Climate Change and Crop Production in The Gambia: Farmers' Perceptions, Agricultural Practices, and Adaptation Strategies

Short title**: Climate Adaptation Among Gambian Crop Farmers**

Sheriff Ceesay[1] Modou Badjan[2], Modou S Gaye[2], Lamin Darboe[2], Sambou LS Kinteh[2], Momodou Alieu Jallow[2], Mansour Badjie[1], Yunusa Jallow[2], Sambou Mbye[2], Ida K Touray[2], Ebrima Y Bojang[2], Mansata Bah[2], Seray Sidibeh[2], Ebrima Jallow[2], Aboubacarr Jallow[3]

[1]Directorate of Research and Development, University of Education The Gambia, Banjul, The Gambia

[2]School of Public Health, University of Education The Gambia, Banjul, The Gambia

[3]Central Administration, University of Education The Gambia, Banjul, The Gambia

Author ORCID iD: Author One: https://orcid.org/0009-0002-5982-4912

Corresponding author: Sheriff Ceesay[1] [1]Directorate of Research and Development, Banjul, The Gambia. Email: sheriffceesay@ueg.edu.gm

Abstract

Background. Climate change threatens crop production, food security, and rural livelihoods, particularly where smallholder farmers depend on rain-fed agriculture. The Gambia is exposed to rising temperatures, rainfall variability, droughts, floods, land degradation, and coastal hazards. This study assessed crop farmers' perceptions of climate change, their agricultural practices and adaptation strategies, and the factors associated with the adoption of coping practices.

Methods. A cross-sectional quantitative study was conducted among 662 crop farmers in the North Bank, Lower River, Central River, and Upper River Regions of The Gambia. Data were collected using a structured questionnaire programmed in KoboToolbox and analysed in IBM SPSS Statistics version 23. Frequencies and percentages were used to summarise the data. The association between perception of climate change and adoption of coping practices was examined using Fisher's exact test and the Pearson chi-square test, with Cramér's V as the effect size. A multivariable binary logistic regression was used to identify factors independently associated with adoption, reported as adjusted odds ratios (AORs).

Results. Most respondents had observed changes in the local climate over the previous five years (95.3%). The most commonly perceived changes were increased temperature (78.3%), decreased rainfall duration (56.7%), and fewer rainfall events (41.7%). The most commonly perceived impacts were a reduced growing season (55.4%), changes in the timing of rains (54.9%), and pest invasion (35.7%). Groundnuts (67.5%) and cereals (64.0%) were the crops most frequently cultivated. Nearly half of the respondents adopted at least one adaptation strategy (49.0%), of which planting different crop varieties was the most common (70.3%). Adoption was higher among respondents who perceived climate change (50.2%) than among those who did not (25.8%); this association was statistically significant (Fisher's exact test, $p = .009$) but weak (Cramér's $V = .103$). In the multivariable analysis ($\chi^2(14) = 46.77$, $p < .001$; Nagelkerke $R^2 = .091$), observation of climate change (AOR = 3.12, $p = .012$), higher educational level (vocational, AOR = 7.50, $p = .003$; tertiary, AOR = 2.38, $p = .032$), and dual household–commercial production (AOR = 1.72, $p = .001$) were independently associated with adoption, whereas gender, marital status, and age were not.

Conclusions. Crop farmers widely perceived climate change and reported effects on crop production, yet many were unfamiliar with climate-smart practices and had not adopted adaptation measures. Although awareness was independently associated with adoption, its modest explanatory power indicates that awareness alone is insufficient. Strengthening extension services, climate-information delivery, education and skills training, access to improved seed, and affordable water management may support adaptation, provided that financial and institutional barriers are also addressed.

Keywords: climate change; crop production; farmers’ perceptions; adaptation strategies; climate-smart agriculture; The Gambia

1 INTRODUCTION

Climate change refers to long-term changes in the climate system, including changes in temperature, rainfall, wind patterns, and extreme weather events. Human activities, particularly greenhouse-gas emissions, have unequivocally warmed the atmosphere, ocean, and land, and many of these changes are widespread, rapid, and unprecedented over centuries to millennia (Intergovernmental Panel on Climate Change [IPCC], 2021).

Agriculture is highly sensitive to climate variability and climate change. Rising temperatures, irregular rainfall, droughts, floods, and extreme weather events can affect crop yields, soil moisture, water availability, crop calendars, pest and disease occurrence, and agricultural labour productivity (Food and Agriculture Organization of the United Nations [FAO], 2023; IPCC, 2022). These consequences can threaten food security, including food availability, access, utilisation, and stability (FAO, 2008).

The Paris Agreement recognises food security and the particular vulnerability of food-production systems to adverse climate-change impacts (United Nations Framework Convention on Climate Change [UNFCCC], 2015). Agricultural adaptation is therefore necessary to reduce climate-related risks, maintain agricultural productivity, and protect rural livelihoods.

The Gambia is vulnerable to climate change because of its dependence on rain-fed agriculture, exposure to droughts and floods, low-lying coastal areas, and reliance on natural resources for livelihoods. Rainfall variability, high temperatures, soil degradation, limited irrigation infrastructure, and coastal risks may negatively affect crop production and food security (FAO, 2018; Government of The Gambia, 2021; World Bank Group, 2021).

Recent research in The Gambia shows that smallholder farmers widely perceive climate risks and use a range of farm-level and off-farm adaptation strategies. However, adaptation choices are influenced by land tenure, market access, government support, experience of extreme weather events, and farmers' perceptions of climate change (Lambarraa-Lehnhardt et al., 2024). Farmers in The Gambia have identified crop diversification, pesticide application, irrigation, and inorganic fertiliser use as commonly adopted and relatively effective strategies, while limited financial resources, inadequate government support, and insufficient knowledge remain significant barriers to adaptation (Ceesay et al., 2025).

This study is guided by a perception–adaptation framework, in which farmers' responses to climate risk are understood as a sequential but non-automatic process: farmers must first perceive a change or risk, and then decide whether and how to respond, subject to their capacity and circumstances (Deressa et al., 2009). Perception is a necessary but insufficient condition for adaptation, because the translation of awareness into action is mediated by household resources, access to inputs and information, and institutional and market conditions (Ceesay et al., 2025; Lambarraa-Lehnhardt et al., 2024). This framework informs both the study objectives and the analysis.

The aim of this study was to assess the impact of climate change on crop production in The Gambia by examining crop farmers' perceptions, agricultural practices, and climate-change adaptation strategies, and by assessing the association between farmers' perception of climate change and their adoption of coping practices.

2 MATERIALS AND METHODS

2.1 Study Design

A cross-sectional quantitative study design was used to assess crop farmers' perceptions of climate change, agricultural practices in response to climate-related impacts, climate-change adaptation strategies, and access to climate information. A cross-sectional design was appropriate because the study aimed to describe perceptions, practices, and adaptation strategies at a single point in time and to examine their association. The design does not permit inferences about causation or temporal sequence, and this limitation is acknowledged in the Discussion.

2.2 Study Area

The study was conducted in four of the seven administrative regions of The Gambia: North Bank Region, Lower River Region, Central River Region, and Upper River Region. These four regions were purposively selected because they are predominantly rural, agriculture is the principal livelihood activity, and crop production is highly exposed to climate-related risks, including rainfall variability, high temperatures, dry spells, flooding, and land degradation. West Coast Region and the urban Greater Banjul area (Kanifing Municipal Council and Banjul) were excluded because agriculture is a comparatively smaller livelihood activity there; West Coast Region was instead used for questionnaire pre-testing. This selective focus improves relevance to rural crop farmers but limits generalisability to the excluded regions.

The Gambia is located on the west coast of Africa and is bordered by Senegal except for its Atlantic Ocean coastline. It has a tropical climate, with a single rainy season from approximately June to October and a dry season from approximately November to May. Crop production is predominantly rain-fed and is therefore sensitive to changes in rainfall onset, duration, intensity, and distribution (FAO, 2018; World Bank Group, 2021). The regional administrative headquarters are Kerewan (North Bank), Janjangbureh (Central River), Mansakonko (Lower River), and Basse (Upper River).

2.3 Study Population

The study population comprised male and female crop farmers aged 18 years and above who resided and actively practised crop farming in North Bank, Lower River, Central River, or Upper River Region during the study period.

2.4 Inclusion and Exclusion Criteria

Individuals were eligible if they were aged 18 years or older, resided in one of the four selected regions, were actively engaged in crop production during [insert season/year], and provided informed consent. Individuals were excluded if they were not active crop producers, were younger than 18 years, were unable to provide informed consent, or declined to participate.

2.5 Sample Size Determination

The minimum sample size was estimated using the Cochran formula for a single proportion, $n0 = Z^2p(1 - p)/e^2$, where $Z = 1.96$ (95% confidence level), $p = 0.50$, and $e = 0.05$ (margin of error). This yielded a minimum of 384 respondents. To account for the multistage (clustered) sampling design and potential non-response, a design effect of 1.5 and a non-response allowance of 15 % were applied, giving a target of 600 farmers. A total of 662 crop farmers were ultimately enrolled and provided valid consent, exceeding the minimum target; the final sample was retained to strengthen regional representation and statistical precision.

2.6 Sampling Procedure

A multistage sampling procedure was used. First, North Bank, Lower River, Central River, and Upper River Regions were selected. Districts and communities were then selected within each region. Eligible crop farmers were identified with support from local authorities and agricultural-extension personnel. Farmers were selected using simple random sampling where farmer lists were available.

2.7 Data Collection

Data were collected using a structured questionnaire comprising closed-ended items, adapted from previously validated tools and published literature on farmers' climate-change perceptions and agricultural adaptation (Bryan et al., 2009; Deressa et al., 2009; Lambarraa-Lehnhardt et al., 2024; Limantol et al., 2016). The questionnaire was programmed in KoboToolbox for electronic data capture and, where relevant, administered in the respondent's local language by trained enumerators. The questionnaire was programmed in KoboToolbox for electronic data collection.

2.8 Pre-Testing

The questionnaire was pre-tested among 60 crop farmers in the West Coast Region, which was not included in the final survey. The pre-test assessed the clarity, relevance, sequence, completeness, and comprehensibility of the questionnaire. Questions that were unclear, ambiguous, repetitive, or unsuitable were revised before the main data collection.

