



**FACTORS INFLUENCING THE ADOPTION OF CLIMATE-SMART
AGRICULTURAL PRACTICES AMONG RICE FARMERS IN BOGORO AND DASS
LOCAL GOVERNMENT AREAS, BAUCHI STATE, NIGERIA**

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ABSTRACT

The study analysed factors influencing the adoption of climate-smart agricultural practices (CSAPs) among rice farmers in Bogoro and Dass Local Government Areas of Bauchi State, Nigeria. Using a multi-stage sampling procedure, 240 farmers were selected, and data were collected through structured questionnaires and analyzed using descriptive and inferential statistics. Results showed that respondents were predominantly male (55%), married (69.6%), and within the productive age range of 36–45 years. About 42.5% engaged in mixed cropping, while 31.3% and 20.8% attained secondary and OND/NCE education, respectively. Farming experience was considerable, with 45% having 6–10 years, with household size of 10–12 members. Regression analysis revealed that education, access to credit, cooperative membership, and annual income ($p < 0.001$) positively influenced adoption, whereas farm size ($p < 0.01$) and sex ($p < 0.05$) were negative predictors. Key constraints included inadequate extension services, high seed costs, and environmental challenges such as drought and rainfall shortages were ranked 1st, 2nd and 3rd respectively. The study concludes that adoption of CSAPs in the area is shaped by both socio-economic and institutional factors but constrained by weak extension delivery, high input costs, and policy gaps. The study recommends the Federal Ministry of Agriculture and Food Security, through State ADPs, to strengthen extension services by training and deploying more agents equipped with digital tools to support rice farmers in adopting CSAPs.

Keywords: Climate, Smart, Agriculture, Adoption, Bogoro, Dass.

INTRODUCTION

Agriculture remains the key sector that plays a vital role in the growth of most economies of the countries in sub-Saharan Africa. However, the sector is greatly impacted by changes in climate because its activities are climate-dependent (Halliru, 2021). Climate change has altered rainfall patterns, agro-ecological zones, cropping calendars, increased the frequency of flooding/drought, diseases and pest outbreaks and infestations, etc (Musafiri *et al.*, 2022). The resultant effects have been poor crop yields, livestock loss, food insecurity, hunger, poverty and severe threat to the well-being of small-scale farmers who bear the brunt of these effects (Chitakira and Ngcobo, 2021). The negative consequences of climate change on food production, food security and the environment have attracted global interest, prompting the need to work with farmers to adopt innovative agricultural practices that will enable them to cope, hence the birth of climate-smart agriculture [CSA] (Waaswa, *et al.*, 2021). CSA is defined as an approach that helps to transform agricultural systems to sustainably increase productivity, adapt and build resilience, and reduce or remove greenhouse gas (GHG) emissions so as to support food security (Hellin and Fisher, 2019). CSA combines devices and tools of conventional agriculture with innovative technologies (which may also be precise information or accurate data from datasets at the farm level or outside sources such as weather stations) to furnish farmers with recommendations for good decision-making in the face of uncertainties caused by climate change (Mizik, 2021). CSA is not “a one-size-fits-all practice” rather it is a mixture of practices (traditional and innovative) that are incorporated into an agricultural system for climate change adaptation thereby making it context-specific (Chitakira and Ngcobo, 2021). For farmers to practice CSA, they need to engage in farming activities that help the soil to capture and/or prevent GHG emissions and store carbon; adopt pro-water conservation practices and innovative technologies that ensure water efficiency and access during periods of water scarcity; adopt weather smart practices



by using information and communication technologies (ICTs) such as the radio, television, mobile phones or internet to access weather information; adopt climate risk insurance; and form and participate in farmer-to-farmer knowledge sharing associations (Anuga *et al.*, 2019). Small-scale farmers especially those in sub-Saharan Africa are already adopting some of these practices in a bid to cope with the adverse effects of climate change (Abegunde *et al.*, 2019).

