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Article

Determinants of Information Needs on Climate-Smart Agriculture Among Male and Female Farmers Across Farming Systems and Agroecological Zones in Sierra Leone: Implications for Anticipatory Actions

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Abstract: This study explores the determinants of information needed on climate-smart agriculture among male and female farmers across farming systems and agroecological zones in Sierra Leone and the implications for anticipatory actions on the basis of espousing the differences in their susceptibilities and coping mechanisms in order to improve their resilience. Eight hundred and sixty-five households were randomly selected from a sampling frame of one million households generated through house listing in twenty-one villages in Sierra Leone. In addition to secondary weather data, primary data were collected with a structured questionnaire covering climate-smart agriculture practices and analyzed using frequencies, percentages, t-test, trend analysis, Probit regression, and relationship maps to enhance data visualization. The results show that a differential in information needs exists between male and female farmers with female farmers having the highest information need. The determinants of information need are agroecological zone, age, education, marital status, household size, number of children below 18 years, household status, length of stay, farming experience, farming system, adoption, and constraints were significant determinants. From the trend analysis, it was inferred that information needs unmet have a high propensity to transform into anticipatory actions of emergencies and humanitarian crises.

Keywords: information need; anticipatory actions; gender; climate-smart; farming systems; agroecological zones

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1. Introduction

Information is a vital tool for empowerment, making decisions for development, and ascertaining readiness and preparedness for incidences of risks. Agricultural production is enhanced through information by creating awareness, knowledge, and skill (Anmol et al., 2021), all activities across the value-chain for efficient management through changing scenes of operations. The utility of information is often correlated to its influence on profitability, thus limited access to information and technical knowledge constitutes a major barrier to the effective management of agricultural risks (Skaalsveen et al., 2020). Information is crucial to the effective management of agricultural risks (McKune et al., 2018), making adoption decisions (Mulwa et al., 2017), increased resilience (Blazquez-Soriano & Ramos-Sandoval, 2022), adaptation and mitigation Ponce (2020), improved capacity (Intergovernmental Panel on Climate Change [IPCC], 2019), decision-making (Antwi-Agyei et al., 2021).

Climate information services have been leading to an increase in adaptation strategies for climate change, specifically, weather variability (Djido et al., 2021), productivity enhancement, and livelihood protection (Alidu et al., 2022). The application and use of information in response to risks through anticipatory actions are changing the landscape of its utility, importance, and worthiness. Anticipatory actions help in the reduction, mitigation, and enhancement of impacts of disaster and post-disaster response, through the early warning systems (Wilkinson et al., 2020). Farmers are simultaneously exposed to multiple risks and thus need access to diverse information along the production cycles of their enterprises (Korell et al., 2020).

Information Needs Among Farmers

The diversity of farmers' information needs extends to the contents (Amah et al., 2021); typologies and message adequacy; alignment to users' needs (Kumar et al., 2020); and preferred sources and channels of information (Mottaleb et al., 2017). The majority of research on information needs focused on production and market risks (Komarek et al., 2020), to the neglect of the adequacy of measures required by end-users (Nwafor et al., 2020) specific information for different stages of the value chain (Diemer et al., 2021) and emerging needs (Chen & Lu, 2020). Farmers' vulnerability is related to agricultural risks, resilience capacity, and perceived consistency of meteorological data (Rapholo & Diko-Makia, 2020), and farmers' perceptions expressed as information need can serve as an important input into the adaptation and anticipatory planning for specific contexts (Ankrah et al., 2023). Several authors have affirmed that gender-gaps exist in relation to resources and opportunities and the gap gets widened due to the effects of climate change leading to differences in the climate information needs between men and women (Diiro et al., 2016), agro-advisory knowledge (Ngigi & Muange, 2022), adaptation strategies (Ouedraogo et al., 2018), and households' roles and responsibilities (Ngigi et al., 2016). Partey et al. (2020) reported the need for climate information services is gender-neutral, while Adzawla et al. (2020) indicated that although males had higher adaptive capacity than females; the livelihoods of females suffered more impacts than males in Ghana. This study explores the research question on what are there differential determinants of information needs of male and female farmers across farming systems and agroecological zones of Sierra Leone. In the context of Sierra Leone, there have not been any studies on information needs underlying the information-seeking behavior, and the choice of mode of access to the best of our knowledge. The concept of information need is operationalized in this study as a gap between what is and what ought to be to facilitate effective decision-making (Case & Given, 2016). This study focuses on Sierra Leone because it is one of the countries with the highest impacts of climate change (IPCC, 2019). The objective of this study is to analyse the determinants of information needs on climate-smart agriculture among male and female farmers across farming systems and agroecological zones in Sierra Leone and their implications for anticipatory actions.

2. Materials and Methods

The study was carried out in Sierra Leone which is bordered by Guinea, Liberia, and the Atlantic Ocean on the north, east, south, and west respectively (Sierra Leone Agricultural Research Institute [SLARI], 2011). Sierra Leone has four (4) agroecological zones (AEZs) and sixteen (16) districts (SLARI, 2017). The AEZs overlapped into 3–4 districts, so the AEZs are not mutually exclusive of the districts. Food production and other activities from agriculture form the most important contributor to the economy of Sierra Leone (Statistics Sierra Leone, 2017; Bryan et al., 2017). The study covered 7 districts including Kailahun, Bo, Bonthe, Moyamba, Kambia, Koinadugu, and, Western Rural District, across the five administrative provinces namely Eastern, Southern, Northern, North-Eastern, Western Areas of Sierra Leone.