2.9 Study Variables

Independent variables included respondents' age, sex, marital status, educational level, farming experience, purpose of crop production, study region, familiarity with climate-smart farming practices, and sources of climate information.

Dependent variables included perception of climate change, agricultural practices in response to climate-related impacts, and adoption of climate-change adaptation strategies.

2.10 Data Analysis

Data were analysed using IBM SPSS Statistics version 23. Categorical variables were summarised using frequencies and percentages, with each percentage calculated as:

$$\% = \frac{(f\ /\ N)}{100}$$

where f is the frequency of a given response category, and N is the number of valid responses for that variable.

Chi-square test of independence

The association between perception of climate change and adoption of coping practices was assessed using the Pearson chi-square test of independence:

$$\chi^2 = \Sigma[\frac{(O_{ij} - E_{ij})^2}{E_{ij}}]$$

where O_{ij} is the observed frequency and E_{ij} is the expected frequency in the cell ij. The expected frequency for each cell was computed as:

$$E_{ij} = \frac{(R_i \times C_j)}{N}$$

where R_i is the row total, C_j is the column total, and N is the grand total. The degrees of freedom were given by:

$$df = (r - 1)(c - 1)$$

where r and c are the numbers of rows and columns, respectively. The strength of association was quantified using Cramér's V:

$$V = \frac{\sqrt{\chi^2}}{(N (k - 1)}$$

where k is the smaller of the number of rows or columns.

Binary logistic regression

To identify factors independently associated with the adoption of coping practices, a multivariable binary logistic regression was conducted. The dependent variable was adoption of at least one adaptation practice (coded 1 = adopted, 0 = not adopted). The predictors were observations of climate change, gender, marital status, educational level, purpose of crop production, and age group. Categorical predictors were entered using indicator coding, with the following reference categories: did not observe climate change (No) for observation of climate change; male for gender; single for marital status; primary for educational level; family use for purpose of production; and 18–27 years for age group.

The probability of adoption was modelled as:

$$P(Y = 1) = \frac{1}{[\, 1 + e^{\wedge} - (\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k)\,]}$$

Equivalently, the model was expressed in logit (log-odds) form as:

$$ln \frac{P}{(1 - P)} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k$$

where P is the probability of adopting a coping practice, β_0 is the constant, and $\beta_1 \ldots \beta_k$ are the coefficients for predictors $X_1 \ldots X_k$ (observation of climate change, gender, marital status, educational level, purpose of production, and age group). The adjusted odds ratio for each predictor was obtained by exponentiating its coefficient:

$$AOR = e^{\wedge}(\beta_i)$$

Overall model significance was assessed using the omnibus likelihood-ratio chi-square test, and the proportion of variance explained was estimated using the Nagelkerke R^2:

$$R^2(Nagelkerke)\frac{1 - (L_0 / L\_M)^\wedge(2/N)}{1 - L_0{}^\wedge(2/N)}$$

where L_0 and L_M are the likelihoods of the null and fitted models, respectively. Statistical significance was set at $p < .05$.

3 RESULTS

3.1 Sociodemographic Characteristics of Respondents

Table 1. Sociodemographic characteristics of crop farmers

Variable	Frequency(n=662)	Percent (%)
Age group (in years)		
18 - 27	149	22.5
28 - 37	174	26.3
38 - 47	117	17.7
48 and above	222	33.5
Gender		
Female	378	57.1
Male	284	42.9
Marital status		
Single	68	10.3
Married	548	82.8
Divorce	10	1.5
Widower	36	5.4
Educational Level		
Primary	125	18.9
Secondary	155	23.4
Tertiary	39	5.9
Non formal	323	48.8
Vocational	20	3.0
Purpose of your crop production		
Family use	283	42.7
Commercial	28	4.2
Both	351	53.1
Total	662	99.8
Work experience		
0 - 9	243	36.7
10 - 19	143	21.6
20 - 29	113	17.1
30 and above	163	24.6

Table 1 shows a farming population that is experienced, predominantly female, largely without formal schooling, and reliant on farming for both food and income. Just over half of respondents were aged 38 years or older, and

62.4% had a decade or more of farming experience. This depth of experience is an asset for perceiving long-term climatic change, but an older workforce may find labour- or capital-intensive adaptations, such as irrigation and mechanised land preparation, difficult to adopt.

Women formed the majority (57.1%), underscoring their central role in crop production and the need for gender-responsive interventions that secure their access to land, credit, inputs, and climate information. Educational attainment was low: more than two-thirds of respondents (67.7%) had no more than primary schooling. Climate and extension messages should therefore be delivered through accessible channels such as demonstrations, farmer field schools, and local-language radio rather than text-based materials.

The findings also indicate that 95.8% of respondents relied on their own production for household food to some degree, and most (53.1%) farmed for both consumption and sale. Climate-related yield losses therefore threaten household food security and cash income simultaneously, heightening vulnerability for the majority of farming households.

3.2 Climate Change Perceptions Among Respondents

As shown in Figure 1, the overwhelming majority of respondents (95.3%) had observed changes in local climate over the previous five years, while only 4.7% had not. This near-universal awareness suggests that climatic change is a lived reality for farmers in the study regions, encountered directly through rain-fed production. Such widespread recognition provides an important entry point for adaptation.

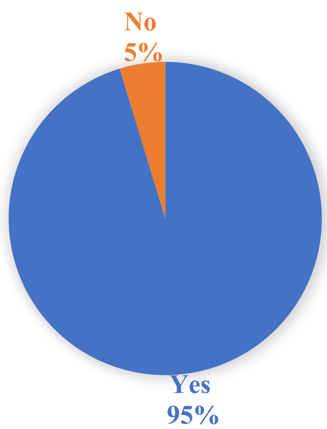

Figure 1. Respondents' reported observations of changes in local climate patterns.

As shown in Figure 2, increased temperature was the most commonly perceived change (78.3%), followed by decreased rainfall duration (56.7%), fewer rainfall events (41.7%), and decreased rainfall intensity (25.4%). Perceptions of increasing rainfall were consistently less common (12.4–20.5%). This predominance of "decreased" over "increased" rainfall responses, alongside near-consensual perceptions of rising temperatures, suggests farmers experience the rainy season as shorter, less frequent, and less reliable, conditions that heighten crop-water stress in rain-fed systems.

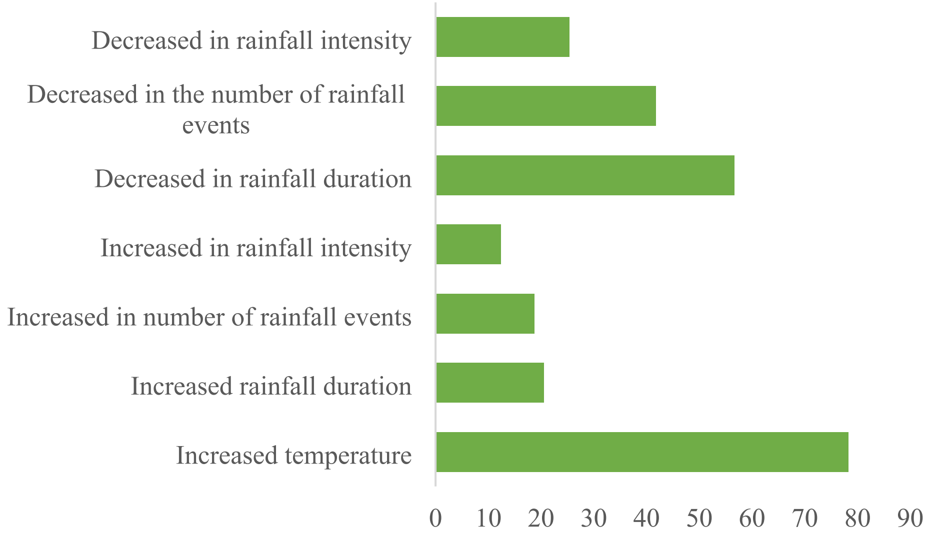

Figure 2. Perceived changes in local climate conditions reported by crop farmers.

As shown in Figure 3, most respondents perceived the extent of climate change as extreme (58%), while 39% considered it low and only 3% moderate. The strong skew towards "extreme" indicates that farmers regard climate change not as a minor variation but as a serious threat to their production, reinforcing the perceptions of rising temperatures and declining rainfall reported above. The sizeable minority perceiving it as low, however, points to uneven risk awareness that targeted climate information could help address.

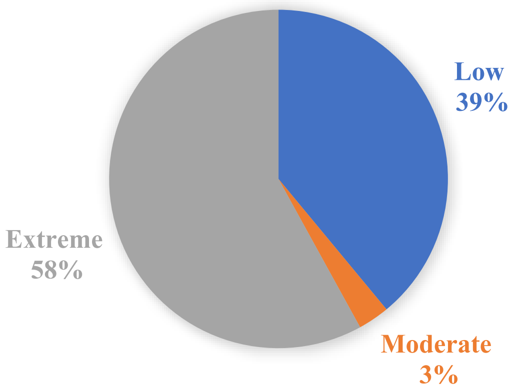

Figure 3. Respondents' perceived extent of climate change.

The most commonly perceived impacts related to disruption of the cropping calendar: changed timing of rains (53%), a reduced growing season (48%), and an abrupt change in seasons (40%). Biological stresses followed, including pest invasion (30%), disease prevalence (26%), and post-harvest losses (24%), alongside poverty and food shortages (24%). Less frequently cited impacts included floods and farm destruction, lack of potable water, disappearance of vegetation cover, erosion, and the extinction of some crops and varieties. The prominence of calendar-related impacts reinforces the earlier finding that farmers experience rainfall as increasingly unreliable, while the breadth of impacts shows that climate change is perceived to affect production, household welfare, and the local environment alike (Figure 4).

