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Impact of Climate Change on Pesticide Usage by Vegetable Farmers in Moromoro in Maiduguri, Borno State

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***Abstract**: Estimating the impact of climate change is crucial for determining optimum production potential and developing a profitable strategy for managing food security. Climate change has induced food crises in some parts of the world. Also, it triggers security challenges in some environments due to resulting friction arising from the struggle to control limited agricultural resources. This study aimed on the impact of climate change on pesticide usage by vegetable farmer in Moromoro. The research also revealed that 68 respondents (85%) had noticed changes in the pest population, 6 respondents (7.5%) hadn't noticed any pest population, 6 respondents (7.5%) were not sure of any pest population, and 70 respondents (87.5%) suggested that they have adjusted, and 10 respondents (12.5%) haven't adjusted. It also shows how familiar the respondents are with climate-resilient farming practices that can help in reducing the impact of climate change on the crops. Out of 80 respondents, 63 respondents (78.75%) are familiar with climate-resilient, and 17 respondents (21.25%) are not familiar with climate-resilient and 27 respondents (33.75%) adopted climate-resilient farming, and 53 respondents (66.25%) haven't adopted any climate-resilient farming practice. The study suggests that climate change had a significant impact on pesticide usage by the vegetable farmer in Moromoro, and adoption of the impact of climate change led to the reduction of the active ingredients of the pesticide, thereby making pest resistant and tolerant to the low-level activeness of the agrochemical and majority of the vegetable are craving for support and training to curtail the impact of the climate change especial in post-insurgency era and couple with the Sahel savanna region.*

***Keywords**: Climate Change; Farmers; Pest; Vegetable*

Introduction

Climate change is the most severe problem that the world is facing today (Ayinde *et al.,* 2011). It has been identified as a more serious threat than global terrorism (King, 2004). Climate change affects food and water resources critical for livelihood in Africa, where much of the population, especially people experiencing poverty, rely on local supply systems sensitive to climate variation (Ayinde *et al.,* 2011). The global vegetable sector is growing faster than any other agricultural sector; it is currently the single largest anthropogenic land user and the source of many environmental problems, including global warming and climate change (Keith, 2008). The switch in food consumption patterns from traditional cereals and root crops to wheat-based processed foods, high protein, and vegetable products has accentuated the demand for more vegetables. The importance of vegetables in providing food and nutritional security and ameliorating nutrient deficiencies has been realized worldwide (Prasad *et al*. 2014). They also offer opportunities for higher farm income apart from livelihood security through employment generation. The worldwide production of vegetables has increased tremendously during the last two decades, and the value of global trade in vegetables now exceeds that of cereals (Dhiman 2012). It is a challenging issue for most nations to feed hunger-laden people. IFAD (International Fund for Agriculture Development) (2009) has reported that climate change is expected to put 49 million additional people at risk of hunger by 2020 and 132 million by 2050 (Devendra 2012).

Climate change is defined as a change in the statistical properties of the climate system when considered over long periods, regardless of cause (ENSAA, 2011; IPCC, 2001). There is concordance amongst scientists that climate change encompasses atmospheric carbon dioxide variations, altered worldwide temperatures, and precipitation variation, all directly or indirectly influencing sea levels and salinity, alterations in arable land, crop yields, changes in soil quality, nitrogen deposition, and plant diversity (Harvell *et al.,* 2002; Jackson *et al.,* 2011; Miraglia et al., 2009). The extensively differing impact on nature, human health, and even the economy implies that climate change is spatially and temporally heterogeneous (EEA, 2012; Fontaine et al., 2009; Harvell *et al*., 2002).

Temperature, light, and water are the key elements that control the growth and development of organisms (Harvell *et al.,* 2002; Chivian, 2001). Consequently, biodiversity responses that depend on these environmental parameters can be expected (Lepetz *et al.,* 2009). For example, altered precipitation patterns and cultivation practices can create a thriving environment for insect and pathogen attacks (Roos *et al.,* 2011) or corresponding advances in phenology (Fontaine et al., 2009). Moreover, the increasing climate variability (Wang *et al*., 2009) can induce alterations in interspecific relationships between organisms, such as competition or predation (Lepetz *et al.,* 2009), possibly resulting in a decrease in food supplies and an increase in microbial and toxic contaminants in food (Kirk, 2002).