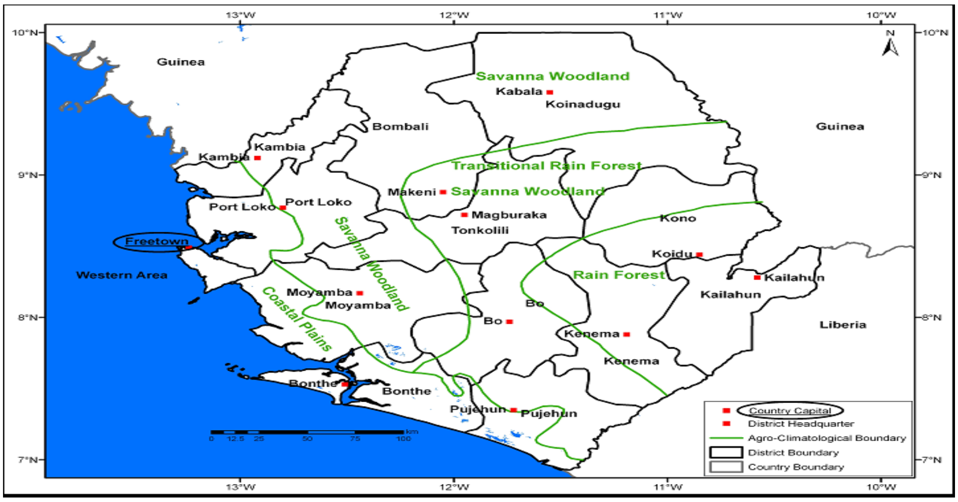

Figure 1. Map of Sierra Leone showing the agroecological zones.

Source: SLARI (2011) Strategic Plan, 2012−2021.

This study used an expo facto design approach (Kerlinger & Lee, 2000), where smallholder farmers across the different agroecological zones and practicing various farming systems in Sierra

Leone constituted the study population. From each of the agroecological zones, districts that are predominantly reflective of the zones were purposively selected. The selected districts are Kailahun, Bo, Bonthe, Moyamba, Kambia, Koinadugu, and Western Rural. Rao Soft sample size calculator was used to obtain sample size from each of the districts with 160, 110, 50, 110, 150, 130, 5, and 150 respectively from the districts. Data were collected through structured questionnaires earlier subjected to face validity of experts in agricultural extension and climate-smart agriculture and recorded a reliability coefficient of 0.87 using a split-half technique. The questionnaire assessed respondents' levels of information needs disaggregated by male and female. Data were analyzed as a reference group. Ethics approval was granted by the committee of the School of Agriculture, Njala University, Sierra Leone. Data were analyzed using percentages and probit regression.

For the probit models, farmers choose from two alternatives of needs or not as expressed by Nagler (1994). The model is appropriate since it can overcome heteroscedasticity and satisfies the assumption of cumulative normal probability distribution (Gujarati, 2004).
It is assumed that Y can be specified as follows:

$$Y = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_{ki} X_{ki} + U_1 \quad (1)$$

And that:

$$Yi = 1\, if\ Y > 0$$
$$Yi = 0 \quad (2)$$

Otherwise, Where $X_1, X_2 \ldots X_n$ represents a vector of random variables, β represents a vector of unknown parameters and U represents random disturbance terms (Nagler, 1994). Table 1 presents the list and level of measurements of variables in the Probit model.

t-test analysis

t-test analysis is applied to assess statistical differences for the means of two groups thus comparing the mean score of socio-economic, information needs, and climate-smart agriculture practices of male and female farmers.

The equation used was as follows:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{N_1}} + \sqrt{\frac{S_2^2}{N_2}}} \quad (3)$$

(Koutsoyiannis, 1977)

Where

X_1 = socio-economic, information needs, and climate-smart agriculture practices of male farmers
X_2 = socio-economic, information needs, and climate-smart agriculture practices of female farmers
S_1^2 = variance of X_1
S_2^2 = variance of X_2
N_1 = number of male farmers
N_2 = number of female farmers

Table 1. Description of variables in the study.

Variables	Description
Agroecological zone	Dummy =1 if rain forest, 0 otherwise
Age	Age in years
Education	Dummy =1 formal education, 0 otherwise
Marital Status	Dummy =1 if married, 0 otherwise
Household size	Number of persons (total)
Dependent Below18	Number of persons below 18 years
Household head status	Dummy =1 if male, 0 otherwise
Length of stay	Length of residence in years
Farming Experience	Farming experience in years
Farming System	Dummy =1 if crop-based, 0 otherwise
Adoption of climate-smart practice	Dummy =1 if yes, 0 otherwise
Constraints to adoption of climate-smart practice	Constraints score

3. Results

Figure 2 presents the results of the gender-disaggregated trends of rainfall, temperature, awareness, incidence, and information needs from the respondents. The trend patterns are very similar between the meteorological data and farmers' perceptions.