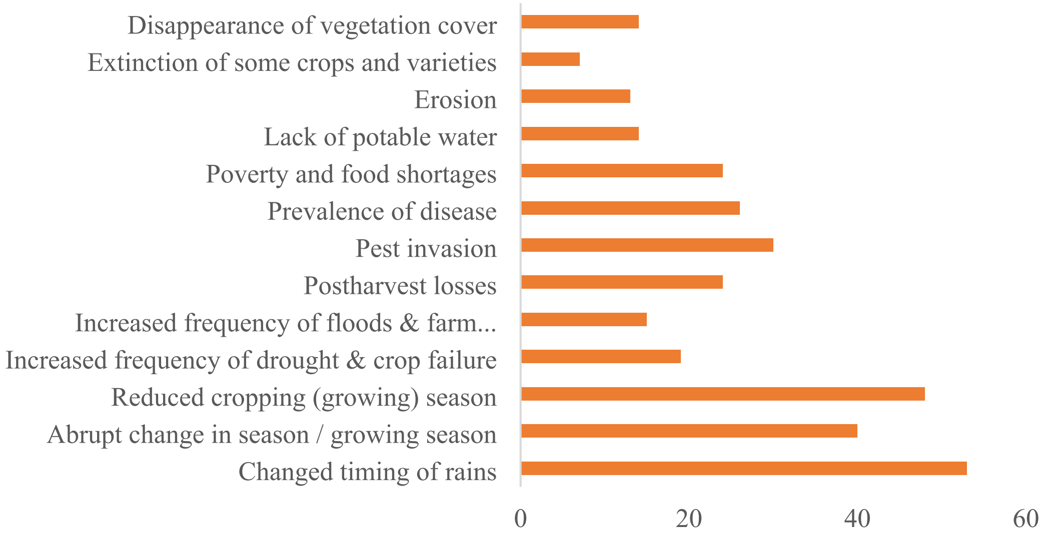

Figure 4. Perceived impacts of climate change reported by crop farmers.

Perceptions of severity were concentrated at the more serious end of the scale: the largest groups described the impacts as extreme (38.5%) or reported experiencing multiple effects simultaneously (30.8%), together accounting for more than two-thirds of respondents. By contrast, only 21.1% regarded the impacts as manageable and 5.6% as limited, while 2.7% were uncertain. This skew towards "extreme" and "multiple" effects indicates that most farmers experience climate change as a compounding threat rather than an isolated or containable one, reinforcing the earlier findings on disrupted cropping calendars and reduced growing seasons (Figure 5).

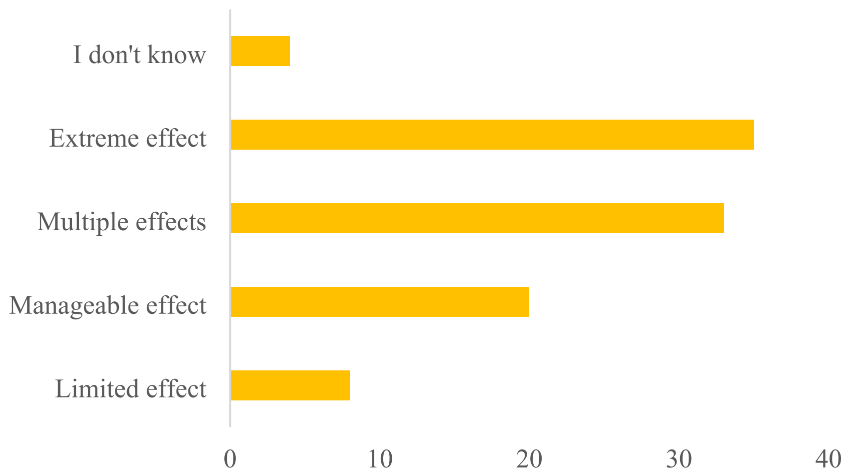

Figure 5. Respondents perceived the severity of climate-change impacts.

3.3 Agricultural Practices in Response to Climate Change Impacts

Groundnuts (67.5%), cereals (64.0%), and vegetables (58.5%) were widely cultivated, whereas fruits were grown by only 11.2% of respondents (Figure 6). The high uptake of three staple foods and cash crops reflects a degree of crop diversification that may buffer households against climate shocks, since these crops differ in their sensitivity to drought, heat, and pests. However, groundnuts and cereals are largely rain-fed and rain-sensitive, leaving production exposed to the shorter, less reliable rainy seasons farmers reported earlier. The limited cultivation of fruits, typically more perennial and drought-resilient, points to an underused opportunity for strengthening long-term climate resilience.

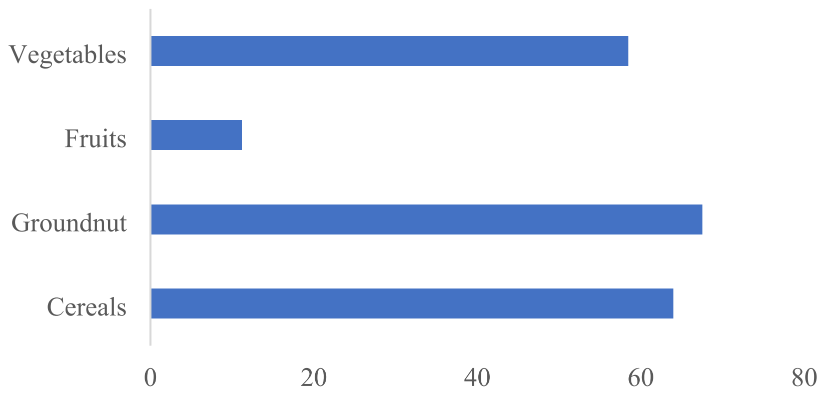

Figure 6. Types of crops cultivated by respondents.

Among respondents who irrigated, overhead watering using watering cans was by far the most common method (67.0%), while rain-fed production (11.0%), drip irrigation (9.0%), sprinkler irrigation (8.0%), and flood irrigation (5.0%) were each used by only small proportions. The dominance of watering cans indicates that irrigation was largely small-scale, manual, and labour-intensive, offering limited capacity to sustain larger plots through dry spells. The very low uptake of more efficient systems such as drip and sprinkler irrigation, typically constrained by cost, equipment access, and technical knowledge, represents a key opportunity for strengthening water-use efficiency and climate resilience (Figure 7).

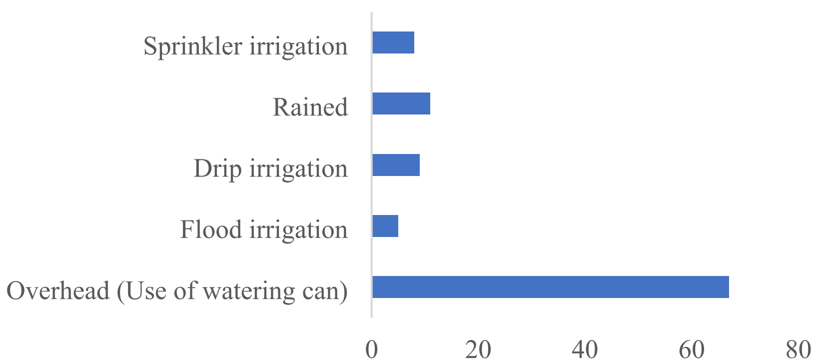

Figure 7. Use of irrigation for crop production among respondents

An overwhelming 93.3% of respondents reported experiencing pest invasion and/or crop disease during production, with only 6.7% unaffected (Figure 8). This near-universal exposure identifies pests and diseases as one of the most pervasive production constraints in the study regions. It also aligns with farmers' earlier perceptions that rising temperatures and irregular rainfall are intensifying pest and disease pressure, underscoring the need for accessible crop-protection support and integrated pest management.

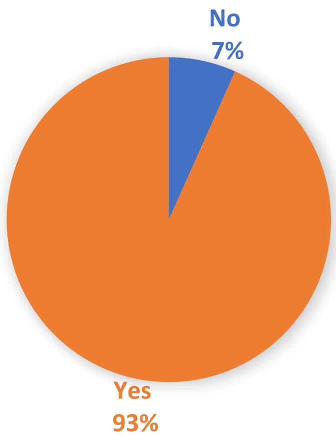

Figure 8. Respondents reported pest invasion and/or crop disease during production.

Chemical application was the dominant control method (53.0%), used more than twice as often as cultural practices (23.0%) or biological control (21.0%), while resistant varieties were used by only 3.0% of respondents (Figure 9). This heavy reliance on pesticides, combined with very limited use of resistant varieties, suggests constrained access to improved seed and integrated pest management. It also raises concerns about cost, safety, and environmental sustainability, pointing to a need for extension support that broadens farmers' crop-protection options.

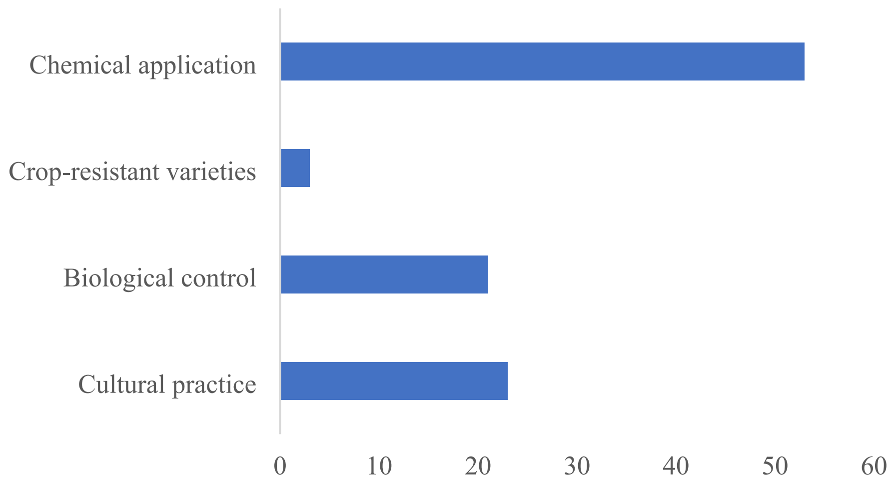

Figure 9. Pest and disease control methods reported by crop farmers.

3.4 Climate Change Adaptation Strategies

More than half of respondents (56%) were unfamiliar with climate-smart farming practices, while 44% reported familiarity (Figure 10). This knowledge gap is striking given the near-universal awareness of climate change reported earlier, and it helps explain the limited uptake of adaptation measures. It indicates that farmers recognise the problem but may lack exposure to the specific practices that could address it, highlighting a clear role for strengthened extension services and farmer training.

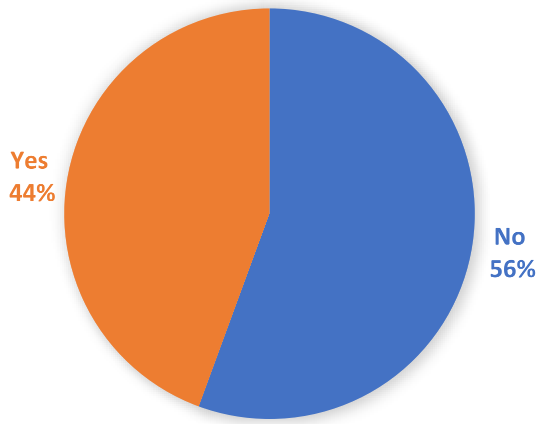

Figure 10. Respondents' familiarity with climate-smart farming practices.

