
EFFECT OF RAINFALL VARIABILITY ON HOUSEHOLD FOOD PRODUCTION AMONG SMALL FARMERS IN IRINGA RURAL DISTRICT

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ABSTRACT

The study aimed to examine the effect of rainfall variability on household food production among small farmers in Iringa Rural District, Tanzania. The study focused on the effects of rainfall variability on crop yield, crop diversity and production stability. A mixed research approach was employed using a cross-sectional research design. Primary data were collected using questionnaires and interview guides. Quantitative data were analysed using descriptive statistics with the Statistical Product for the Social Solutions (SPSS) Version 26, while qualitative data were analysed using thematic analysis. The findings showed that rainfall variability affected household food production through changes in crop yield, crop diversity and production stability. Variations in rainfall patterns influenced the quantity of crops produced, the range of crops cultivated by households and the stability of food production across seasons. The study concludes that rainfall variability has an important effect on household food production among small farmers in Iringa Rural District by influencing crop yield, crop diversity and production stability. The study recommends that small farmers should be supported to adopt climate-smart agricultural practices, drought-tolerant crop varieties and soil and water conservation measures to reduce the effects of rainfall variability on household food production.

INTRODUCTION

1.1 Background to the Study

Household food production is important for rural households because it provides food and supports livelihoods. Small farmers depend largely on crop production to meet household food needs and generate income. However, household food production can be affected by

changes in climatic conditions, particularly rainfall variability, which influences crop growth and agricultural productivity (Food and Agriculture Organization (FAO), 2022; World Bank, 2021).

Rainfall variability refers to changes in the amount, timing and distribution of rainfall across seasons. Agriculture in many rural areas depends heavily on rainfall, making small farmers vulnerable to delayed rains, shortened rainy seasons and uneven rainfall distribution. Such changes can affect crop yield, the diversity of crops cultivated and the stability of household food production (Intergovernmental Panel on Climate Change (IPCC), 2021; World Bank, 2022).

At the global and African levels, rainfall variability has increasingly affected agricultural production, particularly in rain-fed farming systems. Small farmers in Africa are especially vulnerable because many have limited access to irrigation, improved technologies and climate-resilient agricultural practices. Changes in rainfall patterns can therefore influence the quantity and diversity of crops produced by farming households and the stability of food production across seasons (IPCC, 2022; FAO, 2021). In East Africa, dependence on seasonal rainfall makes agricultural production particularly sensitive to changes in rainfall timing and distribution (World Food Programme (WFP), 2022).

In Tanzania, agriculture remains important to rural livelihoods, with most small farmers depending on rainfall for crop production (National Bureau of Statistics (NBS), 2022). Iringa Rural District is among the areas where small farmers depend on seasonal rainfall to produce crops such as maize, beans, Irish potatoes and sweet potatoes. Variations in rainfall may therefore influence crop yield, crop diversity and the stability of household food production. This study consequently examines the effect of rainfall variability on household food production among small farmers in Iringa Rural District, focusing specifically on crop yield, crop diversity and production stability.

Rainfall variability is a major concern in rural agricultural communities where small farmers depend mainly on rain-fed farming for household food production and livelihoods. In Tanzania, agriculture supports a large proportion of the population, while many small farmers depend on seasonal rainfall for crop production (United Republic of Tanzania (URT), 2020; NBS, 2022). In Iringa Region, variations in rainfall timing, amount and seasonal distribution have created uncertainty in farming activities (URT, 2020). Studies in the Little Ruaha Catchment, which covers parts of Iringa Rural District, have also documented variations in rainfall onset, cessation and seasonal totals (Yonah et al., 2023; Omay et al., 2023). These

conditions are important because small farmers in Iringa Rural District depend heavily on stable rainfall patterns for household food production.

Rainfall variability can directly affect household food production by influencing crop yield, crop diversity and production stability. Changes in rainfall amount and timing may disrupt planting and harvesting periods, reduce crop yields and affect the range of crops that farmers can successfully cultivate. Evidence from Tanzania indicates that low rainfall and climate variability can reduce the production of major rain-fed crops among small farmers (Castro et al., 2022; Gwambene et al., 2022). However, despite evidence of rainfall variability in and around Iringa Rural District, there is limited empirical evidence specifically examining its effect on household food production among small farmers in the district. In particular, limited attention has been given to how rainfall variability affects crop yield, crop diversity and the stability of household food production.