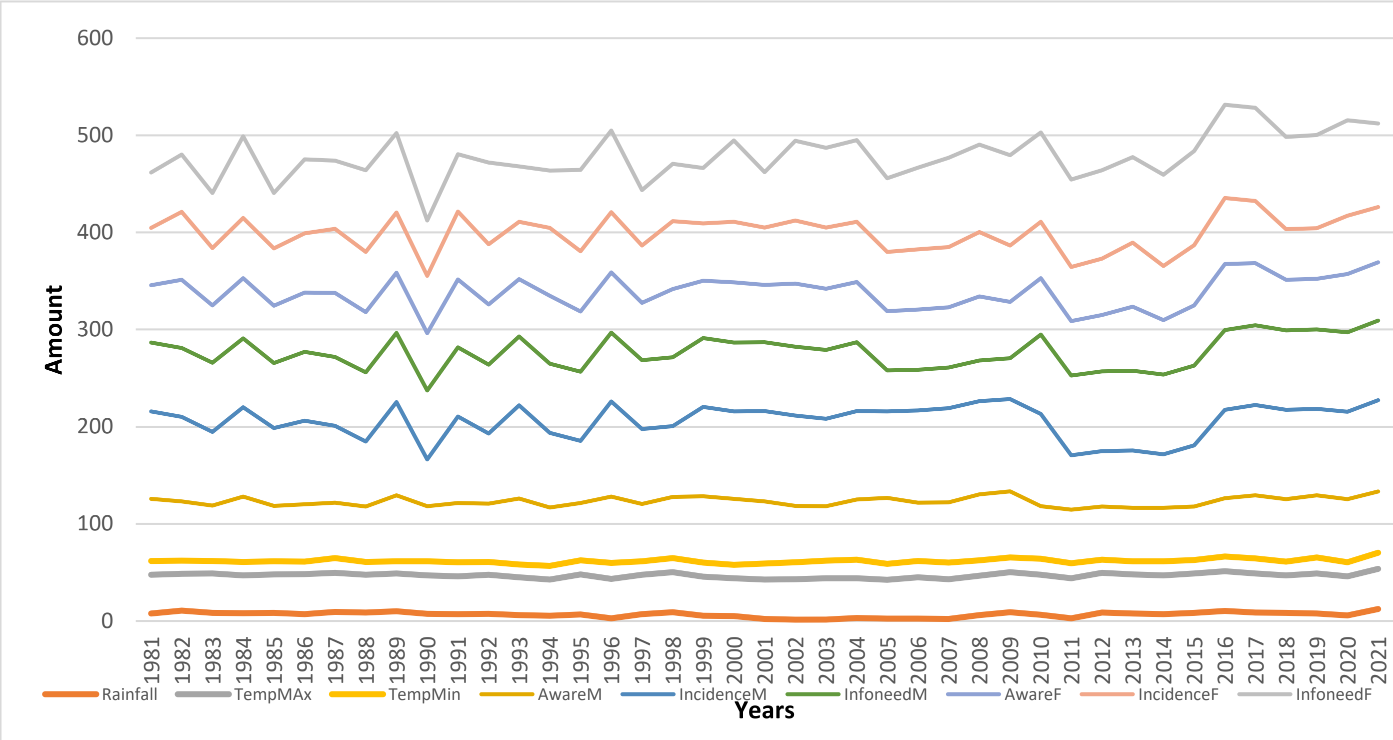

Figure 2. Trends of rainfall, temperature, awareness, incidence, and information need.

Table 2 presents the results on male and female farmers according to information needs on crop-smart practices and their determinants. Twelve crop-smart practices were listed and the results show that 67 % to 69 % of male farmers and 77 % to 79 % of female farmers have high information needs for all practices under crop-smart practices.

Table 2. Male and female farmers according to information needs on crop-smart practices and their determinants.

	Percentage distribution							**Probit regression model of determinants**		
	Male		**Female**		**t-test**			**Male**	**Female**	**Pooled**
Crop-smart practices	Yes	No	Yes	No	t	p	Parameters	Estimate (SE)	Estimate (SE)	Estimate (SE)
Intercropping	421(68.6)	18 (2.9)	197 (78.5)	4 (1.6)	−2.153	.032	AgroZones	.084 (.010)***	.217 (.025)***	.148(.016)***
Crop rotations	418 (68.1)	21 (3.4)	196(78.1)	5(2.0)	−2.095	.037	Age	.014(.001)***	.034(.002)***	−.006(.002)***
Improved crop varieties	420(68.4)	19(3.1)	196(78.1)	5 (2.0)	-2.198	.028	Education	.163(.011)***	.015(.023)	−.267(.021)***
Early maturing crop variety	418(68.1)	21(3.4)	191(76)	10(4)	−2.563	.011	Marital Status	.049(.039)	.073(.040)	.099(.050)
Contingency crop planning	419(68.2)	20(3.3)	191(76)	10(4)	−2.613	.009	HHsize	−.022(.004)***	.050(.008)***	−.029(.006)***
Planting resistant crop varieties	415(67.6)	24(3.9)	190(76)	11(4.4)	−2.506	.013	Below18	.035(.008)***	−.070(.017)***	.109(.010)***
Improved stor. and processing	420(68.4)	19(3.1)	194(77)	7(2.8)	−2.388	.017	HHstatus	.400(.054)***	.318(.048)***	−.638(.067)***
Multiple planting dates	424(69.1)	15(2.4)	194(77)	7(2.8)	−2.593	.010	LoStay	.008(.001)***	−.006(.001)***	−.026(.001)***
Crop diversity	419(68.2)	20(3.3)	196(78)	5(2)	−2.146	.032	Farming Exprienc	−.010(.001)***	−.013(.003)***	.030(.002)***
Use of bio-pesticides/bio-enhancer	423(68.9)	16(2.6)	193(77)	8(3.2)	−2.634	.009	Farming System	−1.716(.088)***	−4.447(.124)***	−1.593(.082)***
Mixed farming	417(67.9)	22(3.6)	193(77)	8(3.2)	−2.330	.020	Adoption	.274(.038)***	.585(.079)	.035(.044)
Creating seed banks	425(69.2)	14(2.3)	194(77)	7(2.8)	−2.645	.008	Constraints	1.420(.130)***	−1.795(.063)***	1.375(.115)***
							Intercept	−5.880 (.364)***	1.782(.292)***	−3.514(.349)***
							Chi-Square	5.087E+15	2.897E+31	1.079E+18
							df	600	238	851
							p	0.00	0.00	0.00

