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Effect of Environmental Change on the Welfare Status of Crop Farmers in Kaduna State and Federal Capital Territory, Nigeria

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ABSTRACT

This study investigated the effect of environmental change on the welfare status of crop farmers in Kaduna State and Federal Capital Territory, Nigeria. A multi-stage sampling technique was used to select 198 crop farmers. Primary data were used based on a well-structured questionnaire. The data were analyzed using descriptive statistics, farmer household income exchange, Foster, Greer, and Thorbecke (FGT), and the Probit model analysis. The results show that the mean age was 49 years with approximately farm experience of 12 years. The on-farm household income (74.41%) is the dominant source. The largest expenditure is on production cost (46.97%) reflecting the significant investment required for agricultural activities. Furthermore, majority of the farm households (61.90%) have an income greater than their expenditures, this suggests that they have their welfare condition enhanced. Approximately, 43 (79.63%) of the farm households without secondary income fell below the poverty line. About 161 (81.31%) of the farm households with both primary and secondary incomes were below the poverty line. The significant socio-economic factor and environmental change that influence the welfare status of crop farmers

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include age, number of years spent in school education, total crop output, change in temperature, reduction in the size of water bodies, and heat waves. The study recommended that climate-smart agriculture training, subsidies for drought-resistant maturing crop varieties should be provided by Government and non-government organizations and establish localized community-based early warning systems in collaborating with NiMet (Nigerian Meteorological Agency) to provide farmers with real-time planting and harvesting schedules.

Keywords: Effect, environmental change, welfare status, crop farmers, probit regression model

INTRODUCTION

Environmental change has become a defining challenge for sustainable development in Nigeria, with far-reaching implications for agriculture and the welfare of farming households. (FAO, 2023). Nigeria's economy and food system remain heavily dependent on agriculture, which employs a substantial proportion of the rural population and contributes significantly to national food security and livelihoods. (FAO, 2023). However, the agricultural sector is increasingly threatened by environmental changes such as climate variability, rising temperatures, erratic rainfall patterns, flooding, drought, land degradation, and desertification. These environmental stressors have intensified in recent decades, posing serious risks to agricultural productivity and farmers' welfare across the country (FAO, 2023; IPCC, 2022).

Farmers' welfare in Nigeria extends beyond income generation to include food security, nutritional status, health outcomes, asset ownership, resilience to shocks, and overall living standards. Environmental change directly affects these welfare dimensions by altering production conditions, increasing uncertainty and risks, and undermining the stability of farm-based livelihoods. (World Bank, 2021). For instance, climate-induced crop failures, livestock losses, and declining soil fertility often result in reduced household income, food shortages, and increased vulnerability to poverty, particularly among smallholder farmers who dominate Nigeria's agricultural landscape (World Bank, 2021).

Nigeria is especially vulnerable to environmental change due to its diverse agro-ecological zones and heavy reliance on rain-fed agriculture. In the northern parts, increasing temperatures and desertification have reduced arable land and intensified conflicts over scarce natural resources. In contrast, the southern regions frequently experience flooding, soil erosion, and waterlogging, which damage crops and rural

infrastructure. These region-specific environmental challenges interact with socio-economic constraints such as limited access to credit, weak extension services, poor rural infrastructure, and low adoption of climate-resilient technologies, thereby exacerbating the welfare impacts on farmers (Nigerian Meteorological Agency [NiMet], 2022). Although Nigerian farmers employ various coping and adaptation strategies such as crop diversification, changes in planting dates, adoption of improved seed varieties, and livelihood diversification the effectiveness of these strategies varies widely (IPCC, 2022). Many smallholder farmers lack the financial, technical, and institutional capacity to adopt sustainable adaptation measures at scale, limiting their ability to protect and improve their welfare in the face of environmental change (FAO, 2023). Consequently, environmental change has emerged as not only an environmental concern but also a major socio-economic and welfare issue in Nigeria.