The adoption of CSA practices by farmers has resulted in improved crop yields, nutrient and water use efficiency, enhanced food security, reduced GHG emissions and subsequently reduced the impact of climate change (Makate *et al.*, 2018; Issahaku and Abdulai, 2019). In spite of these benefits, the adoption and upscaling of CSA practices have remained very low (Issahaku and Abdulai, 2019; Trendov *et al.*, 2021). This is attributed in part to a lack of awareness of CSA technologies/practices, limited skills, and infrastructure (Chitakira and Ngcobo, 2021). Extreme climate events, such as heavy precipitation, on-going flooding, and rising temperatures, have all had a significant negative economic impact on rice agriculture. Rice production contributes to greenhouse gas emissions globally (FAO, 2021; Durodola, 2019). Flooded paddy rice field is a major contributor of global methane emissions. Burning rice leftovers like straw and husks also contributes to the release of greenhouse gases (Niveta and Pathak, 2013 and Pires *et al.*, 2015). Previous studies have demonstrated that the global output of rice is being negatively impacted by climate change. The great majority of climate change's negative effects on rice production are mostly caused by changes in temperature and precipitation, which cause flooding, a shortage of freshwater, and an increase in pests, diseases, and weeds (Phanith and Malyne, 2012; Md. Abdur *et al.*, 2014; Omchand, 2019). Rainfall usually has a negative effect on rice plants during the early and flowering stages of the reproductive phase, which results in significant reductions in rice production (Abbas and Mayo, 2021). Increased water loss, yellowed and wilted leaves, slowed root development, and even seedling death are all effects of high temperatures (Zeng *et al.*, 2017, Ogah and Nwile, 2017; Saliu *et al.*, 2019).

Rice is an important food and cash crop cultivated in all agro ecological zones of Nigeria. The production of the crop has been on the increase over the years owing to its uses in various forms. The cereal is widely consumed all over the country regardless of cultural, religious or geographical boundaries. Thus, a strategic commodity in the Nigerian economy (Dauna *et al.*, 2019). Rice is a staple food crop in Nigeria and among the main crops being promoted under the Agriculture Promotion Policy (APP) (2016 – 2020) of Buhari's administration (FMARD, 2016). Consequently, the agricultural sector in Nigeria, particularly in the Bogoro and Dass Local Government Areas (LGAs) of Bauchi State, faces significant challenges due to climate variability and change. Rice farmers in these regions are especially vulnerable, as traditional farming practices may no longer be sustainable in the face of evolving climatic conditions. The adoption of Climate Smart Agricultural (CSA) practices presents a viable solution to enhance resilience, increase productivity, and ensure food security. However, the extent to which rice farmers in Bogoro and Dass LGAs have adopted these practices remains unclear, necessitating a thorough investigation. The broad objective of the study was to analyze the factors that influence adoption of climate smart agricultural practices in Bogoro and Dass Local Government Areas of Bauchi state, Nigeria. while the specific objectives were to; describe the socioeconomic characteristics of the respondents in the study area; examine the awareness level of climate smart agricultural practices by the respondent; determine the socio-economic factors influencing the adoption of climate smart agricultural practices among rice farmers in the study area; and identify the constraints faced by the respondent in the adoption of climate smart agricultural practices.

RESEARCH METHODOLOGY

THE STUDY AREA

The study area were Bogoro and Dass Local Government Areas (LGAs) of Bauchi State, Nigeria. Bogoro LGA is one of the 20 LGAs that made up Bauchi state which is approximately 83 km away from the state capital and is located in the southern part of state capital. Its headquarters is in the town of Bogoro. Za'ar or Sayawa people are the majority of its inhabitants. According to the National Population Commission (NPC, 2006), the population of Bogoro Local Government Area was 84,215



during the 2006 national census. To obtain the current estimate, the Bauchi State average annual population growth rate of 3.7% was applied using a year-by-year compounding method from 2007 to 2024. This projection yielded an estimated population of approximately 161,960 persons in 2024. Bogoro LGA is located at Latitude: 9.668° N and Longitude: 9.605° E about 690.2 m above sea level. In terms of local government boundaries, it is bordered by Kanke Local Government Area of Plateau state to the south, Tafawa Balewa local government area of Bauchi state to the north, west and to the eastern parts, respectively. Bogoro local government area experience both rainy (cropping) and dry seasons which occur between late October and April, while the Rainy (cropping) season occur between early May and late October. The mean annual rainfall is 680 mm; the temperature ranges from as low as 110C to as high as 400C sometimes. The landscape of this area is slightly undulating towards the South and toward the East. The vegetation compositions comprise both scanty and thick vegetation (Bogoro LGA, 1999). The major economic activity of the area is agriculture with a combination of trade, art and craft practiced by some people. The major crops in the area are Maize, Groundnut, Rice, Acha and Sorghum. In addition, Livestock types found in the area include Cattle, Sheep, Goats, Pigs and Poultry (Bogoro LGA, 1999). Dass LGA is located at l with an estimated population of 200,987 (Information Department Dass Local Government Area, 2017). The climate is characterized by two distinct seasons, dry and wet seasons. The area recorded rainfall of about 1000mm annually. The people of Dass Local Government Area engage in various form of farming activities for livelihood. Different varieties of crops are produced in the area which include rice, millet, sorghum, beans, spinach, sugar cane, groundnut and soya beans. Also, people engaged in livestock production such as sheep, goat and cattle, among others.