Table 3 presents the results on the percentage distribution of male and female farmers and Probit regression model of determinants of water-smart practices information need. Twelve water-smart practices were listed and the results show that 4 % to 7 % of male farmers and 2.8 % to 5 % of female farmers have high information needs for all practices under crop smart practices.

Table 3. Percentage distribution of male and female farmers and Probit regression model of determinants of water-smart practices information need.

Percentage distribution						
	Male		Female		t-test	
Water-smart practices	Yes	No	Yes	No	t	p
Water harvesting	40(6.5)	459(74.8)	12(4.8)	201(80.1)	−1.592	.112
Mulching	32(5.2)	455(74.1)	9(3.6)	200(80)	−1.646	.100
Cover cropping	33(5.4)	454(73.9)	7(2.8)	202(81)	−1.814	.070
Drip/Farrow−bed irrigation	39(6.4)	448(73.0)	14(5.6)	195(77.7)	−1.494	.136
Drainage management	42(6.8)	445(72.5)	13(5.2)	196(78)	−1.648	.100
Land leveling	30(4.9)	457(74.4)	8(3.2)	201(80)	−1.659	.098
Conservation agriculture	30(4.9)	457(74.4)	8(3.2)	201(80)	−1.659	.098
Contour planting	31(5)	456(74.3)	12(4.8)	197(79)	−1.409	.160
Terraces and bunds	32(5.2)	457(74.4)	12(4.8)	197(79)	−1.327	.185
Planting pits	30(4.9)	459(74.8)	11(4.4)	198(79)	−1.340	.181
Water storage	26(4.2)	475(77.4)	12(4.8)	201(80)	−1.072	.284
Dam, pits, ridges	25(4.1)	464(75.6)	11(4.4)	198(79)	−1.199	.231

Probit regression model of determinants			
	Male	Female	Pooled
Parameters	Estimate (SE)	Estimate (SE)	Estimate (SE)
Agroecological zone	.088 (.014) ***	.204(.023) ***	.137(.012) ***
Age	.025(.001) ***	.024(.003) ***	.017(.001) ***
Education	−.102(.018) ***	−.070(.027) ***	−.105(.015) ***
Marital Status	.337(.058) **	.101(.049) **	.226(.038) ***
HHsize	−.055(.006) ***	.076(.007) ***	−.007(.004) *
Below18	.111(.010) ***	−.005(.017)	.060(.008) ***
HHstatus	−.863(.172) ***	−.040(.052)	−.651(.060) ***
LoStay	.003(.001) ***	.013(.002) ***	.005(.001) ***
Farming Experience	−.006(.002) ***	−.012(.003) ***	−.019(.001) ***
Farming System	−2.129(.051) ***	−2.281(.098) ***	−2.176(.045) ***
adoption	.103(.039) ***	.688(.057) ***	.208(.031) ***
Constraints	.170(.045) ***	.090(.059)	.179(.037) ***
Intercept	−2.297(.273)	−4.210(.296) ***	−2.177(.167) ***
Chi-Square	9.045E+14	6.947E+15	2.346E+15
df	600	238	851
p	0.00	0.00	0.00

The results of the distribution of male and female farmers according to information needs on nutrient-smart practices and their determinants are presented in Table 4. Eleven nutrient-smart practices were listed and the results show that 4.4 % to 65 % of male farmers and 4 % to 67% of female farmers have high information needs for all practices under crop smart practices.

Table 4. Distribution of male and female farmers according to information needs on Nutrient-smart practices and their determinants.