Environmental change in Nigeria is driven by a combination of natural processes and human-induced activities, including greenhouse gas emissions, deforestation, unsustainable agricultural practices, rapid population growth, and urban expansion. These factors have accelerated climate variability, land degradation, loss of biodiversity, and depletion of water resources across the country. Nigeria is already experiencing higher average temperatures, unpredictable rainfall patterns, prolonged dry seasons, and more frequent extreme weather events such as floods and droughts (IPCC, 2022; NiMet, 2022). Agriculture in Nigeria is highly sensitive to environmental conditions, as the majority of farmers depend on rain-fed production systems and natural resource availability. Changes in rainfall timing and intensity disrupt planting and harvesting schedules, while increased temperatures affect crop growth, pest and disease prevalence, and livestock productivity. Environmental degradation, particularly soil erosion and declining soil fertility, reduces land productivity and increases the cost of maintaining output levels, thereby threatening the sustainability of farm livelihoods (FAO, 2023).

The welfare of farmers in Nigeria is multidimensional and closely linked to agricultural performance. Reduced productivity resulting from environmental change often leads to lower household income, food insecurity, malnutrition, and reduced access to essential services such as healthcare and education. Furthermore, climate-related shocks frequently force farmers to sell productive assets or resort to unsustainable coping mechanisms, which can have long-term negative consequences for household welfare and resilience (World Bank, 2021).

Regional disparities further shape the welfare impacts of environmental change in Nigeria. In the northern zones, desertification and recurrent droughts have undermined

crop and livestock production, contributing to declining rural incomes and heightened food insecurity. In the central and southern zones, recurrent flooding has destroyed farmlands, displaced farming households, and disrupted rural markets. These environmental challenges are often compounded by weak institutional frameworks, limited social protection, and inadequate access to climate information and agricultural support services (National Bureau of Statistics (NBS, 2022).

Several studies indicated that Nigerian farmers adopt various adaptation strategies to cope with environmental change, including mixed cropping, use of early-maturing and drought-tolerant crop varieties, soil conservation practices, and diversification into non-farm activities. While such strategies can mitigate adverse effects, their adoption is uneven and largely influenced by farmers' socio-economic characteristics, access to extension services, education level, and institutional support. In many cases, resource-poor farmers face barriers that limit the welfare benefits of adaptation efforts (FAO, 2023; World Bank, 2021). Nigeria is not immune to the effects of climate and environmental change affecting the rest of the world (Ani et al., 2021). The effects of climate and environmental change are evident throughout Nigeria's vegetative regions. Nigeria's agricultural productivity is increasingly being threatened by environmental change. Some formerly well-drained agricultural plains have recently become inundated, and the region's agricultural activities are negatively impacted by the Sahel and Sudan savannah belts' growing aridity (Ojo and Adebayo, 2012). Other effects of environmental change, such as excessive precipitation, unusual rainfall initiation and cessation, rising temperatures, and changes in relative humidity, pollution, soil degradation, loss of environmental resources have a severe impact on Nigerian agriculture and food systems (Ani et al., 2021). Due to this change, the seasonal cycle of food production and distribution has been disrupted, leading to a shortage of supplies, which has increased food costs and restricted access to food (Oyinloye et al., 2018). Furthermore, climate change has caused food crises in some regions of the world and security issues in other areas as a result of conflict that results from the competition for scarce agricultural resources (Oyinloye et al., 2018).

Given the increasing intensity of environmental change and its implications for agricultural livelihoods, there is a growing need for empirical research that systematically examines how environmental change affects farmers' welfare in Nigeria. Such research is essential for identifying vulnerable groups, understanding transmission pathways, and informing policies aimed at promoting climate-resilient agriculture and improving rural welfare. Despite increasing policy attention to climate change and environmental sustainability, empirical evidence on how environmental

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change affects the welfare of farmers in Nigeria remains limited and fragmented. Understanding the welfare implications of environmental change is critical for designing evidence-based policies that enhance farmers' resilience, reduce vulnerability, and promote inclusive agricultural development.

This study was conducted to evaluate the effect of environmental change on the welfare status of crop farmers in Kaduna State and Federal Capital Territory, Nigeria.

