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Assessment of Farmers Perception about Climate Change Impact and Adaptation Strategies Use for Tomato Production in The Gambia

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Abstract

Tomato production in The Gambia is ranked second after onion in terms of production acreage among vegetables. Tomatoes are major sources of lycopene, a dietary carotenoid found in high concentration in processed tomato products. The crop is high in vitamin AB and C and also contain good amount of potassium, iron and phosphorus. Fresh tomatoes and

canned types such as concentrates puree and paste are increasingly in demand in West Africa where they form an essential part of the diet. The study investigated farmer's perception about climate change impact and adaptation strategies use for tomato production in the Gambia through survey. The survey was conducted in the West Coast Region originally known as Western Division situated in the west near the capital. Random sampling was used for the selection of farmers for the individual survey and focus group discussions. The findings concluded that significant number of the tomato growers are aware and also strongly believed that climate change is existing. Constant increase in temperature and decrease in rainfall, an unpredictable rainfall pattern and prolonged drought among others served as evidences. Large number of respondents said to have experienced climate change effects for more than five years while minority indicated about 5-10years of experienced. Most of the tomato growers said they became to know about climate change through personal experience. Climate change causes severe dropping of flowers by rain and wind and rotting of tomato fruits as well as pest attack at the reproductive stage. For the case of adaptation strategies, great numbers of the farmers are using synthetic pesticide to control insect pests e.g., red spider mites, planting of trees (wind breakers) to reduce heavy wind speed and application of large quantity of fertilizers to improve the soil fertility.

Keywords: climate change, farmers, tomato, perception, The Gambia, survey

1. Introduction

According e-agriculture development and modernization strategy (2021) indicated that Agriculture is a major commercialactivity in The Gambia, which steadly contributes 25% to gross domestic product (GDP) and creating job opportunities of about 70% of the labour force in which 32% are year round producers. About 72% of the extremely poor rural households are depending on agriculture as their primary source of income. The sector is categorized as small-scale, subsistence rain-fed crop production (mainly rice, groundnuts, coarse grains, and cassava), traditional livestock rearing, semi-commercial groundnut and horticultural production and a large artisanal fisheries sub-sector.

Horticultural crop production has ever been recognized as a strategy of diversifying the production base of the Gambian economy, for increasing the self-reliance of the country's producers and, very importantly, for improving the food security situation of the country. Urban area are the principal producers of horticultural crops consisting of community gardens mainly reserved for dry season vegetable production. The major vegetable crops grown are onions, tomatoes, cabbage and peppers, although some of the older gardens also produce fruit crops including paw-paws, mangoes and citrus. Production is based on community gardens organized and managed by women's groups (Food Agricultural Organization, 2021).

Tomato is an annual crop mainly in temperate climates but plants and fruits suffer physiological injury under low nonfreezing temperature below 12°C (Costa J., *et al* 2018). Tomato production in The Gambia is ranked second after onion in terms of production acreage among vegetables also stated that tomatoes are major sources of lycopene, a dietary carotenoid found in high concentration in processed tomato products. This compound is an antioxidant known to combat cancer, heart disease and premature aging. The crop is high in

vitamin AB and C and also contain good amount of potassium, iron and phosphorus. Fresh tomatoes and canned types such as concentrates puree and paste are increasingly in demand in West Africa where they form an essential part of the diet. According to (Fufa *et al.,* 2011; Malherebe and Marais, 2015; Ochilo *et al.,* 2019) reveals that tomato fruit is an important cash crop. The fruit plays an important role in human nutrition, where it can be eaten as a fresh salad vegetable, processed, stewed, fried, baked and can also be used to produce soup or juice. It may also be put into various dishes as the main ingredient in Sub Saharan Africa (SSA). Tomatoes are a good source of phosphorus, iron and vitamin A, B and C, respectively. The fruit contains vitamins B complex, thiamin, niacin and riboflavin which are important in a healthy diet (Cheema and Dhaliwal, 2005).

China is the largest producer of tomatoes in the world followed by India and Turkey in 2019 where more than 62 million metric tons of tomatoes were produced china.

Twenty one (21) countries produced more than 1 million metric tons of tomatoes in 2019 (FAO, 2019). An increase yield of 108 million tonnes of tomatoes were produced during 2002, with the crop being grown across 9.9 million acres in over 160 different countries. A total world production has increased by over 35% over the last ten years.