Respondents were almost evenly split, with 51% having adopted no adaptation practice and 49% having adopted at least one (Figure 11). This near-even divide is notable against the backdrop of near-universal climate-change awareness, revealing a substantial awareness–action gap. It indicates that recognising climate risk is not, by itself, translating into adaptation for around half of farmers, likely reflecting the barriers of limited knowledge, finance, and access to inputs identified elsewhere in this study.

Figure 11. Adoption of climate-change adaptation practices among respondents.

Planting different crop varieties was both the most widely adopted adaptation strategy (70.3%) and the one most often rated as most effective (47.7%), followed by changing planting dates, improving water management, and crop diversification (Figure 12). For most strategies, adoption exceeded perceived effectiveness, most markedly for changing planting dates (40.2% adopted versus 18.0% rated effective), suggesting that farmers use some measures out of necessity or convenience rather than strong confidence in their results. The prominence of varietal change, a relatively low-cost and accessible option, alongside the more limited uptake of water management, reflects farmers' tendency to favour affordable strategies over more capital-intensive ones.

Figure 12. Adaptation strategies adopted and their perceived effectiveness by respondents.

Radio and television were by far the dominant sources of climate information (70.8%), far exceeding local extension services (16.9%) and mobile applications (12.2%) (Figure 13). This heavy reliance on broadcast media reflects their wide reach and accessibility in rural areas, particularly among a population with limited formal education, and identifies radio and television as the most effective channels for disseminating seasonal forecasts and adaptation advice. The comparatively minor role of extension services is concerning, as it limits farmers' access to the tailored, two-way guidance needed to translate awareness into action, while low mobile-app use reflects persistent constraints in smartphone access and digital literacy.

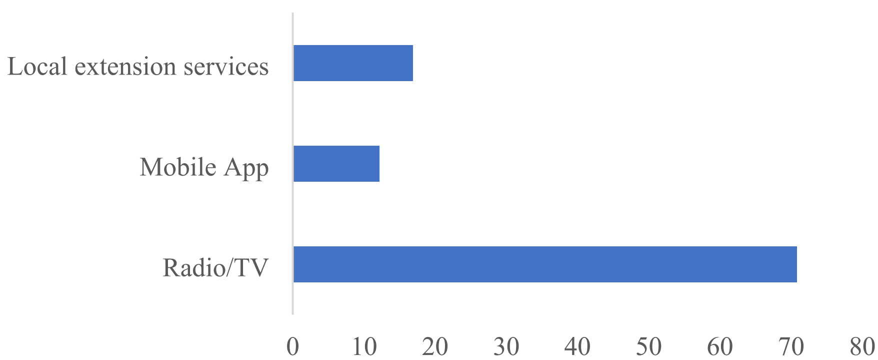

Figure 13. Main sources of weather forecasts and climate-related information.

Organic manure was by far the most widely used soil-management method (87%), followed by fertilisers (46%), while chemical application (19%), crop rotation (13%), and cover crops (5%) were far less common (Figure 14). The strong reliance on organic manure is encouraging for climate resilience, as it improves soil fertility, structure, and moisture retention at low cost. However, the limited use of crop rotation and cover crops, practices that further protect soil health and buffer against climate stress, indicates an underused opportunity to strengthen sustainable soil management through targeted extension support.

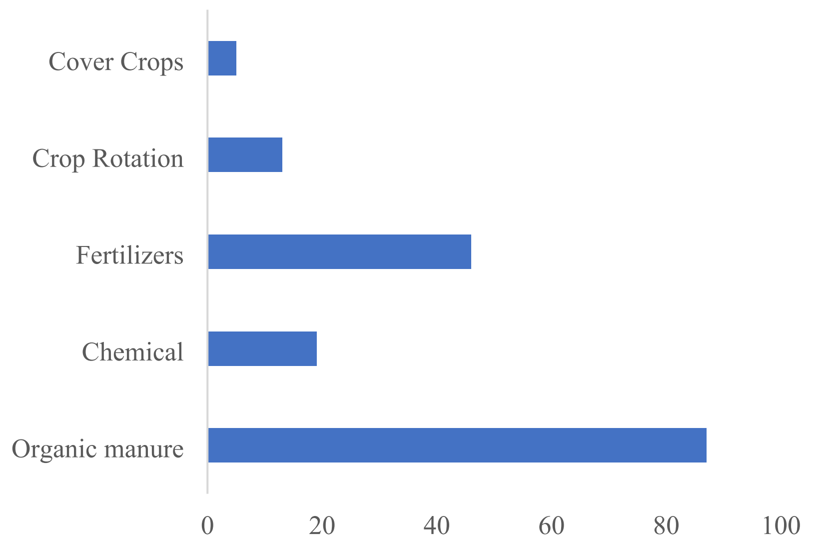

Figure 14. Soil management method

3.5 Association Between Climate-Change Perception and Adoption of Coping Practices

Table 2. Association between climate-change perception and adoption of coping practices

	Adoption: No	**Adoption: Yes**	**Total**
Perception: No — Count (% within perception)	23 (74.2%)	8 (25.8%)	31 (100.0%)
Perception: Yes — Count (% within perception)	314 (49.8%)	316 (50.2%)	630 (100.0%)
Total — Count (% within perception)	337 (51.0%)	324 (49.0%)	661 (100.0%)
Test statistic	**Value**	**df**	**Sig.**
Pearson chi-square	7.011	1	.008
Continuity correction	6.071	1	.014
Likelihood ratio	7.322	1	.007
Fisher's exact test (2-sided)	—	—	.009
Fisher's exact test (1-sided)	—	—	.006
Linear-by-linear association	7.001	1	.008
Phi	.103	—	.008
Cramér's V	.103	—	.008

	Adoption: No	**Adoption: Yes**	**Total**
N of valid cases	661	—	—

Adoption of coping practices was higher among respondents who perceived climate change (50.2%) than among those who did not (25.8%) (Table 2). Fisher's exact test indicated a statistically significant association ($p = .009$), corroborated by the Pearson chi-square test, χ^2 (1, N = 662) = 7.01, $p = .008$ (continuity-corrected $p = .014$). The effect size was weak (Cramér's V = .103), indicating that perception accounted for little of the variation in adoption.

Table 3. Binary logistic regression of factors associated with adoption of coping practices

Predictor	B	SE	Wald	df	p	AOR
Observed climate change (ref: No)	1.137	.453	6.288	1	.012	3.117
Female (ref: male)	.055	.179	.093	1	.760	1.056
Marital status (ref: single)			3.322	3	.345	
Married	.569	.329	3.001	1	.083	1.767
Divorced	.202	.725	.077	1	.781	1.223
Widowed	.691	.516	1.796	1	.180	1.995
Education (ref: primary)			14.209	4	.007	
Secondary	.130	.254	.261	1	.609	1.138
Tertiary	.868	.405	4.593	1	.032	2.382
Non-formal	−.024	.225	.012	1	.914	.976
Vocational	2.014	.689	8.554	1	.003	7.496
Purpose of production (ref: family use)			15.926	2	.000	
Commercial	−.744	.463	2.585	1	.108	.475
Both	.541	.167	10.565	1	.001	1.718
Age group (ref: 18–27)			.410	3	.938	
28–37	.101	.253	.159	1	.690	1.106
38–47	.122	.287	.179	1	.672	1.129
48 and above	.176	.275	.408	1	.523	1.192
Constant	−2.156	.549	15.433	1	.000	.116

The binary logistic regression model in Table 3 was statistically significant, χ^2 (14) = 46.77, $p < .001$, indicating that the predictors collectively distinguished adopters from non-adopters better than chance. The model explained 9.1% of the variance in adoption (Nagelkerke R^2) and correctly classified 58.3% of cases, an improvement over the 50.9% achieved by the null model. Three predictors were independently associated with adoption: observation of climate change, educational level, and purpose of production.

Observation of climate change was a strong independent predictor. Farmers who had observed changes in local climate had more than three times the odds of adopting coping practices compared with those who had not (AOR = 3.12, p = .012). This confirms, after adjusting for sociodemographic factors, that awareness of climatic change is a meaningful correlate of adaptation.

Educational level was significant overall (p = .007), driven by the higher-skilled categories. Relative to farmers with only primary education, those with vocational training had markedly higher odds of adoption (AOR = 7.50, p = .003), as did those with tertiary education (AOR = 2.38, p = .032). Secondary and non-formal education did not differ significantly from primary. This suggests that practical, skills-based and higher education, rather than schooling in general, is linked to a greater likelihood of adaptation, although the very large odds ratio for vocational education should be treated cautiously given the small number of vocationally trained respondents.

Purpose of production was also significant overall ($p < .001$). Compared with farmers producing solely for family use, those producing for both household and commercial purposes had significantly higher odds of adoption (AOR = 1.72, p = .001), while commercial-only production did not differ significantly. This indicates that dual-purpose farmers, who face combined food security and income incentives and are more market-engaged, are more inclined to adapt.

By contrast, gender, marital status, and age group were not independently associated with adoption (all $p > .05$). The absence of a gender effect is notable given the predominance of women in the sample, suggesting that men and women were equally likely to adopt once other factors were accounted for. Similarly, the lack of an age effect indicates that older, more experienced farmers were no more likely to adopt coping practices than younger farmers.

Overall, the model indicates that adaptation is driven more by awareness of climate change, education, and the economic orientation of production than by demographic characteristics. However, the modest variance explained (9.1%) shows that much of the variation in adoption remains unaccounted for, implying that other unmeasured factors, such as access to credit, land tenure, extension contact, and input availability, are likely to play an important role.

4 DISCUSSIONS

This study examined crop farmers' perceptions of climate change, their agricultural practices, their adaptation strategies, and the association between perception and adoption of coping practices in four rural regions of The Gambia. Because the study used a cross-sectional design, the results describe associations at a single point in time and do not establish causation or temporal order.

