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EVALUATING THE IMPACT OF RAINFALL VARIABILITY ON RICE PRODUCTION IN GORONYO LOCAL GOVERNMENT AREA OF SOKOTO STATE, NIGERIA

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Abstract

Climate variability has affected agricultural production globally; this concern has motivated important changes in the field of research during the last decade. Nigeria rice production is mainly rain-fed and naturally prone to threats pose by rainfall variability. However, seasonal rainfall is critical for the availability of water for rice production, which is mostly rain-fed too and rainfall variability over the past decade, is the main cause for poor yield and failure of crops like rice in Nigeria. This study evaluates the impact of rainfall variability on rice production in the study area. The data on rice production and annual rainfall (2014-2023) were obtained from Ministry of Agriculture Sokoto and Meteorological Station of Sultan Abubakar the 3rd International Airport, Sokoto respectively. Line graphs were used to show the trends of annual rainfall and rice production, also Pearson correlation coefficient were employed to test the significant relationship among them. The study finds out that the annual rainfall has been fluctuating over the years during the study period. The trend line indicated a general decreasing trend in the annual rainfall as observed from the linear trend line equation (Y=-5.2465x + 1125.4); likewise, the annual yield of the rice in tons per hectare in the study area from 2014 to 2023 showing an overall increase in its yield with linear trend line equation (Y= 2.3254x + 105.83) and the relationship between rainfall and the rice production in the study area is a negative relationship, which revealed a very weak correlation (r = -0/061). The result depicted a statistically significant relationship between the correlated variable at p < 0.05 level of confidence. The study recommends that government should make awareness campaign to the farmers on mitigation measure for rainfall variability and climate change as well as its effects on rice production.

Keywords*: Production, Climate Variability, Rainfall, Agriculture and Rice*.

Introduction

Climate and agriculture both are highly interrelated. Agriculture is highly dependent on the climatic factors. The climatic factors as well as other factors determined by the climate causes vulnerability of agriculture and agricultural production. Consequentially, climate change has become a major concern to human society because of its potentially deleterious impact worldwide. It poses especially significant threats to agricultural activities and production, as well as sustainable development in developing countries, which have fewer resources and are more vulnerable (Food and Agricultural Organization FAO, 2008).

Climate variability (rainfall, temperature among others) is the short-term departure of climate variability from normal either positively or negatively, as against climate change; where changes are observed or remain constant for a very long period of time range of 30 years. Climatic variability is

very fast, while climate change is very slow (Odingo, 2008; Audu and Rizama, 2014). Climate variability is a continuous process which is mostly observed through rainfall and temperature inconsistency (Intergovernmental Panel on Climate Change IPCC, 2007). It was reported by NiMet (2018) that rainfall variability in space and time is one of the most relevant characteristics of climate that has socioeconomic and ecological implications on most nations of the world.

Rainfall variability impact analysis is a way of looking at the range of consequences of a given rainfall event or change (NiMet 2018). Nevertheless, rainfall is a key determinant of the growing season and the type of agriculture practiced, it plays an important role in agriculture as any shortage or excess of rainfall gives way to a reduction in yields. For instance, places where rice is the main crop, rice production becomes highly susceptible to rainfall variability (IPCC, 2007). However, extreme rainfall variability triggers environmental problems such as flood, gully erosion, drought and desertification, which a serious effect on the yield of rice (Odjugo, 2005 & Adefolalu 2007). It was observed by FOA (2008) and Odjugo (2010) that rainfall variability has generated a lot of influenced in the level of agricultural products.

In Nigeria, rice is one the major crops cultivated within the nation, which clearly show that, change in its production as a result of rainfall variability will affect its general production in the nation (Akinbile *et al.* 2010). The cultivation of rice is also being affected by the impact of rainfall variability in various locations in Nigeria. For example, Adamu (2016) stated that, climatic variability such as rainfall and temperatures are major threat to rice growth which leads tom drop in quantity and quality of rice in Kurfi area of Katsina State.

Nevertheless, recent studies both in Nigeria and outside the country have attributed low production of rice to impacts of climate change. Such studies include Ayinde *et al.* (2013); Adedeji *et al.* (2017); David and Dean (2014) and Adejuwon (2014). However, despite the fact that Sokoto State is one of the states that produce rice in large quantity in Nigeria, but previous studies in the state have concentrated on the incidence of climate change and the impact on farmers in the state. Attention has not been paid to the impact of individual climatic element such as rainfall on rice yield. There is need to determine how changing climate parameters such as rainfall plays critical role in yields of rice in Goronyo, Sokoto State.