MATERIALS AND METHODS

This investigation was conducted in Kaduna State and Federal Capital Territory (FCT) Nigeria. A simple random sampling technique was utilized to select 198 crop farmers from a population of 600 respondents within Kaduna state and FCT, respectively. The total sample size consists of 99 crop growers selected each from Kaduna state and FCT respectively. The simple random sampling was used because it avoids element of bias in selecting the crop farmers. Secondly, the sampling technique gives the probability for every crop farmer to have equal chance of being selected. Primary data of cross-sectional sources were utilized based on a well-structured questionnaire that was subjected to validity and reliability test.

This sample size was calculated following the formula suggested by Cochran (1963) as follows:

$$n = \left(\frac{Z.\delta}{E}\right)^2 = \left(\frac{1.96 \times 0.35896}{0.05}\right)^2 = 198 \qquad (1)$$

Where,
n = Sample size
Z = The z-score 1.96
E = The desired margin of error, 5%
δ = Standard deviation
The data obtained were analyzed using descriptive statistics, Foster, Greer and Thorbecke (FGT), farmer household income exchange, and Probit model analysis.

Farmer Household Income Exchange
This study follows the approach of Kuswanto et al. (2019) who reported that rice farmers' revenue is derived from crop cultivation as well as other farming and non-farming agricultural enterprises. Mathematically, it is expressed as:

$$Y = Y_{sf} + Y_{of} + Y_{nfa} \qquad (2)$$

Where;

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Y = Farmers Income,
Y_{sf} = Income from Crop Farming Businesses,
Y_{of} = Income from Other Farming Enterprises, and
Y_{nfa} = Income from Non-Farming Agricultural Businesses.

Farmers' spending accounts for the majority of their households spending. According to Kuswanto et al. (2019), a farmers' household spending comprises of production expenditures (such as seed, fertilizers, land rent, and agrochemicals) as well as extra capital and household consumption (food, processed food, housing, clothing, health, education, recreation, sports, among others). Agricultural expenditure, non-agricultural expenditure, and home consumption expenditure are the three types of spending that farmers incur.

$$E = E_{sf} + E_{of} + E_{nfa} \qquad (3)$$

Where;
E= Farmers Expenditure,
E_{sf}= Expenditure on Crop Farming Businesses,
E_{of}= Expenditure from Other Farming Businesses, and
E_{nfa}= Expenditure from Non-Farming Agricultural Businesses.

By comparing the total income received by the farmers with the total household expenditure, FHIE was generated as a measure of the level of welfare of farmers as in the equation (4)

$$FHIE = \frac{Y}{E} \qquad (4)$$

Where;
FHIE = Farmer Household Income Exchange,
Y = Total Income, and
E = Total Expenditure.

If FHIE >1 shows that the farmers household incomes have increased. However, if FHIE < 1 shows that the farm household incomes have not increased. Thus, farmers FHIE >1 is more likely to meet their consumption and business needs.

1.1.1 FGT (Foster, Greer and Thorbecke)

This follows Oladele et al. (2024) and it is expressed as:

$$P = \frac{1}{N}\sum_{i=1}^{q}\left[\frac{(Z - Y_i)}{Z}\right]^{\alpha} \qquad (5)$$

Where,
P = Foster, Greer, and Thorbecke Index ($0 \leq P \leq 1$)
N = Total Number of Crop Farmers (Number)

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q = Number of Crop Farmers below the Poverty Line
Z = Poverty Line (Naira)
Y_i = Per Capital Household Expenditure of the Crop based Farmers
α = Non-Negativity Aversion Parameter (0, 1, or 2)
The estimation of poverty status can be decomposed to Prevalence of Poverty(P_0), Poverty Depth(P_1), and Severity of Poverty(P_2). The model is expressed as:

$$P_0 = \frac{q}{N} \ (if\ \alpha = 0) \qquad (6)$$

$$P_1 = \frac{1}{N}\sum_{i=1}^{q}\left[\frac{(Z - Y_i)}{Z}\right](if\ \alpha = 1) \qquad (7)$$

$$P_2 = \frac{1}{N}\sum_{i=1}^{q}\left[\frac{(Z - Y_i)}{Z}\right]^2 (if\ \alpha = 2) \qquad (8)$$