	Percentage distribution						Probit regression model of determinants			
	Male		Female		t-test			Male	Female	Pooled
Nutrient-smart practices	Yes	No	Yes	No	t	p	Parameters	Estimate (SE)	Estimate (SE)	Estimate (SE)
Boundary trees and hedgerows	30(4.9)	398(64.8)	8(4.4)	167(67)	−.430	.667	Agroecological zone	.043(.015) ***	.159(.028) ***	.088(.010) ***
Green manuring	55(9)	363(59.1)	25(10)	133(53)	1.615	.107	Age	.013(.002) ***	.005(.003) *	.022(.001) ***
Integrated soil fertility mangt	42(6.8)	386(62.9)	12(4.8)	166(66)	−.660	.510	Education	−.300(.023) ***	−.081(.027) ***	−.124(.013) ***
Organic fertilizers	40(6.5)	388(63.2)	15(6)	163(65)	−.436	.663	Marital Status	.289(.064) ***	.044(.048)	.611(.028) ***
Green manuring	33(5.4)	395(64.3)	13(5.2)	165(66)	−.385	.700	HHsize	−.057(.006) ***	.032(.009) ***	.024(.003) ***
Nitrogen-fixing trees on farms	35(5.7)	393(64.0)	13(5.2)	165(65.7)	−.433	.665	Below18	.141(.010) ***	−.022(.019)	−.037(.007) ***
Multipurpose trees	38(6.2)	390(63.5)	12(4.8)	166(66)	−.564	.573	HHstatus	−.652(.171) ***	−.099(.050) **	−.788(.062) ***
Imp. fallow fertilizer/shrubs	28(4.6)	400(65.1)	11(4.4)	167(66.5)	−.382	.703	LoStay	−.008(.001) ***	.008(002) ***	.009(.001) ***
Woodlots	27(4.4)	391(63.7)	12(4.8)	146(58)	1.501	.134	Farming Experience	.010(.002) ***	−.011(.003) ***	−.025(.001) ***
Fruit orchards	29(4.7)	389(63.4)	10(4)	148(59)	1.341	.181	Farming System	−2.430(.052) ***	−3.034(.111) ***	−2.327(.046) ***
Organic agriculture/farming	398(64.8)	30(4.9)	169(67.3)	9(3.6)	.023	.981	adoption	.096(.041) **	.294(.053) ***	.084(.024) ***
							Constraints	−.092(.041) **	.189(.055) ***	.279(.027) ***
							Intercept	−.638(.265) **	−1.187(.251) ***	−2.471(.140) ***
							Chi-Square	7.79E+16	8.573E+18	4.597E+16
							df	600	238	851
							p	0.00	0.00	0.00

In Table 5, the results of the percentage distribution of male and female farmers and the Probit regression model of determinants of energy/carbon-smart practices on information needs are presented. Nine crop-smart practices were listed, and the results show that 6 % to 10% of male farmers and 2.8 % to 5.6 % of female farmers have high information needs for all practices under energy/carbon smart practices.

Table 5. Percentage distribution of male and female farmers and Probit regression model of determinants of energy/carbon-smart practices information need.

	Percentage distribution						Probit regression model of determinants			
	Male		Female		t-test			Male	Female	Pooled
Energy/carbon-smart practices	Yes	No	Yes	No	t	P	Parameters	Estimate (SE)	Estimate (SE)	Estimate (SE)
Biogas	46(7.5)	418(68.1)	13(5.2)	144(57)	3.413	<,001	Agroecological zone	−.009(.012)	.274(.023) ***	.149 (.009) ***
Agroforestry	58(9.4)	406(66.1)	14(5.6)	143(57)	3.194	.002	Age	.018(.001) ***	.015(.002) ***	.011(.001) ***
Integrated pest management (IPM)	18(2.9)	469(76.4)	1(0.4)	187(74.5)	.985	.325	Education	.014(.014)	−.023(.025)	−.001(.010)
Biochar	62(10.1)	402(65.5)	14(5.6)	143(57)	3.101	.002	Marital Status	−.104(.046) **	.148(.045) ***	−.121(.030) ***
Solar powered farm implements	46(7.5)	418(68.1)	13(5.2)	144(57)	3.413	<,001	HHsize	−.019(.005) ***	.046(.008) ***	.051(.002) ***
Improved stoves	45(7.3)	419(68.2)	14(5.6)	143(57.0)	3.497	<,001	Below18	.004(.010)	−.038(.016) **	−.036(.005) ***
Reduced tillage	42(6.8)	422(68.7)	13(5.2)	144(57)	3.507	<,001	HHstatus	.314(.069) ***	.179(.048) ***	.180(.028) ***
Carbon trading	42(6.8)	422(68.7)	13(5.2)	144(57)	3.507	<,001	LoStay	.008(.001) ***	.009(.002) ***	.011(.001) ***
Use of renewable energy sources	37(6)	577(94)	7(2.8)	244(97.2)	−2.284	.023	Farming Experience	−.018(.002) ***	−.015(.003) ***	−.020(.001) ***
							Farming System	−1.507(.052) ***	−3.852(.113) ***	−1.921(.045) ***
							adoption	.461(.056) ***	.015(.056)	.003(.029)
							Constraints	0	0	0
							Intercept	−2.980(.191) ***	−.921(.296) ***	−1.883(.120) ***
							Chi-Square	4.515E+9	7.922E+16	9.983E+11
							df	600	238	851
							p	0.00	0.00	0.00

The results on weather-smart agriculture are presented in Table 6, which shows the distribution of male and female farmers according to information needs on weather-smart practices and their determinants. Ten weather-smart practices were listed, and the results show that 5.2 % to 5.9 % of male farmers and 2.4 % to 2.8 % of female farmers have high information needs for all practices under weather-smart practices.

Table 6. Distribution of male and female farmers according to information needs on weather-smart practices and their determinants.