Statement of Research Problem

The scientific evidence on rainfall variability with its significant impacts on rice yield are now stronger than. One indisputable cause of 'famine' in Guinean Savana Nigeria is the failure of crops resulting from insufficient or untimely rainfall has studied the inter-annual variability in climate of West African counties, and particularly the magnitude of rainfall variability impact on human activities, including crop production. However, the yield of crops like rice in Goronyo, Sokoto State is seriously posed with the treat of rainfall variability due to its location in the Guinea Savanna of Nigeria.

Notwithstanding, in the verge this study, the researcher didn't come in contact with any research on analysis of the effect of rainfall on rice production in Goronyo, Sokoto State, which is one of the majors producing local government area in Sokoto states. It is against this background that this study focuses on analyzing the effect of rainfall on rice production in the study area to bridge the gap in knowledge. Nonetheless, in the development of this study, some questions were raised and subsequently enhance the improvement of this research to provide answers to these questions raised.

Aim and Objectives of the Study

The main aim of this study is to examine the effect of rainfall on rice production in study area and this was achieved through the following objectives**:**

i. To examine the trend of rainfall in the study area between 2014 and 2023.
ii. To examine the trend in rice production in the study area between 2014 and 2023.
iii. Analyze the relationship between rice production and the annual rainfall in the study area between 2014 and 2023.

Description of the Study Area

Goronyo Local Government Area (LGA) is located between Latitudes 13° 27′11″ N to 13°27′14″ N of the equator and Longitude 5°40′35″E to 5°40′37″E of the Greenwich Meridian (Sokoto 2006). By its location, it shares boundaries with the Gada and Illela LGAs to the north, Gwadabawa and Wurno LGAs to the west, Rabah LGA to the south and Sabon Birni and Isa LGAs to the east (Figure 1). The LGA covers a total land area of about 1,704 km^2 and is about 559m above sea level. However, the area witnesses two distinct seasons which are the rainy and the dry seasons with the dry seasons in the LGA usually characterized by extremely hot temperatures ranging from 62^0 F and 105^0 F during the hot, in the months of April and January have the greatest and lowest temperatures respectively throughout the year, and have the average humidity level of 24 per cent (Sokoto, 2006).

