BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

DEPARTMENT OF CROP SCIENCE

Farmers' perceptions of climate change in tomato (*Solanum lycopersicum*) production under irrigation schemes in Chief Masembura area (Ward 12), Bindura District

by

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DECLARATION

BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENT SCIENCE

The undersigned certify that they have read and recommended to the Department of Crop Science, this thesis entitled:

Farmers' perceptions of climate change in tomato (Solanum lycopersicum) production under irrigation schemes in Chief Masembura area (Ward 12), Bindura District

Supervisor : ……………………………………

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ABSTRACT

Anticipated climate change is likely to be a major constraint to production of both rain-fed and irrigated crops including tomatoes (*Solanum lycopersicum*), which, is one of the most valued vegetable crops globally. Information on farmers' perception on the effect of climate change on tomato production is scanty, therefore a survey was undertaken to assess farmers' perceptions and effects of climate change on tomato production under irrigation schemes in Masembura under chief Masembura area of Bindura District. Data was collected using structured questionnaire and participants were drawn using convenience sampling techniques. The study revealed that 58% of the participants were between the ages 25 and 45years, majority of them being males (67%). All of the farmers interviewed demonstrated knowledge about climate change. More than 60% of the total respondents perceived that climate change has resulted in erratic rainfall, wilting of tomato crops and increase in tomato insect pests. This study also revealed that climate change effects has caused reduction tomato yield, increase in tomato insects (*Tuta absoluta*), late blight disease (*Phytophtora infestans*) and a decrease (37%) in land hectarage due to shortage of irrigation water. Farmers' knowledge could have emanated from the outreach programmes by Non-Governmental Organisation and AGRITEX extension services in the area. The study concludes that most of the tomato farmers under irrigation schemes were aware of the effects of climate change and result in erratic rainfall and increase in temperature which may result in wilting of tomato crops.

Key words: *Solanum lycopersicum*, perceived effect, climate change, Irrigation schemes

DEDICATION

I would like to dedicate this project to my husband Murungwa Samuel and my sister Patience Mujuru. These people have been supportive throughout my degree program. Above all, the praise goes to the almighty God whose name is Jehovah.

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CHAPTER 1

1.0 INTRODUCTION

Climate change is anticipated to be one of the critical environmental calamities that has contributed to a public menace in most parts of the world, such as China, India, USA, Russia, Iran, Tunisia, Canada, South Africa and Israel due to its drastic effects on agriculture including horticultural sector, particularly in tomato (*Solanum lycopersicum*) production (Biratu, 2018). Tomato*,* one of the most crucial vegetables in the world, is grown mostly in open field, and may be seriously affected by climate change (Adebisi-Adelani & Oyesola, 2014; Litskas *et al*., 2019). Farmers in tomato production require to adapt to an increase in the potential for the infestations of pest and diseases as a result of climate change. Guodaar (2015), asserted that climatic changes will result in massive challenges to Africa a continent where hunger, poverty and diseases already available on farmers.

The tomato is fruit vegetable, which belongs to the Solanaceae family and native to South America and grown commercially around the world (Biratu, 2018) . The Solanaceae family also includes other crops such as potato, tobacco and eggplant. It is ranked second amongst the most important vegetables in the world, potato being the first (Litskas *et al*., 2019) . Biratus, (2018) alluded that in 2009 the production of tomato reached approximately 152 metric tonnes (MT) fresh tomatoes produced on 4.4 Metric tonnes per ha. The top five leading tomato producing countries include China, USA, India, Turkey and Egypt (Ochieng *et al*., 2016). The production of tomatoes has been affected by many biotic and abiotic constraints. The anticipation in the scope of climate changes such are expected to have significant effect on tomato productivity and land hectarage (Biratu, 2018).

It was observed by the United Nations Framework Convention on Climate Change (UNRCC) that there is need to address the issue of climate change especially in developing countries like Zimbabwe to safeguard food security (FAO, 2017). According to the Government of Zimbabwe (2018), the Inter-governmental Panel on climate change (IPCC) has projected that global warming between $1^{o}C$ and $2^{o}C$ will have a moderate effect on the planet's biodiversity. Considering the agricultural ecosystem point of view, there is evidence that some crop species and cultivars presently grown in a particular field may not be able to adapt rapidly adequate to the changes. Mutamiswa *et al*., (2017) noted that pests and diseases that were not previously on are now prominent, however accurate information is scarcity e.g., in Zimbabwe, the Tomato leaf miner has emerged probably as a result of climate change. Climate change will also lead to existing long-term environmental calamities, such as ground water depletion and soil degradation, which will adversely affect food and agriculture production systems (Arora, 2019).

The anticipated variation of precipitation and the frequency of droughts and floods (e.g., cyclone Eline which recently affected the Chimanimani community) are likely to reduce yields in general (Chatiza, 2020). Despite high temperatures enhancing crop growth and development, the crop yields may drop significantly when diurnal temperatures exceed the optimum temperatures of a specific crop (Biratu, 2018) . In this regard, climate change is likely to reduce yields in the long run. High temperature and less reliable provision of water are expected to create severe hardships for producers of tomatoes in Sub-Saharan Africa. In the same vein, heat and shortage of water will have direct impact on tomato productivity hence critically affecting the land hectarage (Chatiza, 2020).

Mavhura *et al*., (2017) observed that the impacts of climate change are likely to be most adverse in low –income countries (e.g., Zimbabwe, Malawi and Zambia) and middle –income countries (Algeria, Rwanda, Egypt and Tunisia), where millions of people depend on agriculture are vulnerable to hunger. Climate change is likely to drastically modify the face of agriculture as well as intensifying the vulnerability of hundreds of millions of poor farmers (Bhatasara, 2015). Climate change has a direct effect on agricultural production (e.g., tomato production), as agriculture is apparently susceptible to climate conditions and is one of the most affected economic sectors (Bhatasara, 2015). Tomato production is affected in several ways, one of which is the direct impact on quality.

1.1 PROBLEM STATEMENT

Tomato production is a source of livelihood of most communal farmers in Masembura area. The rising temperature as well as erratic rainfall trend that are attributed to the changing climate have been the cause of great distress of the tomato farmers. The anticipated change of the climate in recent times has resulted in reduction in yield of tomato in Zimbabwe. Unfortunately, the Masembura area of Bindura District happens to be among the places in the country that is vulnerable to climate change and has experienced a decrease in tomato yield over the years due to climate change. The perspective of tomato farmers on the effect of climate change on tomato has not been documented. An investigation on perception of farmers on impacts of climate change on tomato production was conducted.

1.2 JUSTIFICATION

The outcome of climate change is anticipated to lead to climate risks including drought, heat waves, can also cause secondary stresses inclusive of the spread of insects as well as increased competition. The research will provide appropriate interventions to the policy makers on sustainable ways to mitigate the anticipated devastating effects of climate change as well as scaling up meeting the sustainable developmental goals (SDGs) by 2030.

1.3 Aim

To assess farmers' perceptions and effects of climate change on tomato production under irrigation schemes in Masembura area of Bindura District.

1.3.1 Specific objectives

- To determine farmers' perceptions of climate change in tomato production under irrigation schemes in Masembura area.
- To assess the effects of climate change in tomato production under irrigation schemes in Masembura area

1.4 Hypothesis

H_1: Farmers have a knowledge of climate change on tomato production under irrigation schemes of Masembura area.

H_1: Climate change has a significant influence on tomato production under irrigation schemes of Masembura area

CHAPTER 2

LITERATURE REVIEW

2.1 TOMATO PRODUCTION IN ZIMBABWE

According to FAO (2020), Zimbabwe produces approximately 250 000tons of fresh tomatoes per year. Tomato is considered as one of the major vegetables grown for hawking by those in the informal sector inclusive of small-scale entrepreneurs (Madhiri, 2018). In Zimbabwe, tomatoes are consumed in several ways such as raw, sauces, soups, peeled tomatoes as well as various forms of juice (Madhiri, 2018).

As far as distribution of tomatoes is concerned, approximately 42%, 45% ,10% and 2% caters for direct sales, fresh produce markets, processing export market respectively (Madhiri, 2018). Tomatoes are usually grown almost throughout the year in all the provinces. Zimbabwe's smallholder horticultural production has over the past decade expanding leading to the vegetable sector to be on top. According to the Government of Zimbabwe (2010) as cited in Madhiri study of (2018), the small-scale sector is approximated to give around 60% of the quantity that is locally marketed as well as other 40% is given by the large commercial sector.

2.2 CLIMATE CHANGE

Climate change can be defined as a change in the average of various climatic parameters including temperature, rainfall, relative humidity and atmospheric gases composition as well as in properties over a prolonged period and large geographical area (Abewoy, 2018). It can also be termed as any change in climate overtime, whether because of natural variability or due to anthropogenic activity (Abewoy, 2018; Guodaar, 2015). According to Spaldon *et al.*, (2015), the altering radiation patterns of climatic parameters such as increase in atmospheric temperature, changes in rainfall patterns, excess UV radiation and devastating weather events including droughts and floods are causing main threats for vegetable production in the tropical zone.