Climate change has a powerful effect on the environmental fate and behavior of pesticides by altering fundamental mechanisms of partitioning between the ecological compartments, also affecting pesticide use (Noyes *et al.,* 2009). A lower pesticide residue on crops due to climate change results in an increased vulnerability to pests and diseases, meaning that in the future, farmers may have to spray more often during the growing season. A higher pest or disease pressure will also enhance application frequencies and volumes. Consequently, the detected residue concentrations might double for some products, while others will disappear faster and, hence, do not increase crop residues. This zonal production disparity predates climate and weather conditions' significant role and influence on agriculture practice in Borno State, Nigeria. Research for the effects of climate change is generally not limited to pesticides and, consequently, not very detailed in a way that only limited influencing factors or effects are described. This research will combine the current knowledge of possible climate change effects on pesticide use, and a detailed explanation of the impact on pesticide use will be distilled. The importance of this effect lies in the implications of adapted pesticide use for consumer exposure to pesticide residues at the end of the food supply chain.

Materials and Methods

Study Area

An experiment was conducted in Moro-moro vegetable farm, Maiduguri, Borno State, Nigeria, during the 2023 rainy season to assess the impact of climate change on pesticide usage by vegetable farmers and the area lies within the GPS coordinate of ***11.85873 N, and 13.17079 E.***

Data collection

The Moromoro was selected based on the degree of the total number of vegetable-cultivating families from designated areas. Thus, the final sample consisted of 100 respondents. They were interviewed on their farming site. Before the commencement of the data collection, the questionnaires would be pre-tested to assess the suitability of the Questionnaires. Modifications enabled the easy recording of responses from vegetable-cultivating farmers on the impact of climate change on pesticide usage. The findings were based on an in-depth analysis of primary and secondary data sources. The secondary data was derived from existing published academic works.

Data Analysis

Descriptive statistics was used for questionnaires to explore the socioeconomic status of vegetable farmers, assess the different types of pesticides used, and analyze the impact of climate change on pesticide usage. Data collected were subjected to statistical analysis using R studio version 4.4.

Results and Discussion

Table 1 shows the respondents who responded to our questionnaires. Out of 80 respondents, 65 were males (85%) and 15 were females (15%). This analysis implies that more males in the study responded to the questionnaire than female customers. This means that male customers are many compared to females. The findings are in agreement with other studies and reports.

It also presents the age of respondents who responded to our questionnaire. Out of 80 under 18 were 1(1.25%), 18-30 were 35(43.75%), 31-45 were 31(38.75%),46-60 were 13(16.25%), over 60 were 0(0). This analysis suggests that the majority, aged between 18 and 30, use pesticides on their vegetables. More are more likely to explicitly define higher levels of pesticide performance in terms of vegetables.

The educational level of those who responded to our questionnaire. Out of 80 respondents, 14(17.5%) possess PLSC education, 17 respondents (21.25%) have SSCE education, 3 respondents (3.75%) have diploma education, 1 respondent (1.25%) possess NCE, 0-degree respondents, 2 respondents (2.25%) possess post-graduate education, 43 respondents (53.75%) possess no formal education. This analysis suggests that most respondents who responded to our questionnaire have no formal education; the rest include PLSC, SSCE, NCE, diploma level, or post-graduate education. This could indicate that most farmers regard farming as a source of life worth.

Table 4.1 Demographic characteristics

SOURCE	FREQUENCY	PERCENTAGE (%)
Gender		
Male	65	85%
Female	15	15%
Total	**80**	**100%**
AGE		
Under 18	1	1.25%
18 - 30	35	38.75%
31 - 45	31	43.75%
46 - 60	13	16.25%
Over 60	0	0%
Total	**80**	**100%**
Level of Education		
PSLC	14	17.5%
SSCE	17	21.25%
Diploma	3	3.75%
NCE	1	1.25%
Degree	0	0%
Post graduate	2	2.5%
No formal education	43	53.75%
Total	**80**	**100%**

SOURCE: FIELD SURVEY, 2023

The years of experience of the respondents are presented in Table 4.2. Out of 80 respondents, 13(16.25%) have the experience level of less than 5 years, 34 respondents (42.75%) have the experience level of about 5-10 years, 22 respondents (27.25%) have the experience level of about

11-20 years, 11 respondents (13.75%) have the experience level of approximately over 20 years. This analysis suggests that most of our respondents have a farming experience of about 5-10 years.