	Percentage distribution						Probit regression model of determinants			
	Male		Female		t-test			Male	Female	Pooled
Weather-smart practices	Yes	No	Yes	No	t	p	Parameters	Estimate (SE)	Estimate (SE)	Estimate (SE)
Weather forecasting	33(5.4)	581(94.6)	7(2.8)	244(97.2)	−1.869	.062	Agroecological zone	−.162(.014)***	.627 (.027)***	.020(.014)
Farm Insurance	36(5.9)	578(94.1)	7(2.8)	244(97.2)	−2.182	.029	Age	.036(.001)***	.060(.003)***	.028(.001)***
Agro-weather advisory services	36(5.9)	578(94.1)	7(2.8)	244(97.2)	−2.182	.029	Education	−.173(.017)***	−.090(.030)***	−.292(.020)***
Climate housing	34(5.5)	580(94.5)	7(2.8)	244(97.2)	−1.975	.049	Marital Status	.138(.052)***	.603(.050)***	.503(.035)***
Climate data, maps and atlas	33(5.4)	581(94.6)	7(2.8)	244(97.2)	−1.869	.062	HHsize	−.116(.006)***	.060(.009)***	−.015(.005)***
Early weather warning systems	36(5.9)	578(94.1)	7(2.8)	244(97.2)	−2.182	.029	Below18	.211(.010)***	−.083(.019)***	.041(.010)***
Agro-ecological maps	32(5.2)	582(94.8)	7(2.8)	244(97.2)	−1.762	.079	HHstatus	−.519(.163)***	.526(.053)***	−.638(.064)***
Agrometeorological Bulletins	33(5.4)	581(94.6)	6(2.4)	245(97.6)	−2.247	.025	LoStay	.016(.001)***	−.001(.002)	.004(.001)***
Seasonal climate forecasting	32(5.2)	582(94.8)	7(2.8)	244(97.2)	−1.762	.079	Farming Experience	−.018(.002)***	−.045(.003)***	−.017(.002)***
Agrometeorological advisories services	425(69.2)	14(2.3)	194(77)	7(2.8)	−2.645	.008	Farming System	−.504(.034)***	−.867(.070)***	−.409(.032)***
							adoption	−.563(.035)***	.418(.057)***	−.337(.034)***
							Constraints	.184(.038)***	.087(.054)	.096(.036)***
							Intercept	−2.913(.241)***	−8.392(.285)***	−3.606(.165)***
							Chi-Square	2.001E+11	4.152E+11	3.171E+7
							df	600	238	851
							p	0.00	0.00	0.00

Figure 3 shows the results of the relationship map exploring data visualization to describe the interactions among gender and information needed for crop-smart, nutrient-smart, energy/carbon-smart water-smart, and weather-smart. The total scores on the information need score rating scale were obtained for each of the climate-smart practices as well as the information needed. The total scores were further categorized into high and low, using the mean scores, and the relationship map was plotted. In the map, based on the interpretation of data visualization, the thickness of the lines, and the size of the circles represent the magnitude of the relationship and the number of respondents in each linkage, such that the thicker the lines and bigger the circles the higher the proportion of respondents that have indicated the magnitude of the effects. Similarly, color codes for the different variables enhance the readability and the manifestations of features associated with such variables. Berry (2018) reveals that relationship mapping shows patterns and the likelihood of their occurrence for exploring new patterns and hypothesis exploration without implying causation. International Business Machines (2021) stated that relationship maps show through visual representation the relationships, influence, and connections among variables using the nodes, and links to show strength of influence between nodes.

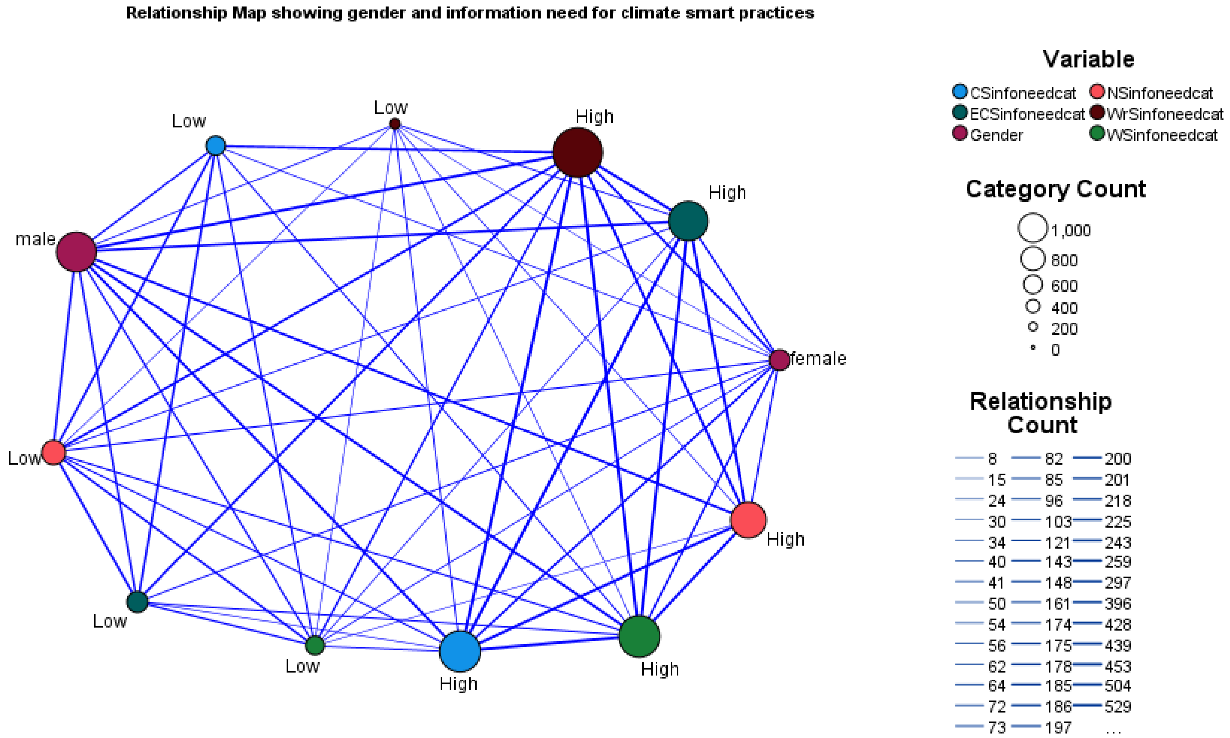

Figure 3. Relationship map showing gender and information needs for climate-smart practices.