2.2.1 Perception of climate change

Climate change is a scenario that is perceived differently by different people. The perception of people may be relied upon their indigenous knowledge or to some extent, their educational backgrounds, it is critical to note that, the perception of people on the varying climate may be regionally biased as different people across different region may perceive climate change differently.

According to Gbetibouo & Ringler (2009), African countries indicate that large numbers of farmers perceive that climate has become hotter and the precipitations less predictable and shorter in duration. According to Tunde (2011) on farmers' perception of climate variability on Agriculture in Nigeria, majority if farmers (47.2%) in the region perceived climate variability as delayed rainfall.

A study by Mudombi (2011), revealed that in Zimbabwe, particularly, the Murewa district perceive climate variability as increase in drought conditions, heavy precipitation as wells as violent storms that were never encountered in the past decades. The findings indicate that communal farmers in Zimbabwe perceive the altering in the timing of the season, and changes in features within seasons for example extreme situations, including droughts, floods as well as destructive hailstorms becoming common (Mudombi, 2011).

Mubaya *et al*., (2010) asserts that most communal farmers (80%) in Zambia and Zimbabwe were aware of the changes in climate over the years. The study further asserted that, farmers in the two regions perceived climate variability as floods and excessive rainfall coupled with the oscillations in the weather patterns over the years. Notably from the study, even though flood and excessive rainfall were perceived by most farmers in Zambia as well as Zimbabwe as evidence of changing climate, a portion of the farmers in Zambia (10%) and Zimbabwe (18%) forming the minority highlighted that they have not seen any changes in the climate (Mubaya et al., 2020) .

2.2.2 EFFECTS OF CLIMATE CHANGE ON TOMATO PRODUCTION

Vegetable crops inclusive of tomatoes are very sensitive to climatic uncertainties as well as rise in temperature and irregular rainfall at any phase of crop growth and development can influence the normal growth, flowering, pollination, fruit development as well as subsequently decrease the crop yield (Afroza *et al*., 2010). According to the Intergovernmental Panel on Climate Change (IPCC) Africa will be hit hardest by climate change as larger areas could be stricken by yield reduction of over 50% by the year 2050 due to an increasingly hotter as well as drier climate (Eitzinger *et al*., 2015; Tshiala & Olwoch, 2010).

Climate change is anticipated to have a main effect on agriculture and horticulture, hence affecting the world's food supply (Adebisi-Adelani & Oyesola, 2014). Anticipated changes in ecological and agro-economic zones, land degradation, reduced availability of water, elevated carbon dioxide (CO_2), sea level increase as well as salinization will lead to a critical threat to fruit and vegetables inclusive of tomatoes. According to Chatterjee & Solankey (2015), the shortage of water worsened by climate change will be felt in crop production, given the fact that agriculture accounts for 70% of water utilization globally. Water is a critical requirement for tomato production in Sub-Saharan Africa, and will increasingly become a main limiting aspect as a result of its scarcity and irregular availability(Adebisi-Adelani & Oyesola, 2014) .

Tomatoes are one of the agricultural products and the sources of livelihood for a majority of rural as well as urban populations. Tomatoes are available all year round, easy to cook and rapid growing naturally. However, the extreme effects of climate change threaten to sink tomato farmer vulnerability as well as undermining their prospects for development (Williams et al., 2018b). According to Williams *et al*., (2018b), tomato faces numerous challenges apart from environmental stresses including prolonged erratic rainfall. There are several problems associated with tomato growing including contamination linked to pathogens of fruit vegetables that is closely associated to climate change. A research done by Datta (2013) and Deuter & White, (2014), separately as cited in Fadairo *et al*., (2020), concurs that temperature and rainfall is positively related to the cases of *Salmonellosis* in subtropical as well as tropical regions.

A tomato crop is negatively imparted by climate change attributing to exposure to heat that reduces yields and variation in rainfall that affects production on areas where irrigation is significant. Similarly, Datta (2013) observed that reduced precipitation and increased temperatures result in serious crop water-stress condition as a result of a decrease in available water for irrigation and increase in evapo-transpiration. Also, increase in temperature alters tomato production timing or calendar of planting and may result in a reduction in potential yields attributed to unpredictability of the planting season and reduce in water availability for irrigation(Adebisi-Adelani & Oyesola, 2014).

Another critical aspect of climate change effect on tomato farming was documented by Oxfam (2008) in a research on climate and poverty in Uganda, where tomato farmers attributed the elimination of some local cultivars of tomatoes to climate change impact. The research revealed that tomato farmers no longer grow a particular local cultivar of tomatoes as result of shortened duration of rains, and subsequently early maturing types of fruit vegetables have been adopted as a replacement (Fadairo *et al*., 2020).

According to Fadairo *et al*., (2020), climate in sub-Saharan Africa where horticulture is an essential economic sector is highly variable across geographical zones. This is due to horticultural production systems in this region are greatly rain-fed and therefore vulnerable to unexpected changing weather conditions. Asserted that climate change in African countries will result in adverse effects on agriculture, food security and economic development, particularly smallholder tomato farmers are encountering increased climate change. Deuter & White (2014) noted that vegetable production in the tropics is a combined effect of varied conditions of season and region. Researches in Ghana, Uganda and Nigeria have shown an anticipation of extreme events and changes in rainfall and temperature (Fadairo *et al*., 2020; Fitzmaurice, 2014).

Climate change also affects the ecology as well as the biology of insect pests (Mutamiswa *et al*., 2017). Increased temperature, in some group of insects with short life cycles including aphids and tomato leaf miner, escalates fecundity, earlier completion of life cycle. Therefore, these can produce more generations per year than their normal rate. According to Newton *et al.,* (2011), higher temperatures result in higher quicker disease cycles in air borne pathogens and escalate their survival because of decreasing in frost. The earlier appearance and increase in the number of insect vectors of viral diseases due to increase in temperature, lead to increasing viral diseases of tomato such as Tomato Torado virus, Alfalfa mosaic virus and tobacco mosaic virus (TMV) (Newton *et al*., 2011). According to Pautasso *et al*.,(2012), floods can lead to the proliferation of water-borne pathogens easier, droughts as well as heat waves can predispose plants to infection as well as storms can promote wind-borne dispersal of spores such as tomato late blight .

CHAPTER 3

3.0 Materials and Methods

This chapter explain how the study was carried out. The chapter discussed the study site, research design, sampling techniques, data collection, pretesting, data management and analysis, data presentation and ethical considerations.

3.1 Study site

The study was conducted in Masembura area (***See Figure 1)*** of Mashonaland Central in Zimbabwe.