LITERATURE REVIEW

2.1 Theoretical Review

This study was guided by the Sustainable Livelihoods Theory developed by Chambers and Conway (1992). The theory explains that rural households depend on livelihood assets and environmental conditions to sustain their livelihoods, with natural resources playing an important role in agricultural production. The theory is relevant to this study because small farmers in Iringa Rural District depend mainly on rain-fed agriculture, making household food production vulnerable to changes in rainfall amount, timing and distribution. Rainfall variability may influence crop yield, crop diversity and production stability by affecting planting periods, crop growth and harvesting outcomes. The theory therefore provides a useful basis for understanding how rainfall conditions influence household food production among small farmers. However, its broad focus on livelihoods gives limited attention to the specific effects of individual rainfall characteristics on crop production. Despite this limitation, the theory is appropriate for linking environmental conditions, agricultural livelihoods and household food production in the study area (Scoones, 2015; Department for International Development (DFID), 2020).

2.2 Empirical Literature Review

Empirical studies have shown that rainfall variability affects household food production among small farmers through changes in crop yield and the quantity of food produced. Variations in rainfall amount, timing and distribution can disrupt planting and harvesting schedules and affect crop growth, resulting in fluctuations in agricultural output. Studies by

Abebe (2020), Singh (2021), Ochieng (2022) and Mashauri (2023) reported that unpredictable rainfall reduced agricultural productivity and contributed to unstable harvests among small farmers. Other studies by Njoroge (2020), Tesfaye (2021) and Patel (2021) found that rainfall variability also affected crop diversity, as farmers adjusted the types of crops cultivated in response to changing rainfall conditions. Kumar (2022) and Mlenge (2023) further showed that irregular rainfall contributed to instability in food production across farming seasons. These studies demonstrate that rainfall variability can affect crop yield, crop diversity and production stability, which are important dimensions of household food production. However, most of the studies examined these effects in different settings and provided limited evidence on small farmers in Iringa Rural District.

Evidence from Tanzania further supports the relationship between rainfall variability and crop production. Nassary and Magubika (2025) found that seasonal rainfall distribution and regional conditions explained substantial variations in maize production across Tanzania, showing the importance of rainfall conditions in agricultural productivity. Similarly, Aziz et al. (2026) reported that rainfall was a major driver of yield variability in rain-fed maize production in selected Sub-Saharan African locations, including Monduli in Tanzania, with both excessive and insufficient rainfall contributing to yield losses. These studies confirm that rainfall variability can influence crop production, but they mainly focused on specific crops or broader regional settings rather than household food production among small farmers in Iringa Rural District. Therefore, a research gap exists regarding the effect of rainfall amount, timing, dry spells and rainfall distribution on household food production, particularly in terms of crop yield, crop diversity and production stability among small farmers in Iringa Rural District.

METHODOLOGY

Research Design

This study employed a mixed research approach, combining quantitative and qualitative methods. Creswell and Plano Clark (2018) explain that mixed methods research combines quantitative and qualitative approaches to provide a more comprehensive understanding of a research problem. The approach enabled the researcher to collect quantitative data on rainfall variability and household food production, while also obtaining detailed views and experiences from small farmers and agricultural extension officers. A cross-sectional research design was used, whereby quantitative and qualitative data were collected during the same period. This design was appropriate because it enabled the researcher to examine the effect of

rainfall variability on household food production while obtaining detailed explanations of farmers' experiences with changing rainfall conditions. The approach therefore provided a broader understanding of how rainfall variability affects crop yield, crop diversity and production stability among small farmers in Iringa Rural District.

Area of the Study

This study was conducted in Iringa Rural District, located in the Southern Highlands of Tanzania within Iringa Region (URT, 2020). According to the National Bureau of Statistics (NBS, 2022), the district has a population of approximately 254,032 people, with a large proportion residing in rural areas. Agriculture is the main economic activity and small farming is an important source of household livelihoods and food production. The district is characterised by highland climatic conditions, fertile soils and diverse farming systems, with major crops including maize, beans, Irish potatoes and sweet potatoes (URT, 2022). The study specifically covered Isimani, Idodi, Pawaga and Kalenga, where registered small farmers were identified as the main study population. The area was selected because of its dependence on rain-fed agriculture, making it suitable for examining the effect of rainfall variability on household food production.