It also presents how familiar the respondent is with the impact of climate change. Out of 80 respondents, 3 respondents (3.75%) are not aware, 7 respondents (8.75%) are somewhat familiar, 2 respondents (2.5%) are moderately mindful, and 68 respondents (85%) are very knowledgeable. This analysis suggests that most or most of the respondents are very familiar with the impact of climate change on their vegetable farming.

The respondents' opinions on observing changes in local weather patterns over the past few years. Out of 80 respondents, 45 respondents (56.25%) have observed an increase in temperatures, and 35 respondents (43.75%) have observed changes in rainfall patterns. This specifies that most of our respondents have observed the differences in local weather patterns over the past few years. It also suggests whether the respondents believe climate change impacts agriculture. Out of 80 respondents, 10 respondents (12.5%) strongly do not believe, 3 respondents (3.75%) disagree, 1 respondent (1.25%) is neutral, 65 respondents (81.25%) have accepted, and 1 respondent (1.25%) strongly agree. This analysis suggests that most of our respondents agree or believe climate change impacts agriculture.

Table 4.2 Assess the trend of Climate Change

SOURCE	FREQUENCY	PERCENTAGE (%)
How familiar are you with the impact of climate change?		
Not familiar at all	3	3.75%
Somewhat familiar	7	8.75%
Moderately familiar	2	2.5%
Very familiar	68	85%
Total	**80**	**100%**
In your opinion, have you observed any change in local weather patterns over the past few years?		
Increased temperatures	45	56.25%
Changes in rainfall patterns	35	43.75%
More frequent and severe storms	0	0%
Others	0	0%
Total	**80**	**100%**
Do you believe that climate change has an impact on agriculture?		
Strongly disagree	10	12.5%
Disagree	3	3.75%
Neutral	1	1.25%
Agree	65	81.25%
Strongly agree	1	1.25%
Total	**80**	**100%**

Source: Field Survey, 2023

Table 4.3 suggests whether the respondents use pesticides in their vegetable farming practices. Out of 80 respondents, 80 (100%) use pesticides in their vegetable farming practices. More so, it shows the type(s) of pesticide use by the respondents; out of 80 respondents, 77 respondents (96.25%) uses chemical pesticide, and 3 respondents (3.75%) use organic/biopesticides. This shows that most respondents use chemical pesticides in their vegetable farming practices.

Suggestion on average how frequently the respondents use pesticides on his/her vegetable crops. Out of 80 respondents, 14 respondents (17.5%) uses pesticides daily, 61 respondents (76.25%) use pesticides weekly, 1 respondent (1.25%) uses pesticide monthly, and 4 respondents (5%) uses pesticides rarely. This analysis specifies that most of our respondents use pesticides weekly in their vegetable farming practices.

Table 4.3 Effect of Climate Variability on Pesticide Usage

SOURCE	FREQUENCY	PERCENTAGE (%)
Do you use pesticides in your vegetable farming practices?		
Yes	80	100%
No	0	0%
Total	**80**	**100%**
What type(s) of pesticides do you use		
Chemical pesticides	77	96.25%
Organic/biopesticides	3	3.75%
Synthetic pesticides	0	0%
Total	**80**	**100%**
On average, how frequently do you use pesticides on your vegetable crops?		
Daily	14	17.5%
Weekly	61	76.25%
Monthly	1	1.25%
Rarely	4	5%
Never	0	0%
Total	**80**	**100%**

Source: Field Survey, 2023

Table 4 suggests whether the respondents noticed any change in pest populations on their crops in recent years that could be attributed to climate change (e.g., new pests, increased pest activity). Out of 80 respondents, 68 respondents (85%) have noticed changes in the pest population, 6 respondents (7.5%) haven't seen any pest population, and 6 respondents (7.5%) are not sure of any pest population. This suggests that most of our respondents noticed changes in pest population on their crops in recent years that could be attributed to climate change. This table also indicates whether the respondents had adjusted their pesticide application practices due to changing climate conditions. Out of 80 respondents, 70 (87.5%) suggested that they have adjusted, and 10 (12.5%) haven't. This specifies that most of our respondents modified their pesticide application practices due to changing climate conditions (e.g., increased frequency and different types of pesticides).