4. Discussions

In Figure 2, the perceptions of awareness, incidence, and information need were more pronounced between 2011 and 2017 than what the patterns from meteorological data revealed. This may be due to the fact that the intensity of the consequences of the climatic variability was so strong among farmers. Simelton et al. (2013) reported that farmers observed high variability in the inter-yearly timing of rain onsets, dry days, volume of rainfall, and rainfall cessation to be different from recorded meteorological data. The meteorological data similarly proved otherwise, although farmers reported decreasing rainfall, sunshine, maximum, and minimum temperature from 2009 to 2018 in southern Ghana. Hubertus et al. (2023) found that farmers' perception of increasing unreliability of short and long rainfall seasons, delayed beginning, and earlier stoppage, high rainfall intensity, and unstable pattern of rainfall and droughts, partially disagree with meteorological data. According to Balasha et al. (2023), farmers' perceptions and local historical climate data were consistent; while Nduwayezu et al. (2023) found that the perception of farmers from different elevations matched the Weather data in terms of increasing rainfall and decreasing temperature. The trend of these findings affirms the report of Omasaki and Mokoro (2023) that farmers with limited information on climate variations have high information needs, and a high propensity to perceive changes in weather patterns.

The results in Table 2 may be attributed to the fact that a high proportion of male and female farmers engage in crop production activities and may not be aware of crop-smart practices. Bai et al. (2022) reported that smallholder crop farmers in Sierra Leone required information on suitable crop varieties, pest and disease management, soil conservation, and water management. Kansiime et al. (2021) reported that men and young people meet their information needs by exploring a diversity of information sources than women and elderly people. Similarly, the results of the t-test show significant differences between male and female farmers across the 12 practices. According to Gebre et al. (2019) and Oduniyi and Tekana (2021), male and female farmers experience different levels of access to inputs and information acquisition. Nadeeshani Silva (2022) noted that information availability is ranked as an important factor than cultural proximity for information access among farmers in Sri Lanka. The determinants of information needs on crop-smart techniques among male and female farmers, as well as the pooled data are agroecological zone, age, education, household size, number of children below 18 years, household status, length of stay, farming experience, farming system, adoption, and constraints. Marital status was not significant either for male or female farmers as well as the pooled data. Kosoe and Ahmed (2022) reported factors influencing information needs to include gender, education level, Mamun et al. (2021) indicated agroecological zones, land tenure systems, religion; Myeni and Moeletsi (2020) noted marital status, access to credit, access to extension services, and Kassa and Abdi (2022) stated education, household size, income, climate change perception, and farmland size.

The findings in Table 3 may be attributed to the fact that a high proportion of male and female farmers do not engage in water-smart activities and may not be aware of water-smart practices. Smallholder farmers in Sierra Leone require information for climate-resilient production systems (Bai et al., 2022); targeting information to various gender and age categories (Kansiime et al., 2021). The t-test results show that significant differences between male and female farmers were recorded for 3 techniques namely cover cropping, land leveling, and conservation, while no significant differences were recorded for other techniques. Nadeeshani Silva (2022) found that agricultural instructors and neighbors are the most trusted and reliable sources of information among farmers; and a negative but significant relationship between gender and information needs (Addison et al., 2018; Namonje-Kapembwa & Chapoto, 2016). The results of the probit regression analysis on the determinants of information needs on water-smart techniques among male and female farmers, as well as the pooled data show that agroecological zone, age, education, marital status, household size, number of children below 18 years, household status, length of stay, farming experience, farming system, adoption and constraints were significant determinants. Information needs have been reported to be influenced by climate and ecological settings, access to extension services, farming systems, market, knowledge, awareness, and skills, (Nyang'au et al., 2021; Dhehibi et al., 2022).

The findings in Table 4 may be attributed to the fact that organic farming is the most popular technique among all the nutrient-smart practices. Several reports suggest that meeting the information needs and removing information mismatches enhance higher adaptation (Djido et al., 2021; Yegbemey et al., 2021; Kumar et al., 2020). Similarly, the results of the t-test show no significant differences between male and female farmers across the eleven practices. Freeman and Qin (2020) noted that low acquisition of agricultural information leads to poor adoption of improved inputs and technologies. The determinants of information needs on nutrient-smart techniques among male and female farmers, as well as the pooled data, are agroecological zone, education, household size, length of stay, and farming experience. According to Serote et al. (2023), information need is influenced by contact with extension and advisory services; agricultural information access (Kelil et al., 2020), information awareness and understanding (Elia, 2017), information source (Colussi et al., 2022), farming systems and household size (Akano et al., 2023).