1.1 Impact of Climate Change on Tomato Production

The intergovernmental panel on Climate change revealed climate change as a change in the state of the climate that can be known (using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. The panel also recognized it as any change in climate over time, whether due to natural variability or as a result of human activity. This meaning has established a distinction from that of United Nations Framework Convention on Climate Change (UNFCCC), whose definition stated it as change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (IPCC, 2011).

The influence on the variable rainy season has reduced the ability of the farmers to cultivate their own food which has resulted in the increasing need to import rice. This has dramatically increased Gambia's financial expenditures on importations and may likely promote instances of malnourishment and starvation if demands are not meet (FAO, 2021). Also food including mangoes ripen simultaneously and therefore cannot be sold quickly enough so capital generation is focused and insufficient due to erratic rains. The movement of saline water from the River Gambia and the erratic rains causes the destruction of an olden livelihood of rice growing in the region. Therefore, it can be observed that climate change is not only having physical effects on food production but is also eroding a culture. The insufficient water and increasing hotness and coldness have affected crop production more especially perishable types. This reduces the income of the women and therefore prevents the generation of wealth for e.g. their children's schooling and medications (MBG, 2018).

Sub-Saharan African farmers, are confronting with climate shocks such as droughts, flooding, hailstorms, pests and diseases manifestation, while not all the farmers are applying

adaptation strategies to minimize climate change (Rahut *et al.,* 2021). Generally, Agriculture, more particularly rain-fed is extremely sensitive and highly vulnerable to climate change and probably will be affected (Al-Bakri *et al.,* 2011). It was predicted that the global agricultural productivity will decrease between 3 to 16% by 2080 due to climate change, and this estimation may vary depending on geographical location (Cline, 2008). Climatic extremities occurring in different time interval in the crop cycle decreases the productivity higher than the normal yield loss (Beilloiin *et al.,* 2020). High or low temperatures have direct effect on the growth of insects and pests, with higher temperature the growth rate of insects increases. Continuous rise in temperature can cause more destruction to the crops from fungi, bacteria and insects (Johkan *et al.,* 2011). The rate of new pest's introduction, outbreaks, and high risks of pesticides residues in food are reported as an impact of climate change (Dhanush *et al.,* 2015).

Furthermore, Johkan *et al.*,(2011) also depicted that during the time of flowering, higher temperature results in abscission of flowers, very poor flowering and low fruit quality, pollen sterility and low color development in tomato. It was also observed that an increase of coldness or hotness in the South Florida has lower fruit numbers and yield of tomatoes, with little pollen viability and fruit set and the continuous rise in temperature could further reduce the productivity (Ayankojo and Morgan, 2020). The increase of rainfall and high relative humidity are also destructive to tomato plants, as the proliferation of leaf diseases is higher during the period of humid conditions (Kalibbala, 2011). The types of late blight diseases in tomato and potato inducing low yields in Egypt have expanded since the early 1990s, which could be attributed to climate change (Fahim *et al.,* 2007). It was observed that higher level of moisture indicated by the low vapor pressure deficit reduces the growth of tomato crop, further in the extreme cases it might cause death of the apical region of tomato. Yield of tomatoes may be reduced significantly when exposed to low moisture along with low calcium supply or excess salinity which causes increment in the blossom-end rot incidence plants (Bhandari R. *et al.,* 2021)**.**

1.2 Farmers Adaptation Strategies of Climate Change on Tomato Production

Akinnagbe O.M1 And Irohibe I. J (2014) reported that farmers continuous adhere to adaptation strategies to climate change can greatly reduce vulnerability to climate change by making sure that farming communities are better able to adjust to climate change and variability, moderating potentials damages, and helping them to cope with adverse consequences. Adaptation to climate change includes many possible responses, such as change in crop management practices (e.g., choice of fields, planting dates, planting densities, cropcultivars) land use and land management (e.g., fallowing, tree planting or protection, irrigation and water harvesting techniques, soil and water conservation measures, tillage practices, soil fertility management. Similar statement was also reported by Benedicta *et al.* (2010), indicated that the main adaptation strategies of farmers in Sekyedumase District in Ghana include change in crop types, planting short season \cultivars, changing planting dates and crop diversification.

