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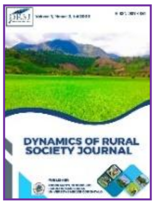


# Disaggregating household food insecurity access scale indicators based on climate change impacts among smallholder farmers in KwaZulu-Natal Province, South Africa

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## Abstract

The growing threat of climate change has worsened food insecurity worldwide, particularly for smallholder farmers in KwaZulu-Natal (KZN) Province, South Africa. This study aims to compare the Household Food Insecurity Access Scale (HFIAS) indicators before and after the impacts of climate change on smallholder farmers in KZN in 2024. A systematic sampling approach, combined with a descriptive study design, was employed to select sixty farmers. Data on personal characteristics and HFIAS were collected, subjected to face validity and reliability tests, and analyzed using the Statistical Package for Social Sciences (SPSS) version 29, with frequency counts, percentages, and paired sample t-tests. The comparison of food security before and after the effects of climate change shows a significant difference ($t = -6.70$, $p < 0.01$). The findings suggest that climate change exacerbates food insecurity, particularly affecting elements such as food availability, access, perception, and insecurity prevalence. The study concludes that climate change has worsened food insecurity on smallholder farms, particularly by increasing dependence on purchased food. The policy implications emphasize areas that need targeted interventions, driven by increased indicators of food availability, access, perception, and insecurity following the onset of climate change. The study recommends strategies to enhance farmers' resilience, including expanding access to climate-smart agricultural technologies and extending agricultural extension services.

## Introduction

Food security, nutritional results, and the global agricultural system are threatened by climate change (Bakht et al., 2020; Musafiri et al., 2022). According to current analyses, unless drastic measures are taken to accelerate progress, hunger and all forms of malnutrition will not be eradicated by 2030 (FAO, 2021). This includes addressing inequality in access to safe and nutritious food for healthy diets and accelerating climate action, as well as increasing agricultural productivity and incomes in a sustainable manner (FAO, 2021). Millions of people in Sub-Saharan Africa have experienced food insecurity due to climate change, which exacerbates drought conditions throughout the continent, making it more challenging to secure water for agricultural and food development (Ogundeji, 2022). Smallholders and subsistence farmers in the nations face a worsening food security scenario as a result, making it more difficult for their household members to have adequate food for daily needs (Gebre et al., 2021; Kogo et al., 2020; Ndiritu & Muricho, 2021).

The sustainability of South Africa's agriculture sector, which provides food, income, and jobs to over 70% of the population, is closely tied to the food security of rural households (Cammarano et al., 2020), less reliance on rain-fed agriculture (Adetoro et al., 2020), and an effective response to seasonal changes and weather patterns brought by climate change (Musafiri et al., 2022). Smallholder farmers' efforts to achieve food security are hampered by climate change (Lottering et al., 2021); thus, immediate climate action is required in response to the growing threat of food insecurity (Burki, 2022). In 2023, KwaZulu-Natal Province recorded the warmest year due to floods, a result of climate change, leading to severe harm to the livelihoods and food security of smallholder farmers and other regionally context-specific elements related to food security (Lenderking et al., 2021).

The household Food Insecurity Access Scale (HFIAS) is important for measuring food security by determining the prevalence and severity of household food insecurity. Andarge (2022) and Gebre et al. (2021) used the HFIAS to measure the prevalence of food insecurity and impacts of climate variability on households' food insecurity in East Africa and Ethiopia, respectively, and found that more than half of the study population were food-secure in East Africa and half of the population were moderately food insecure in Ethiopia. Shisanya and Mafongoya (2016) used the HFIAS. They discovered that nearly all households were profoundly food insecure, expected significant impacts on their crop production systems, and were aware that the climate was changing. According to Adesete et al. (2023) and Randell et al. (2021), rising greenhouse gas emissions cause sub-Saharan Africa's food security to decline and the prevalence of malnutrition to rise. Nkoko et al. (2024) assessed the Household Food Insecurity Access Scale (HFIAS) among agricultural households in Lesotho, revealing that two-thirds experienced varying degrees of food insecurity, while approximately half of the households were food secure. Using the HFIAS, Gassara and Chen (2021) and Gujo and Modiba (2024) discovered that the frequency of food insecurity among pastoralists and farming households was approximately in the 50th percentile.

