming activities in Ghana. Labour cost was also a daunting challenge to the farmers. The ability to hire a labourer on a farm during the land preparation stage through the planting stage to the harvesting stage could have potential effects on the efficiency and productivity of tomatoes.

*3.3.3. Irrigation technology barriers*

Under factor 3 (irrigation technology barriers), the prominent variables that loaded high values include high cost of irrigation materials (0.745) and inadequate irrigation facilities (0.711). This finding supports the study of Antwi-Agyei et al. (2013) who found that lack of appropriate technologies across sub-Saharan Africa is a major constrain to the adaptation opportunities and capabilities of smallholder households in enhancing their livelihood and food security.

**Table 3. Factor analysis of barriers to climate variability adaptation of tomato farmers**

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 |
|---|---|---|---|---|---|---|---|
| Inadequate financial assistance to farmers in coping with climate variability | 0.696 | | | 0.314 | 0.330 | 0.409 | |
| Inadequate knowledge of farmers in coping with climate variability | 0.623 | | 0.467 | | | | |
| High cost of agro-chemicals | 0.564 | | | 0.501 | | | |
| Inadequate knowledge of farmers on climate variability | 0.564 | | 0.392 | | | | 0.303 |
| Non-availability of farm labour | 0.453 | 0.412 | | | 0.398 | | |
| Untimely education of farmers on right adaptation by extension personnel | | 0.895 | | | | | |
| Poor extension services | | 0.820 | | | | 0.364 | |
| Inability of extension officers in building farmers adaptive capacity | | 0.791 | | | | | |
| High cost of farm labour | 0.421 | 0.709 | | | | 0.326 | |
| Unavailability of tomato processing facility by government | | 0.580 | | | 0.423 | 0.544 | |
| High cost of irrigation materials | 0.345 | | 0.745 | | −0.314 | | |
| Unavailability of access to climate or weather information | | | 0.727 | | | | 0.418 |
| Inadequate irrigation facilities | | | 0.711 | | | 0.491 | 0.303 |
| Poor access to improved tomato variety | 0.431 | | 0.476 | 0.385 | | 0.354 | 0.382 |
| Unavailability of storage facilities for tomato farmers | | | | 0.829 | 0.382 | | |
| Inadequate credit facilities to tomato farmers | | | | 0.775 | | | 0.315 |
| High cost of farm lands | 0.457 | | | | 0.723 | | |
| Lack of political will to improve farmers' adaptive capacities | 0.456 | | 0.422 | | | 0.349 | 0.501 |
| **Eigen value** | **3.567** | **3.265** | **2.702** | **2.132** | **1.662** | **1.438** | **1.149** |
| **Percentage variance** | **18.773** | **17.182** | **14.223** | **11.221** | **8.748** | **7.570** | **6.045** |
| **Cumulative percentage** | **18.773** | **35.954** | **50.177** | **61.399** | **70.147** | **77.717** | **83.762** |
| **Cronbach alpha = 0.70** | | | | | | | |

**Source: Authors Fieldwork (2014)**

***Factor 1: Personal barriers; Factor 2: institutional and labour barriers; Factor 3: irrigation technology barriers; Factor 4: inadequate credit and farm inputs barriers; Factor 5: cost of land barriers; Factor 6: facility barriers; Factor 7: lack of political will barriers.***

*3.3.4. Inadequate credit and farm inputs barriers*

Regarding factor 4 (inadequate credit and farm inputs barriers), the variables that loaded high include high cost of agro-chemicals (0.501), lack of storage facilities for tomato farmers (0.829) and inadequate credit facilities to tomato farmers (0.775). Finance serves as the fulcrum of any business establishment, especially in most parts of developing countries. In most cases, the sustainability of farming activities largely depends on farmers' access to credit which enables them to procure the requisite farm inputs. Therefore, lack of credit has far-reaching effects on the production levels and scale of farming. This finding is consistent with the study of Deressa, Hassan, Alemu, Yesuf and Ringler (2008) who found that lack of credit impedes farmers from getting the relevant resources and technologies in adapting to the changing climate. They further opine that the high cost of technologies requires that farmers get the needed financial assistance to enable them boost their adaptive capacities.