Most respondents reported observing changes in local climate over the previous five years, most commonly increased temperature, decreased rainfall duration, and fewer rainfall events. These patterns are consistent with farmer-reported perceptions in other African settings (Bryan et al., 2009; Deressa et al., 2009; Limantol et al., 2016) and with recent evidence from The Gambia (Lambarraa-Lehnhardt et al., 2024), suggesting that they reflect widely shared experiences among rain-fed smallholder farmers. Nevertheless, perceived changes should be interpreted with caution, because farmers' perceptions do not always correspond to instrumental meteorological records. Limantol et al. (2016), for example, found that farmers perceived declining rainfall where long-term records showed no significant rainfall trend, although temperatures had risen. Because the present study did not incorporate meteorological data, it cannot determine whether the perceived changes correspond to measured climatic trends.

Groundnuts, cereals, and vegetables were the most frequently cultivated crops, reflecting their importance for household food supply and income. Although more than half of respondents reported using some form of irrigation, the dominant method was the watering can, indicating that irrigation was largely small-scale and labour-intensive; the limited use of drip and sprinkler systems is consistent with reports that cost, equipment access, technical knowledge, and water availability constrain irrigation uptake among smallholders (Ceesay et al., 2025). Pests and diseases were reported by most respondents, and chemical application was the most common control method, while the use of resistant varieties was very low; this may indicate limited access to improved seed and integrated pest management, although these factors were not measured directly.

Approximately half of respondents reported adopting at least one adaptation strategy, and more than half reported being unfamiliar with climate-smart practices. Among adopters, planting different crop varieties was both the most commonly reported strategy and the strategy most frequently rated as most effective, broadly consistent with Ceesay et al. (2025). Farmers may favour options perceived as affordable and feasible over more capital-intensive measures, although this study did not directly measure the reasons for strategy choice. Notably, widespread perception of climate change coexisted with limited adoption of adaptation practices, an awareness–action gap that is well documented in the adaptation literature (Ceesay et al., 2025; Lambarraa-Lehnhardt et al., 2024).

Adoption of coping practices was higher among respondents who perceived climate change than among those who did not, and this difference was statistically significant, but the effect size was weak (Cramér's $V = .103$), indicating that perception accounted for only a small proportion of the variation in adoption. Because the design is cross-sectional, it is not possible to determine whether perceiving climate change preceded, followed, or merely co-occurred with adoption; the association should not be read as evidence that perception causes adoption. The weak association is consistent with evidence that adaptation is shaped by many factors beyond perception, including land tenure, market access, government support, exposure to extreme events, finance, labour, improved seed, and extension services (Ceesay et al., 2025; Deressa et al., 2009; Lambarraa-Lehnhardt et al., 2024). Because the primary analysis was bivariate, the extent to which perception is independently associated with adoption, after accounting for socioeconomic and institutional factors, cannot be established from the results reported here.

The multivariable analysis provided further insight into the factors independently associated with adaptation. After adjusting for sociodemographic characteristics, observation of climate change remained a significant predictor, with farmers who had observed climatic changes having more than three times the odds of adopting coping practices than those who had not (AOR = 3.12). This strengthens the bivariate association reported earlier and indicates that awareness is a genuine, independent correlate of adaptation rather than an artefact of confounding. Educational level was also significant, with vocationally and tertiary-educated farmers showing higher odds of adoption than those with only primary schooling, suggesting that practical, skills-based and higher education may enhance farmers' capacity to interpret climate information and implement adaptive practices. Purpose of production emerged as a further predictor: farmers producing for both subsistence and commercial purposes were more likely to adapt than those producing solely for family use, possibly because combined food-security and income incentives, together with greater market engagement, both motivate and enable adaptation. These findings are consistent with evidence that adaptation is shaped by socioeconomic and institutional factors rather than awareness alone (Ceesay et al., 2025; Deressa et al., 2009). Notably, gender, marital status, and age were not independently associated with adoption, indicating that adaptation behaviour was driven more by awareness, education, and economic orientation than by demographic characteristics. Nevertheless, the model explained only a modest proportion of the variance in adoption (Nagelkerke $R^2 = .091$), implying that unmeasured factors—such as access to credit, land tenure, extension contact, and input availability—are likely to play an important role and warrant investigation in future research.

Limitations

Perceptions, practices, and adaptation were self-reported and not verified against farm observations, so responses may be affected by recall and social desirability bias.

Implications and Recommendations

Because perception was only weakly associated with adoption, and because barriers such as finance, inputs, and extension access are well documented in this setting (Ceesay et al., 2025), awareness-raising alone is unlikely to be sufficient. The Ministry of Agriculture and extension services should strengthen farmer-facing extension on climate-smart practices, delivered through demonstrations, farmer field schools, and local-language channels. National meteorological and extension services, with broadcast media, should expand timely, local-language climate and seasonal-forecast information via radio and television, which were the dominant information sources, while developing extension- and mobile-based channels. Seed systems and input suppliers, supported by government and development partners, should improve access to affordable early-maturing, drought-tolerant, and pest-resistant varieties. Government and financial institutions should facilitate access to affordable irrigation and water-management technologies and to credit. Policymakers should ensure interventions are gender-responsive, given the high proportion of women farmers. Future research should use longitudinal or mixed-methods designs, incorporate meteorological data, apply multivariable modelling, and extend to the excluded regions.

5 CONCLUSIONS

Most crop farmers in this study perceived changes in local climate, especially increased temperatures, reduced rainfall duration, fewer rainfall events, and changes in rainfall timing, and reported effects on crop production, including reduced growing seasons, pest invasion, drought, crop failure, poverty, and food shortages. Groundnuts, cereals, and vegetables were the main crops. Although more than half of respondents used irrigation, watering cans predominated, indicating small-scale, labour-intensive systems, and pest and disease occurrence was widespread. Approximately half of respondents adopted at least one adaptation strategy, most commonly planting different crop varieties, yet many were unfamiliar with climate-smart practices. Perception of climate change was significantly but weakly associated with the adoption of coping practices, indicating that adaptation depends on more than awareness. The study recommends strengthening extension services, expanding accessible climate-information delivery, improving access to improved seed and affordable water management, promoting integrated pest management, and ensuring gender-responsive support, while addressing the financial and institutional barriers that constrain adaptation.

Acknowledgments

The authors thank all crop farmers who participated in this study, as well as the regional, district, and community authorities, agricultural-extension personnel, research assistants, and data collectors who supported data collection.

Ethics Statement

Ethical approval was obtained from the Gambia College ethics committee GC/REC/2024/009. Administrative permission was obtained from the relevant regional, district, and community authorities. All participants provided informed consent before enrolment. Participation was voluntary; participants could withdraw at any time without penalty, and no direct personal identifiers were collected.

Funding Statement

The authors received no funding for this work.

Competing Interests

The authors declare that they have no competing interests.

Data-Availability Statement

The anonymised dataset supporting the findings of this study is available from the corresponding author upon reasonable request.

REFERENCES

Bryan, E., Deressa, T. T., Gbetibouo, G. A., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: Options and constraints. Environmental Science & Policy, 12(4), 413–426. https://doi.org/10.1016/j.envsci.2008.11.002

Ceesay, S., Lambarraa-Lehnhardt, F., Ndiaye, M. B. O., Thiaw, D., Sawaneh, M., & Schuler, J. (2025). Farmers' perceptions of the efficacy of current climate risk adaptation and mitigation strategies on agriculture in The Gambia. Land, 14(3), Article 622. https://doi.org/10.3390/land14030622

Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change, 19(2), 248–255. https://doi.org/10.1016/j.gloenvcha.2009.01.002

Food and Agriculture Organization of the United Nations. (2008). An introduction to the basic concepts of food security. FAO. https://www.fao.org/4/Al936e/Al936e00.pdf .

Food and Agriculture Organization of the United Nations. (2017). Climate-smart agriculture sourcebook (2nd ed.). https://openknowledge.fao.org/handle/20.500.14283/i7994en

Food and Agriculture Organization of the United Nations. (2018). Climate-smart agriculture in The Gambia: CSA country profiles for Africa series. FAO. https://reliefweb.int/report/gambia/climate-smart-agriculture-gambia

Food and Agriculture Organization of the United Nations. (2023). The state of food and agriculture 2023: Revealing the true cost of food to transform agrifood systems. Author. https://doi.org/10.4060/cc7724en

Government of The Gambia. (2021). The Gambia updated its nationally determined contribution. United Nations Framework Convention on Climate Change. https://unfccc.int/NDCREG

Intergovernmental Panel on Climate Change. (2021). Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://doi.org/10.1017/9781009157896

Intergovernmental Panel on Climate Change. (2022). Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://doi.org/10.1017/9781009325844

Lambarraa-Lehnhardt, F., Ceesay, S., Ndiaye, M. B. O., Thiaw, D., & Sawaneh, M. (2024). Climate risk perception and adaptation strategies of smallholder farmers in The Gambia. Discover Sustainability, 5(1), Article 506. https://doi.org/10.1007/s43621-024-00755-2

Limantol, A. M., Keith, B. E., Azabre, B. A., & Lennartz, B. (2016). Farmers' perception and adaptation practices to climate variability and change: A case study of the Vea catchment in Ghana. SpringerPlus, 5, Article 830. https://doi.org/10.1186/s40064-016-2433-9

United Nations Framework Convention on Climate Change. (2015). Paris Agreement. https://unfccc.int/sites/default/files/english_paris_agreement.pdf

World Bank Group. (2021). Climate risk country profile: The Gambia. https://climateknowledgeportal.worldbank.org/country/gambia

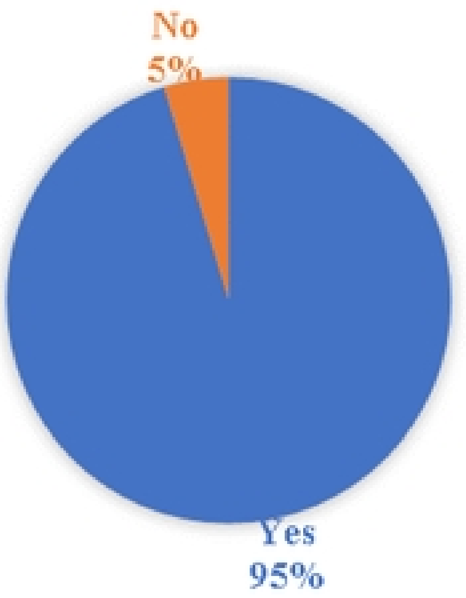

Figure 1. Respondents' reported observations of changes in local climate patterns.