The combination of scores from the HFIASS primary dimensions has been utilized to quantify food insecurity. The complex nuances of the effects of each indicator through weighted averages and pooled scores have occasionally been obscured by merging, which has resulted in poor intervention alignment and the inability to identify the underlying causes of the overall state of food security. To obtain a more detailed picture of food insecurity trends, disaggregating data from the HFIAS entails examining food insecurity by particular subgroups or attributes, such as wealth, location, or other pertinent criteria. According to Gebreyesus et al. (2015), the HFIAS is a direct and reliable instrument for assessing the access component of household food insecurity; however, adjustments must be made to the questions, wording, and examples before implementation in order to prevent disparities in comprehension. The household dietary diversity score and the household food insecurity access scale are both valid and trustworthy proxy measures for assessing nutritional status, according to Hussein et al. (2018). According to Gustafson (2015), experience-based indicators help track how food access has changed over time within a specific community. They also indicate how households have responded behaviorally to food insecurity and the coping mechanisms employed.

HFIAS focuses on assessment and monitoring, but not for home targeting due to its low predictive power (Becquey et al., 2010). It also performed well in approximating the sufficiency of households' meals and providing information on food insecurity. Gustafson (2015), states that HFIAS is lacks in measuring of micronutrients, food cultural norms, individual preferences, and accuracy over varied contexts. The standardized HFIAS questionnaire, according to Becquey et al. (2010), includes specific questions about a household's concerns, food availability, and accessibility over a 30-day period. The HFIAS score is the sum of the questions, which ranges from 0 (food security) to 27 (maximum food insecurity), confirming the non-normality of the data obtained from the HFIAS. Food security assessment scales must simplify several variables, employ a common framework and vocabulary, adjust to the goal of the intervention, and use established, routine, large-scale data collection across numerous nations, according to Gustafson (2015). According to Knueppel et al. (2010), the HFIAS measurement instrument avoids the disadvantages of relying heavily on coping strategies that supplement a household's resource base, can be used by non-specialists with ease of analysis and interpretation, and demonstrates validity and reliability in measuring household food insecurity by capturing issues of both food quality and quantity in the local contexts.

This study differs from previous studies in that it disaggregates the indicators within the HFIAS scale and compares household food insecurity conditions before and after the impacts of climate change. Although various studies have previously applied the HFIAS to measure food insecurity using composite scores, most of these studies obscure the actual impacts of each indicator, leading to a lack of alignment in the interventions designed to effectively address food insecurity (Andarge, 2022; Gebreyesus et al., 2015; Omotoso et al., 2024). The aggregation of complex indicators hinders a deeper understanding of the underlying factors affecting household food insecurity and obscures the precision of interventions. Furthermore, while HFIAS has proven effective in assessment and monitoring, previous research has not sufficiently focused on disaggregating the indicators to uncover the underlying conditions that influence food insecurity (Becquey et al., 2010; Gustafson, 2015). This study compared the HFIAS indicators before and after the impacts of climate change on smallholder farmers in KZN.

## Method

The study was carried out in Mid Illovo a rural region situated in the KwaZulu-Natal Province of South Africa's Mkhambathi Local Municipality, and a section of uMgungu district, on longitude 30.51576°, or 30° 30' 57" east, and latitude -29.96573°, or 29° 57' 57" south, as coordinates. It is surrounded by hills and mountains in the Midlands and an altitude of 729 meters.