The Construction of Poverty Line
The poverty line is defined as:

$$MPCHE = \frac{THPHE}{TNR} \qquad (9)$$

$$PL = \frac{2}{3} \times MPCHE \qquad (10)$$

Where,
$MPCHE$ = Mean Per Capital Household Expenditure (Naira)
TNR = Total Number of Respondents
$THPHE$ = Total Household Per Capital Expenditure (Naira)
PL = Poverty Line

Probit Model Analysis
The Probit model follows Alabi et al. (2013) and is stated explicitly as:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \cdots \beta nXn + \mu_i \qquad (11)$$

Where;
Y_i= Welfare Index (1, Crop Famers have Increase Income; 0, Otherwise),
i = Crop Farmers,
β_0 = Constant Term,
$\beta_1 - \beta_{12}$ = Regression Coefficients,
X_1 = Age of the Farmer (Number),
X_2 = Number of Years spent in Schooling (Years),
X_3 = Household Size (Total Number of Persons),

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X_4 = Access to Credit (1, Yes; 0, Otherwise),
X_5 = Total crop Output (Kg),
X_6= Change in Temperature (1 = Yes, 0 Otherwise)
X_7 =Loss of Farmland as a result Urbanization (Number)
X_8 = Reduction in the Size of Water Bodies (Number)
X_9= Migration (Rural-Urban) (Number)
X_{10}= Conflicts (Farmers-Herders Clashes) (Number)
X_{11}= Heat Waves/Stress (Number)
X_{12} = Loss of Forest Resources as a result of Urbanization (Number)
U_i= Error Term

RESULTS AND DISCUSSION

Socio-economic characteristics of crop farmers

Table 1 shows the descriptive statistics of variables of crop farmers. Approximately, 85% of crop farmers were male, while 15% were female. The mean age of crop farmers was evaluated at 49 years. This implies that the crop farmers are middle-aged, and they can easily adopt new technologies. This study is in line with the results of Alabi et al. (2022). The household sizes were large with an average of 10 persons per household. The number of years spent in school education was 7. This low educational attainment agrees with the findings of Aminu et al. (2022), who noted that limited education among Nigerian farmers restrict them access to information and innovation, perpetuating poverty. They had considerable experience of 12 years in crop farming. The average farming experience of 12 years show considerable expertise, which could enhance productivity but may not translate to poverty reduction without access to complementary resources like credit (Ojo & Baiyegunhi, 2020).

Table 1. Descriptive statistics of variables of crop variables

Variables	Mean Values
Gender (% Male)	85
Age (Years)	49
Household Size	10
Number of Years Spent in School Education	7
Farm Experience (Years)	12

Source: Field Survey Data (2025)

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Welfare Status of Farm Household based on Farm Household Income Exchange (FHIE)

Types of farm household income

Table 2 shows that on-farm household income is the dominant source, contributing approximately 74.41% of the total household income. This indicates that most households in the study area rely heavily on agricultural activities for their livelihood. While, off-farm income makes up 25.59% of the total income, suggesting that a significant portion of households also engaged in secondary activities to supplement their earnings.

Table 2. Types of Farm Household Income

Sources of Income	Value (₦ Per Month)	Percentage
On-Farm	331,102.733	74.41
Off-Farm	113,863.343	25.59
Total	444,966.076	100.00

Source: Field Survey Data (2025), Exchange Rate = 1 USD = ₦ 1400

Types of household expenditure

The largest expenditure is on production costs (46.97%), reflecting the significant investment required for agricultural activities (Table 3). The non-food expenses and food purchases together accounted for a substantial portion of the expenditure, indicating that households also prioritize essential needs beyond agriculture.

Table 3. Types of household expenditure

Type of Household Expenditure	Value (₦ Per Month)	% Expenditure
Food		
(i) Non-Purchased Food	29,141.04	11.10
(ii) Purchased Food	29,595.08	11.27
Non-Food	80,495.65	30.66
Production Cost	123,314.13	46.97
Total Expenditure	262,545.90	100
Residual	47,454.10	
Total	310,000	

Source: Field Survey Data (2025), Exchange Rate = 1 USD = ₦ 1400

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Income and expenditure of the farm households

Table 4 reveals that majority of the farm households (61.90%) have an income greater than their expenditure, this suggests that they have their welfare condition enhanced. However, 38.10% of farm households experience higher expenditures than income, this indicates that they are in financial stress or their welfare status are not enhanced.