SAMPLING TECHNIQUES AND SAMPLING SIZE

Multi stage sampling technique was used for the study, in the first stage a purposive selection of two LGAs, that is, Bogoro and Dass. The two LGAs were selected based on the concentration of rice farmers in the study areas. In the second stage two districts were randomly selected from each of the LGAs selected making a total of four districts (Bogoro, Mwari, Bundot and Bagel). In the third stage two communities were randomly selected from each of the selected districts, making a total of eight communities (Gwaska Bom, Yola, Mallar, Dinki, Bagel, Bundot, Baraza and Durr). In the fourth stage, proportionately 15% of the registered Rice farmers were selected and this gave a sample size of 240 farmers. These 240 respondents formed the final sample for the study.

Method of Data Collection

Primary data were collected through the administration of questionnaire to the communities selected with the aid of trained enumerators. The sections of the questionnaire include; section A (Socio Economic background of the respondent), section B (socio economics and institutional factors that influence adoption of CSA) and section C (Constraints to adoption of CSAP).

Method of Data Analysis

Data were analyzed using both descriptive and inferential statistics. Descriptive statistics such as frequency, percentage and mean. Inferential statistics such as linear regression was used.

Descriptive statistics

Descriptive statistics was used to achieve objectives i (the socioeconomic characteristics of rice farmers), ii (the level of awareness of climate smart agricultural practices adopted by rice farmers) and v (the constraints of rice farmers toward adoption of climate smart agricultural practices). It involved the use of percentages, and frequency distribution.

Inferential statistics

linear regression analysis was employed to analyze objective (ii); this is because of it is versatile and powerful tool that provides a comprehensive way to analyze economic data. It allows for the simultaneous examination of multiple variables, controls for confounding factors, quantifies relationships, and supports robust hypothesis testing and forecasting. These capabilities make it an invaluable method for addressing complex economic questions and informing sound economic decision-making.

The regression model that was used is specified as; Linear function:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5 X_5 + b_6 X_6 + b_7X_7 + b_8X_8 + e \quad \dots (1)$$



Where;

Y= Technology adopted (Number of technologies adopted)

X₁= Sex (Male = 1, Female = 2)

X₂= Age (Measured in years)

X₃ = marital status (Single = 1, Married = 2, Widowed = 3, Divorced = 4) X₄ = Occupation

X₅= farm size Measured in hectares (ha)

X₆= Educational level Categorical (Primary = 1, Secondary = 2, OND/NCE = 3, HND = 4, Bachelor = 5, MSc/PhD = 6)

X₇= Years of farming experience (Measured in years)

X₈ = Household size (Measured in number of persons)

X₉ = annual income (Measured in Naira (₦) per year)

X₁₀= Access to credits (Yes = 1, No = 0)

X₁₁ = Cooperative membership (Yes = 1, No = 0)

X₁₂ = sources of capital Categorical (e.g., Personal savings = 1, Bank loans = 2, Friends/family = 3, Cooperatives = 4, Money lenders = 5)

a=Constant term of intercept

b_i (i=1...12) are regression coefficients.

u=Error term.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Respondents (n=240)

The results from Table 1a show that significant proportion of respondents were within their productive ages, with 29.6% between 36–45 years and 25% between 46–55 years, indicating strong potential to adopt climate-smart agricultural practices (CSAPs) for higher productivity and income. Farming experience was also considerable, as 45% had 6–10 years, while 22.9% and 18.8% had 11–15 and 16–20 years, respectively. This suggests that most farmers possessed substantial knowledge of rice production and climate variability, thereby enhancing their willingness to adopt CSAPs. These findings align with evidence that younger and more experienced farmers are more receptive to agricultural innovations and adaptation strategies (Okeke *et al.*, 2024; Zakari *et al.*, 2025).

