

1

2 **Determinants of Factors Influencing Adoption of Climate Change Adaptation Practices**  
3 **(CCAPs) Among Farmers in Dutsin-Ma Agricultural Zone of Katsina State, Nigeria**

4

5 **Abstract**

6 *The study was carried out in Dutsin-Ma agricultural zone of Katsina state, Nigeria. A total of*  
7 *281 registered farmers were randomly drawn from three Local Government Areas (LGAs) of the*  
8 *zone. Data were collected using a well-structured questionnaire administered to the selected*  
9 *respondents. Both descriptive statistics (frequency distributions, percentages, and means) and*  
10 *inferential statistics (Tobit regression) were used to analyse the data collected. The findings*  
11 *revealed that, majority (85.7%) of the respondents were males with a mean age of about 44*  
12 *years. Majority (82.0%) were married with a mean household size of six persons, while more*  
13 *than half (57.1%) had farm size between 1-3 hectares, with a mean farming experience of about*  
14 *15 years. Majority (63.6%) had extension contact, while more than half (55.8%) belonged to*  
15 *cooperative societies. Drought-resistant varieties (73.3%), use of organic fertilizers (65.4%),*  
16 *and agroforestry (45.2%) were some of the adaptation strategies adopted by the respondents.*  
17 *Access to credit ( $P=<0.000$ ), extension contact ( $P=<0.000$ ), cooperative membership*  
18 *( $P=<0.000$ ), income diversification ( $P=<0.035$ ), and educational level ( $P=<0.024$ ) were found*  
19 *to be statistically significant factors determining the adoption of climate change adaptation*  
20 *practices by the respondents. The study therefore recommended that; climate change adaptation*  
21 *infrastructure should be provided by government and other stakeholders in the agricultural*  
22 *sector to farmers at affordable prices to enable their access with ease and extension services*  
23 *should be further intensified to provide the necessary training and other services needed by*  
24 *farmers, government and private extension service providers should be made to enforce this.*

25 **Keywords:** Agricultural Productivity, Climate Change Adaptation, Livelihoods

26

27 **Introduction**

28 Agriculture sustains food security and livelihoods but faces rising pressures from the growing  
29 population, dietary shift toward meat, and competition for land, water, and energy (Singh, et. al.,  
30 2024). The increased intensification to meet human food needs make agricultural sector one of  
31 the largest contributors to global greenhouse gases (GHGs) emissions, such as methane (CH<sub>4</sub>),  
32 nitrous-oxide (N<sub>2</sub>O), and carbon-dioxide (CO<sub>2</sub>) - accounting for 10-24% of anthropogenic totals

33 (Soegoto, et. al., 2025). Agriculture is therefore, highly vulnerable to climatic change, which  
34 disrupts yields, livestock health, and ecosystem stability (Boccan, 2025). Agriculture is both a  
35 driver and a victim of climate change, contributing significantly to global greenhouse gas (GHG)  
36 emissions while being highly vulnerable to its impacts (Mohammed, et. al., 2025).

37 The aforementioned has led to increased disruption of agricultural productivity, livelihoods, and  
38 food security due to rising temperatures, altered rainfall, and extreme weather events  
39 (Mohammed, et. al., 2025). Yield decline accelerates once thermal thresholds crossed, as heat  
40 stress reduces grain filling and water use efficiency (Tian, et. al., 2023). The adoption of climate-  
41 smart agricultural practices (CSAPs) therefore, becomes the major option to avert this ugly trend  
42 in farm operations.

43 The adoption of climate-smart agriculture (CSAPs) among smallholder farmers is influenced by  
44 a combination of socio-economic, institutional, and environmental factors. Socio-economic  
45 characteristics such as farmers' age, level of education, farm size, household income, and  
46 farming experience play a significant role in determining the likelihood of adopting new  
47 agricultural innovations. Studies indicate that younger farmers with higher education levels are  
48 more likely to adopt climate change adaptation practices because they are more receptive to new  
49 technologies, better able to understand climate information, and more willing to take calculated  
50 risks (Shiferaw, et. al., 2023).