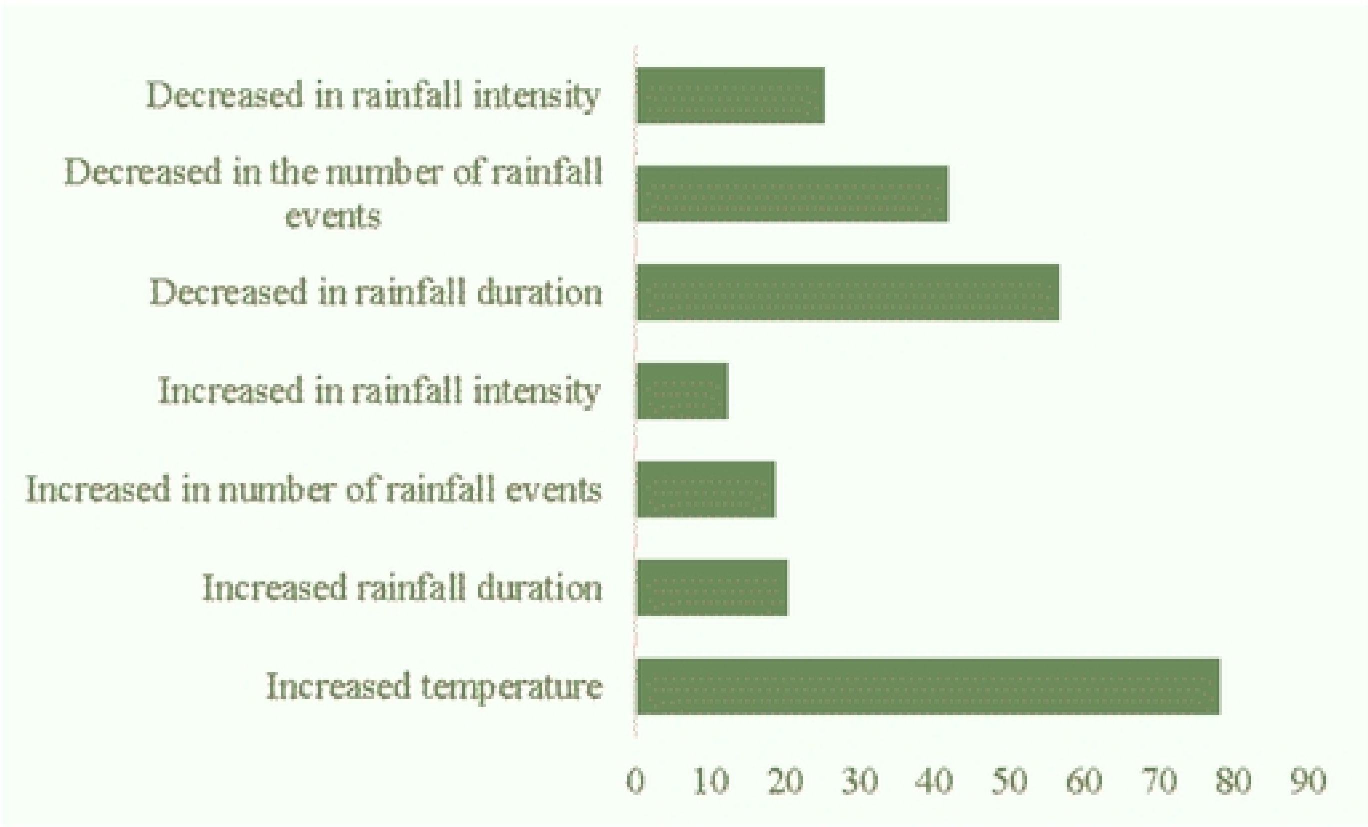

Figure 2. Perceived changes in local climate conditions reported by crop farmers.

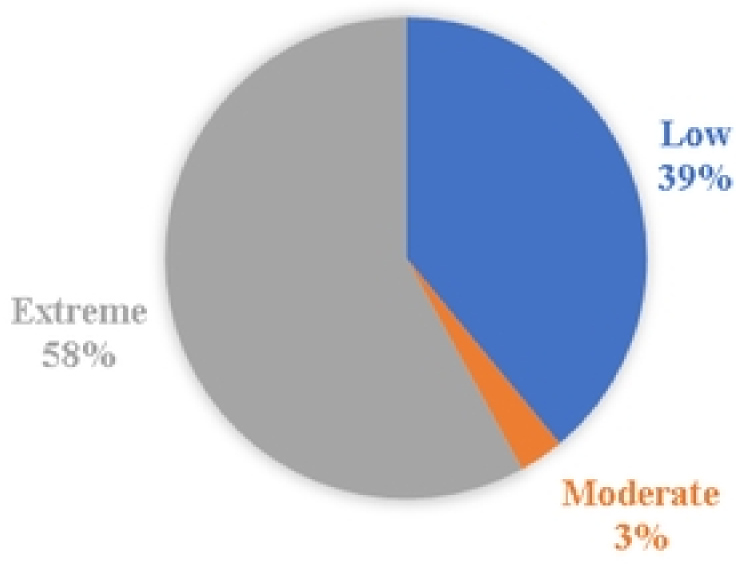

Figure 3. Respondents' perceived extent of climate change.

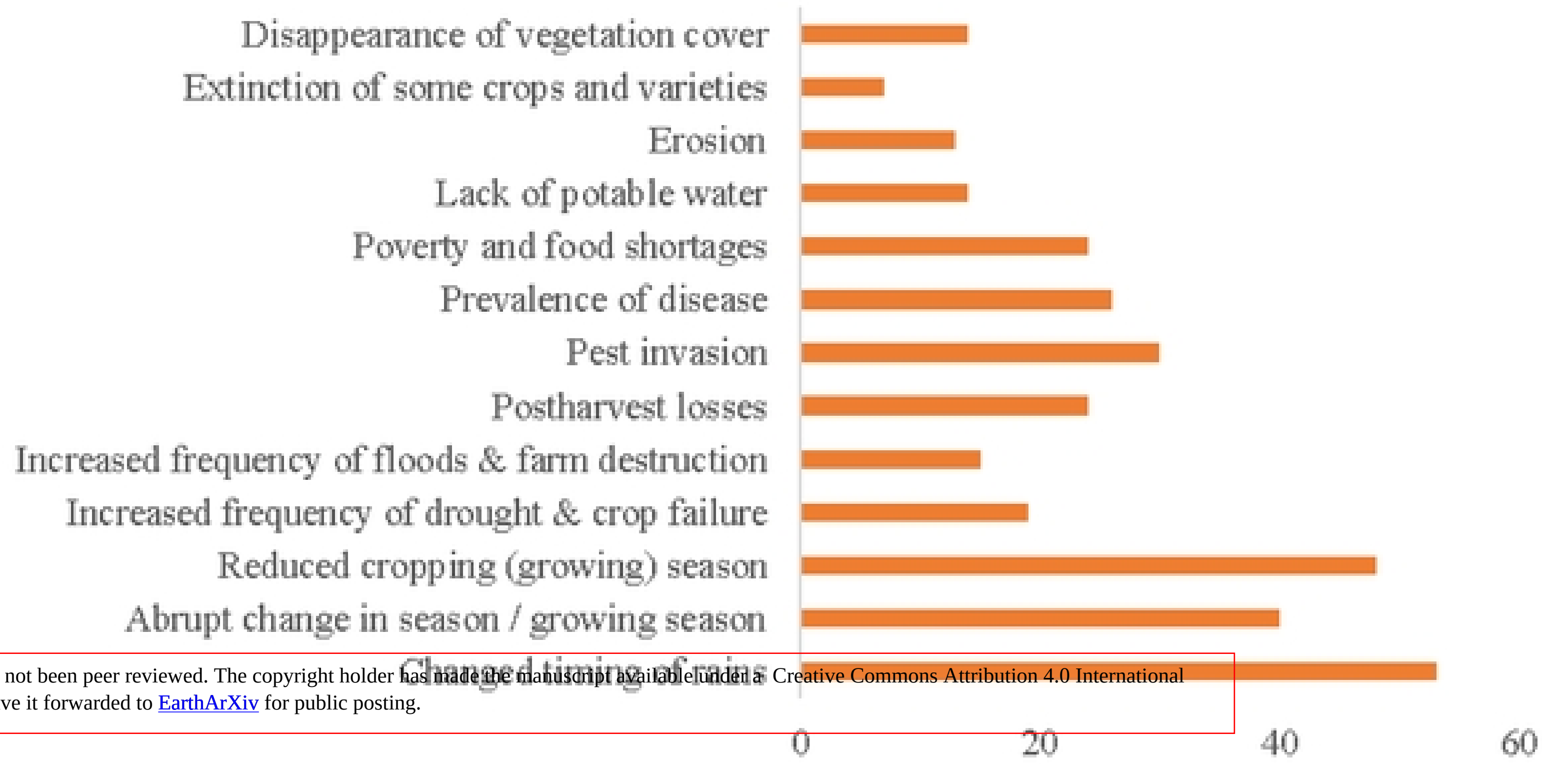

Figure 4. Perceived impacts of climate change reported by crop farmers.