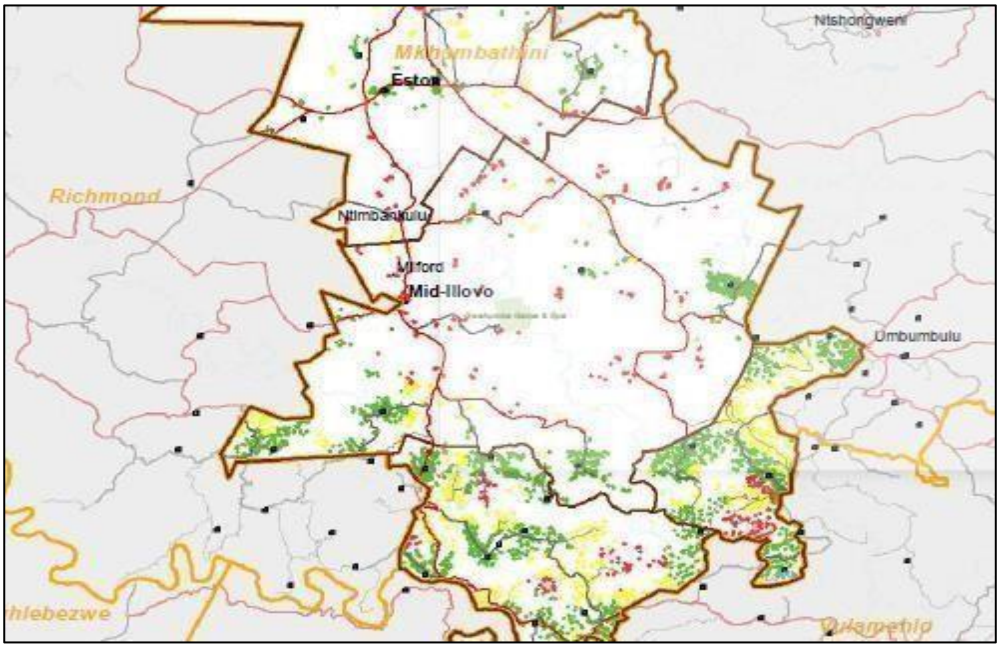


**Figure 1.** A map showing the study area Mid-Illovo

In this study, a descriptive research design was employed, and the population of study consists of all smallholder farmers within the commercial sugarcane production blocks in the study area made up the population of the study (300). The inclusion criteria were based on smallholding farming that have experienced the climate variability in the study areas for a minimum of 3 growing seasons. The list of farmers was obtained from the agricultural extension office, and 60 farmers were chosen using a systematic sampling technique with a 5-point interval. The questionnaire is made up of personal characteristics and the HFIAS scale—which has nine "occurrence" and nine "frequency-of-occurrence" questions. The questionnaire was subjected to face validity by specialists on food security, agricultural extension, climate change, and rural development. In addition, a split-half technique was used to establish the reliability of the questionnaire with Cronbach alpha value of 0.82. The responses to the questionnaire were based on the farmer's recall of experience with food security over the preceding 30 days. Data were analyzed using Statistical Package for Social Sciences (SPSS) version 29 and the HFIAS were broken down into the question and the corresponding indicators. Frequency counts and percentages were used to summarize the disaggregated variables, and the t-test paired sample case was used to evaluate the food insecurity status before and after the effects of climate change. The formula for the paired t-test is given by:

$$t = \frac{\sum d}{\sqrt{\frac{n(\sum d^2) - (\sum d)^2}{n-1}}}$$

Where, Σd is the sum of the differences, n is the number of samples, and d is the difference per pair value.

## Results and discussions

In Mid-Illovo, equal half of the smallholder farmers are men and women as indicated by the results in Table 1. This could be because the region is rural and have strong conventional gender roles, as women might have more access to agricultural opportunities, which are prompted by economic necessity. Ndlovu et al. (2024b) reported that women comprised almost half of smallholder farmers in KwaZulu-Natal Province, which is in line with Anderson et al. (2021) findings that women comprise roughly 50 percent of smallholder farmers in South Africa. In contrast, Hlatshwayo et al. (2021) discovered that women only make up 35% of smallholder farmers in South Africa, indicating that men still control the agricultural sector. According to Table 1, the age group of 40–49 years old accounts for the largest percentage of smallholder farmers in Mid-Illovo. This age group are more likely to adopt innovations on climate smart agriculture. Younger farmers' participation in smallholder farming may also be hampered by restricted access to resources and land. Similar findings were made by Moyo et al. (2025), who stated that most South African smallholder farmers were between the ages of 40 and 59. The average age of smallholder farmers in KwaZulu-Natal was 45 years old, according to However, Henning et al. (2022) and Ndlovu et al. (2024b) discovered that younger farmers predominate in smallholder farming because they are more likely to embrace new agricultural innovations and technologies, which may lead to an increase in their involvement in smallholder farming.