The findings in Table 5, energy-smart is one of the categories of climate-smart agriculture that reduces greenhouse gas emissions; soil carbon sequestration; and crop resilience (Taneja et al., 2014). Similarly, the results of the t-test show significant differences between male and female farmers across the nine practices except for integrated pest management. Zhang et al. (2016) stated that differences exist between male and female farmers in relation to agricultural information. The determinant of information needs on energy/carbon-smart techniques among male and female farmers, as well as the pooled data are agroecological zone, age, education, household size, number of children below 18 years, household status, length of stay, farming experience, farming system, adoption, and constraints. Khatri-Chhetri et al. (2017) found that factors influencing information needs include technologies and their cost of implementation. Omodara et al. (2023) and (Musafiri et al., 2020) reported similar findings in Nigeria and Zimbabwe respectively.

In Table 6, the results may be attributed to the fact that there is a high level of awareness of the roles weather information plays in helping farmers adapt to climate change a high proportion of male and female farmers engage in crop production activities and may not be aware of crop-smart practices. The depiction of climate change as an existential threat to livelihoods has stressed the need for adequate information and timely training on climate change (Olorunfemi et al., 2020). Similarly, the results of the t-test show significant differences between male and female farmers across the 10 practices although mostly at a 10% significance level. Ajadi et al. (2015) and Dhehibi et al. (2022) found that culture manifests through gender in terms of access to information and decision-making. The determinants of information needed on crop-smart techniques among male and female farmers, as well as the pooled data are agroecological zone, age, education, household size, number of children below years, household status, length of stay, farming experience, farming system, adoption and constraints. The correlates of information needs are social networks and information, finance and extension services, inputs and market linkages (International Fund for Agricultural Development, 2018), information, extension services, and market opportunities (Kargbo et al., 2023); weather information, extension services, credit, social networks, and community-based organizations (Muyanga et al., 2022; Nhemachena et al., 2020), access to, land tenure security, access to finance, household size, and education level (Haregewoin et al., 2020) access to credit, market information, and technical assistance, access to inputs, credit, and extension services, (International Fund for Agricultural Development, 2018) and access to training and technical assistance (Iiyama et al., 2014).

Figure 3 shows that most thick lines are linked to male farmers, while most thin lines are linked to female farmers. This implies that more female farmers have higher information needs than their male counterparts on crop-smart, nutrient-smart, energy/carbon-smart, water-smart, and weather-smart. Haque et al. (2023) and Ge et al. (2023) noted that socioeconomic characteristics and, access to agricultural extension influence gender and climate change perception. The results show that weather information need has the highest number of thick lines connected to other variables. This may be associated with the fact that weather information is believed to have overarching effects and impacts on adaptation. Matere et al. (2023) found that farmers accessed weather forecasts and agrometeorological advisories. Similarly, high information needs are depicted by big circles are much bigger than the low information needs that were represented by small circles.

Implications for Anticipatory Actions

The effects of the cumulative duration, magnitude, frequency, and severity of climate-related hazards have manifested in different forms of disasters and poor progress toward the achievement of sustainable development goals. The novelty of this study is the extrapolation of the links between information needs and anticipatory actions. There is therefore a need for a comprehensive, systemic perspective on risks and underlying causes (United Nations Office for Disaster Risk Reduction, 2022). Information need is a precursor to anticipatory actions and disaster risks due to the fact that risk assessments for complex risks often rely on information in various forms and formats on the hazard, exposure, and vulnerability. The information needs would serve as inputs into data for risk identification and analysis (Zebisch et al., 2021), which will enhance anticipatory adaptation to potential risks (Association of Southeast Asian Nations, 2022) in terms of information, planning, and priority setting (Blazquez-Soriano & Ramos-Sandoval, 2022) and thus the capacity for anticipatory actions are situated within the adaptation-mitigation continuum (de la Poterie et al., 2023). The anticipatory action continuum consists of early warning and action space, forecast-based financing-early action gaps, and livelihood protection. The gaps in effective recognition of information needs often transform into a disaster that requires anticipatory actions. Across the landscape of development activities, anticipatory actions have activated reactive programming where adaptation actions are responsive rather than proactive programming that builds on preparedness to potential shocks (Levine et al., 2020). The usefulness of risk assessment depends on the determination of information needs and its correlates to prevent climate-related hazards and ensure that future development pathways do not create new risks.

5. Conclusions

The findings from this paper have added to the literature through large-scale evidence of the Determinants of information need on climate-smart agriculture among male and female farmers across farming systems and agroecological zones in Sierra Leone: Implications for anticipatory actions. Male and female farmers' information need was specifically compared on indicators of crop, water, nutrient, energy/carbon, and weather-smart agricultural practices. A differential exists in information needs exists between male and female farmers with female farmers having the highest information need. The determinants of information need are agroecological zone, age, education, marital status, household size, number of children below 18 years, household status, length of stay, farming experience, farming system, adoption, and constraints were significant determinants. It can be inferred from the findings that information need is a precursor to anticipatory actions and disaster risks due to the fact that risk assessments for complex risks often rely on information in various forms and formats on the hazard, exposure, and vulnerability. The usefulness of risk assessment depends on the determination of information needs and its correlates to prevent climate-related hazards and ensure that future development pathways do not create new risks. The trend patterns are very similar between the meteorological data and farmers' perceptions. It is therefore conditional that unmet information needs have a high propensity to transform into anticipatory actions for emergencies and humanitarian crises.

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