*3.3.5. Cost of land barriers*

With respect to factor 5 (cost of land barriers), the only issue that featured prominently was high cost of farm lands (0.723). Land is a major factor of production in the agricultural sector. Access to and cost of the farm land are major determinants of the scale of production of agricultural crops. When the cost of obtaining land for farming is expensive, it becomes a disincentive for the youth and landless peasants to engage in agricultural activities. Also, the cost of land reduces the purchasing power of farmers, especially in procuring farm inputs. This supports the finding of Kassahun (2009) whose study of the Nile Basin of Ethiopia found land barrier as a major hindrance to farmers in their adaptive agricultural practices.

*3.3.6. Tomato processing facility barriers*

Under factor 6 (tomato processing facility barriers), the variables that loaded high include unavailability of a tomato processing facility in the district (0.544). Tomato is a perishable commodity which requires early processing for preservation for future use. The absence of ready markets, especially when there is bumper harvest, results in many of the produce being left on the farm to rot. This threatens the security of tomato production in the region and livelihoods of poor smallholder farmers. Indeed, the unavailability of a tomato processing facility as a medium of indirectly storing tomato weakens the bargaining power of the farmers in negotiating for an acceptable price for their produce especially when there is a bumper harvest.

*3.3.7. Lack of political will barriers*

Finally, factor 7 (lack of political will barriers) had only one variable which loaded high—lack of political will to improve farmers' adaptive capacities. The eagerness of farmers to employ appropriate strategies in response to climatic variability will become a mirage if government fails to exude the needed political will to help farmers in building their adaptive strategies. This supports the study of Otitoju and Enete (2016) who found lack of government policies to empower food crop farmers as a major constraint to adaptation practices by farmers in Southwest Nigeria.

***3.4. Socioeconomic factors influencing adaptation barriers of tomato farmers***

A multivariate binary logistic regression model was used to determine the socio-economic factors that influence farmers constrained with the barriers to climate adaptation as against their unconstrained counterparts (Table 4). The reference category for the logistic regression analysis was those who did not encounter barriers in their adaptive practices.

From Table 4, the coefficient of farmers age was found to be statistically significant ($P < 0.05$) and positive for encountering barriers in their adaptive practices. The odd value of farmers not encountering barriers was (1.21). This implies that there is a high probability that the aged may encounter barriers in their adaptive strategies. Hence, the more advanced in age a farmer is, the more the likelihood that such a farmer will encounter barriers that will hinder the implementation of successful adaptation in response to climate variability. The implication is that when farmers grow older, their energy and psychological preparedness in fashioning out measures to respond to

**Table 4. Logistic regression of socio-economic factors influencing farmers with adaptation barriers to climate variability**

| Variables | *β (SE)* | OR (*95.0% CI*) | *p* Value |
|---|---|---|---|
| Age | 0.19 (*0.19*) | 1.21 (*0.83–1.75*) | *0.03** |
| Gender | 0.00 (*0.28*) | 1.00 (*0.58–1.75*) | *0.05** |
| Formal education | 0.22 (*0.26*) | 1.25 (*0.75–2.08*) | *0.39* |
| Marital status | 0.25 (*0.36*) | 1.28 (*0.63–2.59*) | *0.02** |
| Access to credit | −0.43 (*0.58*) | 0.65 (*0.21–2.02*) | *0.45* |

OR: Odds ratio; CI: confidence interval; *statistically significant at $P \leq 0.05$.

environmental stimuli and farming challenges potentially reduces. Also, they may be living in an "empty nest" in the Chayanovian sense.