Population and Sampling

Population

A population refers to the entire group of people or units that possess characteristics relevant to a particular study. Kothari (2004) explains that a study population comprises the units from which information relevant to the research problem is obtained. The population for this study consisted of 1,896 registered small farmers from Isimani, Idodi, Pawaga and Kalenga wards in Iringa Rural District. These farmers were included because they depend largely on rain-fed agriculture and have direct experience with rainfall conditions and household food production. The study also included five agricultural extension officers as key informants. These officers were included because they have relevant professional knowledge and experience concerning rainfall variability, agricultural practices and crop production in the district.

Sampling

Sampling is the process of selecting a smaller group from a larger population to participate in a study. Kothari (2004) notes that appropriate sampling procedures enable researchers to select participants who can provide relevant information about the study population. This

study employed a combination of simple random sampling and purposive sampling. Simple random sampling was used to select 95 small farmers from the population of 1,896 registered small farmers, giving eligible farmers an equal opportunity to participate. The sample size was determined using Slovin's formula at the specified margin of error. Purposive sampling was used to select five agricultural extension officers because of their knowledge and experience concerning local farming conditions, rainfall variability and crop production. The quantitative sample therefore consisted of 95 small farmers, while the five agricultural extension officers provided qualitative information, giving a total sample of 100 participants.

Data Collection Instruments

A questionnaire was used to collect quantitative information from the 95 selected small farmers. The questionnaire collected information on rainfall conditions experienced by farmers and household food production, with particular attention to crop yield, crop diversity and production stability. Semi-structured interview guides were also used to collect detailed information from the five agricultural extension officers. Creswell and Plano Clark (2018) emphasise the importance of using appropriate quantitative and qualitative data collection procedures when conducting mixed methods research. The interviews focused on rainfall variability, changes in rainfall amount and timing, dry spells, rainfall distribution and their observed effects on crop production. The use of questionnaires and interview guides enabled the study to obtain both measurable information from small farmers and detailed explanations from agricultural extension officers.

Data Analysis

Quantitative data were coded, entered and analysed using the Statistical Product for the Social Solutions (SPSS), Version 26. Descriptive statistics, including frequencies and percentages, were used to summarise information on rainfall variability and household food production. The quantitative analysis focused on indicators such as crop yield, crop diversity and production stability. Qualitative data collected through semi-structured interviews were analysed using thematic analysis. Braun and Clarke (2006) describe thematic analysis as a flexible approach for identifying and analysing patterns or themes within qualitative data. In this study, interview responses were reviewed, coded and grouped into themes related to farmers' experiences and observed effects of rainfall variability on household food production. The qualitative findings were then compared with the quantitative findings to

provide a clearer understanding of the effect of rainfall variability on household food production among small farmers in Iringa Rural District.

Ethical Considerations

The study observed ethical principles to protect the rights, privacy and welfare of participants. Creswell and Plano Clark (2018) emphasise the importance of appropriate ethical procedures when collecting and integrating data from research participants. An introductory letter was obtained from the University of Iringa and permission to conduct the study was obtained from the relevant authorities in Iringa Rural District. Participants were informed about the purpose of the study and the procedures involved before data collection. Participation was voluntary and informed consent was obtained from all participants. Confidentiality and anonymity were maintained by avoiding the use of participants' names and using codes where necessary. Information collected from small farmers and agricultural extension officers was securely stored and used only for academic purposes. Academic integrity was maintained by properly acknowledging all sources used in the study through APA referencing.

DATA PRESENTATIONS AND DISCUSSIONS

4.1 Effect of Rainfall Variability on Households' Food Production

This section presents and discusses the findings on the effect of rainfall variability on household food production among small farmers in Iringa Rural District. Household food production is assessed using three indicators: crop yield, crop diversity and production stability. The findings are presented using frequencies and percentages in tables, followed by discussions supported by information obtained from agricultural extension officers and previous empirical studies. The purpose is to explain how rainfall variability affects household food production among small farmers in the study area.