However, Boko *et al.* (2007) noted that strategies of adaptation already observed in Africa

include diversification of livelihood activities, adjustments in farming operations and selling of labour. Sekaleli and Sebusi (2013) reveals that some of the farmers 'adaptation strategies in Lesotho include water harvesting technologies, conservation tillage, use of keyhole and trench gardens, agro-forestry and application of traditional medicine to control pests and diseases. Farmers in China have introduced their own adaptation strategies, such as changing cropping patterns, increasing investment in irrigation infrastructure, using water saving technologies and planting new crop \cultivars to increase resistance to climatic shocks (Wang *et al.*, 2010).

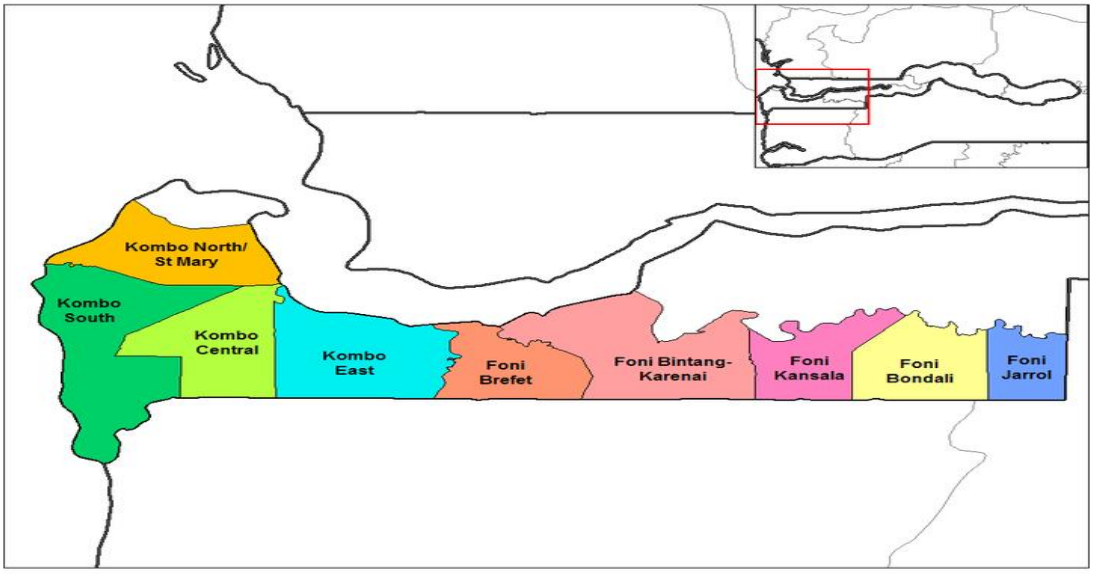
Furthermore, farmers in Cameroun are planting improved cultivars of tomatoes as adaptation strategies which according to them has been a major response to drought and pest. Irrigation is considered as one of the major adaptive strategies that could improve tomatoes yields in era of climate variability (Majoumo Christelle and Malyse, 2021)

Tomatoes are not tolerant to drought. Yields reduces significantly after any short period of water deficiency. It is therefore, essential to water the plants regularly during flowering and fruit formation. The amount of water that is needed depends on the type of soils. Irrigation is one of the adaptive measures used by famers in Santa during periods of drought and low rainfall. Among the different irrigation methods used by farmers in Santa on their farms includes the use of water pipes and watering canes to obtain water from wells to water farms. Tomatoes farmers in Santa are shifting from monoculture to mixed cropping, crop rotation, and intercropping to avoid the risk of reduction in yields as well as crop failure and to equally allow the soils to regain its fertility. 2010 Tshiala, M. F., & Olwoch, J. M. (2010) reveal that the application of agrochemicals and fertilizers enhance soil fertility and eliminate crop diseases, insects, and pests. Also, the use of agrochemicals particularly fertilizer is a good adaptation strategy that increase tomatoes yields. Most of the farmers in this area apply the NPK 20:10:10 fertilizer in order to increase fertility of their soils especially soils that have been rendered fertile during heavy rainfall or changing rainfall.