51 Access to financial resources and credit facilities is another critical factor influencing adoption of  
52 climate adaptation practices. Farmers with sufficient income or access to loans are better  
53 positioned to invest in improved seed varieties, irrigation systems, and organic fertilizers, which  
54 are often required for effective implementation of CSA practices. Conversely, resource-poor  
55 farmers face constraints that limit their ability to adopt even low-cost adaptation strategies,

56 highlighting the importance of targeted credit schemes and subsidies in enhancing adoption rates  
57 (Adeleke, et. al., 2021).

58 Studies equally show that, institutional support such as extension services significantly affect  
59 adoption of climate change adaptation practices. Farmers who receive regular guidance, training,  
60 and information from extension agents or agricultural cooperatives are more likely to implement  
61 climate-smart agriculture practices successfully. Extension services provide technical  
62 knowledge, demonstrate best practices, and offer updates on weather forecasts and pest  
63 management, all of which build farmers' confidence and capacity to adopt CSA (Obayelu, et. al.,  
64 2019). Similarly, membership of farmers' cooperatives or social networks facilitates access to  
65 collective resources, knowledge sharing, and community-based adaptation strategies.

66 Access to climate information services (CIS) and early warning systems further influences  
67 adoption decisions. Farmers who can obtain timely and reliable information on rainfall patterns,  
68 temperature fluctuations, and potential hazards are more likely to adjust planting dates, select  
69 appropriate crop varieties, and implement water management strategies. Research in northern  
70 Nigeria has shown that households with greater exposure to climate information adopt more  
71 CSA practices, thereby enhancing their resilience to climate variability (Lawal, et. al., 2024).

72 Agboola, et. al., (2023) assert that, cultural beliefs, risk perception, and local knowledge can  
73 either facilitate or constrain adoption. In some communities, traditional farming practices are  
74 deeply rooted, and innovations may be perceived as risky or incompatible with local conditions.  
75 Farmers' perception of climate risks and the expected benefits of CSA practices directly affect  
76 their willingness to adopt these strategies. Therefore, interventions aimed at increasing adoption  
77 must integrate local knowledge, address perceived risks, and demonstrate tangible benefits to  
78 encourage wider uptake (Agboola, et. al., 2023).

79 Recent climate data revealed alarming trends in the region, such as: erratic and shortened rainy  
80 seasons, prolonged droughts, higher temperatures, increased desertification, and a rise in the  
81 frequency and intensity of extreme weather events (Adeleke, et. al., 2021). These climatic  
82 changes have led to declining soil fertility, unpredictable planting seasons, increased pest  
83 infestations, and significant yield losses, thereby undermining food security and household  
84 income for maize farmers in the area (Usman & Ibrahim, 2021).

85 The import of various climate change adaptation practices such as drought-resistant seeds, soil  
86 conservation techniques, agroforestry, and small-scale irrigation adopted by farmers in the study  
87 area to mitigate these challenges remains relatively low. Factors such as low adoption rates  
88 include limited access to climate information services, poor dissemination of adaptation  
89 technologies, inadequate extension support, lack of financial capital, and socio-cultural  
90 resistance to innovation (Obayelu, et. al., 2019; FAO, 2018) impair effective adoption of climate  
91 change adaptation practices. This study therefore looked into the factors influencing the adoption  
92 of climate change adaptation practices among farmers in Dutsin-Ma agricultural zone of Katsina  
93 state, Nigeria.

## 94 **Methodology**

### 95 **Description of the Study Area**

96 The study was carried out in the Dutsin-Ma Agricultural Zone of Katsina State, Nigeria. Dutsin-  
97 Ma is one of the three agricultural zones in Katsina state and is strategically located within the  
98 Sudan-Savanna ecological belt, which provides favorable climatic conditions for the cultivation  
99 of cereal crops, particularly guinea corn, maize, rice, etc. The Dutsin-Ma Agricultural Zone  
100 comprises ten (10) Local Government Areas (LGAs), namely: Kurfi, Safana, Batsari, Kankia,  
101 Musawa, Ingawa, Kusada, Matazu, Sandamu, and Dutsin-Ma.