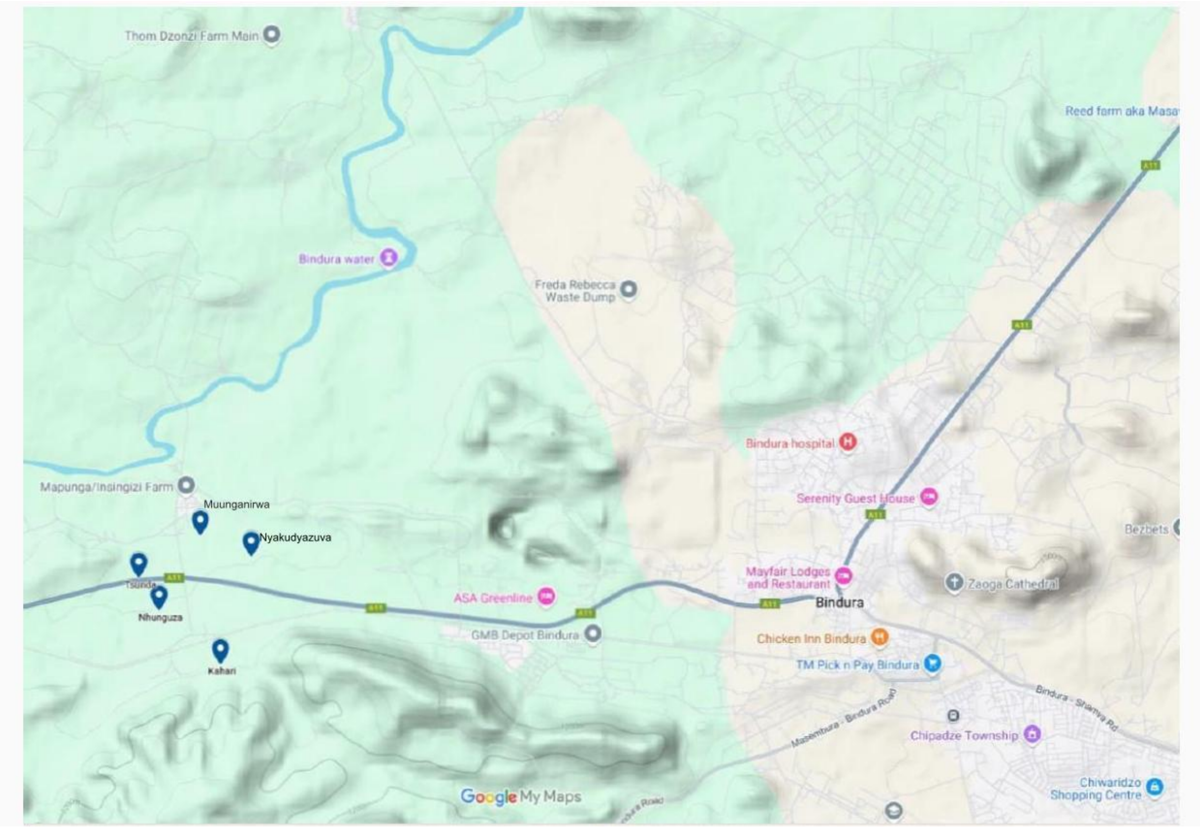

Figure 3. 1: Showing irrigation schemes under Chief Masembura area

It is located in the Mashonaland Central Province of Zimbabwe. The district is located in Agro-ecological region II which receives the mean annual rainfall between 750-1 000 mm. It is located in Bindura South District.. Hot summer is usually, between September and December with October being the hottest month of the year with maximum temperatures above 30^{o}C. Usually, the temperature in October averages 19. 5^{o}C.The month of July is the coldest month in Masembura District, with mean temperature of approximately 11.9^{o}C. The average day length is approximately 13.2 hours and 11.1hours in summer and winter, respectively.

3.2 SAMPLING FRAME

The sampling frame which composed of list of all the irrigation schemes in Masembura area in Bindura District. Tomatoes were selected as study population. Out of 7 irrigation schemes in Masembura area, five were confirmed to be undertaking production including, Tsunda, Nhunguza, Muunganirwa, Kahari and Nyakudyazuva. The frame consisted of the names of irrigation schemes, area covered, and number of plot holders as well as plot sizes per each irrigation scheme.

Table 3. 1: Showing sampling frame of irrigation schemes in Masembura area.

Irrigation schemes name	Area covered (Ha)	Total Number of plots holders	Plot size (Ha)
Tsunda	70	129	0.54
Nhunguza	28	55	0.51
Muunganirwa	21	33	0.64
Kahari	152.5	60	2.54
Nyakudyazuva	36	48	0.75
Total	**307.5**	**325**	**4.98**

Source: (Field ,2025)

3.3 RESEARCH DESIGN

The convenience sampling was used to sample 64 farmers, which is at least 10% of the total communal farmers from irrigation schemes under Chief Masembura area of Bindura District.

3.4 QUESTIONNAIRE LAYOUT

A structured questionnaire (***See Appendix 1***) was characterised with a total of 40 questions closed ended questions. It is considered essential because most of the respondents to be included may not read and write the English Language. Data on perception of climate change on agronomic practices and land hectarage, tomato production, pest ad diseases was collected.

3.5 SAMPLING TECHNIQUE

Convenient sampling was employed due to financial constraints as well as the coronavirus (COVID-19) diseases which affected the data collection process. The researcher interviewed any farmer who was present at that given target irrigation schemes.

3.5.1 SAMPLE SIZE

The sample size of 64 respondents was sufficient to obtain the validity of the data to be obtained.

Table 3. 2: Showing sampling units

Irrigation Schemes	Total number of plot holders	Proportion for the number of plot holders	Sample size (n)
Tsunda	129	0.15	19
Nhunguza	55	0.31	17
Muunganirwa	33	0.36	12
Kahari	60	0.13	8
Nyakudyazuva	48	0.17	8
Total	**325**	**1.0**	**64**

3.5.1.1 CALCULATIONS

Sample size per irrigation scheme at least 10% (Smith, 2004) = sample size (n) for Tsunda = 19. A sample size of 19 out of 55 farmers is at 10% as per Tsunda irrigation scheme as shown by calculations below:

Sample size per Irrigation scheme (i.e., Tsunda) / Total number of farmers per irrigation scheme (i.e., Tsunda.)

$= 19/129 \times 100$

= 15% (**See table 3.2)**

These calculations apply to other irrigation schemes in T**able 3.2**.

3.6 PRE-TESTING
Pre-resting was conducted to improve the questionnaire and check if they fetch appropriate answers to the questions to avoid distortion of information. Errors noted during the pre-testing exercise was amended prior to actual data collection in Masembura area.

3.7 DATA COLLECTION
Questionnaires were administered by the researchers together with trained enumerators. Two enumerators interviewed the farmers in vernacular language and record answers right away. The AGRITEX officers from Bindura participated voluntarily in terms of providing essential information, which includes farm records of the Masembura area irrigation schemes.

3.8 DATA MANAGEMENT
Filled questionnaire were audited for completeness at the end of each data collection day within the field to note any missing data before leaving the field. At the end of each data collection day all field questionnaire was handled to the team leader for safe storage.

3.9 ETHICAL CONSIDERATIONS
Ethics was observed during data collection process, inclusive of the consent form written separately in English and Shona (***See Appendix 2 and 3***) respectively. Therefore, we ensured that sensitive information was protected and the data was used for academic purposes only. The researcher collected information from farmers considering race, gender and level of education.

3.10 DATA ANALYSIS
Data coding was considered prior to analysis, followed by testing for normalcy. Descriptive and frequencies in Microsoft Excel 2016® was used to explore the data. Data was tested for reliability and analysed using Cronbach alpha in IBM Statistical Package for Social Sciences (SPSS)® version 21 for windows. Quantitative data obtained was organised, summarised and analysed using descriptive statistics to calculate means, standard deviations and ranges using IBM SPSS® version 20 for windows. Cross-tabulation and Chi-square test of independence was used to test for associations.

CHAPTER 4

4.0 RESULTS

Sixty-four (64) farmers from irrigation schemes in Masembura area namely; Kahari, Nyakudyazuva, Tsunda, Nhunguza and Muunganirwa with 8, 8, 19,17 and 12 respondents respectively were involved in this research work. These are described in **Table 4.1** for the purpose of the study background. Several characteristics included the farmer's sex, age, level of education, marital status etc.

4.1 SOCIO-DEMOGRAPHIC DATA OF RESPONDENTS

Results (Table 4.1) shows that tomato farming in Masembura area was predominantly undertaken by male farmers with 67% whereas female farmers were 33%. Data showed that age of the respondents was one of the most essential characteristics in understanding their views about the effects of climate change. Thus, most of the participants were between the age group of 25 and 34 years with a percentage of 30% followed by age group of 35 and 44 and the least age groups of 55 and 64 years and above 64 years with 3% (Table 4.1).

Table 4. 1: Showing farmers' socio-demographic characteristics

Variable	Categories	Percentage (%)
Irrigation Scheme	Kahari	12
	Nyakudyazuva	12
	Nhunguza	27
	Muunganirwa	19
	Tsunda	30
Gender	Male	67
	Female	33
Age in years	<25	25
	25-34	30
	35-44	28
	45-54	11
	55-64	3
	>64	3
Marital status	Single	28
	Married	62
	Divorced	5
	Widow/Widower	5

Educational status	Illiterate	8
	Primary	23
	Secondary	58
	Tertiary	11
Number of years lived in the community	1-5	23
	6-10	39
	11-19	24
	20 and above	14
Number of kids	Zero	24
	1-2	25
	2-3	45
	>3	6
Farming experience in years	<5	34
	5-10	44
	>10	22
Land holding in hectares	0.5-1	20
	1.1-1.5	38
	1.6-2	22
	>2	20
Access to weather forecast	Acquired	23
	Not acquired	28
	Other means	49

The perception of the farmer can also differ by marital status of the farmers since the marriage might consider more responsibility as well as maturity in understanding and providing the responses to the questions interviewed (Table 4.1). Out of 64 respondents, 62% were married followed by single, divorced and widow/widower with 28% and 5% respectively. More than half of the respondents had secondary level of education followed by primary and tertiary with 23% and 11% respectively. Only 8% had no formal education as shown in **Table 4.1**.

Most respondents with 39% as shown in **Table 4.1** indicated that they lived in the community between 6-10 years followed by (11-19) years and (1-5) years with 24% and 23% respectively and the least being 14% of more than 20years. Out of 64 respondents, 45% of them had the number of kids between 2 and 3 followed by 25% and 24% with kids between (1-2) and zero respectively. The least recorded on the number of kids was 6% for those who had 3 kids and above.

In terms of farming experience, most farmers with 44% responded that they have farming experience between 5 to 10 years. 34% and 22% reported that they were into farming for below 5 and above 10 years respectively. Apart from the above, land holding is also another pertinent issue as shown in **Table 4.1** where 38%, 22% and 20% had land holding of 1.1-1.5 ha, 1.6-2 ha, >2 ha and 0.5-1 ha respectively. Lastly on socio-demographic data ,49% of the respondents used other means such as tradition had an access to weather forecast followed by 28% who do not have access to weather forecast and the least percentage noted being 23% who acquire an access to weather forecast.