4.1.1 The effect of rainfall amount and crop yield

Results in Table 4.1 showed that 71.6% of respondents reported that crop harvests decreased by more than half during the last farming season; increased harvests represented 16.8%, while 7.4% reported a slight decrease and only 4.2% reported that the quantity harvested remained about the same. The high proportion reporting a substantial decline shows that the amount of rainfall received during the season was associated with poor crop-yield performance among the surveyed households. An Agricultural Extension Officer explained that low rainfall affected crop growth and maturity, particularly for maize and beans. The

officer also noted differences in crop performance among farmers using soil-moisture conservation practices. The officer stated:

The amount of rainfall we receive has a direct effect on the harvest obtained by most farmers. When rainfall is low, crops do not grow well and some dry before they reach maturity. During the last farming season, many farmers harvested much less maize and beans than they had expected because the rainfall was insufficient. Only a few farmers who conserved soil moisture managed to obtain better harvests than others. We continue encouraging farmers to use better farming practices so they can reduce the effects of changing rainfall patterns (Interview with Agricultural Extension Officer 1, 18 June 2026).

The officer's position involves direct contact with farmers and provision of agricultural advice, giving the observation relevance to crop production conditions in the district. The reference to crops drying before maturity explains how inadequate rainfall affected the production process, while the difference between farmers using soil-moisture conservation and those relying mainly on rainfall indicates variation in crop performance within the same farming environment. This observation corresponds with the 16.8% who reported increased harvests and the 7.4% who reported only slight changes in crop output were also reflected in district agricultural production records. White maize production declined from 370,896.70 tonnes in 2023/2024 to 324,966 tonnes in 2024/2025, before increasing to 364,877.5 tonnes in 2025/2026. Yellow maize production declined from 189.5 tonnes in 2023/2024 to 136.5 tonnes in 2024/2025 and 124.2 tonnes in 2025/2026. The National Climate Change Response Strategy identifies rainfall variability, drought and prolonged dry periods as risks to agricultural production in Tanzania (URT, 2021). Gwambene et al. (2023) similarly found that climate variability affected agricultural production and food security among small farmers in Rungwe District in the Southern Highlands of Tanzania. The variation in district maize production across the three seasons, together with the 71.6% reported reduction in household harvests, gives a consistent picture of changes in crop output associated with seasonal agricultural conditions.

4.1.2 The effect of rainfall amount and crop diversity

Results in Table 4.1 showed that 61.1% of respondents harvested two different food crops, while 30.5% harvested three different food crops. Those who harvested one food crop represented 7.4% and only 1.1% harvested four or more food crops. The dominance of two- and three-crop production shows that farmers maintained some crop diversity, while wider diversification was uncommon.

The pattern also shows that crop diversity differed across households. The 7.4% producing one crop had the narrowest production range, while the 30.5% producing three crops had a wider range of food crops. The very small proportion of 1.1% producing four or more crops indicates that extensive diversification was uncommon in the farming season. This distribution gives a clearer picture of the range of crops maintained by households under the rainfall conditions experienced during the season. The Agricultural Extension Officer explained that:

When rainfall becomes uncertain, some farmers reduce the number of crops they plant because they fear losing the money spent on farm inputs and labour. Some farmers also choose drought-tolerant crop varieties because these crops are more likely to survive when rainfall is low or poorly distributed. These changes in crop selection help some households maintain food production under unfavourable rainfall conditions (Interview with Agricultural Extension Officer 2, 18 June 2026).

Finding shows that rainfall uncertainty influenced farmers' crop selection decisions. The use of drought-tolerant varieties and adjustment in the number of crops planted represented practical responses to production risks associated with changing rainfall conditions. The findings differ in an important way from the pattern reported by Makate et al. (2023). Their study, using household panel data from Tanzania and Malawi, found that smallholder farmers responded to rainfall shocks by intensifying crop diversification and that previous diversification experience and household assets influenced subsequent diversification. In the present study, the concentration of households around two and three crops shows a narrower level of diversification. The difference points to the importance of local production conditions and household resources when examining how farmers respond to rainfall conditions.