As can be seen from Table 1, the majority of smallholder farmers in the study area are single, which may be due to the prevailing rural communities' social ties, serving as support systems to married couples through difficult times. Hlatshwayo et al. (2021) and Moyo et al. (2025) reported that low educational levels and skills among single individuals in rural areas predispose them to engagement in farming (Carelson et al., 2021). In contrast, lower percentages of farmers in the Free State province were not married (Thobejane et al., 2023), while in Mpumalanga Province, a larger proportion of married smallholder farmers were reported by Zondo & Ndoro (2024). In Table 1, the largest proportion of farming households have five to seven individuals. This result implies that the average size of smallholder farming households is moderate, which provide ample labour supply for the adoption of climate adaptation practices. There are four to six individuals per household in Limpopo Province (Hlatshwayo et al., 2021); 5.5 family members per household in Free State province (Thobejane et al., 2023) and seven to ten people in Mpumalanga Province (Zondo & Ndoro, 2024).

The largest percentage of smallholder farmers (66%) are found in homes with one to three people, and have primary education (40%). The household size stress the need for food security for members and the level of education affects awareness, knowledge and use of climate adaptation practices. Hlatshwayo et al. (2021) discovered that the largest percentage of smallholder farmers in the Province of Limpopo had larger households. According to Thobejane et al. (2023), almost half proportion of smallholder farmers in the Free State province had completed primary school, however holding a post- secondary degree in KwaZulu-Natal Province (Baiyegunhi, 2024). The results further show that the vast majority of the respondents have been farming for seven or more years, a trend that has implications for application of climate adaptation solutions. In the Eastern Cape Province, farmers with more than ten years of farming experience were reported by Moyo et al. (2025), thus, projecting smallholder households as heterogeneous population with a range of livelihood requirements rather than a monolithic group (Carelson et al., 2021; Mbatha, 2024).

**Table 1.** Demographics characteristics of smallholder farmers

| Characteristics | Options | Frequency | Percentage |
|---|---|---|---|
| Gender | Female | 30 | 50 |
| | Male | 30 | 50 |
| Age | 20-29 | 1 | 1.7 |
| | 30-39 | 8 | 13.3 |
| | 40-49 | 21 | 35.0 |
| | 50-59 | 17 | 28.3 |
| | 60 and above | 13 | 21.7 |
| Marital | Single | 24 | 40 |
| | Married | 20 | 33.3 |
| | Divorce | 6 | 10 |
| | Widow | 10 | 16.7 |
| Household size | 1-3 | 11 | 18.3 |
| | 3-5 | 13 | 21.7 |
| | 5-7 | 14 | 23.3 |
| | 7-9 | 11 | 18.3 |
| | 9 and above | 11 | 18.3 |

| | | | |
|---|---|---|---|
| Education | No formal education | 20 | 33.3 |
| | Primary | 24 | 40 |
| | Secondary | 13 | 21.7 |
| | Tertiary | 3 | 5 |
| Farming Experience | Less than 1 year | 2 | 3.3 |
| | 1-3 years | 17 | 28.3 |
| | 3-5 years | 14 | 23.3 |
| | 7 and above | 27 | 45 |
| Contact with extension services | Rarely | 48 | 80 |
| | Sometimes | 11 | 18.3 |
| | Often | 1 | 1.7 |
| Credit access | No | 28 | 46.7 |
| | Yes | 32 | 53.3 |
| Farm size | <1 | 33 | 53.3 |
| | 1-2 | 22 | 36.7 |
| | ≥3 | 6 | 10 |

Table 2 displays the pre- and post-climate change effects on farmers' food insecurity. Prior to the effects of climate change, 73.3% of smallholder farmers relied mostly on purchased food, but this figure rose to 78.3%. This may be due to reduced crop yields, rising food prices, the loss of agricultural livelihoods, and a move towards cash-based economies, using food purchases as a coping strategy. These findings, which are supported by Kapari et al. (2023) and Watts et al. (2024), demonstrate that smallholder farmers' dependence on purchased food has significantly increased due to climate change. The effects of climate change on smallholder farmers' dependence on purchased food, however, has not changed over time (Smith et al., 2022). The number of households reporting no improvement in food intake increased from 55% to 86.7% after the incidence of climate change (Table 2). The lack of access to production resources, could have reduced their productivity and consequently their food intake. Leonard (2022); Mthembu et al. (2024); Ndlovu et al. (2024b); Ndlovu & Zenda (2024a), who found that climate-related shocks caused households in rural KZN to improve their food intake. However, Shelembe et al. (2024), found that the increased reliance on indigenous food sources caused households in rural KZN to improve their food intake.