4.2 Farmers perceptions on the effects of climate change in tomato (*S. lycopersicum*) production under irrigation schemes in Masembura area

The production of tomatoes usually includes the aspects of yield, growth and development as well as insects and diseases. Therefore, the results were presented herein showing the perceptions of farmers on the effects of climate change inclusive of erratic rainfall, wilting of tomato crops and increase in tomato pests and diseases. Results indicate that 61%, 66%, and 64% of tomato farmers across all irrigation schemes interviewed believed that climate change has led to erratic rainfall, increase in tomato pests, and wilting of tomato crops respectively (Figure 4.1). Within 61%, 19% farmers from Tsunda irrigation scheme perceived that climate change have led to erratic rainfall, followed by Nhunguza, Muunganirwa, Kahari and Nyakudyazuva which recorded 16%, 14% and lowest 6% respectively. Of the 66% of the tomato farmers who perceived that climate change has caused wilting of tomatoes, the highest and lowest percentage noted was 21% and 5% respective of Tsunda and Nyakudyazuva Irrigation schemes (Figure 4.1). Among 64% of the tomato farmers who demonstrated that an increase in tomato insect pest and diseases is attributed to climate change, the maximum and minimum percentage was 21% and 5% for Tsunda and Irene irrigation scheme respectively. The percentage of the farmers who disagreed and not sure about effect of climate change recorded maximum of 14 % and 6% respectively (Figure 4.1).

The results for the Chi-square test for an association of the perceived effects of climate change with irrigation schemes indicated that there was a significant association between an irrigation scheme and increase in tomato pests and diseases and wilting of tomato crops with P-values (0.008 > 0.05) and (0.013>0.05) respectively (***See appendix 4***).

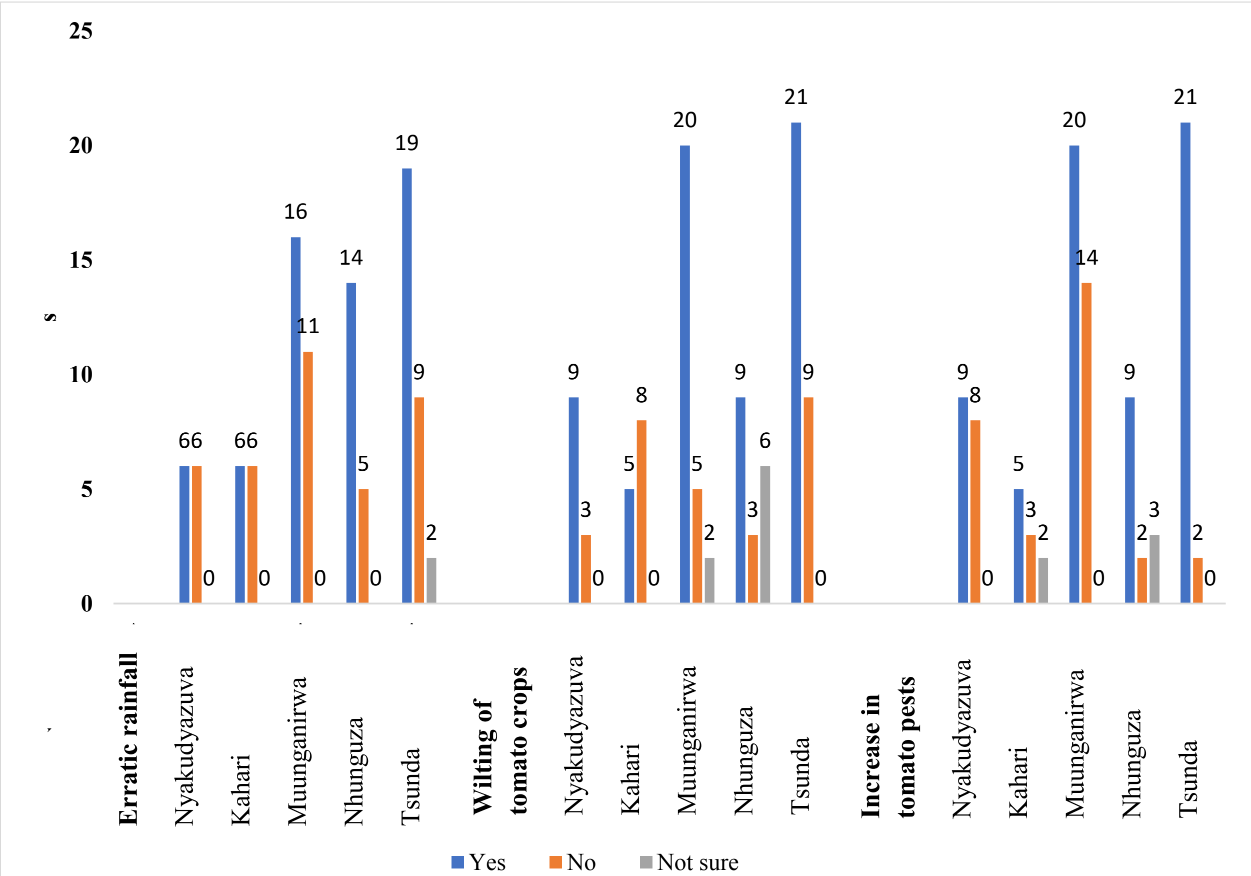

Figure 4. 1: Showing cross tabulation farmers perceptions of climate change

4.2.1 FARMERS' PERCEPTIONS ON THE EFFECTS OF CLIMATE CHANGE ON TOMATO YIELD WITH FARMING EXPERIENCE

Among 64 respondents, 78% demonstrated that climate change affects tomato yield as shown in (Figure 4.2). Within 78 %, the highest recorded was 33% showing most of the farmers had a farming experience of between 5 to 10 years followed by 25% and 20% who indicated that they were into farming for less than five and more than 10 years respectively. 18% of the respondents disagreed that climate change affects tomato yield and 4% of the total respondents were not sure about the effects of climate change on tomato yield.

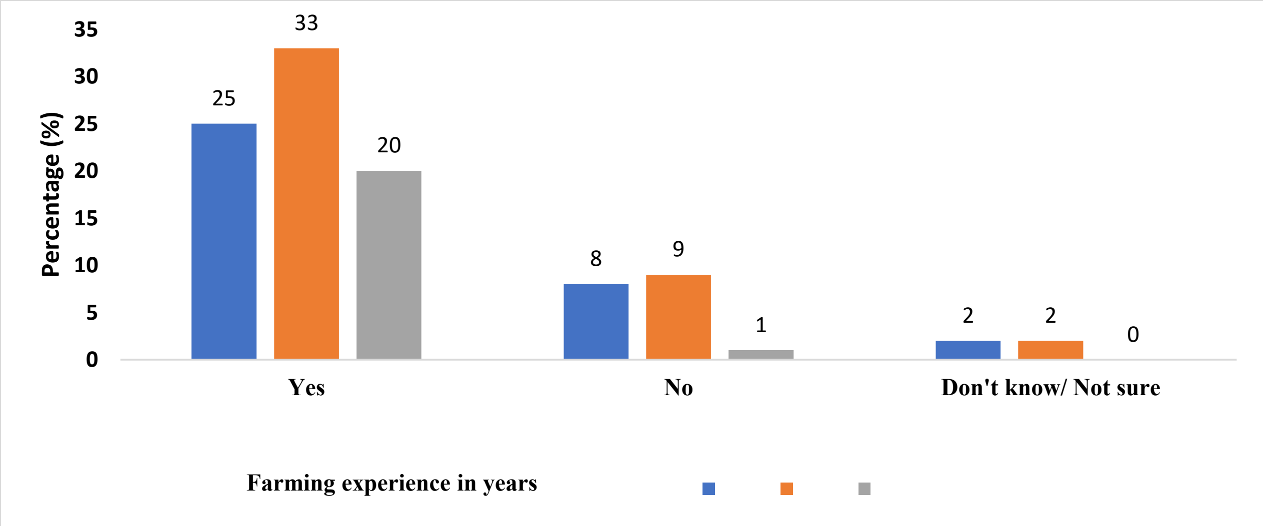

Figure 4. 2: Cross tabulation of farmers' perception of climate change with farming experience in years.

4.2.1.1 CHI-SQUARE TEST OF THE RELATIONSHIP BETWEEN THE FARMING EXPERIENCE AND THEIR PERCEPTION OF CLIMATE CHANGE ON TOMATO YIELD.

The Chi-square test outcome with (**α=0.05**) indicated that there is no significant association (**p>0.05**) between farmers' farming experience and their perception of the effects of climate change on tomato yield (***See Appendix 3***). Thus, the hypothesis that there is no significant association `exists between the farmers' farming experience and their perceptions on the effects of climate yield is therefore accepted.