The study observed that gender is statistically significant ($P < 0.05$) and positive with an odd value of 1.00. This means that there is a greater probability of more males encountering adaptation barriers to climate variability as compared to their female counterparts. The implication is that so long as males continue to dominate their female counterparts in agricultural activities, they will encounter more adaptation challenges. Also, females encountered less challenges because some had other businesses that provided them cash to invest in the farming business unlike the males who as breadwinners were mostly relied on for support by their respective household members. Moreover, female farmers had more access to credit facility than the female counterparts. Hence, creditors preferred giving credit to females because they are credit worthy in terms of repayment. Also, it was easier for an unmarried lady to have the fiancé helping her on the farm than for a male having his fiancée helping him on the farm. All these emanate from the fact the male is the breadwinner.

In terms of the marital status of farmers being a barrier to their adaptation practices to climate variability, the study found that marital status of the farmers was statistically significant ($P < 0.05$) and positive with an odd value of 1.28. This means that there is a greater propensity for married farmers to experience more barriers to climate variability adaptation measures than those who are not married. The implication is that married farmers will experience more financial barriers to their adaptation strategies because of the numerous economic and social responsibilities they perform in the home and society as a whole.

## 4. Conclusion and policy recommendations

The study analysed the barriers that constraint tomato farmers' adaptation practices to climate variability in the OND of Ashanti Region, Ghana. It was observed that smallholder tomato farmers in the study area have adopted both on-farm and off-farm adaptation techniques to mitigate the effects of the changing climate on tomato production. These adaptation strategies include changes in farm location, changes in crop variety, crop diversification, application of agro-chemicals, irrigation, mixed cropping, migration and diversification to non-farm activities. The study also revealed that some farmers sometimes failed to employ any adaptive strategy in the event of climate variability risks. The major barriers that impede tomato farmers' adaptive practices were personal barriers, institutional and labour barriers, irrigation technology barriers, inadequate credit and farm inputs barriers, cost of land barriers, facility barriers and lack of political will barriers. There is urgent need to unpack and address these barriers encountered by tomato farmers in adapting to the pressures of climate variability as this will have far-reaching implications on policy implementation that is geared towards the provision of adequate tomato for human consumption. Also, the study revealed that age, gender and marital status are major determinants that influence the barriers tomato farmers encounter in their adaptive responses to climate variability.

There is therefore the need for public and private financial institutions to provide farmers with some financial support to enable them get access to farming inputs such as agro-chemicals to improve production levels. The Ministry of Food and Agriculture should also ensure that extension officers do their work effectively through strict supervision in order to build farmers adaptive capacities and resilience to increase tomato production in the study area. The Government needs to also include Southern Ghana in the "one village one dam" agricultural policy, especially in the vegetable producing areas, to enable farmers have access to irrigation facilities to improve crop production. It is also recommended that future studies on adaptation barriers be focused on modelling the socio-economic effects of adaptation barriers on vegetable crop production. Notwithstanding the success of the research, the researchers encountered some limitations in the area of data collection exercise and study scope. Some farmers did not want to respond to the questions; however, through persuasions, most of the respondents later accepted and responded to the questions. Also, due to inadequate finance and time, the study could not cover a wider area. This had the potential to affect the generalization of the study to other areas; however, the few communities studied were enough to draw major conclusions.

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**Competing interests**
The authors declare no competing interests.

**Ethical Approval**
Since the study had smallholder tomato farmers as the target group for the study, there were some ethical issues that the researchers took into consideration, to respect and upheld their fundamental rights as individuals. First and foremost, the field researchers showed their identification cards (ID) to the respondents as a means of introduction before eliciting responses from them. Also, the anonymity and confidentiality of respondents' information were assured and their names and identity were hidden as far as their responses were concerned. Moreover, an appointment was booked and arranged between the researchers and the respondents to give them the convenience they deserve as individuals. Finally, the consent of some respondents was sought before taking them photograph to use for the study.

**Conflict of Interests**
Authors declare no conflict of interests.

**Cover image**
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