4.1.3 The effect of rainfall amount and production stability

Results in Table 4.1 showed that 58.9% of respondents reported that similar rainfall amounts resulted in similar crop production in only one of the three farming seasons. Another 20.0% reported similar production in two seasons, while 11.6% reported that similar rainfall amounts never resulted in similar production. Only 9.5% reported similar production in all three seasons. This means that 90.5% of respondents did not experience similar production under similar rainfall amounts throughout all three farming seasons.

The rainfall records provide a specific explanation for this production pattern. Iringa recorded 1,227.3 mm of rainfall in the 2023/2024 season and 479.2 mm in 2024/2025. The difference was 748.1 mm, representing a 61.0% reduction from the 2023/2024 level. This large change

in rainfall amount indicates that the three farming seasons did not provide equal rainfall conditions for crop production. The production records also show this difference in maize performance. White maize production decreased from 370,896.7 tonnes in 2023/2024 to 324,966 tonnes in 2024/2025, a reduction of 45,930.7 tonnes. Yellow maize production also decreased from 189.5 tonnes to 136.5 tonnes during the same period.

Rainfall amount alone does not determine the level of crop production among small farmers. The timing and distribution of rainfall during the growing season also influence crop performance and the final harvest. This was explained by an Agricultural Extension Officer during the key informant interview:

Receiving the same amount of rainfall does not always produce the same harvest because rainfall conditions during the growing period also affect crop performance. The timing and distribution of rainfall within the crop-growing period determine whether crops receive sufficient moisture during important growth stages. When rainfall comes too early, too late, or is poorly distributed, crop growth and final harvest can be affected (Interview with Agricultural Extension Officer 3, 30 June 2026).

The finding is aligned with Rowhani et al. (2011), who found that climate variability affected crop production in Tanzania. The present finding is more specific to Iringa Rural District because it shows that 90.5% of respondents did not report similar production under similar rainfall amounts across all three seasons, while the rainfall and maize production records show measurable differences between farming years. This establishes a direct relationship between changes in rainfall conditions and instability in household crop production.

Table 4.1: Rainfall Amount on Households' Food Production. (n = 95)

Response	Frequency	Percent (%)
Rainfall amount and crop yield		
Harvest decreased by more than half	68	71.6
Harvest decreased slightly	7	7.4
Harvest remained about the same	4	4.2
Harvest increased	16	16.8
Rainfall amount and crop diversity		
One crop	7	7.4
Two crops	58	61.1
Three crops	29	30.5
Four or more crops	1	1.1
Rainfall amount and production stability		
Never	11	11.6
Once	56	58.9

Twice	19	20.0
All three seasons	9	9.5
Rainfall amount and household food stocks		
Less than 3 months	77	81.1
3–5 months	11	11.6
6–8 months	2	2.1
More than 8 months	5	5.3
Rainfall amount and food storage		
None	30	31.6
Less than one-quarter	10	10.5
One-quarter to one-half	2	2.1
More than one-half of harvest	53	55.8
Rainfall amount and months of food sufficiency		
Less than 3 months	35	36.8
3–5 months	53	55.8
6–8 months	4	4.2
More than 8 months	3	3.2

Source: Field Data (2026)

4.1.4 The effect of rainfall amount and household food stocks

Results in Table 4.1 showed that 81.1% of respondents reported that household food stocks lasted for less than three months. A further 11.6% reported three to five months, 2.1% reported six to eight months and 5.3% reported more than eight months. The researcher observes that the short duration of food stocks indicates that the amount of rainfall received during the farming season was associated with the quantity of food available for retention after harvest. The finding indicates that rainfall affected household food stocks through the quantity of food produced during the farming season. Where rainfall was insufficient, households had less food to retain for later consumption. This reduced the period covered by household food stocks and increased the need for households to obtain food before the next harvest. The researcher further observes that maintaining food stocks for several months is important for households that depend mainly on crop production. Short food stocks leave limited reserves for periods when household production is unavailable. The result is thus important to food security because the amount of rainfall received during production influences not only harvest outcomes but also the availability of food after harvest. The National Climate Change Response Strategy 2021–2026 identifies unreliable rainfall as a risk to rain-fed agricultural production and food security in Tanzania (URT, 2021). This provides a national context for the present finding because food stocks among farming households depend on the quantity of agricultural produce obtained from rain-dependent production. Evidence from previous studies also supports the finding. Randell et al. (2022) found that dry