4.2.2 FARMERS' PERCEPTIONS ON THE POINT AT WHICH CLIMATE CHANGE AFFECTS TOMATO PRODUCTION

The results in **Figure 4.3** revealed that 22% of the total tomato farmers of the middle age group (35-44) as well as 25-34years perceived that climate change critically affects tomato production during flowering development. The least percentage of 3% was noted on the age group of 64years and above. Less than 25% of the total respondents perceived that climate change affects tomato production during land preparation, fruit set as well as ripening period across all age groups. The Chi-square test for independence indicated that age in years is independent of the perceptions of farmers on the state at which climate change affect tomato production since P-value (**0.707 > 0.05**) with Pearson correlation coefficient of -0.245.

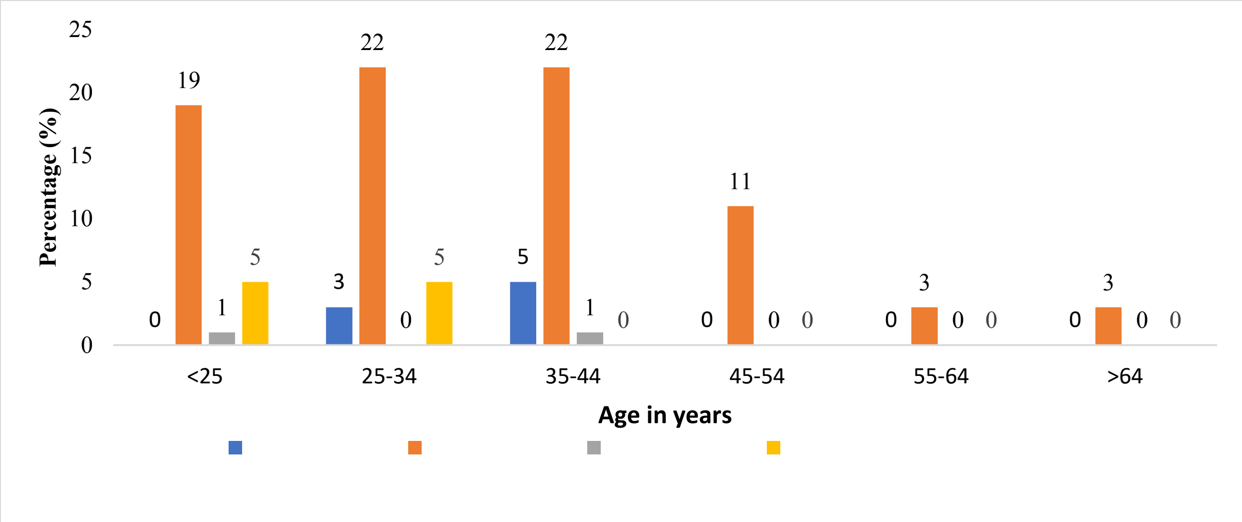

Figure 4. 3 : The perception of farmers on stage at which climate change affect tomato production

4.2.3 THE INSECT STATUS AS A RESULT OF CLIMATE CHANGE IN TOMATO PRODUCTION

From the results in **Figure 4.4**, out of 64 respondents the highest recorded 53%, who has attained secondary level perceived that they have attributed an increase in insect populations due to the effects of climate change.20%, 11% and 8% who has an educational status of tertiary, primary and illiterate had demonstrated that climate change has increased the insect status. Only 5% and 3% who had attained secondary and primary level respectively perceived that an increase in the insect population status emanated from the effects of climate change. There was no significant association between educational status and farmers' perceptions on attributed insect status due to climate change since P-value (0.647>0.05) at 5% level of significance with Pearson correlation coefficient of -0.069.

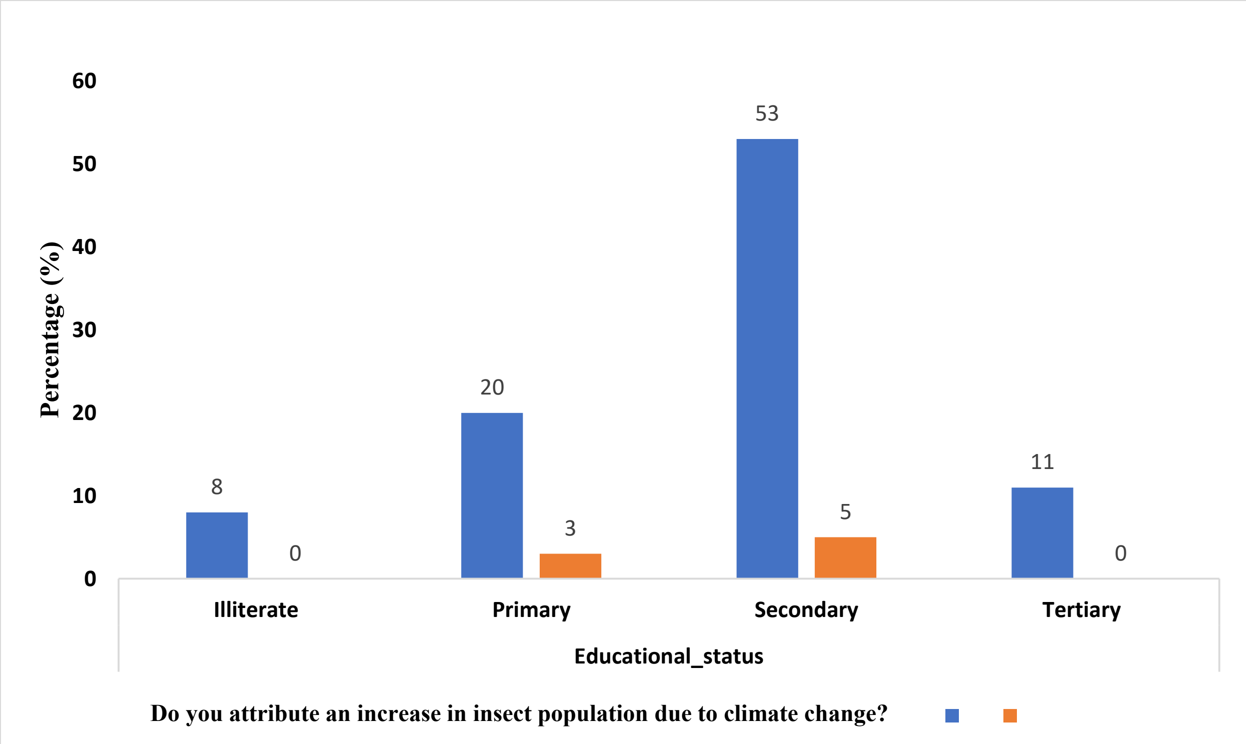

Figure 4. 4 : The cross tabulation of educational status and insect's status due to climate change

4.2.4 INSECT PESTS WHICH EMERGED AS A RESULT OF CLIMATE CHANGE

As shown in **Figure 4.5**, *Tuta absoluta* recorded the highest percentage (30%) across all educational level attained among red spite mite, aphids and white flies which recorded the highest of 14%, 8% and 6% respectively. Most of the farmers who attained secondary level perceived that *Tuta absoluta* has emerged as a result of climate change across all the irrigation schemes of Masembura area in Bindura District. A weak positive correlation ($r=0.061$; $p=0.634$) between perceived insects which emerged due to climate change with educational level. In this regard, there was no significant association between the two since the p-value was 0.634.