Household size, income distribution, and farm size further influenced adoption. About 36.7% of respondents had households of 10–12 persons, and 25.4% had 7–9 persons, providing sufficient family labor for implementing labor-intensive CSAPs. Income levels were relatively high, with 29.2% and 27.9% earning ₦750,001–₦1,000,000 and ₦500,001–₦750,000 annually, which supported investment in improved seeds, fertilizers, and irrigation technologies. Farm size was also important, as 68.8% cultivated 1–5 hectares, giving them flexibility to experiment with CSAPs. Collectively, these results highlight that socio-economic factors—age, experience, household size, income, and land access—play a decisive role in shaping adoption decisions (Onyeneke *et al.*, 2021; Abegunde *et al.*, 2024).



Table 1a: Distribution of Respondents based on the Quantitative Socioeconomic Characteristics (n=240)

Variables	Frequency	Percentage	mean
Age (years)			
15-25	35	14.6	42
26-35	40	16.7	
36-45	71	29.6	
46-55	60	25.0	
56-65	24	10.0	
above 65	10	4.2	
Years of farming experience			
1-5	32	13.3	10
6-10	108	45.0	
11-15	55	22.9	
16-20	45	18.8	
Household size			
1-3	16	6.7	8
4-6	39	16.3	
7-9	61	25.4	
10-12	88	36.7	
Annual income (₦)			
<100,000	8	3.3	742,000
100,000-250,000	20	8.3	
250,001-500,000	26	10.8	
500,001-750,000	67	27.9	
750,001-1,000,000	70	29.2	
Above 1,000,000	49	20.4	
Farm size (ha)			
<1	36	15.0	3
1-5	165	68.8	
above 6	39	16.3	

Source: Field Survey, (2024)

The results from Table 1b show that 55% of the respondents were male and 45% female, indicating male dominance in rice production, largely due to cultural norms and the labor-intensive nature of farming. Male farmers often have greater access to resources, enabling higher adoption of climate-smart agricultural practices (CSAPs), while female farmers face barriers such as limited access to land, inputs, and training (Adelekan *et al.*, 2023; Ojo *et al.*, 2024). Occupational distribution revealed that 42.5% engaged in mixed cropping and 32.5% in mixed farming, while smaller proportions were civil servants (12.5%), rice farmers only (7.9%), and traders (4.6%). These multiple livelihood strategies enhanced household income and resilience, enabling better investment in CSAPs such as crop diversification and agroforestry (Okeke *et al.*, 2024). In addition, 69.6% of respondents were married, a status associated with greater responsibility and long-term commitment to adaptation strategies, thereby increasing the likelihood of adopting CSAPs (Zakari *et al.*, 2025).

Education, credit access, and sources of capital further shaped adoption outcomes. About 31.3% of respondents attained secondary education and 20.8% OND/NCE, while fewer had HND, primary, or university education, and only 5% reached MSc/PhD level. This indicates that most had at least some education, which supports CSAP adoption through improved understanding of extension messages and technologies (Abegunde *et al.*, 2024). Moreover, 70% had access to credit, which enhances the ability to purchase inputs and adopt climate-resilient technologies (Kanu & Przezbórska-Skobiej, 2025). Personal savings (48.3%) were the main source of capital, followed by commercial banks (23.8%) and friends/family (15.8%), while cooperatives (8.8%) and moneylenders (3.3%) were less common. However, 67.1% of respondents were not members of cooperatives, limiting their



collective access to inputs and extension support, despite cooperatives being recognized as key facilitators of CSAP adoption (Okeke *et al.*, 2024; Abegunde *et al.*, 2024).