102 Geographically, the zone lies between latitude 12°27’N and longitude 7°29’E, with an annual  
103 rainfall ranging between 800 mm and 1,000 mm and an average temperature of 26°C to 35°C.  
104 These conditions are suitable for cereal production both as a subsistence and cash crop. Most  
105 farmers in the zone operate as smallholders, cultivating between 1 to 5 hectares, while a few  
106 commercial farmers manage farms exceeding 10 hectares. The LGAs within the Dutsin-Ma  
107 Agricultural Zone are recognized for their vibrant farming communities and intensive grain  
108 production. Farmers employ a mix of traditional and modern farming techniques, ranging from  
109 manual land preparation and animal traction to mechanized systems involving tractors, improved  
110 crop varieties, and the application of inorganic fertilizers.

111 In recent years, however, these farming systems have come under increasing threat from the  
112 adverse effects of climate change, including erratic rainfall, prolonged dry spells, and declining  
113 soil fertility. These challenges have led to reduced crop productivity and heightened food  
114 insecurity. In response, climate change adaptation practices (CCAPs) such as the adoption of  
115 drought-tolerant crop varieties, water harvesting, agroforestry, crop rotation, and soil  
116 conservation methods are being gradually introduced through the support of agricultural  
117 extension services, non-governmental organizations (NGOs), and government intervention  
118 programmes.

### 119 **Sampling Technique and Sample Size**

120 The sample size for this study was determined using Yamane’s (1967) formula:

121

122

123  $n = N/1+N(e)^2$

$$n = \left( \frac{N}{1 + N(e)^2} \right)$$

124 Where:

125  $n$  = Sample Size

126  $N$  = sample frame

127  $e$  = error term (level of precision or 0.05)

128

129 Multi-stage sampling technique was used for the study. At stage 1, Dutsina Agricultural zone  
130 was purposively selected for the study due to the intensity of agricultural activities in the area. At  
131 the 2<sup>nd</sup> stage, three Local Government Areas (LGAs) noted for high level of farm production  
132 were randomly selected, these were Kurfi, Kankia, and Safana. At the 3<sup>rd</sup> stage, three  
133 communities were randomly selected from each LGA hence making a total of nine communities  
134 for the study. At the 4<sup>th</sup> stage, a list of 3, 017 registered maize farmers obtained from Katsina State  
135 Agricultural and Rural Development (KTARDA) constitute the total sample frame ( $N$ ) for the  
136 study. Taro Yamane formula was used to determine the sample size ( $n$ ) of 281. At the 5<sup>th</sup> stage,  
137 proportionate sampling technique was used to select the respondents from each of the  
138 communities sampled. Structured questionnaire was designed and administered to the  
139 respondents for data collection.

140

141

142

143

144

145

146 **Table 1: Sampling Procedure and Sample Size**

| LGAs         | Communities sampled | No. of registered farmers | Sample size |
|--------------|---------------------|---------------------------|-------------|
| Kurfi        | 1. Birici           | <b>200</b>                | 18          |
|              | 2. Rawayau          | <b>160</b>                | 15          |
|              | 3. Kurffi A         | <b>220</b>                | 20          |
| Kankia       | 1. Guchi            | 100                       | 9           |
|              | 2. Rimaye           | 200                       | 18          |
|              | 3. Kafinsoli        | 150                       | 14          |
| Safana       | 1. Tsaskiya         | 663                       | 62          |
|              | 2. Safana           | 556                       | 52          |
|              | 3. Runka            | 768                       | 73          |
| <b>TOTAL</b> | <b>9</b>            | <b>3,017</b>              | <b>281</b>  |

147

148 **Data Analysis**

149 Both descriptive and inferential statistics were adopted to analyze the data collected. Descriptive  
 150 statistics such as frequency distributions, percentages and means were used, while inferential  
 151 statistics such as Tobit regression were used to measure the stated objectives of the study.