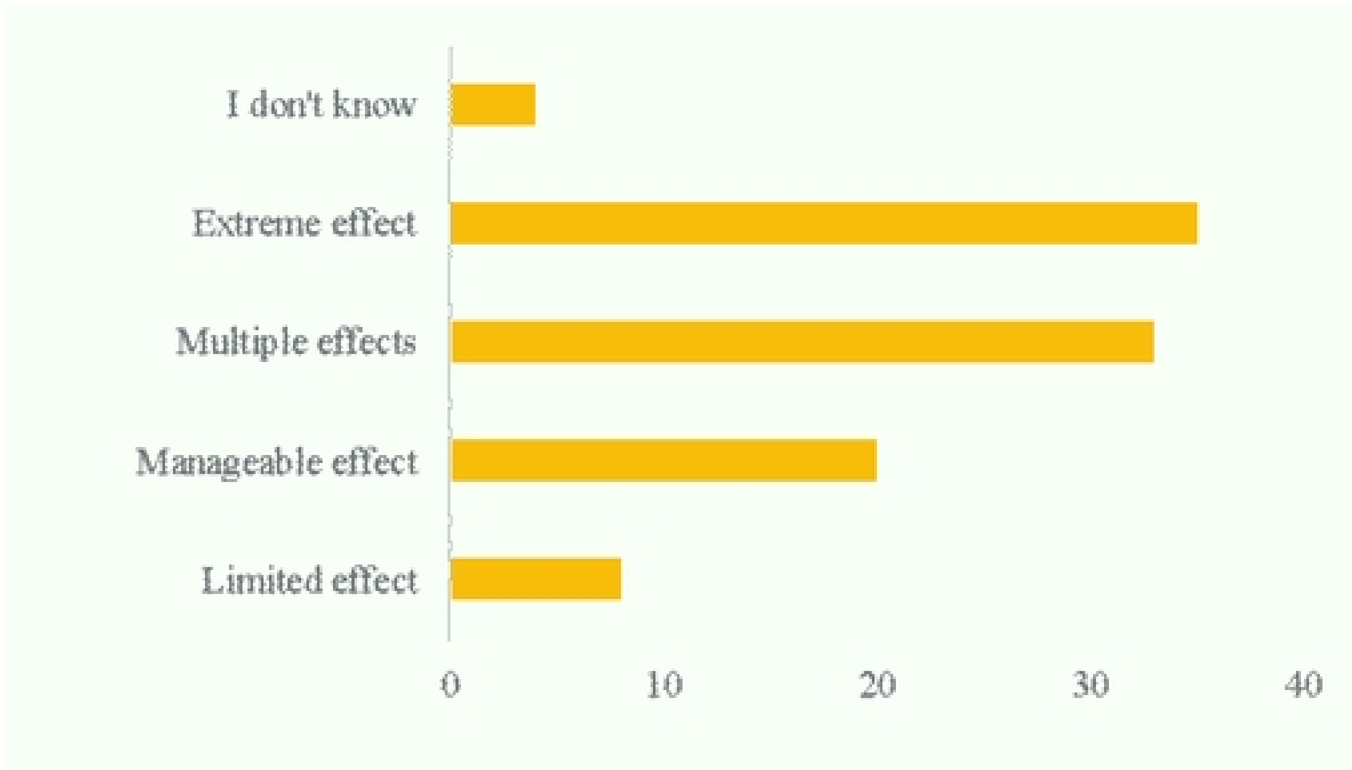

Figure 5. Respondents perceived the severity of climate-change impacts.

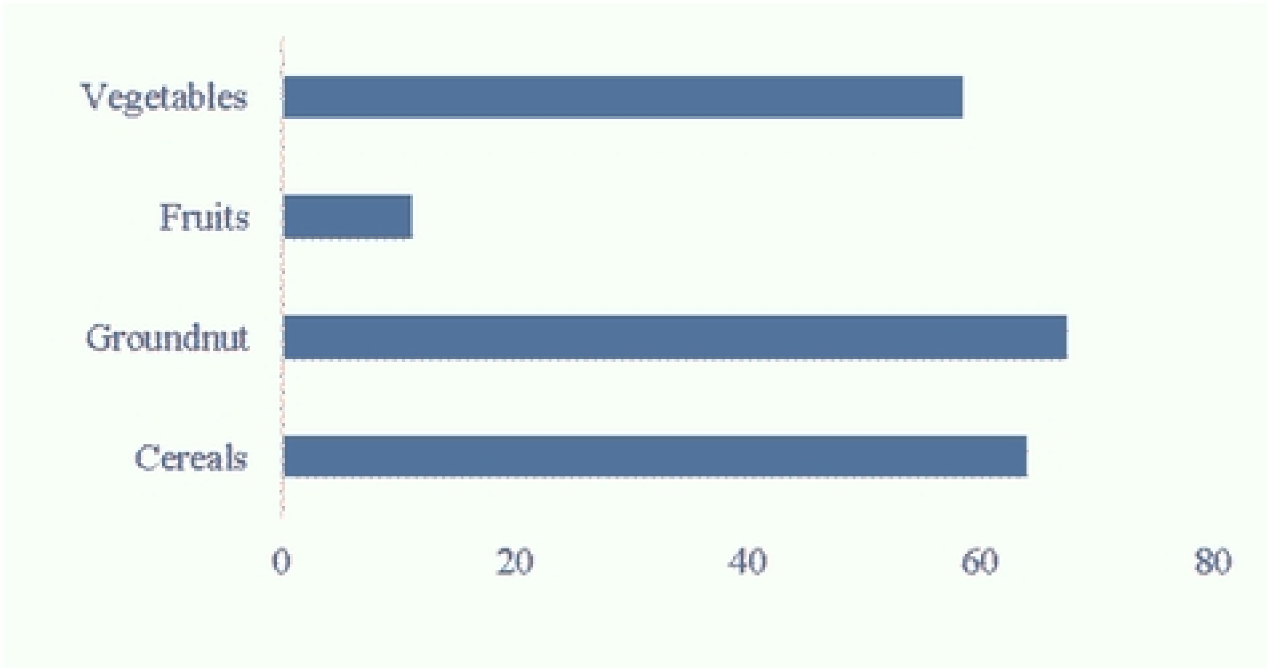

Figure 6. Types of crops cultivated by respondents.

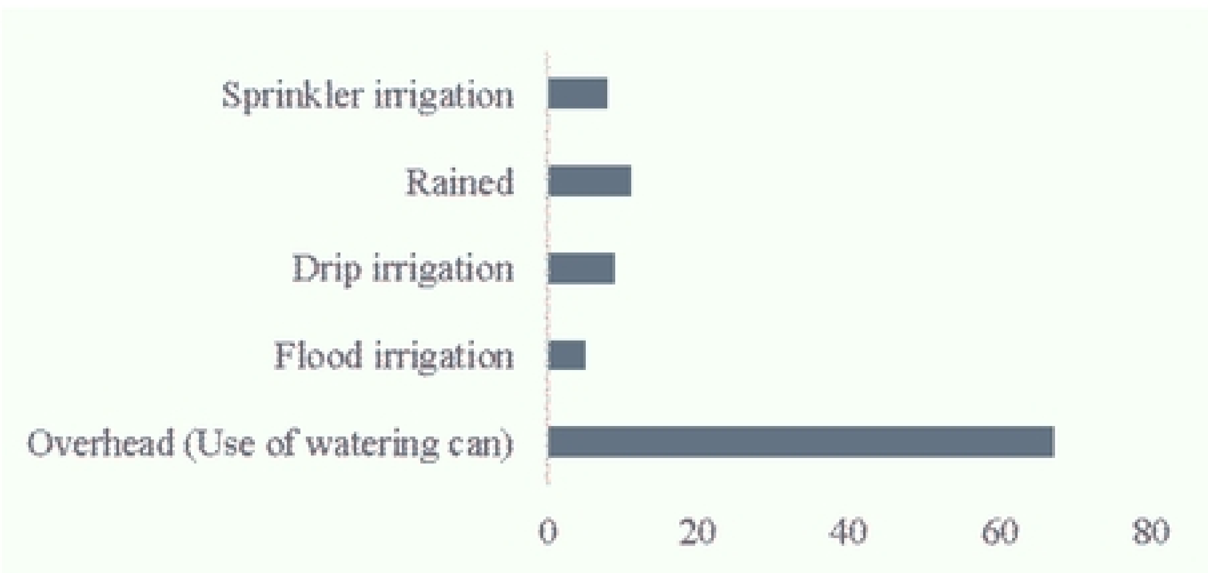

Figure 7. Use of irrigation for crop production among respondents

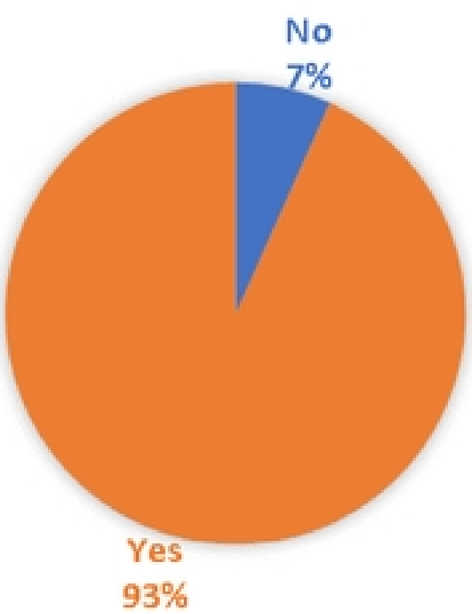

Figure 8. Respondents reported pest invasion and/or crop disease during production.

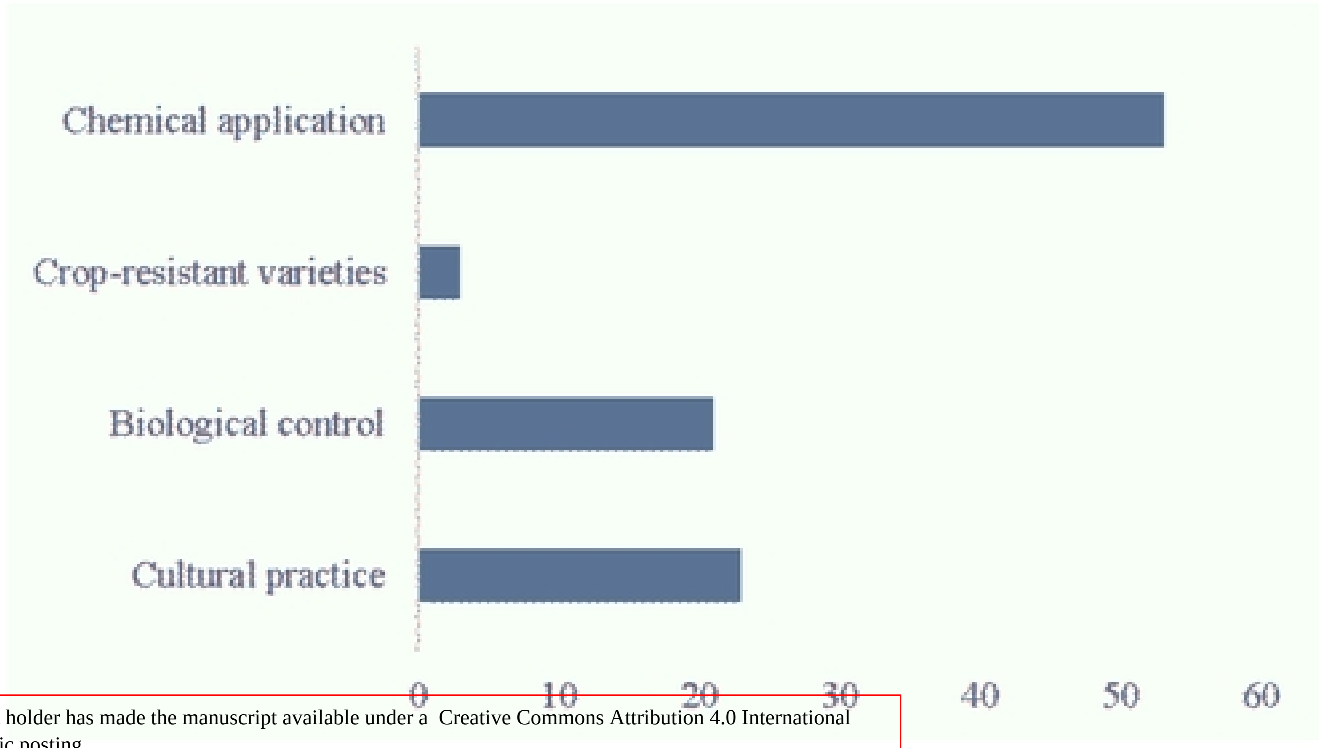

Figure 9. Pest and disease control methods reported by crop farmers.