Table 1b: Distribution of Respondents based on the Qualitative Socioeconomic Characteristics (n=240)

Variables	Frequency	Percentage
Sex		
Male	132	55.0
Female	108	45.0
Occupation		
rice production only	19	7.9
mixed farming	78	32.5
mixed cropping	102	42.5
civil servant	30	12.5
Trader	11	4.6
Marital status		
Single	41	17.1
Married	167	69.6
Widowed	25	10.4
Divorce	7	2.9
Educational/ Qualification		
Primary	35	14.6
Secondary	75	31.3
OND/NCE	50	20.8
HND	39	16.3
Bachelor degree	29	12.1
MSs/PhD	12	5.0
Access to credits		
Yes	72	30.0
No	161	67.1
Source of capital		
Personal saving	116	48.3
Loan from bank	57	23.8
Friends and family	38	15.8
Cooperatives	21	8.8
Money lenders	8	3.3
Cooperative membership		
Yes	79	32.9
No	161	67.1

Source: Field Survey, (2024)

LEVEL OF AWARENESS ON CLIMATE SMART AGRICULTURAL PRACTICES BY THE RESPONDENTS

The results from Table 2 reveal that respondents had high levels of awareness of several climate-smart agricultural practices (CSAPs). Improved seed varieties ($\bar{X} = 3.5$), crop rotation ($\bar{X} = 3.9$), and the use of organic fertilizers ($\bar{X} = 3.9$) were the most widely recognized practices, reflecting farmers' awareness of their direct impact on yield and soil fertility. Awareness was also high for intercropping with cover crops ($\bar{X} = 3.7$), minimum/zero tillage ($\bar{X} = 3.5$), and mulching ($\bar{X} = 3.1$), showing knowledge of conservation-oriented practices that improve soil moisture and fertility. These findings are consistent with previous studies reporting high awareness of CSAPs among smallholder farmers, largely due to visible yield benefits and promotion of sustainable practices through extension campaigns (Asfaw *et al.*, 2016; Ojo *et al.*, 2024; Nazifi *et al.*, 2024; Omotoso & Omotayo, 2024; Zougmore *et al.*, 2024).

Conversely, awareness of water management practices ($\bar{X} = 2.8$) and the use of mobile phones for accessing weather information ($\bar{X} = 2.7$) was low. Limited access to irrigation facilities



and weak extension delivery systems likely contributed to farmers' poor exposure to water-saving techniques. Similarly, the low awareness of mobile-based weather services reflects the relatively recent introduction of digital climate tools, which often face challenges of affordability, literacy requirements, and institutional support in rural settings. These results align with earlier findings that, although ICTs and irrigation technologies have potential to enhance CSAP adoption, their uptake remains constrained by infrastructural and socio-economic barriers (Usman *et al.*, 2023; Yakubu *et al.*, 2024).

TABLE 2: LEVEL OF AWARENESS ON CLIMATE SMART AGRICULTURAL PRACTICES BY THE RESPONDENTS.

Variables	Mean	Decision
Improved seed varieties	3.46	High
Crop rotation	3.92	High
Use of organic fertilizers	3.89	High
Intercropping with cover crops (legumes)	3.69	High
Minimum/zero tillage practice	3.46	High
Mulching	3.08	High
Water management practices	2.79	Low
Use of mobile phone to access weather conditions	2.79	Low

Source: Field Survey, (2024)

Decision rule; <3.0 = Not aware, ≥ 3.0 = aware

Socio-economic Factors Influencing Adoption of Climate Smart Agricultural Practices

Table 3 shows regression analysis and identified several socio-economic and institutional variables that positively and significantly influenced the adoption of climate-smart agricultural practices (CSAPs). These included educational level ($\beta = 0.178$, $p < 0.001$), years of farming experience ($\beta = 0.134$, $p < 0.01$), occupation ($\beta = 0.095$, $p < 0.05$), access to credit ($\beta = 0.221$, $p < 0.001$), cooperative membership ($\beta = 0.163$, $p < 0.001$), and annual income ($\beta = 0.195$, $p < 0.001$). The results suggest that better-educated and more experienced farmers are more likely to understand and evaluate CSAPs, while those primarily engaged in agriculture adopt them more readily than those with off-farm occupations. Institutional support through access to credit and cooperative participation also proved critical, as these enable financial access, collective learning, and risk-sharing. Similarly, higher-income farmers were more capable of investing in climate-smart technologies, consistent with the notion that wealthier farmers have greater resources to manage production risks (Abegunde *et al.*, 2019; Anuga *et al.*, 2019; Makate *et al.*, 2018; Trendov *et al.*, 2021).