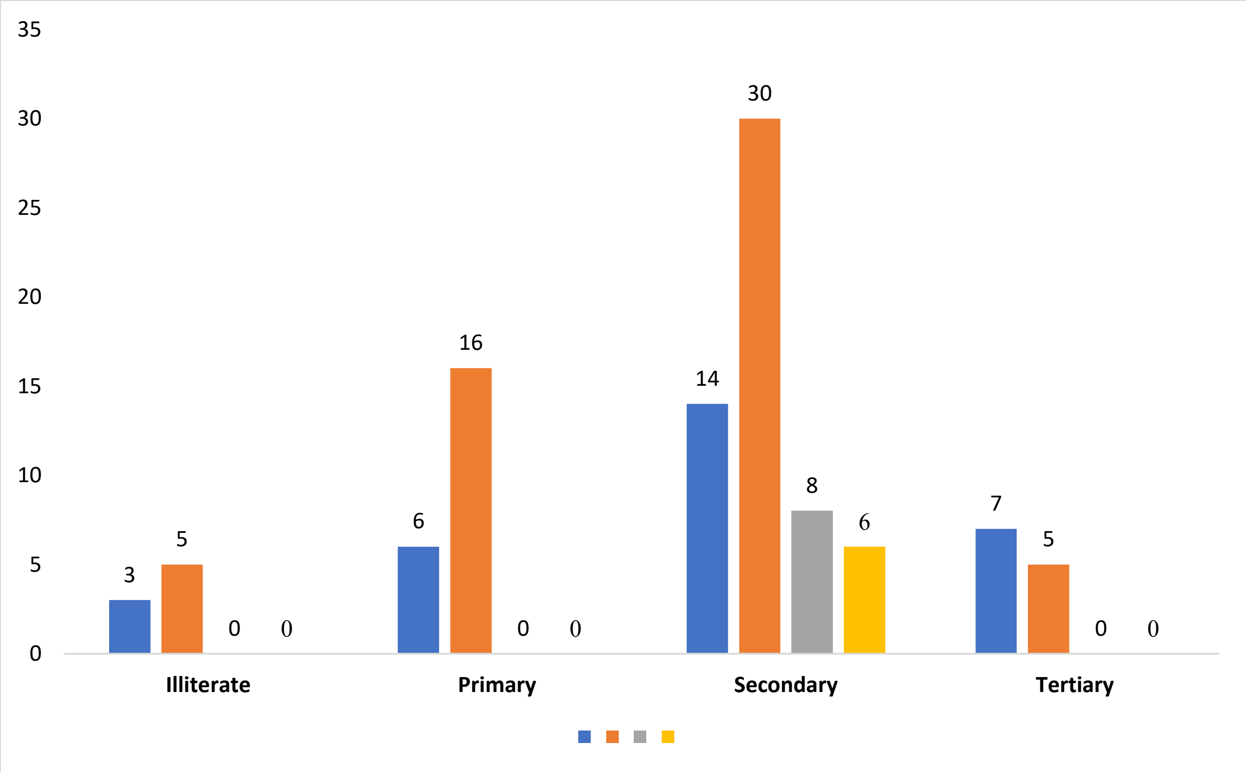

Figure 4. 5 : Showing insect pests emerged as a result of climate change

4.2.5 Tomato diseases attributed as a result of climate change in tomato production

Out of 64 tomato farmers, 34%, 22% and 19% who have farming experience between 5-10, <5 and >5 years respectively perceived that tomato late blight has emerged as a result of climate change as shown in **Figure 4.6**. The remaining 25% of total respondents across all farming experience categories demonstrated that soft rot, tomato mosaic virus (TMV) emanated from the effects of climate change. The bivariate analysis indicated that the farming experience in years was independent of the perceived effects of tomato diseases which emerged due to climate change (p=0.533). Thus, the p-value 0.533 was greater than 0.05 showing no significant associating between the two variables.

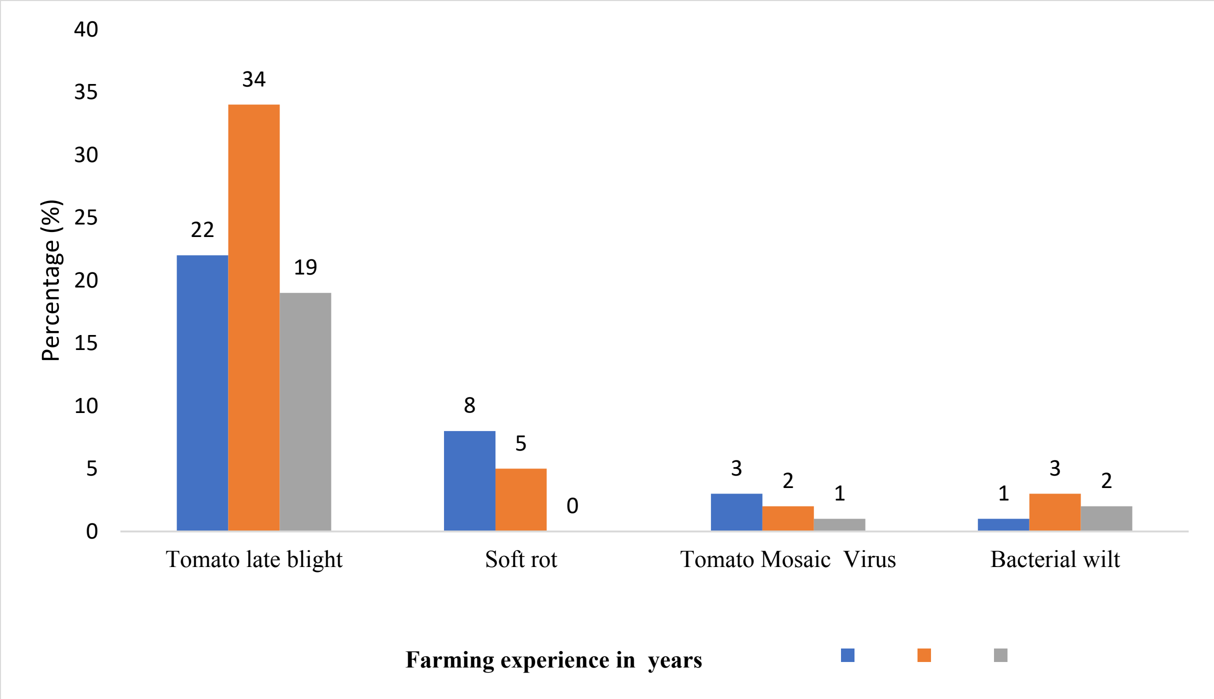

Figure 4. 6 : Cross tabulation of farmers' perception of tomato diseases emerged due to climate change with farming experience.

4.2.6: TOMATO VARIETIES AFFECTED BY CLIMATE CHANGE

Among 64 tomato farmers as shown in **Figure 4.7**, 28% of the respondents from Tsunda irrigation scheme demonstrated that Rodade tomato variety was the most affected by the effects of climate change. 22%, 16%, 11% and 8% of the respondents from Nhunguza, Muunganirwa, Nyakudyazuva and Kahari respectively also perceived that Rodade tomato cultivar is vulnerable to the effects of climate change. The remaining 15% of the respondents across all irrigation schemes perceived that Tengeru and Star 9009 are affected by climate change better than Rodade. The Chi-square test for association indicated that there was a significant association between the irrigation scheme and the perceived effects of climate change on tomato variety influenced by climate change

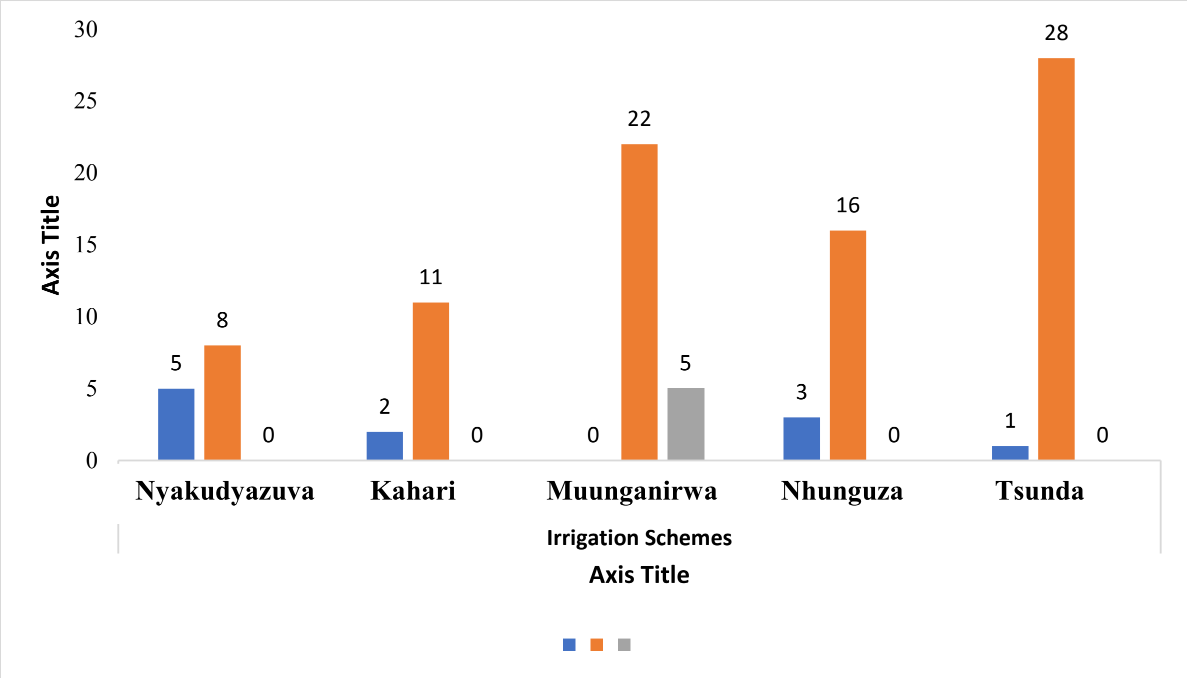

Figure 4. 7 : Perceptions of farmers on tomato varieties affected by climate change

4.3 THE PERCEIVED EFFECTS OF CLIMATE CHANGE ON TOMATO LAND HECTARAGE UNDER IRRIGATION SCHEMES IN MASEMBURA AREA

The shortage of irrigation water as a reason a decrease in tomato land hectarage was perceived by 22%, 19%, 17%, 11% and 8% of the total respondents from Tsunda, Nhunguza, Muunganirwa, Kahari as well as Irene irrigation scheme respectively as shown in **Figure 4.8** 9%, 5% and 2% from Muunganirwa, Kahari and Tsunda and Nyakudyazuva respectively demonstrated that erratic rainfalls resulted in the reduction of land hectarage. Only 2% of the total respondents from Tsunda irrigation scheme perceived that floods caused a decrease of tomato land hectarage. Bivariate analysis test for association indicated that there was a weak positive correlation (r=0.012) between irrigation scheme with the perceived reasons on the reduction of land hectarage due to climate change.