Table 5 shows that the national poverty line 2024 per month is 1300. Approximately, 43 (79.63%) of the farm households without secondary income fell below the poverty line, with incomes ranging from 45.11-720.00 Naira per month, while 11 households (20.37%) exceed the poverty line, with incomes per month ranges between 1 1,200.00-1,501.41. In contrast, households with both primary and secondary income have a range of 9.59-547.95 Naira per month with 161 households (81.31%) are below the poverty line and 37 farm households (18.69%) were above the poverty line. Thus, secondary income contributes to increasing per capita monthly income for farm households and has enhanced welfare status of seventeen additional households, this shows that a minority of the farm households enjoys relatively better economic conditions. A significant portion of farm households (79.63% and 81.31%) are below the national poverty line, indicating widespread poverty in the study area.

Table 4. The income and expenditure of the farm households

Description	Income (₦ Per Month)	Expenditure (₦ Per Month)	Number of Households
Income < Expenditure	23781.01	32201.25	72(38.10)
Income > Expenditure	29491.76	27072.32	117(61.90)

Source: Field Survey Data (2025), Exchange Rate = 1 USD = ₦ 1400

Table 5. The household welfare based on poverty line

Description	Household Income without Secondary Income (₦ Per Month)	Number of Households	Total Household Income in ₦ Per Month	Number of Households	The National Poverty Line 2024 (Per Month)
Household Income below the Poverty Line	45.11 - 720.00	43(79.63)	9.59-547.95	161(81.31)	1300
Household Income above the Poverty Line	1,200.00 - 1,501.41	11(20.37)	1,015.93-1,643.86	37(18.69)	

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The household welfare based on ratio of the farmer household income to farmer household expenditure

Table 6 shows that the majority of households (67.92% and 79.29%) have the ratio of farmer household income to expenditure (ERFHI) less than 1, meaning their income does not sufficiently cover their expenditure. Also, a smaller portion (32.08% and 20.71%) of the farm households have an ERFHI greater than 1, indicating they are better able to manage their financial situation even when considering exchange rate fluctuations. This demonstrates that secondary income contributes to an increase in the income of each household and reduces the number of households that have lower welfare status. If the ERFHI value is calculated based on the income of each household without the secondary income, then 157 farm households (79.29%) would not have their welfare status enhanced. However, if the ERFHI value was determined from the total household income including the secondary income, the number of farm households that do not have welfare status enhanced decreases to 36 households (67.92%). This result is in line with the findings of Mustapha et al. (2018).

Table 6. The Household Welfare based on Exchange Rate of the Farmer Households (Income and Farmer Household Expenditure)

Description	Household Income without Secondary Income (₦ Per Month)	Number of Households	Total Household Income in ₦ Per Month	Number of Households
ERFHI < 1	45.11-1120.00	36(67.92)	9.59-1300.29	157(79.29)
ERFHI > 1	1,400.00-1,501.41	17(32.08)	1,409.41-1,643.86	41(20.71)

Source: Field Survey Data (2025), ₦1, 400 per USD

The effect of socio-economic factors and environmental change on the welfare status of crop-based farmers

The Table 7 presents the results of a Probit regression analysis examining the effects of socio-economic factors and environmental changes on the output of crop farmers. Below is an interpretation of each variable and its implications:

Model Fit and overall implications

The Log pseudo likelihood value of -103.82101 with an associated Wald chi-square value of 29.59 and a Prob > chi square of 0.0032. This suggests that the overall model is statistically significant at 1% probability level, meaning that the variables collectively have significant impact on the welfare of the crop-based farmers.

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Age of the farmers: The negative coefficient (β_1= -0.0167, z = -1.73) suggests that as farmers' age increases, crop output tends to decrease slightly. This is significant at the 10% probability level, this implies that older farmers might have lower productivity, possibly due to less physical ability or reluctance to adopt new techniques.