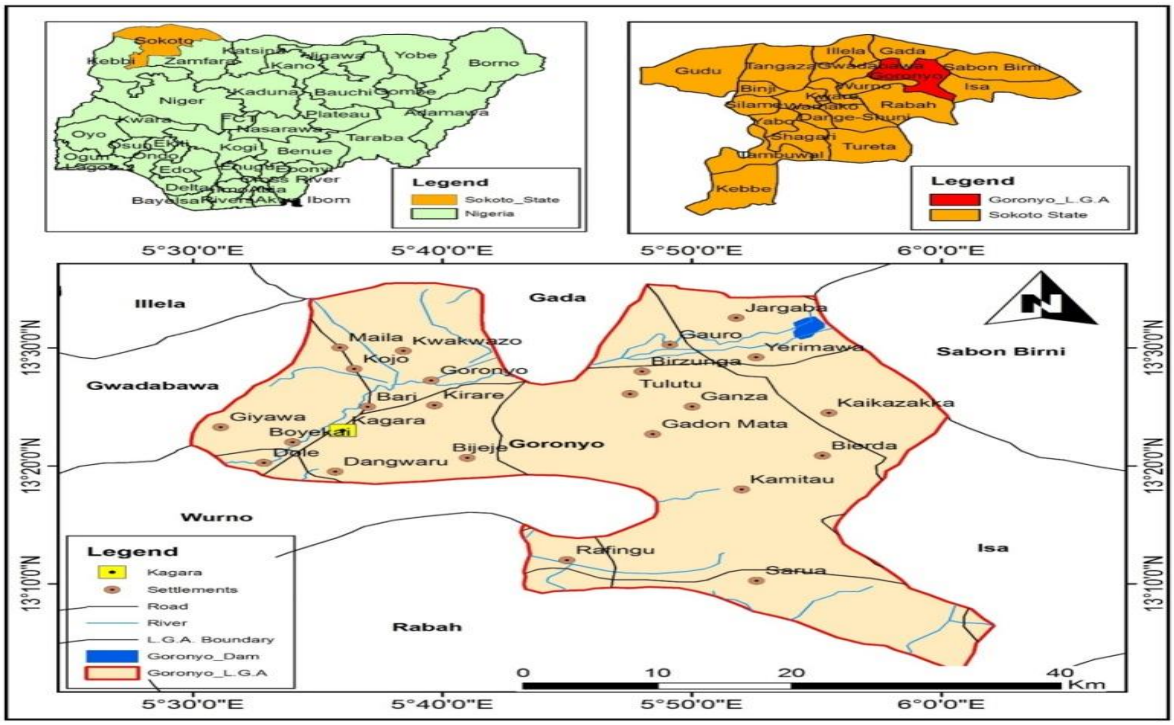

Figure 1: Map of the Study Area
Source: GIS Laboratory, Department of Geography, Sokoto State University, (2023)

Nevertheless, according to 2006 National Population and Housing Census Goronyo LGA has a population of 182,296 and it has a total projected population of 291,674 for the 2022, with an average annual growth rate of 3%. The projection was done using the Newman's (2001) formula:

{Pn = Po + (1+R/100 X Po) N} as cited by Aliyu & Barau (2023) and Barau & Sani (2023), where Pn = population in the recent year, Po = population in the base year (150,268), R = annual growth rate (3%) and N = number of intermediary years (2023 -2006 = 15). Similarly, farming is the major occupation of the people in the area, with a number of crops such as millet, guinea corn, maize, rice, potatoes, cassava, groundnuts, beans for subsistence, while cotton and vegetables are cultivated for cash, and a number of domestic animals such as camels, donkeys, and rams are also reared and sold. Local crafts such as blacksmithing, weaving, food processing and sales of cakes also play an important role in the economic life of the people in the area, state and nation at large (Sokoto, 2006).

Materials and Methods

In this research, secondary data on rice production and annual rainfall from 2014 to 2023 were obtained from Ministry of Agriculture Sokoto (MAS) and Meteorological Station of Sultan Abubakar the 3rd International Airport, Sokoto (MSSAIAS) respectively. Therefore, quantitative approach was employed for the purpose of this study, the reason for employing approach is due to the fact that some findings needed qualitative while some conclusions need descriptive statistical approaches such as graph and tabulation. According to Kaur, Sttoltzfus and Yellapu (2018), the research design represents the major methodological thrust of the study, being the distinctive and specific approach, which is best suited to answer the research questions. The research questions, the aim and the objectives of the study thus influence the selection of the research design (Kaur, Sttoltzfus and Yellapu, 2018).

Besides that, these data collected were entered into Excel Microsoft (2013) application and the data were subjected to time series analysis to determine the trends of annual rainfall and rice production over the period of ten years (2014-2023) and Pearson correlation coefficient (two tailed) were also employed to examine the relationship between annual rainfall and rice produced in the study area, all using Statistical Package for Social Science (SPSS) version 20 software to perform the analysis with a significant level (0.05) and the stated hypothesis were tested.

Results and Discussions

Annual Rainfall and Rice Production Data Used

Table 1 shows the annual rainfall (mm) and rice production (tons/ha) data used for the analysis, also present the harmonized data in Log10 for both annual rainfall (mm) and rice (tons/ha) for the study area.

Table 1: Annual Rainfall, Rice Production and Log10 of both Variables

Years	Rainfall (mm)	Log10 rain fall	Rice (ton/ha)	Log10 Rice
2014	953.40	2.98	136.43	2.13
2015	917.20	2.96	154.45	2.19
2016	1237.30	3.09	148.75	2.17
2017	1183.30	3.07	130.55	2.12
2018	1128.90	3.05	139.36	2.14
2019	1020.0	3.01	141.00	2.15
2020	945.10	2.98	138.95	2.14
2021	905.50	2.96	139.13	2.14
2022	1015.50	3.01	143.45	2.16
2023	927.60	2.97	163.55	2.21

Source: MAS and MSSAIAS, (2023)