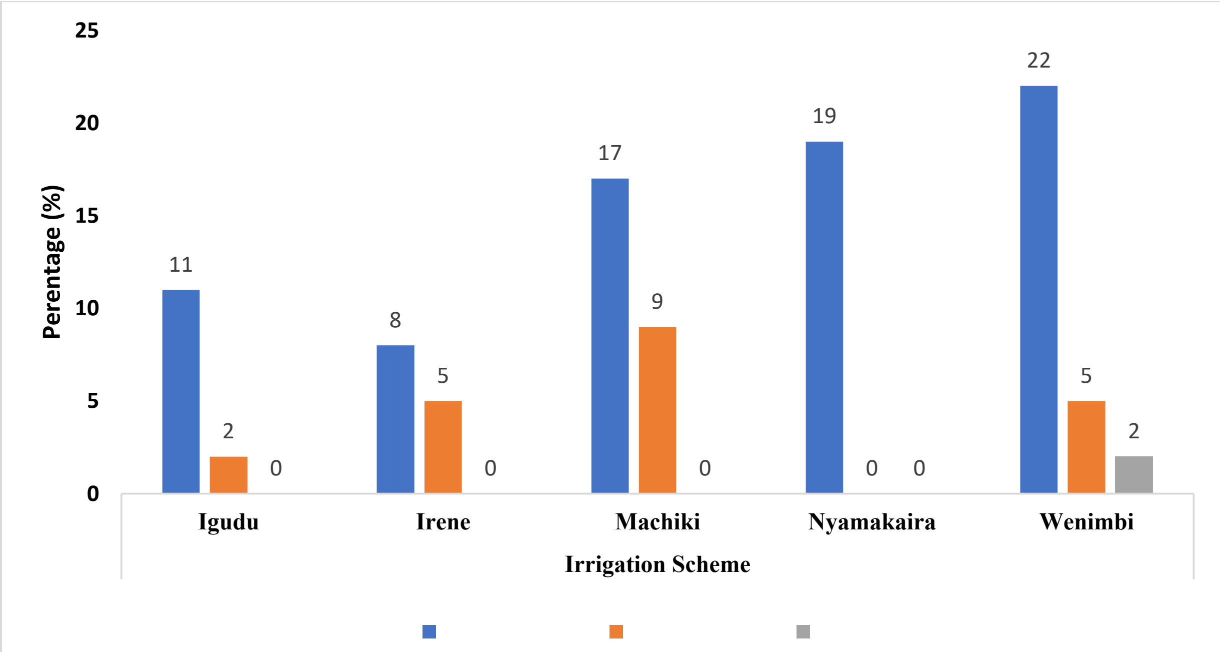

Figure 4. 8 : Perceived effects of climate change on hectare of tomatoes with irrigation schemes

CHAPTER 5

DISCUSSION

Climate change is a significant and emerging threat to agricultural production in sub-Saharan Africa, especially in lower income. It has been shown that people of Africa were the least likely to perceive global warming as a threat. In Zimbabwe, little research has been conducted concerning the perceptions of effects of climate change on human health. A survey was conducted in Bindura district to ascertain farmer's perception on this emerging threat. Data from this study revealed that age of a farmer is very critical in tomato production activities. The reason why the aged are still participating in tomato production could be due to land ownership and therefore have greater access to the land that invariably pushes them into farming business.

The 67% to 33% male and female ratio respectively indicate that both males and females are involved in the production of tomatoes. This implies that a greater proportion of the respondents were males with the females forming the least percentage group. Also, the sex distribution provides credence to the fact that tomato farming in Masembura area of Mashonaland Central district is dominated by males. This could be attributed to the labour as well as energy demands of cultivation of tomato.

The level of education as shown in **Table 4.1** concur with the findings by Madhiri (2018) and this implies that the majority of tomato farmers in rural areas have secondary education. In a discussion with the district extension officer, it was identified that high education among of the communities under Chief Masembura area influence their ability to understand the effects of climate change in tomato production. This also indicates that the majority of the tomato farmers can read and follow guidelines from their extension officers as far as tomato production is concern.

All of the tomato farmers interviewed are aware of the effects of climate change in tomato production. As shown in **Figure 4.1** most farmers from all the irrigation schemes confirmed that climate change has led to erratic rainfall, wilting of tomato crops and increase in tomato pests and diseases. This knowledge could have originated from the use of Information, Communication and Technologies (ICT's) inclusive of mobile phone and internet. Some could have obtained the information from the AGRITEX programmes as well as other Non-Governmental Organisations (NGOs) that conscientized the farmers.

During the data collection process, the researcher noted that some of the farmers were using the smart phones, which could have been the source of information for some of the farmers. Thus, the variable of the smart phone was not captured by the questionnaire. On the contrary, the researcher noted that some of the farmers do not have Information Communication Technologies (ICTs) such as smart phones which could have contributed to lack of knowledge of the vagaries of climate change on tomato production. This may be as a result of the fact that most of the farmers under Chief Masembura area have access to Radio Zimbabwe which broadcast in vernacular language "Shona and Ndebele" that give them information about climate change on daily basis.

As shown in **Figure 4.2** most tomato farmers with farming experience of between 5-10 years across all irrigation schemes perceived that climate has an effect on tomato yield. The knowledge of the devastating effects of climate change on tomato yield could have emanated from the observations as well as proper record keeping by the farmers which enables them to identify a decrease in tomato yield. These findings are similar to those obtained by Afroza et al. (2010) who demonstrated that climate change greatly affects crop yield.

Most farmers of the middle age group of 25-34 years demonstrated that climate change greatly affects flower development in comparison with land preparation, fruit set and ripening period as shown in **Figure 4.3**. In a similar study conducted by Biratu (2018) , it was observed that high temperatures as a result of climate change greatly affect the tomato production at flowering stage.

Figure 4.4 clearly highlighted that tomato farmers who reached secondary level demonstrated that they have attributed insect pest population as a result of climate change. Their ability to identify the insect pest population could be due to their knowledge their secondary level period. On the contrary, to have attained the secondary level does not necessarily mean that you may clearly identify the insect populations, but some of the tomato farmers may gain the skill of identifying the insect pest through following the ‘footprints ‘of the extension officers as well as other experienced farmers. The presence of the insect pest tallies with the research which was conducted by Madhiri (2018), who asserted that the presence of the insect pest such as *Tuta absoluta* could have resulted from the devastating effects of climate change.

Tomato leaf miner was perceived the most across all irrigation schemes by most of the farmers who attained secondary level followed by red spider mite as shown in **Figure 4.5**. These data are similar to findings by Madhiri (2018) who observed that the environments in which crops are grown are expected to change significantly within the next decade as a result of climate change. The research further asserts that climate change has led to the temperature increase, relative humidity fluctuations as well as erratic rainfall that could have cause emergence of new insect pests such as tomato leaf miner. The results obtained also tallies with the study which was done by Mutamiswa *et al*., (2017), who asserted that climate change tends to affects the biology of insects inclusive of tomato leaf miner. The level of education may not determine to know about the emergence of insect pest as a result of climate change. However, the tomato farmers may get to know about insect pests such as tomato leaf miner through information from the non-formal education such as Focus Group Discussion (FGDs) courtesy of the Non-Governmental Organisations such as Word Vision.

Most farmers across all irrigation schemes of farming experience between 5-10 years perceived that tomato late blight have emerged because of the vagaries of climate change as shown in **Figure 4.6**. This proliferation of tomato late blight could have emerged from the canal irrigation water as well as other different types of irrigation systems. Also, the tomato late blight could have emerged due to flash floods such as Cyclone Eline which hit hard most parts of the Mashonaland Central Province inclusive of Masembura area. This concurs with the research which was carried out by Pautasso *et al*., (2020), who alluded that climate change may lead to recurrence of diseases.

Apart from tomato late blight, Tomato Mosaic Virus (TMV) was also perceived as emerged as a result of climate change and this could have originated from the high temperature which were experienced previously across all irrigation schemes under Masembura area. Tomato Mosaic Virus (TMV) was also noted as emanated from high temperature as a result of climate change (Newton *et al*., 2011).

Across all the irrigation schemes inclusive of Tsunda, Nhunguza, Muunganirwa, Kahari and Nyakudyazuva as shown in **Figure 4.7** farmers perceived that Rodade is the most affected tomato variety by the devastating effects of climate change. During the data collection process, we discussed with the tomato farmers that what could be the reason why it is the most affected and they indicated that shortage of irrigation water could be the contributing factor as well as the insect and diseases which may result in the reduction in the shelf life of the tomato fruit. The reason for the Rodade to have a short shelf life could have emanated from the seed retention as well as poor agronomic practices.