conditions increased household food insecurity in Tanzania through their effects on agricultural production and food availability. Brander et al. (2021) also found that improved on-farm storage reduced seasonal food insecurity among small farmer households in Tanzania. These findings support the present study by showing that rainfall-related production conditions and the retention of harvested food are important for maintaining household food supplies across seasons.

4.1.5 The effect of rainfall amount and food storage

Results in Table 4.1 showed that 55.8% of respondents reported that more than one-half of their harvest was available for storage. In contrast, 31.6% reported that no produce was available for storage, while 10.5% had less than one-quarter available and 2.1% had between one-quarter and one-half available. The researcher observes that although most respondents had a substantial share of their harvest available for storage, a considerable proportion had no produce available for storage. This indicates that the amount of rainfall received during the farming season was associated with differences in the quantity of harvest that households could preserve for later consumption. The limited food storage reduces the ability of households to maintain food supplies between harvest periods. The finding shows that food storage was closely linked to the amount of produce remaining after meeting immediate household needs. Households with sufficient harvest had a larger quantity available for storage, while households with limited harvest had little or no surplus to preserve.

The quantitative findings were also supported by information obtained from key informant interviews. An Agricultural Extension Officer explained that the amount of rainfall received during the farming season affected the quantity of food that farmers harvested and later stored. The officer also noted that households with better harvests were able to keep part of their produce for future consumption, while households with poor harvests often used most or all of their produce for immediate needs. The officer stated:

The amount of rainfall received during the farming season affects how much food farmers harvest and how much they are able to store. When rainfall is sufficient and well distributed, farmers usually obtain better harvests and keep part of the produce for later use. When rainfall is low, the harvest becomes small and most families use the little food they have for immediate consumption, leaving very little or nothing for storage (Interview with Agricultural Extension Officer 1, 18 June 2026).

The finding helps explain the variation in household food storage. Households with better harvests were able to retain part of their produce for future consumption, while households

with poor harvests used most or all of their produce for immediate needs. This shows that rainfall amount influenced food storage through its effect on the quantity of food harvested and the amount remaining after immediate household consumption.

Evidence from previous studies supports this finding. Gwambene et al. (2023) found that climate variability affected agricultural production and food security among small farmers in Rungwe District in the Southern Highlands of Tanzania. Reduced agricultural production limits the quantity of food available for household use and storage. Brander et al. (2021) also found that improved on-farm storage reduced seasonal food insecurity among small farmer households in Tanzania, showing that retaining harvested food is important for maintaining household food supplies between seasons. These findings support the present study by demonstrating the connection between agricultural production, food storage and household food security.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study concludes that rainfall variability affects household food production among small farmers in Iringa Rural District by influencing crop yield, crop diversity and production stability. Changes in rainfall amount and its distribution affect crop growth and harvesting outcomes, while uncertain rainfall conditions influence farmers' decisions about the number and types of crops cultivated. The findings also indicate that production does not remain stable across farming seasons because rainfall conditions differ from one season to another. Therefore, rainfall variability represents an important environmental factor affecting the capacity of small farmers to maintain consistent household food production in the study area.

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Recommendations

Small farmers should adopt soil-moisture conservation and water-management practices that reduce dependence on rainfall conditions and protect crops during periods of inadequate rainfall. Agricultural extension officers should provide practical guidance on appropriate conservation practices, crop selection and planting decisions based on prevailing rainfall conditions. The use of drought-tolerant crop varieties and suitable crop diversification should also be strengthened because these practices can help farmers maintain production when rainfall becomes uncertain. Pasted markdown. The Tanzania Meteorological Authority and district agricultural authorities should strengthen the provision of timely, location-specific rainfall information to small farmers and integrate this information into agricultural extension

services. Farmers should be supported to use seasonal rainfall forecasts when making decisions on planting periods, crop varieties and farm management practices.

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