From Table 1, it can be observed that there are variations in the total annual rainfall in the study area from 2014 to 2023. There is a clear sign of the variability of rainfall as it occurs in the study area. From the table, the year that received the highest annual rainfall is 2016 which had a record of 1237.30mm and the year with the lowest amount of rainfall was 2021 having a record of 905.50mm. The study area has its range and average mean in the annual amount of rainfall at 313.50mm and 1065.08mm respectively, for the study period of 10 years (2014-2023). On the other hand, just like rainfall data which showed variations in its figures, rice production record showed variations too but a general increase in its production was noticed from 2014 at 136.43ton/ha to 2023 at 163.55 ton/ha. The year 2017 scored the lowest production records of rice, with 130.55ton/ha and the highest record, 163.55 ton/ha in the year 2023. Furthermore, the study area has its range and average mean in rice production at 67.96ton /ha and 132.58ton/ha respectively, for the study period of 10 years (2014-2023).

Trend in Annual Rainfall in the Study Area

The trend in annual rainfall (mm) in the study area is shown on Figure 2 which presents the original trend and annual rainfall trend line from 2014 to 2023. It reveals the rainfall experienced in the study area.

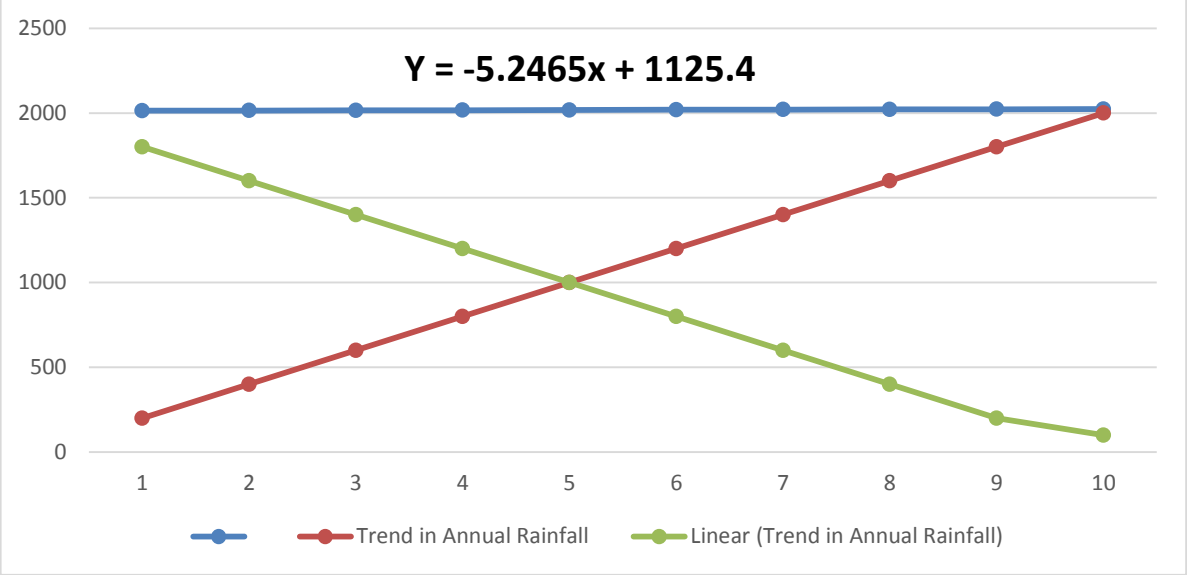

Figure 2: Trend in Annual Rainfall in the Study Area
Source: Field Work, (2023)

From Figure 2, it can be observed that the annual rainfall in area has been fluctuating over the years during the period of study. The trend line indicates a general decrease trend in the annual rainfall as observed from the linear trend line equation (Y = -5.24658 + 125.4). However, this infers that the annual rainfall is progressively decreasing in the study area from (2014-2023). This fluctuation and decrease in the trend of rainfall can be attributed to the issue of climate change in which intellectuals projected abnormalities in rainfall pattern.

Comparing the result of this analysis with that of David and Dean (2014) who studies of impact of rainfall on rice output in Indonesian, in which the researcher noted that rainfall in Ebonyi State was generally increasing and as such rice yield in the study are experience an increase too as well a bit of

stability in it yields over the year. Likewise, Audu and Rizama (2014) who studied the rainfall trends and patterns in North-west Nigeria; they observed that, during the 2006 to 2010 raining season, there was serious rainfall variability and crops like cotton, groundnut, millets, and sorghum" were affected in their yield, because of onset, duration and cessation variation in the study area. This contrary to the findings of this study, which implies rainfall trend, was generally decreasing within the study period of years in the study area.