152 **Model Specification**

153 **Tobit Regression Model**

154 The Tobit regression model is implicitly represented below;

155  $Y = f(X_1+X_2+X_3+X_4+X_5+ \dots X_n + \mu) \dots \dots \dots$  (Eq. 1)

156 The functional form is expressed explicitly as seen below;

157  $Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + \dots b_nX_n + \mu \dots \dots \dots$  (Eq. 2)

158 Where:

159  $Y =$  Participation in APPEALs programme (Participation =1, Non-participation= 0)

160  $X_1 =$  Extension contact (Yes =1 No= 0)

161  $X_2 =$  Income (₦)

- 162  $X_3$  = Membership of cooperative society (Yes = 1 No =0)  
163  $X_4$  = Household size (Actual number of people living together under same roof)  
164  $X_5$  = Farm size (Hectares)  
165  $X_6$  = Farming experience (Years)  
166  $X_7$  = Educational level (Years)  
167  $X_8$  = Gender (Male =1 Female =2)  
168  $\mu$  =Error term

169

## 170 **Results and Discussion**

### 171 **Socioeconomic Variables of Respondents**

172 Findings in Table 2 show the socioeconomic characteristics of the respondents.

173

174

175

176

177

178

179

180

181

182

183

184

185

186

187 **Table 4.1: Socio-economic Characteristics of Maize Farmers (N=217)**

| <b>Characteristic</b>             | <b>Category</b>     | <b>Frequency</b> | <b>Percentage (%)</b> | <b>Mean</b> | <b>Std. Deviation</b> |
|-----------------------------------|---------------------|------------------|-----------------------|-------------|-----------------------|
| <b>Age (Years)</b>                | Below 30            | 28               | 12.9                  | 43.7        | 10.2                  |
|                                   | 31–40               | 74               | 34.1                  |             |                       |
|                                   | 41–50               | 68               | 31.3                  |             |                       |
|                                   | Above 50            | 47               | 21.7                  |             |                       |
| <b>Gender</b>                     | Male                | 186              | 85.7                  | –           | –                     |
|                                   | Female              | 31               | 14.3                  |             |                       |
| <b>Marital Status</b>             | Single              | 19               | 8.8                   | –           | –                     |
|                                   | Married             | 178              | 82.0                  |             |                       |
|                                   | Widowed             | 15               | 6.9                   |             |                       |
|                                   | Divorced            | 5                | 2.3                   |             |                       |
| <b>Educational Level</b>          | No formal education | 67               | 30.9                  | –           | –                     |
|                                   | Primary             | 89               | 41.0                  |             |                       |
|                                   | Secondary           | 48               | 22.1                  |             |                       |
|                                   | Tertiary            | 13               | 6.0                   |             |                       |
| <b>Farming Experience (Years)</b> | Less than 5 years   | 22               | 10.1                  | 14.5        | 8.3                   |
|                                   | 6–10 years          | 58               | 26.7                  |             |                       |
|                                   | 11–20 years         | 91               | 41.9                  |             |                       |
|                                   | Above 20 years      | 46               | 21.2                  |             |                       |
| <b>Farm Size (Hectares)</b>       | Less than 1 ha      | 41               | 18.9                  | 2.8         | 1.9                   |
|                                   | 1–3 ha              | 124              | 57.1                  |             |                       |
|                                   | 4–6 ha              | 38               | 17.5                  |             |                       |
|                                   | Above 6 ha          | 14               | 6.5                   |             |                       |
| <b>Household Size</b>             | 1–4 persons         | 63               | 29.0                  | 6.2         | 2.4                   |
|                                   | 5–8 persons         | 112              | 51.6                  |             |                       |
|                                   | Above 8 persons     | 42               | 19.4                  |             |                       |
| <b>Access to Extension</b>        | Yes                 | 138              | 63.6                  | –           | –                     |
|                                   | No                  | 79               | 36.4                  |             |                       |
| <b>Cooperative Membership</b>     | Yes                 | 121              | 55.8                  | –           | –                     |
|                                   | No                  | 96               | 44.2                  |             |                       |