Number of years spent schooling: This shows that number of years in schooling is positive (β_2 -0.0379, z = 1.63) and significant at 10% probability level. This suggests that for each additional year of schooling, welfare status is expected to improve by 0.0379 units. This study is in line with the findings of Alabi and Anekwe (2023), who reported that education helps farmers to make better informed decision and increase welfare and productivity. This results also agrees with the research conducted by Aminu et al. (2022), who reported that education enhances farmers' ability to adopt productivity-enhancing technologies and access information, thereby reducing poverty.

Table 7. The influence of socio-economic factors and environmental change on the welfare status of rice farmers

Variables	Parameters	Coefficient	Standard Error	Z-Value
Age of the crop farmers	β_1	-0.0167*	0.0097	-1.73
Number of years spent schooling	β_2	0.0379*	0.0230	1.65
Household size	β_3	-0.0232	0.0174	-1.33
Access to credit	β_4	0.3117	0.2582	1.21
Total crop output	β_5	0.1147***	0.0400	2.87
Change in temperature	β_6	-0.3596***	0.0960	-3.75
Loss of farmland as a result of urbanization	β_7	-0.1145	0.2070	-0.55
Reduction in the size of water bodies	β_8	-0.2356*	0.1336	-1.76
Migration	β_9	0.3737	0.2639	1.42
Conflict	β_{10}	-0.2891	0.2193	-1.32
Heatwave	β_{11}	-0.0650**	0.0286	-2.27
Loss of foresry resources as a result urbanization	β_{12}	0.0995	1.1131	0.88
Constant	β_0	-0.9558	1.1294	-0.85
Log Pseudo Likelihood	-103.82101			
Wald Chi^2	29.59			
Prob > Chi^2	0.0032			
Number of Observation	198			

Source: Field Survey Data (2025)

*** = significant. @ 1%, ** = significant @ 5% and * = significant @ 10%

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Total crop output: This finding shows that an increase in total crop output is associated with an increase in welfare by 0.1147 units. This relationship is highly statistically significant at the 1% probability level. This suggests that the farmer enjoys increased income, improved food security and poverty alleviation in the study area.

Change in Temperature: This shows that an increase in temperature negatively affects welfare, with a coefficient of (-0.3596). This factor was statistically significant at the 1% probability level; this implies that temperature changes may not favour certain crops or farming conditions.

Heat Waves: The negative and highly significant coefficient (β_{11} = -0.0650, z = 2.27) indicates that heat waves drastically reduce crop output. This highlights the severe impact of extreme heat on agricultural productivity.

Reduction in the Size of Water Bodies: The result indicate that the coefficient is negative and statistically significant (β_8= -0.2356, z = 1.76) at 10% probability level. This implies that as a unit increase in reduction in the size of water bodies, while keeping all other variables constant will lead to 0.2356 unit reduction in the welfare status of crop farmers.

CONCLUSION

The socio-economic factors and environmental change do not have a significant effect on the welfare status of crop-based farmers in the study area.

The socio-economic factors that had significant effect on welfare status of crop farmers included age of crop farmers, year of school education, and total crop output. The environmental change that significantly affected the welfare status of crop farmers. That included heat waves, change in temperature, and reduction in the size of water bodies.

RECOMMENDTIONS

- Extension agents should prioritize teaching crop farmers about zero-tillage, crop rotation, and contour farming to preserve soil moisture and prevent erosion.

- Government and NGOs should provide subsidies for drought-resistant and early-maturing crop varieties to bypass shortened rainy season.

- Establishing localized, community-based early warning systems in collaborating with NiMet (Nigeria Meteorological Agency) to provide farmers with real-time planting and harvesting schedules.

- Policies and programmes should be there to promote small-scale irrigation particularly for Fadama (Wetland) farming.

- "Climate-Resilience Loans" with low interest rates should be provisioned to the smallholder farmers to purchase necessary inputs.

- Implementing the climate action plan by encouraging the composting of agricultural waste into organic manure should be provisioned.

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