2. Material and Methods

2.1 Description of the Study Areas

The study was conducted in the West Coast Region. The Region was originally known as Western Division, also known as Foni or Fonyi, was one of the five administrative divisions of the Gambia. Its capital is still Brikama. The region is positioned in the western part of the country, West of the Atlantic Ocean, north of the Big Banjul Region and Lower River Region and Senegal is located in the south. The region itself is divided into nine districts. These districts are Foni Bintang-Karenai, Foni-Bondali, Foni-Brefet, Foni-Jarrol, Foni-Kansala, Kombo Central, East, and Kombo North / Saint Mary. The area is 1,764 square kilometers and it has a population of 699,704 according to 2013 data (GBOS, 2013). The field survey was limited to only three different communities (Lamin, Sukuta and Banjulnding) where the intensification of vegetable gardening are so high plus Horticulture Research Programme and Regional Directorate of Agricultural Extension Services. The area lies between a latitude of 13.2229° N, and a longitude of 16.5820° W (Ceesay, 2004).



2.2 Sampling Methods and Techniques

For the tomato farmer's survey, district field Agric extension workers were involved in the selection process of communities and sampling of respondents. A selection criterion was established and used to select communities and respondents such as: level of tomato production and respondents' adequate knowledge about climate change etc. Five vegetable gardens were identified within the districts in the West Coast Region and 20 farmers were selected in each community garden which was later randomized to 10 respondents per orchard using the random sampling method to avoid biasness. A total number of 50 respondents were interviewed. However, similar approach was also used for Focus Group discussions.

2.3 Data Collection Detail from the Field Survey

A comprehensive design structured questionnaire was developed and used as a tool for guiding the proceedings of tomato farmer's survey and Focus Group Discussions (FDG) in the selected communities. This was followed by recruitment of field enumerators and training on how to translate the questionnaires into different local languages in order to ensure that the data that is going to be obtained from the respondents are reliable and accurate. Prior to the field data collection, the enumerators were deployed to the non-sample tomato growing community for pretesting of questionnaires. This has helped and determined the strengths and weaknesses of the survey concerning the question format and wording, order and as well as the ability and capability of the enumerators. Five persons were involved in the survey exercise i.e.; 4 Enumerators and 1 Driver.

2.4 Tomato Growers Survey

Four field enumerators were assigned to administer fifty set of questionnaires to the selected respondents in each vegetable garden. Respondents were also free to give answers to the questions without the enumerators leading them.

2.5 Focus Group Discussions (FDGs)

However, one FDG was held in each community garden, a minimum of 30 participants were selected which comprises of women, men and youth. During the FDGs, the selected tomato producers in each orchard were divided into two sub-groups and the facilitators were assigned to each group and aid the FDG proceedings. After the FDGs, all the participants were converged in a plenary session during which the findings of the FDGs were presented for adoption by the entire participants.

2.6 Data Analysis

STATA VERSION 14 was used for data analyzes and generates frequencies and percentages.

4. Results and Discussions

4.1 Socio-Demographic Information

The results depicted that (70.00%) of the respondents were female and (30.00%) male. Which means that female are the main dominant tomato producers in The Gambia. For the case of age, (34.00%) of the farmers reported to have attained an age bracket of (35-45) years followed by (26.00%) that falls in the age bracket between 45-55 which is not significantly different from (22.00%) those age are 55 years above and (4.00%) was observed as the least age bracket between 15-25. The survey also revealed that (54.00%) of the respondents did not have formal education due to religious sensitivity and low income earning. Only (24.00%) had achieved tertiary, (14.00%) with Secondary and (6.00%) primary education.

Table 4.1. Socio-Demographic Characteristics of Respondents

Variables	Frequency	Percentage
Gender		
Male	15	30.00
Female	35	70.00
Age		
15-25	2	4.00
25-35	7	14.00
35-45	17	34.00
45-55	13	26.00
55 Above	11	22.00
Education		
Bible	1	2.00
Koranic	27	54.00
Primary	3	6.00
Secondary	7	14.00
Tertiary	12	24.00

4.2 Production Information on Tomato

The survey indicated that agriculture is a very important activity in the West Coast Region of

the Gambia because almost all the communities are engaging into vegetable production more especially women's who are into tomato production. Years spent on tomato production, (86.00%) said to have spent 1-15years, followed by (12.00%) who had been cultivating tomatoes between 15-30years and the least percentage spent 30-45years on growing tomatoes. Significant numbers of the farmers are cultivating their tomatoes on sandy loamy soils. For the area under cultivation, (72.00%) are cultivating tomatoes between0.1-0.25ha and the smallest percentage are cultivating an area of 0.75above.