Table 2 shows that respondents went a full day without eating because of lacking food, (96.7%) before the effects of climate change, and 80% after the effects. The reduction in proportion suggests that food scarcity is affecting more smallholder farmers. Shelembe et al. (2024), found that smallholder farmers are increasingly food insecure as a result of climate change, with more people going a whole day without eating. However, Popoola et al. (2020), discovered that smallholder farmers in KZN Province were not significantly impacted by climate change in terms of their ability to secure food.

Table 2 shows that 85% of the respondents did not reduce the portion sizes of their kids' meals because of a shortage of food. Following climate change, a smaller majority of smallholder farmers (68.3%) stated that they have never had to reduce the portion size of their kids' meals because of food shortages. This suggests that food insecurity among smallholder farmers may have increased significantly as a result of climate change, forcing more families to cut back on the size of their kids' meals. Following climate change, the percentage of farmers who had never reduced meal sizes reduced from 85% to 68.3%. This could be because climate change may have caused crop yields to decline, which would have left families with less food to eat; climate-related shocks may have caused food prices to rise, making it more difficult for families to afford enough food. In Amajuba District of KZN, Mthembu et al. (2024) reported increased food insecurity, and decreased quantity of children's meals due to food shortage.

**Table 2.** Distribution of smallholder farmers’ food security experience before and after impact of climate change

| HFIAS food security experience indicators | Options | Food in security Before | Food insecurity After |
|---|---|---|---|
| Sources of food for HH | Own farm production | 4 (6.7) | 5(8.3) |
| | Purchased food | 44(73.3) | 47(78.3) |
| | Own Farm and Purchased Food | 12(20) | 8(13.3) |
| HH food intake improved | No | 33(55) | 52(86.7) |
| | Yes | 27(45) | 8(13.3) |
| Extent of food intake improve if yes | No group | 32(53.3) | 50(83.3) |

| | | | |
|---|---|---|---|
| | Slightly better | 18(30) | 3(5) |
| | Better | 6(10) | 5(8.3) |
| | Much Better | 3(5) | 2(3.3) |
| | No Response | 1(1.7) | 0(0) |
| | Yes Group | 28(46.7) | 10(16.7) |
| If no extent intake | Same | 30(50) | 24(40) |
| | Worse | 2(3.3) | 26(43.3) |
| HH member skipped meal due to not having enough money to buy food | Weekly | 4(6.7) | 4(6.7) |
| | Monthly | 2(3.3) | 9(15) |
| | Quarterly | 2(3.3) | 7(11.7) |
| | Half-yearly | 8(13.3) | 12(20) |
| | Never Happened | 44(73.3) | 28(46.7) |
| Not eat a whole day because of no food | No | 58(96.7) | 48(80) |
| | Yes | 2(3.3) | 12(20) |
| Often not eat a whole day | Weekly | 1(1.7) | 293.3) |
| | Monthly | 0(0) | 6(10) |
| | Quarterly | 1(1.7) | 0(0) |
| | Half-yearly | 0(0) | 4(6.4) |
| | Never Happened | 58(96.7) | 48(80) |
| Eat less than normal | No | 47(78.3) | 35(58.3) |
| | Yes | 13(21.7) | 25(41.7) |
| | Weekly | 2(3.3) | 0(0) |
| | Monthly | 1(1.7) | 10(16.7) |
| | Quarterly | 1(1.7) | 4(6.7) |
| | Half-yearly | 9(15) | 10(16.7) |
| | Never Happened | 47(78.3) | 36(60) |
| Lose weight because of not enough food | No | 57(95) | 45(75) |
| | Yes | 3(5) | 15(25) |
| Cut size of children meal because of no food | No | 51(85) | 41(68.3) |
| | Yes | 9(15) | 19(31.7) |
| Often cut size of children meal because of no food | Once a week | 0(0) | 191.7) |
| | Monthly | 2(3.3) | 3(5) |
| | Quarterly | 2(3.3) | 2(3.3) |
| | Half-yearly | 5(8.5) | 13(21.7) |
| | Never Happened | 51(85) | 41(68.3) |
| Children ever skip meal | No | 57(95) | 54(90) |
| | Yes | 3(5) | 6(10) |
| Often children Skip meal | Weekly | 2(3.3) | 0(0) |
| | Monthly | 0(0) | 1(1.7) |
| | Quarterly | 0(0) | 1(17) |
| | Half-yearly | 1(1.7) | 4(6.7) |
| | Never Happened | 57(95) | 54(90) |
| Children do not eat for whole day | No | 58(96.7) | 58(96.7) |
| | Yes | 2(3.3) | 2(3.3) |
| Often children do not eat for whole for day | Weekly | 1(1.7) | 0(0) |
| | Monthly | 1(1.7) | 1(1.7) |
| | Quarterly | 0(0) | 0(0) |
| | Half-yearly | 0(0) | 1(1.7) |
| | Never Happened | 58(96.7) | 58(96.7) |