Figure 10. Respondents' familiarity with climate-smart farming practices.

Figure 11. Adoption of climate-change adaptation practices among respondents.

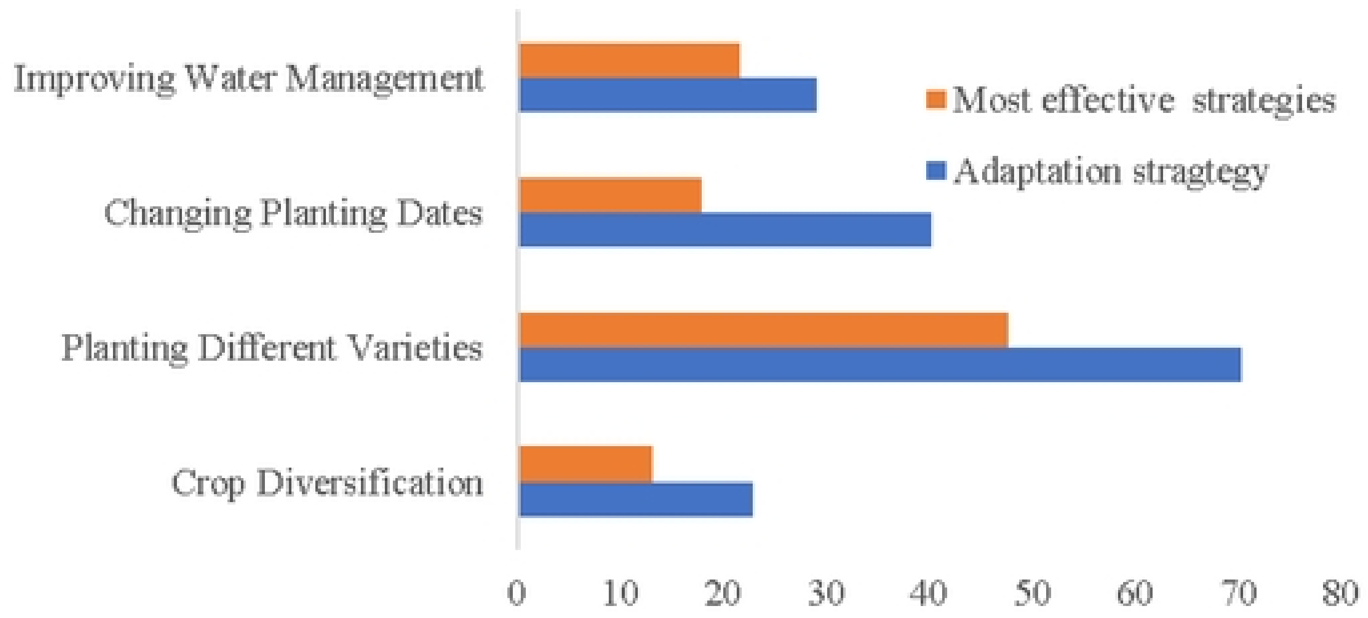

Figure 12. Adaptation strategies adopted and their perceived effectiveness by respondents.

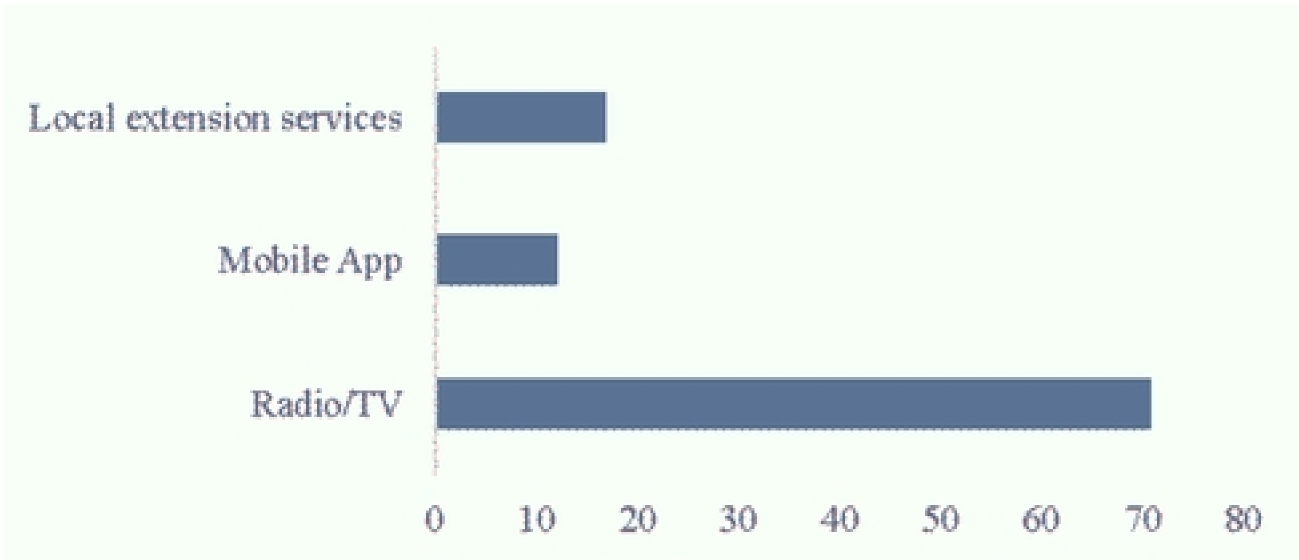

Figure 13. Main sources of weather forecasts and climate-related information.

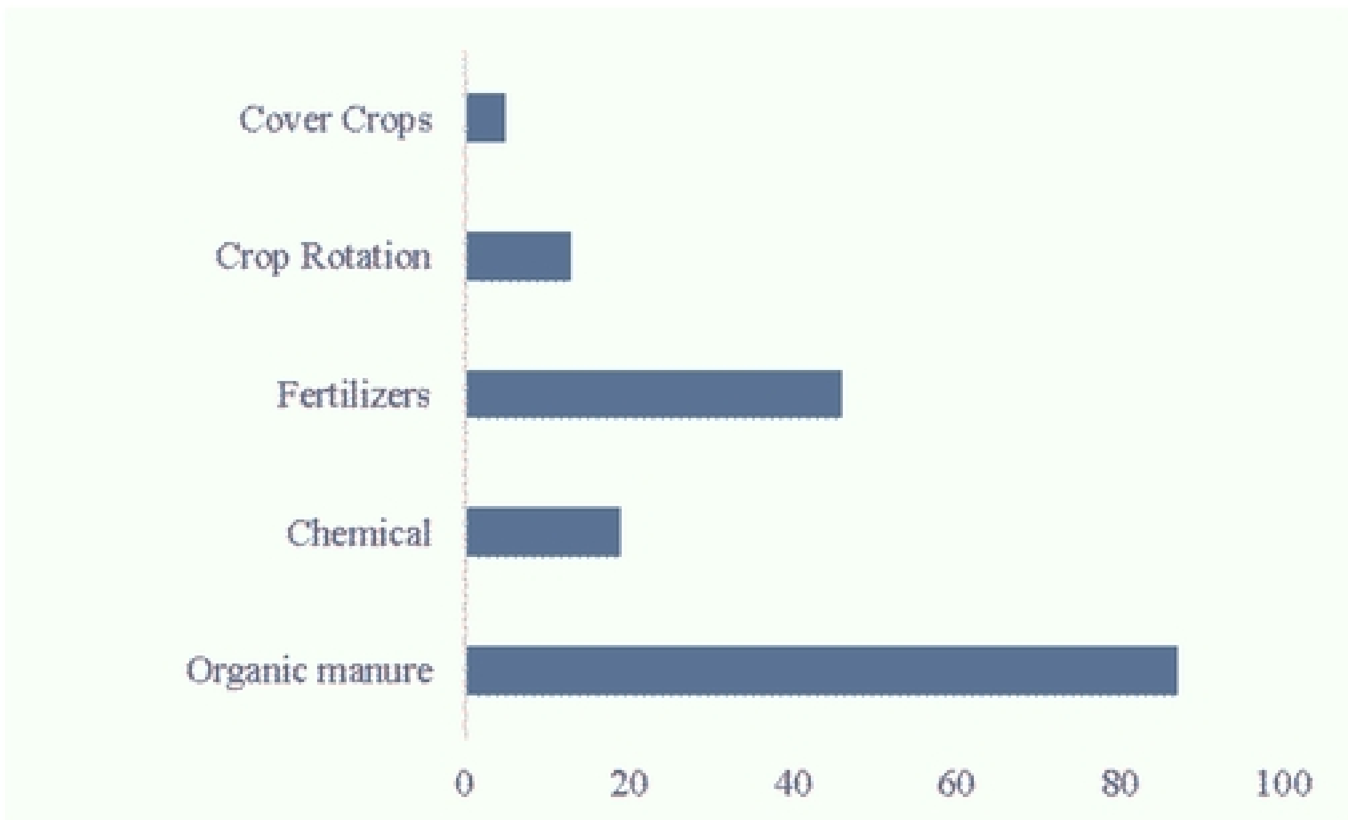

Figure 14. Soil management method.