Table 4.2. Information on Tomato Production

Variables	Frequency	Percentage
Do you grow tomato		
Yes	50	100
Duration of growing tomato		
1-15years	43	86
15-30years	6	12
30-45years	1	2
Scheme of the soil		
Sandy loamy	39	78
Sandy soil	11	24
Area under cultivation		
0.1-0.25ha	36	72
0.25-0.5ha	13	26
0.75above	1	2

4.3 Type of Tomato cultivars Cultivated in the Study Area

The findings revealed that (88.00%) of the tomatoes growers are cultivating improve tomato cultivars such as (Monga, Thorgal and Mbolo etc) followed by (12.00%) who said they are still growing localcultivars . However, (84.00%) of the farmers said they are sourcing their seeds from agro-chemical seed stores through purchasing while (14.00%) sourced from their own seed stores and only(1.00%) received as a gift. For the method of watering, large majority (58.00%) are depending on the rainfall where (42.00%) are using irrigation. For the period of sowing seeds, (37.93%) do transplant their seedlings immediately after the first heavy rain dropped, while (34.48%) are relying on the first two heavy rains and (24.00%) observed transplanting a week after the beginning of the raining season. For the case of sowing (86.00%) reported using row sowing method and only (14.00) are broadcasting their seeds.

Table 4.3. Common Cultivars al Information

Variables	Frequency	Percentage
Tomato cultivars commonly grown		
Local	6	12.00
Improved	44	88.00
Source of seeds		
Gift	1	2.00
Own Seeds	7	14.00
Purchased	42	84.00
Method of watering		
Only irrigation	21	42.00
Rainfall and Irrigation	29	58.00
If raining season period normally sow the Tomato seeds		
A week after the beginning of the raining season	7	24.00
After the first heavy rain	11	37.93
After two heavy rain	10	34.48
Method of sowing		
Broadcasting	7	14.00
Row Sowing	43	86.00

4.4 Farm Inputs used During Tomato Production

The survey findings revealed the following inputs applied during tomato production. All the tomato growers are applying on their plots. Furthermore, (44.68%) of the respondents informed that fertilizers are normally purchased by themselves followed by (27.00%) who said they received their fertilizers as a gift, (14.00%) through purchased and gift compare to minorities indicated they sourced fertilizers either from agriculture or NGOs. However, the results also stated that tomato growers are using different types of fertilizers and the most common type is chemical fertilizers used by (42.00%) which is not significantly different from (36.00%) applying animal dung and others revealed using both Chemical fertilizer + animal dung. Majority of the tomato growers applied these different fertilizers in the middle of the season through broadcasting. In addition, (88.00%) of the respondents reported that synthetic pesticides are commonly used by many farmers but a small percentage also indicated using botanicals and ash and it is applied on tomatoes in the mid-season through spraying.

Table 4.4. Tomato Production Inputs

Variables	Frequency	Percentage
Application of fertilizers		
Yes	50	100.00%
Sources of fertilizers		
Agriculture	3	6.00
Gift	13	27.00%
Purchased + Gift	7	14.00%
NGOs	1	2.00%
Purchased	21	44.68%
Purchase +Agriculture & NGOs	1	2.00%
Purchase + agriculture	1	2.00%
Types of fertilizer applied		
Animal Dung	18	36.00%
Chemical Fertilizer	21	42.00%
Chemical fertilizer + animal dung	11	22.00%
Time of application		
Before + Mid season	11	22.00%
Before the season	10	20.00%
Mid-Season	28	56.00%
Mid season + Late season	1	2.00%
Method of application		
Row application	18	36.00%
Broadcasting	32	64.00%
Pesticides Application		
No	6	12.00%
Yes	44	88.00%
Sources of pesticides		
Agriculture	2	4.88%
Locally Prepared	1	7.32%
Purchased	38	92.68%
Type of pesticides applied		
Botanicals	6	15.00%
Synthetic pesticide	33	82.50%
Ash	2.50	2.50%
Time of application		
Before the season	2	2.44%
Late season	6	13.33%
Mid-Season	36	80.00%
Mid-Season + Late season	1	2.22%

4.5 Agronomic Practices and Yield Obtained

Weeding is one of the most important activities carried-out during crop production. The results obtained from the survey depicted that all the farmers weed their tomato plots, where (84.00%) of the respondents are manually weeding their tomato beds and few people are removing weeds through the application of herbicide and hand-picking methods. However, for the frequency of weeding, large numbers of the respondents are weeding their tomato plots either twice or three times. For the case of yield, the results depicted that (60%) of the tomato producers are obtaining 100-200kg as their highest yield followed by (23%) whose tomato yielded between 200-400kg and the lowest yields were resulted from 0-100kg by (17%).