Trend in Rice Production in the Study Area

The trend in rice production (tons/ha) in the study area is shown on Figure 3, which presets the original trend in rice trend line from 2014 to 2023 showing rice production accounted for in the study area.

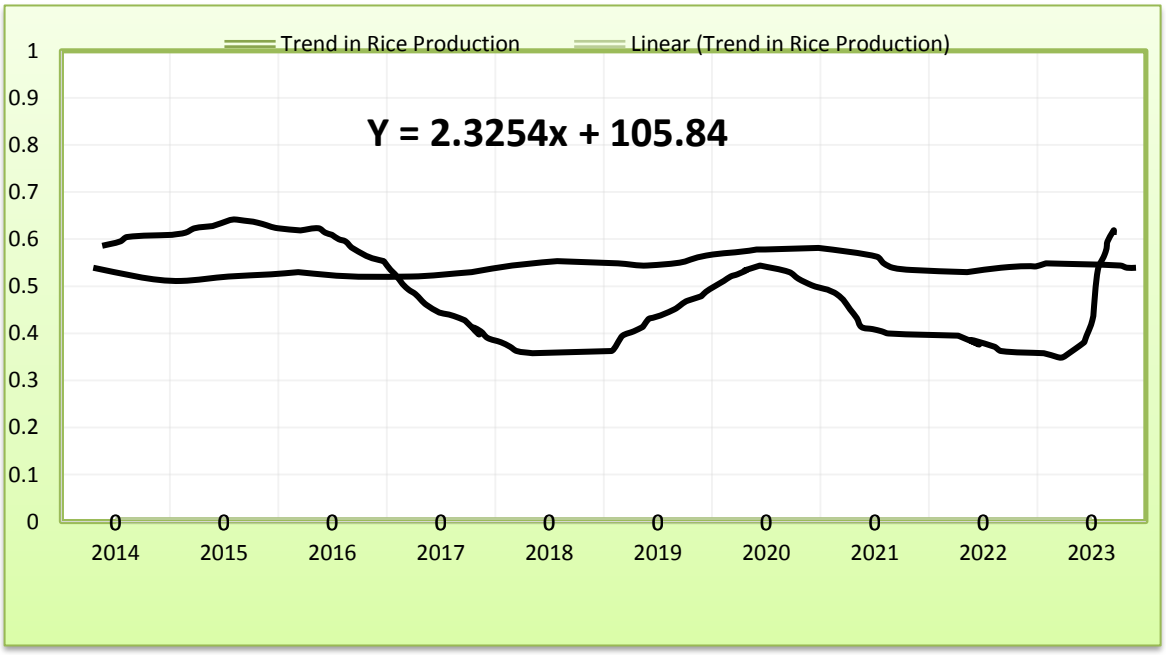

Figure 3: Trend in Annual Rice Production in the Study Area
Source: Field Work, (2023)

From Figure 3, it can be seen that the annual rice production in tons/ha in the study area from 2014-2023 has shown fluctuation in its production, however, rice production has been progressively increasing generally over the years in the study area as shown by the trend line equation (Y = 2.3254x + 105.84). This increase may have been as a result of the availability of soil-water made available by rainfall, irrigation and other climatic variables which plant is required for their growth and development.

Comparing the result of this research with that of Rahman *et al.*, (2017) studied the impacts of temperature and rainfall variation on rice production in major ecosystems of Bangladesh, the researchers observed that, they were a general increase in the trend of rainfall which led increase in the production of rice to about 278.23tons/ha. Likewise, Ramirez (2010) who studied the impact of climate change on rice production in Brazil Metropolis, Brazil for period of 20 years (1990-2010). The research observed that rice production in the study area has progressively increase with rainfall and other factor like soil fertility influencing the yield to about 214.24ton/ha in the ears 2006 in the

study area. Also, Nwalieji and Uzuegbunam (2014) evaluated the effect of climate change on rice production in Anambra State, Nigeria. They discovered that there was significant increase in rainfall and rice production in the study area, which was more pronounced within the period up to 261 mm for rainfall and rice 3 l 2.46tons/ha in the study area.