From Table 3, the findings show that, prior to climate change, the majority of smallholder farmer household members (96.7%) never skipped a meal because due to lack of money to purchase food, but reduced to 80% after climate change. This suggests that food insecurity among smallholder farmer households may have slightly increased as a result of climate change, leading to more households skipping meals because they are short on cash. This could result in lower household income, which would make it more difficult to buy food. According to Mthembu et al. (2024) and Popoola et al. (2020), more household members never skipped a meal because of financial constraints following climate change impacts.

A significant majority of smallholder farmers (78.3%) stated that they had never had financial difficulties paying for a balanced diet prior to climate change, while a smaller majority (56.7%) stated that they had never had financial difficulties following climate change, according to the results in Table 3. This suggests that smallholder farmers' food insecurity may have significantly increased due to climate change, making it more difficult for them to have enough money for healthy diet. Following climate change, the proportion of farmers who said they never had trouble paying for a nutritious food fell by 21.6% (from 78.3% to 56.7%). These could include the possibility that crop yields have decreased due to climate change, which has decreased smallholder farmers' incomes and limited access to wholesome food. Nonetheless, Wijerathna-Yapa & Pathirana (2022) discovered that smallholder farmers in iLembe District of KZN have reported a progressive change in nutritional status and food consumption due to climate change.

**Table 3.** Distribution of smallholder farmer's food security expectations based on climate change impacts

| HFIAS food security expectations indicators | Options | Food insecurity | |
|---|---|---|---|
| | | Before | After |
| | No | 53(88.3) | 35(58.3) |
| | Yes | 7(11.7) | 25(41.6) |
| Food would run out before money | Once a week | 0(0) | 1(1.7) |
| | Once a month | 4(6.7) | 4(6.7) |
| | Once in 3 months | 3(5) | 8(13.3) |
| | Once in 6 months | 5(10) | 13(21.7) |
| | Never Happened | 47(78.3) | 34(56.7) |
| | Once a week | 1(1.7) | 0(0) |
| | Once a month | 0(0) | 6(10) |
| Could not afford balance diet | Once in 3 months | 3(5) | 8(13.3) |
| | Once in 6 months | 13(21.7) | 15(25) |
| | Never Happened | 43(71.7) | 31(51.7) |
| | No | 37(61.7) | 17(28.3) |
| HH food shortage for past 12 months | Yes | 22(36.7) | 43(71.7) |
| | No response | 1(1.7) | 0(0) |
| | No group | 33(55) | 12(20) |
| | Decline in farm yield by drought | 1(1.7) | 2(3.3) |
| | Decline in farm yield by labour | 2(3.3) | 1(1.7) |
| | Decline in farm yield by soil | 5(23.3) | 18(30) |
| If yes, reasons for food shortage for past 12 months | Decline in farm yield by inputs | 14 | 6(10) |
| | Increase of food prices | 4(6.6) | 7(11.7) |
| | Decline in farm yield by poor timing | 2(3.3) | 1(1.7) |
| | Decline in farm yield by pests and diseases | 0(0) | 6(10) |
| | Lack of funds to purchase food | 0(0) | 19(31.7) |
| | No response | 22(36.6) | 4(6.7) |
| How you dealt with food shortage | Borrowing from friends, & neighbours | 21(35) | 32(53.3) |
| | Use of simple food | 16(21) | 21(35) |
| | Adults skip meals once a day | 1(1.7) | 2(3.3) |
| | Reduce expenditures on health | 2(3.3) | 3(5) |
| | Sickness/ health costs | 7(11.6) | 2(3.3) |
| | Demise of household head | 4(6.6) | 2(3.3) |
| Difficulties impacting food shortage | High cost of food | 33(55) | 16(26.7) |
| | Debt burden | 2(3.3) | 3(5) |
| | Crop disease | 7(11.6) | 6(10) |
| | Animal disease | 4(6.6) | 4(6.7) |