Table 4.5. Information on Agronomic Practices and Yield Obtained

Weeding of Tomato field		
Variables	**Frequency**	**Percentage**
Yes	50	100.00%
Method of weeding		
Manual	42	84.00%
Herbicide	3	6.00%
Hand-picking	5	10.00%
Frequency of weeding		
Once	4	8.00%
Twice	25	50.00%
Three Times	21	42.00%
Average Yield Obtained (Kg)		
0-100	17	17.00%
100-200	60	60.00%
200-400	23	23.00%

4.6 Farmer's Awareness of Climate Change

The findings also investigated whether farmers are aware about climate change. The study depicted that (98.00%) of the tomato growers said are seriously aware and also strongly believe that climate change has/is still existing. Many climate elements were highlighted as a factor responsible for the declining of tomato production and as well as a results of low yielding, however, (46.94%) of the respondent interviewed seriously complained about continues heat generation which is as a result of high temperatures followed by (20.41%) experiencing high temperatures and low rainfalls and (10.00%) of the interviewee's did also mentioned high temperatures plus heavy winds. Minorities reported about observing either low rainfall, heavy winds and as well facing drought. For the case of year experienced the existence of climate change, significant number of respondents (69.39%) said they have been experiencing and facing tomato production challenges caused by climate change for the past five years now while (24.49%) indicated about 5-10years of experience and the lowest percentage of experiencing climate change resulted from (6.12%). The survey had continued

on finding how tomato growers came to know about climate change, (77.55%) of the respondents informed that they have known the reality of climate change through personal experience followed by (24.41%) who said they heard it from the different social medias and only insignificant percent of (2.04) said it was through personal experience plus social medias.

Table 4.6. Awareness of Climate Change

Awareness of climate change		
Variable	**Frequency**	**Percentage**
Yes	49	98
No	1	2
Farmers believe of climate change existing		
Yes	49	98
No	1	2
		Evidence for believes
All the climate elements	2	4.08
Drought	1	2.04
Heavy rain	2	4.08
Heavy wind	3	6.12
High Temperatures	23	46.94
High temperature + Low rainfall	10	20.41
High temperatures + heavy wind	5	10.20
Low rainfall	3	6.12
Year realized the existence of climate change		
1-5years 5-1years	34 12	69.39 24.49
10years	3	6.12
Knowledge of the existence of climate change		
Personal experience	38	77.55
Personal experience + media	1	2.04
Through media	10	20.41

4.7 Impact of Climate Change on Tomato Production

The survey reveals that (95.92) of the respondents reported that their tomatoes are affected by numerous climate change elements while (4.08%) said their tomatoes are not disturbed by climate change. Furthermore, (28.57) of the respondent indicated about severe rotting of tomato fruits at the reproductive stage which is due to high temperatures which is also similar to (20.41%) that observed dropping of flowers by heavy rain and wind. Some percentage raised about introduction of pests, severe discoloration of leaves and low yielding due to continues rain and heavy winds. For the case of adaptation strategies for the menace above,

(63.27%) of the tomato growers said they have some options for climate change adaptation strategies and (36.73%) accentuated that they don't have any adaptation strategies. The findings also reveal that (56.67%) said they are using synthetic pesticide to control insect pest's e.g. red spider mites followed by (23.33%) using planting of trees (wind breakers) to reduce heavy wind speed and (13.33%) said they are applying large quantity of fertilizers to improve the soil fertility Generally, farmers lamented that the strategies they used for adapting to climate change are very useful.