Table 4.4 Pesticide strategies used and their associated constraints

SOURCE	FREQUENCY	PERCENTAGE (%)
Have you noticed any changes in pest populations on your crops in recent years that could be attributed to climate change?		
Yes	68	85%
No	6	7.5%
Not sure	6	7.5%
Total	**80**	**100**%
Have you had to adjust your pesticide application practices due to changing climate conditions?		
Yes	70	87.5%
No	10	12.5%
Total	**80**	**100**%
Are you familiar with climate-resilient farming practices that can help reduce the impact of climate change on your crops?		
Yes	63	78.75%
No	17	21.25%

Total	**80**	**100%**
Have you adopted any climate-resilient farming practices on your farming?		
Yes	27	33.75%
No	53	66.25%
Total	**80**	**100%**
If you haven't adopted such practices, what are the reasons?		
Lack of information	42	52.5%
Cost considerations	15	18.75%
Lack of resources	23	28.75%
Traditional farming methods are preferred.	0	0%
Total	**80**	**100%**
Would you be interested in receiving information or training on climate-resilient farming practices?		
Yes	80	100%
No	0	0%
Total	**80**	**100%**

Source: Field Survey, 2023

It also shows the respondents' familiarity with climate-resilient farming practices that can help reduce the impact of climate change on crops. Out of 80 respondents, 63 (78.75%) are familiar with climate resilience, and 17 (21.25%) are unaware of climate resilience. This suggests most of the respondents are familiar with the climate-resilient farming practices that can help to reduce the impact of climate change on your crops, e.g., crop rotation, integrated pest management, & crop rotation. And also Suggestions on whether the respondents adopted any climate-resilient. Out of 80 respondents, 27 (33.75%) adopted climate-resilient farming, and 53 (66.25%) haven't adopted any climate-resilient farming practice. This analysis shows that most respondents haven't adopted climate-resilient farming in their vegetable farming.

This point shows the reason for the respondents not adopting climate-resilient practices. Out of 80 respondents, 42 respondents (52.5%) haven't because of lack of information, 15 respondents (18.75%) haven't because of cost consideration, and 23 respondents (28.75%) haven't because of lack of resources. This shows that most respondents haven't performed climate-resilient farming due to a lack of information and resources. This analysis shows whether the respondents want information or training on climate-resilient farming practices. Out of 80 respondents, 80 (100%) are interested in receiving information on climate-resilient farming training.

Several elements that can influence pesticide use have been presented. In the first instance, pesticide-producing companies will strive to supply optimal products. New pesticide-active ingredients will have to be formulated in rain-fast products for agricultural use. For farmers, the reasons and timing of the pesticide application, seasonal precipitation, and temperature environmental factors will strongly influence management decisions (Nolan *et al.,* 2008; Reilly *et al.,* 2003).

Climate change affects crop characteristics and appearance due to lengthening active growing seasons. Corresponding advances in phenology are expected, while climatic variation can alter plant resistance to pests and pesticides. According to Reilly *et al.,* (2003), overall climate change will benefit crop productivity, despite the regional-level risks. Local climates will strongly determine which areas are still suitable for cultivating a crop. The critical factor for pesticide use is the presence and severity of weeds, pests, and diseases in crops. These organisms are affected by climate change in a similar way as the crops. There is also a high likelihood of genetic adaptation. However, the first response is a phenology alteration or geographical redistribution. Pest and disease invasions are aided mainly by temperature effects. Finally, pesticide efficiency, represented by the initial deposit, pesticide fate, and toxicity, also significantly impacts pesticide usage.

In general, pesticide losses of mobile active substances are mainly influenced by the time gap between extreme weather events and pesticide application. In soil, the transport of pesticides is thus primarily driven by rainfall seasonality, intensity, and temperature increases but also land-use changes, which indirectly impact the long-term impact. The soil's biological microbial activity is affected by moisture content and temperature. Even though some reducing effects, increasing temperatures overall will result in higher volumes of pesticides that must be applied more often. An increased intensity of pesticide use is expected in the form of more elevated amounts, doses, frequencies, and different varieties or types of applied products. Adapted pesticide use will finally impact consumer exposure at the end of the food chain.

Conclusion

The study suggests climate change significantly impacted pesticide usage by the vegetable farmers in Moromoro. Adopting the effects of climate change led to reducing the active ingredients of the pesticide, thereby making pest resistant and tolerant to the low-level activeness of the agrochemical. Most vegetables craved support and training to curtail the impact of climate change, especially in the post-insurgency era and coupled with the Sahel savanna region.

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