Most farmers as shown **in Figure 4.8** demonstrated that shortage of irrigation water could have caused a decrease in tomato land hectarage. The shortage of irrigation water could be due to a decrease of water in rivers such as Tsunda, which could have led to a critical shortage of irrigation water thereby affecting the area under tomato production. The results obtained from this survey concurs with the research which was conducted by Abewoy (2020).

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

The study concludes that most of the tomato farmers under irrigation schemes of Masembura area are very much aware of the effects of climate change. The farmers perceived climate change to result in erratic rainfall and increase in temperature which may result in wilting of tomato crops. Climate change was perceived to result in an increase in insect pests and diseases such as *Tuta absoluta* and tomato late blight.

The study accepts the hypothesis that farmers are knowledgeable about climate change on tomato production under irrigation schemes of Masembura area. It also accepts another hypothesis that climate change has a significant effect on tomato production under irrigation schemes of Masembura area.

The study recommends that perceived effects of climate change inclusive of erratic rainfall, wilting of tomato crops and shortage of irrigation water would give the basis for policy formulation as well as implementation that seeks to perfect the adaptive capacity of tomato farmers under Chief Masembura area with similar effects of climate change. The policies should consider establishment of irrigation projects within Masembura area to supply tomato farmers with water for their tomato crops. This again has the great potential to enhance tomato production in Bindura District and Zimbabwe at large. Also, legislative policies should be geared towards coming up with more drought tolerant cultivars than can withstand the vagaries of climate change as well as to boost tomato production.

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7.0 APPENDICES

APPENDIX 1: STRUCTURED QUESTIONNAIRE

Name of Interviewer	
District	
Name of community	
GPS Coordinates	
Name of Interview	

SECTION A: SOCIO- DEMOGRAPHIC CHARACTERISTICS

1. **GENDER:** Male ☐ Female ☐
2. **Age:** <25 years ☐ 25 – 34years ☐ 35 – 44 years ☐

45 – 54 years ☐ 55-64 years ☐ >64 years ☐

3. **Marital status:** single ☐ married ☐ Divorced ☐ widow/ widower ☐

4. **Number of years lived in the community:** 1-5 years ☐ 6-10 years ☐ 11-19 years ☐ >- 20years ☐
5. **Educational status:** Illiterate ☐ Primary ☐ Secondary ☐ Tertiary ☐
6. **Number of kids:** 1-2 Kids ☐ 2- 3 kids ☐ > 3kids ☐
7. **Farming experience:** < 5 years ☐ 5- 10 years ☐ > 10 years ☐
8. **Land holding :** 0.5- 1ha ☐ .1- 1.5 ha ☐ 1.6- 2 ha ☐ > 10 ha ☐
9. **Access to weather forecast:** Acquired ☐ Not acquire ☐ Other ☐ means v

SECTION B: EFFECTS OF CLIMATE CHANGE ON TOMATO YIELD

10. Have you heard about climate change? YES ☐ NO ☐

11. If yes, which factors below are as a result of climate change?

Tick as appropriate

Meaning	**YES**	**NO**
Changes in temperature		
Changes in rainfall pattern		
Change in solar radiation		
Frequency of drought		

12. As a result of climate change, has this led to the following?s

	yes	**no**	**Don't know/not sure**
Erratic rainfall			
Increase in tomato insect and pests			
Erosion within tomato field			
Wilting of tomato crops			
Increase in air temperature			
Floods			

13. Is climate change affecting your tomato yield? YES ☐ NO ☐

14. Which of the following cultivars of tomato do you grow?

Rodade ☐ tenguru ☐ Daisy F1 ☐ Heinz ☐ Roma VF. ☐

15. Which type of cultivar mentioned above is affected by climate change?

…………………………………………………………………………………

16. Does climate change affect tomato availability? YES ☐ NO ☐

17. To what extent does it affect tomato availability?

Increase ☐ Decrease ☐ No effect ☐

18. Is the tomato yield changing as a result of climate change?

YES ☐ NO ☐ No idea ☐

19. What is the trend quality of tomato yield?

Increasing ☐ decreasing ☐

20. Is it important to know about climate change in tomato production?

Strongly agree ☐ agree ☐ Neutral ☐ Disagree ☐ strongly disagree ☐

21. If yes, at what point of production does it affect?

Land preparation ☐ **flower development** ☐

Fruit set ☐ **ripening period** ☐

22. Is there any significant association between climate change and tomato production?

Yes ☐ **No** ☐ **No idea** ☐

23. If yes, which type of association?

Positive ☐ **Negative** ☐

24. What is the state of your soil you grow your tomatoes?

Clay ☐ **loam** ☐ **sandy – loam** ☐ **sandy** ☐

25. Do you retain tomato seed after harvesting?

Yes ☐ No ☐

26. If yes, give reason for the tomato seed retention.

Yield ☐ pest resistance ☐ Quality ☐

27. Do you attribute an increase pest population due to climate change?

Yes ☐ **NO** ☐

28. **If yes, which are these pests?**

Red spider mite ☐ tomato leaf miner ☐ aphids ☐ whiteflies ☐

29. **Which tomato diseases do you think have emerged due to climate change?**

Tomato late blight ☐ soft rot ☐ tomato mosaic virus ☐ bacteria wilt ☐

30. **Has your hacterage changed as a result of climate change?**

Yes ☐ No ☐

31. **If yes, what is the percentage increase in land hactarage as a result of climate change?**

0% ☐ 1- 24% ☐ 25-49% ☐ 50-74% ☐ 75-100% ☐

32. **If there is a change in land hacterage in Q31, give reasons for the change?**

Shortage of irrigation water ☐ erratic rainfalls ☐ floods ☐

33. **How many hectares do you cultivate?**

Tick appropriate

period	**0.5-1ha**	**1.1-1.5ha**	**1.6-2ha**	**Above 2ha**
This year				
Last year				
3 years ago				

34. **Is the hectarage you are growing enough to feed the family?**

Yes ☐ No ☐

35. **If no in 34, do you hire additional land from others?**

Yes ☐ No ☐

36. **If yes in 35, how many hectares?**

<0.5ha ☐ 0.5- 1ha ☐ > 1ha ☐

37. **How much land do you have as a farmer under irrigation in hectares?**

<1ha ☐ 1-2ha ☐ above 2ha ☐

38. Are you meeting the irrigation scheduling programme?

Yes ☐ NO☐

39. Is climate change affecting your irrigation scheduling?

Strongly agree ☐ Agree ☐ Neutral ☐

Disagree ☐ strongly disagree ☐

40. Does climate change affect area under irrigation?

Strongly agree ☐ Agree ☐ Neutral ☐

disagree ☐ strongly disagree ☐

APPENDIX 2: STATISTICAL ANALYSES OUTPUTS

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.402[a]	4	.662
Likelihood Ratio	3.098	4	.541
Linear-by-Linear Association	1.800	1	.180
N of Valid Cases	64		

a. 5 cells (55.6%) have expected count less than 5. The minimum expected count is .44.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.633[a]	15	.707
Likelihood Ratio	16.230	15	.367
Linear-by-Linear Association	3.780	1	.052
N of Valid Cases	64		

a. 20 cells (83.3%) have expected count less than 5. The minimum expected count is .06.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.656[a]	3	.647
Likelihood Ratio	2.489	3	.477
Linear-by-Linear Association	.130	1	.718
N of Valid Cases	64		

a. 5 cells (62.5%) have expected count less than 5. The minimum expected count is .39.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.082[a]	6	.533
Likelihood Ratio	6.516	6	.368
Linear-by-Linear Association	.462	1	.497
N of Valid Cases	64		

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .88.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.228[a]	8	.189
Likelihood Ratio	11.015	8	.201
Linear-by-Linear Association	.402	1	.526
N of Valid Cases	64		

a. 10 cells (66.7%) have expected count less than 5. The minimum expected count is .38.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.966[a]	8	.030
Likelihood Ratio	16.586	8	.035
Linear-by-Linear Association	.328	1	.567
N of Valid Cases	64		

a. 10 cells (66.7%) have expected count less than 5. The minimum expected count is .38.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.656[a]	9	.774
Likelihood Ratio	6.516	9	.687
Linear-by-Linear Association	.569	1	.451
N of Valid Cases	64		

a. 12 cells (75.0%) have expected count less than 5. The minimum expected count is .61.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.138[a]	8	.331
Likelihood Ratio	11.453	8	.177
Linear-by-Linear Association	.010	1	.922
N of Valid Cases	64		

a. 10 cells (66.7%) have expected count less than 5. The minimum expected count is .13.

Correlations

		Educational status	Whicharethesepests
Educational_status	Pearson Correlation	1	.061
	Sig. (2-tailed)		.634
	N	64	64
Whicharethesepests	Pearson Correlation	.061	1
	Sig. (2-tailed)	.634	
	N	64	64

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	19.911[a]	6	.003
Likelihood Ratio	20.796	6	.002
Linear-by-Linear Association	4.898	1	.027
N of Valid Cases	64		

a. 8 cells (66.7%) have expected count less than 5. The minimum expected count is 1.69.