Table 4.7. Climate Change Challenges and Adaptation Strategies for Tomatoes

Impact of climate change on tomatoes on fields		
Variables	**Frequency**	**Percentage**
No	2	4.08
Yes	47	95.92
Effects of climate change on tomatoes		
Dropping of flowers by rain and wind	10	20.41
Fallen of tomato plant due to heavy wind	5	10.20
Introduction of pests	8	16.33
Low yielding due to continues rain and heavy winds	1	2.04
Severe discoloration of leaves	6	12.24
Severe rotting of tomato fruits	14	28.57
Stunted growth due to high temperatures	5	10.20
Strategies of adapting to climate change		
No	18	36.73
Yes	31	63.27
Farmers Adaptation strategies used for Climate Change		
Application of large quantity of fertilizers	4	13.33
Planting of trees (wind Breakers)	7	23.33
Practice of staking	2	6.67
Use of synthetic Pesticide	17	56.67
Usefulness of strategies		
No	4	12.90
Yes	27	87.10
Degree of usefulness		
High	13	48.15
Low	3	11.11
Medium	11	40.74

5. Discussions of Results

5.1 Farmer's Awareness and Perception of Climate Change on Tomato Production

The findings reveal that tomato producers are strongly aware and also believe about the existence of climate change effects on tomatoes. Many climate elements were highlighted as a factor responsible for the declining of tomato production and as well as a results of low yielding, however, (46.94%) of the respondent interviewed seriously complained about continues heat generation which is due to increase in temperatures followed by (20.41%)

experiencing high temperatures and low rainfalls and (10.00%) of the interviewee's did also mentioned high temperatures plus heavy winds. Minorities reported about observing either low rainfall, heavy winds and as well facing drought. Similar study was conducted by Guodaar L. *et al* (2017) reported that respondents observed temperature rise (90.2%), decrease in rainfall (87.3%), prolonged drought (87.3%), increase in solar radiation (74.6%) and an unpredictable rainfall pattern (73.5%). For the case of year experienced the existence of climate change, significant number of respondents (69.39%) said they have been experiencing quite numerous of tomato production challenges caused by climate change for the past five years now while (24.49%) indicated 5-10years of experience and the lowest percentage experienced climate change resulted from (6.12%). In addition, international journal of vegetable science (2014) published a study report from Nigeria which indicated that tomato farmers have been experiencing climate change effects on tomatoes since year 2000. The survey had continued on finding how tomato growers came to know about climate change, (77.55%) of the respondents informed that they have known the realities of climate change through personal experience followed by (24.41%) who said they heard it from the different social medias and only insignificant percent (2.04) said it was through personal experience plus social medias. Furthermore, similar study was conducted by Bagagnan *et al* (2019) revealed that farmers generally perceive an increase in the frequency of extreme weather events and a decrease in the duration of the growing season.

5.1.1 Climate Change Impact and Adaptation Strategies on Tomato Production

The survey reveals that (95.92) of the respondents reported that their tomatoes are affected by numerous climate change elements while (4.08%) said their tomatoes are not disturbed by climate change. Furthermore, (28.57) of the respondent indicated about severe rotting of tomato fruits at the reproductive stage which is due to high temperature, which is also similar to (20.41%) observed dropping of flowers by rain and wind. Some percentage raised about introduction of pests, severe discoloration of leaves and low yielding due to continues rain and heavy winds. Report from Roshan Bhandari *et al* (2022) stated that change of climate had detriment effect on tomatoes. Tomato production and yield falls drastically in the area due to the incidence of disease increase such as late blight by fungal manifestation, black spot and burning (yellowing) of plants. For the case of adaptation strategies for the menace above, (63.27%) of the tomato growers said they have some strategies to climate change adaptation strategies and (36.73%) accentuated that they don't have any adaptation strategies. The findings reveal that (56.67%) said they are using synthetic pesticide to control insect pest's e.g. red spider mites followed by (23.33%) using planting of trees (wind breakers) to reduce heavy wind speed and (13.33%) said they are applying large quantity of fertilizers to improve the soil fertility in which (87.10%) lamented that the strategies they used for adapting to climate change very useful.

5.2 Conclusion

The following conclusions could be drawn from the survey undertaken in this study.

1. Significant numbers of the tomato farmers are aware and also strongly believe that climate change is existing.

2. Majority of the respondent reported about constant increase in temperature and decrease in rainfall, an unpredictable rainfall pattern and prolonged drought
3. Large number of respondents said to have experienced climate change effects for more than five years while minority indicated about 5-10years of experienced
4. Most of the tomato growers said they became to know about climate change through personal experience
5. Climate change causes severe dropping of flowers by rain and wind and rotting of tomato fruits as well as pest attack at the reproductive stage.
6. For the case of adaptation strategies, great numbers of the farmers are using synthetic pesticide to control insect pests e.g. red spider mites, planting of trees (wind breakers) to reduce heavy wind speed and application of large quantity of fertilizers to improve the soil fertility.

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