Relationship between Annual Rainfall and Rice Production in the Study Area

The relationship between annual rainfall (mm) and rice (tons/ha) yield in the area is indicated in Table 2.

Table 2: The Correlation Coefficient between Annual Rainfall and Rice Production in the Study Area

Variables		Rainfall (mm)	Rice Production (tons/ha)
Rainfall (mm)	Pearson Correlation	1	-.061
	Sig. (2-tailed)		.786
	N	22	22
Rice Production (tons/ha)	Pearson Correlation	-.061	1
	Sig. (2-tailed)	786	
	N	22	22

Source: Field Work, (2023)

Table 2 shows illustrate that there is a negative relationship between rainfall and rice production in the study area, however, the correlation result reveals that the relationship between two variables (rainfall and rice) is very weak one, where r = -0.061. Consequentially, this means that annual rainfall had no or little effect on rice production in the study area within the period of study.

Unlike Davi and Dean (2014) examined the impact rainfall on rice output in Indonesian, in which the researcher discovered that there is little or no significant relationship between rainfall and temperature on rice production in the study area, with rainfall and rice showing r = 0.084 and temperature and rice showing 0.214. Likewise, Rahman *et al.*, (2017) examined the impacts of temperature and rainfall variation on rice production in major ecosystems of Bangladesh, and observed that they were a significant relationship of r = 0.03 between rainfall and rice production from 1983-1985 in Bangladesh. Also, Ramirez (2010) who studied the impact of climate change on rice production in Brazil Metropolis, Brazil for period of 10 years (1990-2010). The researcher's analysis of correlation for the relation hip between rainfall and rice production in the study area depicted r = 0.732, implying that there is a strong relationship between rainfall and rice production in the study area for the period of study.

Hypothesis Testing

The result from this research (Table 2) shows a negative and weak relationship between annual rainfalls and rice production as a result of this the stated hypothesis**:** there is no significant relationship between annual rainfall and rice production in study area earlier stated in chapter one of this research is here by accepted. From the evaluation of the researcher, decrease in annual rainfall didn't lead to decrease in rice production, however, rice production. in the study area showed increase in its production over the years. This outcome could be as result of other factors in the study area like; soil fatality/nutrients, improved rice varieties and even the cultivation system of rice (availability of irrigation water for dry season farming). However, increase in the land area of cultivation over time and an improvement in the method of cultivation of rice also may have led to the positive result record from the study are.

Conclusion and Recommendations

This study which covered a period of ten (10) years has shown the prevalence of rainfall variability in the study area. The effect of rainfall on rice production was not statistically significant during the period of study. However, rainfall variability had adverse effect on the rice production in the study area. The adverse effect, though insignificant during the period of study, is a warning signal to rice stakeholders to take some precautionary measure against unfavorable effects of rain in all its variations on rice production. Having analyzed the effect of rainfall on rice production in Goronyo, Sokoto State, Nigeria, the need to adopt improved agricultural and environmentally sensitive has become very paramount. Whereby, in Goronyo, Sokoto State, the trends revealed that there was a general increase in the annual rainfall and increase in rice production in over the study period of years.

Nevertheless, rice production in the study area is still progressively increasing over the years, which implies that with improvement in rice production in the study area, to level of mechanized system of rice production, where the mechanize and technological system of rice production is being introduced and encouraged, most especially in the study area, rice production in Goronyo, Sokoto State undoubtedly will continue to increase in years to come. Additionally, with the correlation analysis showing a negative relationship between rainfall and rice production in the study area, rice production has an unfortunate disadvantage to experience decline in its production but reverse is the case with rainfall generally decreasing and rice production generally increasing in the study area. However, if only the study area keeps a close check on rainfall and its variations and other factors of responsible for rice production in the study area, rice production menace of declining in the future can addressed now. Therefore, this study centered on the findings and conclusion drawn for this research with the following major recommendations**:**

1. The government needs to put in place proper structure aim at mitigating the rainfall variability; this step may entail awareness campaign on mitigation measure for rainfall variability specifically and climate change in general to the farmers.
2. The training on soil and water management in rice production is essential factor in averting the adverse effect of rainfall variability on rice production.
3. Deliberate policy aimed at organizing training for farmers on early warnings in coping with rainfall variability and change, most especially the irrigation farmers.

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