188 **Source:**Field Survey, 2025

189 According to the table, majority (85.7%) of the farmers were males with a mean age of about 44  
190 years. Akinola and Adeyemi (2023) reported that, men dominate agricultural production in  
191 southwestern Nigeria due to stronger control over productive assets. Nearly half (40.1%) of the

192 farmers had primary education, and 22.1% of the farmers had secondary education. More than  
 193 half (57.1%) had farm size between 1-3 hectares with a mean farming experience of about fifteen  
 194 years. Majority (63.6%) had access to extension services, while more than half (55.8%) of these  
 195 farmers belong to cooperative societies. Adeagbo, et. al., (2021) reported positive correlation  
 196 between extension contact and adoption decision of farmers. Extension contact influences  
 197 farmers' adoption of climate change technologies positively.

### 198 **Climate Change Adaptation Strategies Adopted by Farmers**

199 Results in Table 3 reveal the various adaptations strategies adopted by farmers to cushion the  
 200 effects of climate change.

201 **Table 3: Distribution of respondents according to climate change adaptation strategies**

| <b>Adaptation Practice</b>        | <b>Frequency</b> | <b>Percentage (%)</b> |
|-----------------------------------|------------------|-----------------------|
| Drought-resistant maize varieties | 159              | 73.3                  |
| Organic fertilizers               | 142              | 65.4                  |
| Agroforestry or intercropping     | 98               | 45.2                  |
| Water harvesting techniques       | 74               | 34.1                  |
| Conservation tillage              | 63               | 29.0                  |
| Crop rotation                     | 45               | 20.7                  |

202 **Source:**Field Survey, 2025

203 The findings in Table 3 revealed that majority (73.3%) of the respondents adopted drought  
 204 resistant crop varieties to adapt to climate change. In a related study carried out by Abubakar, et.  
 205 al., (2025), more than half (58%) of maize farmers in Bauchi local government area of Bauchi  
 206 state adopted improved crop varieties to mitigate the effect of climate change. Table 3 further  
 207 show that 65.4% of the respondents applied organic fertilizers/manures instead of synthetic

208 fertilizers like NPK or single super-phosphate (SSP). Application of organic fertilizers help to  
 209 improve soil fertility, water holding capacity and increased microbial activities especially at the  
 210 root zones. Agroforestry (45.2%) was fairly adopted, this could be due to arid nature of study  
 211 area and the high cost of raising plant seedlings to maturity.

## 212 **Factors Determining Adoption of Climate Change Adaptation Strategies**

213 Some selected factors determining the adaptation to climate change by farmers in the study area  
 214 are shown in Table 4.

215 **Table 4: Binary Logistic Regression on Determinants of Adoption of Climate Change**  
 216 **Adaptation Practices**

| Variable               | B      | S.E.  | Wald   | Odds Ratio (Exp(B)) | p-value  |
|------------------------|--------|-------|--------|---------------------|----------|
| Age                    | -0.012 | 0.018 | 0.445  | 0.988               | 0.505    |
| Education Level        | 1.204  | 0.532 | 5.128  | 3.333               | 0.024*   |
| Farm Size              | 0.156  | 0.132 | 1.397  | 1.169               | 0.237    |
| Income Diversification | 1.058  | 0.501 | 4.458  | 2.880               | 0.035*   |
| Access to Credit       | 1.742  | 0.489 | 12.694 | 5.711               | 0.000*** |
| Extension Contact      | 2.315  | 0.612 | 14.301 | 10.125              | 0.000*** |
| Cooperative Membership | 2.891  | 0.674 | 18.394 | 18.000              | 0.000*** |
| Constant               | -4.112 | 1.203 | 11.683 | 0.016               | 0.001*** |

217 **Source: Field Survey, 2025; \*=sig. @ 10%; \*\*=sig. @ 5%; \*\*\*=sig. @1%**