| | | | |
|---|---|---|---|
| | Bad climate (poor crop yield/harvest) | 3(5) | 32(53.3) |

There is a difference in food security due to the effects of climate change, based on Table 4, the comparison of food insecurity before and after these impacts ($t = -6.70$, $p < 0.01$). Due to climate change, the mean score for food insecurity was higher than it was prior to climate change ($\bar{X}_{before} = 62.57$; $\bar{X}_{after} = 74.40$). This suggests that food insecurity is made worse by climate change and could be because, that the incidence of climate change, lead to the high prevalence of the elements related to food unavailability, inaccessibility, and poor perception. The inverse relationship between food security and the effects of climate change is represented by the negative sign as reported by Al Dirani et al. (2021) in Lebanon. While Maziya et al. (2024), found that responding to climate change is associated with lower levels of food insecurity, Armah et al. (2019) found that the majority of farming households in Ghana reported changes in weather patterns, and were eleven times more likely to be food insecure due to fluctuating weather. The adoption of climate smart agriculture enhances household food security (Omotoso et al., 2024), climate-related hazards linked to food insecurity weakened the resilience capacity of rural households (Demisse et al., 2024), and a twentieth of the percentile of households experiencing food insecurity where climate variability is prevalent Lolaso et al. (2023).

**Table 4.** Paired samples statistics of food security before and after the impact of climate change

| | Mean | N | Std. Deviation | Std. Error Mean | Difference Mean | t | Df | Sig. |
|---|---|---|---|---|---|---|---|---|
| Food insecurity before CC | **62.57** | 60 | 8.40 | 1.08 | -11.38 | -6.70 | 59 | 0.00 |
| Food insecurity after CC | **74.40** | 60 | 13.46 | 1.74 | | | | |

## Conclusions

This study applied a descriptive research methodology and a systematic sampling procedure to evaluate the disaggregation of the Household Food Insecurity Access Scale variables and assess the effects of climate change on smallholder farmers' food security before and after scenarios. The study shows that climate change has exacerbated food insecurity in smallholder farms, particularly by increasing reliance on purchased food. Similarly, the impacts of climate change on each of the individual indicators in the HFIAS, would enhance a proper alignment of the interventions designed to effectively address food insecurity According to the results, there are equal numbers of male and female smallholder farmers, the majority of whom are under 50 years, fall into the category of single marital status, have large households, have completed primary school, have less than ten years of farming experience, hardly ever interact with extension agents, have access to credit, and have a farm size of at least one hectare. Food security before and after the incidence of climate change differs significantly. This suggests that food insecurity is made worse by the effects of climate change. The policy implications include that the findings reveal areas for real-world interventions. This could be because, following the occurrence of climate change, indicators related to food availability, access, perception, and prevalence of insecurity are higher. This study recommends strategies for improving farmers' resilience, such as enhancing access to climate-smart technologies or expanding extension services.

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### Statement of originality and plagiarism-free

The authors declare that this article is an original work that has not been published elsewhere and is free from plagiarism. All references and citations have been properly acknowledged according to the applicable standards.

### Declaration of conflicts of interest

The author declares no conflicts of interest related to this research, authorship, or publication.

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