In contrast, farm size ($\beta = -0.140$, $p < 0.01$) and sex ($\beta = -0.112$, $p < 0.05$) had negative and significant effects. The findings indicate that smaller farm holders adopt CSAPs more readily than large-scale farmers, who may rely on established production systems, while female farmers were more likely than their male counterparts to adopt CSAPs, possibly due to their stronger role in ensuring household food security (Issahaku & Abdulai, 2019; Chitakira & Ngcobo, 2021). Other variables, including age, marital status, household size, and source of capital, exhibited either positive or negative coefficients but were not statistically significant, showing weak or inconclusive effects on adoption. These results suggest that while socio-economic and institutional factors such as education, income, credit, and cooperatives strongly drive CSAP adoption, demographic and family-related factors play a less decisive role (Salisu, 2022; Waaswa *et al.*, 2021).

Table 3: Factors Influencing the Adoption of Climate-Smart Agricultural Practices (CSAPs) by the Respondents

Variables	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	0.842	0.217		3.880	0.000***
Sex	-0.112	0.053	-0.091	2.110	0.036**
Age	-0.048	0.029	-0.075	-1.650	0.101
Marital status	0.018	0.037	0.024	0.490	0.624
Household size	-0.062	0.033	-0.081	-1.880	0.061
Educational level	0.178	0.049	0.231	3.630	0.000***
Years of farming exp.	0.134	0.046	0.204	2.910	0.004**
Farm size	-0.140	0.045	-0.188	3.110	0.002**
Occupation	0.095	0.041	0.115	2.310	0.022**
Access to credit	0.221	0.055	0.276	4.020	0.000***
Cooperative membership	0.163	0.048	0.212	3.400	0.001***
Annual income	0.195	0.052	0.248	3.740	0.000***
Source of capital	-0.081	0.043	-0.097	1.890	0.060

Source: Field Survey, (2024). $p < .05$ (significant, **), $p < .01$ (highly significant, ***), $p < .001$ (very highly significant, ****); ns = not significant ($p > .05$).

Constraints faced by Rice Farmers in the Adoption of Climate Smart Agricultural Practices

The findings indicate that the major constraints to the adoption of climate-smart agricultural practices (CSAPs) were inadequate extension services, high cost of seeds, and challenges related to drought and rainfall shortages, which were ranked first, second, and third by respondents, respectively. These were closely followed by deforestation, poverty, limited access to organic fertilizers, and pest and disease outbreaks, ranked fifth, sixth, seventh, and eighth in order of importance. Additional barriers identified included poor infrastructure, weak policy support, and flooding, which occupied the ninth and tenth positions. This suggests that, despite respondents' awareness and adoption of CSAPs, both institutional and environmental challenges continue to hinder smooth and widespread adoption in the study area (Salisu, 2022; Anuga *et al.*, 2019; Chitakira & Ngcobo, 2021; Waaswa *et al.*, 2021).

TABLE 4: DISTRIBUTION OF RESPONDENTS BASED ON THE CONSTRAINTS TO ADOPTION OF CSAPs

Variables	Percentage	Rank
Inadequate extension service	67.5	1 st
High cost of seeds	62.9	2 nd
Poverty	62.1	3 rd
Deforestation	61.7	5 th
Drought	60.7	6 th
Inadequate organic fertilizers	57.9	7 th
Pest and disease	52.0	8 th
Inadequate infrastructure	40.4	9 th
Inadequate policy support	38.3	10 th
Flooding	38.8	10 th

Source: Field survey, (2024)

CONCLUSION AND RECOMMENDATIONS

The study concludes that Strengthening farmers' access to credit and cooperative platforms is essential to accelerate widespread adoption of Climate-Smart Agricultural Practices. To enhance CSAP adoption in the study area, the following are recommended:



- i. Strengthen extension and institutional support by government to improve extension delivery by training and deploying more agents, while also supporting farmer cooperatives to facilitate collective access to knowledge and resources.
- ii. Ensure affordable access to inputs and technologies by relevant agencies to subsidize key inputs such as seeds and fertilizers, and promote affordable technologies that improve productivity and resilience.
- iii. Promote enabling environments through infrastructure and policies through Investment in rural roads, irrigation, and storage facilities, alongside supportive agricultural policies and environmental management strategies, will provide a stronger foundation for sustainable CSAP adoption.

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