218 Membership of cooperative societies, extension contact, and access to credit were the major  
 219 statistically significant factors influencing farmers' decision to adopt climate change adaptation  
 220 practices. Cooperative society (B= 2.891) was significant at 1% (P= 0.000); implying that as  
 221 farmers registered in cooperative society there is a likelihood that they will adopt more climate  
 222 change adaptation strategies, while extension was equally significant at 1% (B= 2.315), which  
 223 implies that, as farmers have extension contact there is a probability that farmers will adopt more

224 climate change adaptation strategies. Abubakar, et. al., (2025) found out that, majority (75%) of  
225 maize farmers in Bauchi local government area of Bauchi state had extension contact. The  
226 import of extension contact could not be overemphasized, as farmers are exposed to modern  
227 adaptation practices, exchange innovative ideas, and participate in training that can bring about  
228 improvement in their practices and livelihoods. Access to credit (B=1.742) and significant at 1%  
229 (P= 0.00) was found to be another significant factor influencing adoption of climate change  
230 adaptation practices. The result implies that as farmers have access to credit, more of climate  
231 change adaptation strategies will be adopted by farmers. Jibril, et. al., (2025) reported that,  
232 access to resources both informational and financial emerges as the most decisive factor shaping  
233 the uptake of climate-smart agricultural practices. The table also revealed that income  
234 diversification (B=1.058) and educational level (B= 1.204) were significant at 10% respectively,  
235 which equally serve as determinants of adaptation strategies to climate change.

### 236 **Conclusion and Recommendations**

237 Climate change is a critical phenomenon with strong implications for socio-ecological,  
238 biophysical, human systems, and human development (Tarki, et. al., (2025). The need to adapt to  
239 the effect of climate change is therefore apt to avert to its ugly effect. Agriculture which is the  
240 major backbone of Nigerian economy has been witnessing major downturn due to climate  
241 change. Farm yield have shriveled, and farmers' livelihood now nosedived leading to food  
242 insecurity and poverty. Adoption of drought-resistant crop varieties, use of organic fertilizers and  
243 agroforestry etc. were some of the adaptation strategies adopted by farmers in the study area to  
244 mitigate climate shocks. Several factors influenced the adoption of these adaptation strategies  
245 such as extension contact, membership of cooperative societies, and access to income. This study  
246 therefore recommends that;

- 247 ➤ Climate change adaptation infrastructure should be provided by government and other  
248 stakeholders in the agricultural sector to farmers at affordable prices to enable access  
249 with ease.
- 250 ➤ Extension services should be further intensified to provide the necessary training and  
251 other services needed by farmers, government and private extension service providers  
252 should be made to enforce this.

### 253 **References**

- 254 Abubakar, I. A., Babuga, U. S., and Bulus, B. (2025). Factors influencing adoption of climate  
255 adaptation strategies by smallholder maize farmers in Bauchi local government area of  
256 Bauchi state, Nigeria. *Proceedings of the 37<sup>th</sup> Annual National Conference of Farm  
257 Management Association of Nigeria (FAMAN)*, held between 10<sup>th</sup>-14<sup>th</sup>November, 2025 at  
258 University of Jos, Nigeria, Pp.244-253.
- 259 Adeagbo, O. A., Ojo, T. A., and Adetoro, A. A. (2021). Understanding the determinants of  
260 climate change adaptation strategies among smallholder maize farmers in south-west,  
261 Nigeria. *Heliyon*, 7: 1-10.
- 262 Adeleke, O. A., Musa, I. J., & Garba, A. (2021). Factors influencing the adoption of climate-  
263 smart agricultural practices among smallholder farmers in northern Nigeria. *African  
264 Journal of Agricultural Research*, 16(8), 1123-1134.
- 265 Agboola, O. O., & Ibrahim, H. (2023). Socio-economic determinants of climate-smart  
266 agriculture adoption: A novel perspective from agritourism farmers in Nigeria. *Journal of  
267 Agricultural Extension and Rural Development*, 15(2), 45-58.
- 268 Akinola, A. A. and Adeyemi, A. A. (2023). Gender differentials on productivity of rice farmers  
269 in southeastern Nigeria. *Heliyon*, 9(4),  
270 e14714. <https://doi.org/10.1016/j.heliyon.2023.e14714>
- 271 Food and Agriculture Organization of the United Nations. (2018). *Climate-smart agriculture  
272 sourcebook*. <http://www.fao.org/climate-smart-agriculture-sourcebook/en/>
- 273 Jibril, S. A., Barnabas, B., Abdullahi, S., Abdulrahman, M. U., and Baraza, S. A. (2025).  
274 Determinants of adopting climate-smart agricultural practices among farmers in Toro  
275 local government area, Bauchi state, Nigeria. *Proceedings of the 37<sup>th</sup> Annual  
276 National Conference of Farm Management Association of Nigeria (FAMAN)*,  
277 held between 10<sup>th</sup>-14<sup>th</sup>November, 2025 at University of Jos, Nigeria, Pp. 224-233.

278 Lawal, A., Suleiman, M., & Mustapha, A. (2024). Adoption of agricultural practices with  
279 climate-smart agriculture potentials and food security among farm households in northern  
280 Nigeria. *Journal of Sustainable Agriculture and Environment*, 3(1), 88-102.

281 Obayelu, A. E., Bolarin, T. O., & Okunade, S. O. (2019). State of climate smart agriculture  
282 (CSA) practices in the north central and northwest zones of Nigeria. *Nigerian Journal of*  
283 *Agricultural Economics*, 9(1), 67-79.

284 Shiferaw, B., Abate, T., & Menkir, A. (2023). Adoption and impacts of drought-tolerant maize  
285 varieties in sub-Saharan Africa: A review. *Food Security*, 15(1), 45-63.

286 Sogoeto, H. S., Pohan, M. A. R., Luckyardi, S., Supatmi, S., Amasawa, E., Phithakkitnukoon,  
287 S., and Hasibuan, Z. A. (2025). Contributing factors to greenhouse gas emissions in  
288 agriculture for supporting Sustainable Development Goals (SDGs): Insights from a  
289 systematic literature review completed by Computational Bibliometric Analysis. *ASEAN*  
290 *Journal of Science and Engineering*, 5(2): 199-230.

291 Singh, A., Pandey, A. K., Santhosh, D. T., Ganavi, N. R., Sarma, A., Deori, C., Das, J., and  
292 Kumar, D. S. (2024). A comprehensive review on greenhouse gas emissions in  
293 agriculture and evolving agricultural practices for climate resilience. *International*  
294 *Journal of Environment and Climate Change*, 14(5): 455-464.

295 Tarki, S. K., Bako, B. D., Hamidu, K., and Michael, J. (2025). Assessment of sesame farmers'  
296 perception and adaptation strategies to climate change in Biliri local government area,  
297 Bauchi state, Nigeri *Proceedings of the 37<sup>th</sup> Annual National Conference of Farm*  
298 *Management Association of Nigeria (FAMAN)*, held between 10<sup>th</sup>-14<sup>th</sup> November, 2025 at  
299 University of Jos, Nigeria, Pp. 215-223.

300 Tian, H., Xu, R., Canadell, J. G., Arneeth, A., Thompson, R. L., and Winiwarter, W. (2023).  
301 Intensifying nitrogen fertilizer use and nitrous oxide emissions in agriculture: Global  
302 trends and implications. *Global Environmental Change*, 81, 102695.  
303 <https://doi.org/10.1016/j.gloenvcha.2023.102695>

304 Muhammed, D., Abdulsalam, R. Y., and Apeh, C. C. (2025). Reducing greenhouse gas emission  
305 through sustainable agricultural practices: A review. *Proceedings of the 37<sup>th</sup> Annual*  
306 *National Conference of Farm Management Association of Nigeria (FAMAN)*, held  
307 between 10<sup>th</sup>-14<sup>th</sup> November, 2025 at University of Jos, Nigeria, Pp.622-629.

308

309

310