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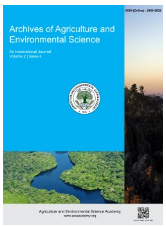

ORIGINAL RESEARCH ARTICLE

Farmers' adaptation strategies towards soil salinity effects in sunflower cultivation: A gender-based analysis of some selected south-central coastal areas in Bangladesh

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ABSTRACT

Rising salinity levels in the coastal regions of Bangladesh, driven by climate change, significantly affect agricultural productivity. Adaptation strategies to mitigate the effects of salinity are crucial for increasing crop production. This paper examines the adaptation strategies employed by male and female sunflower farmers in response to salinity intrusion in the south-central coastal zones of Bangladesh. We collected data through a household survey of 50 men and 50 women, supplemented by interviews and focus group discussions with farmers. The sample size was determined using a probabilistic sampling method. The questionnaire included open-ended and closed-ended questions and pretested with farmers before conducting final interview. Our results indicated that significant variables influencing adaptation strategies among male sunflower farmers included age, communication exposure, and training experience ($p < 0.05$). For female sunflower farmers, significant factors were age, communication exposure, training experience, and cultivated sunflower area ($p < 0.01$). Both regression models exhibited a satisfactory fit. Additionally, the primary adaptation strategies adopted by both male and female farmers included the application of fertilizers and pesticides. These findings provide valuable insights for policymakers in formulating future farm-level gender based adaptation strategies for cultivating sunflower.

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INTRODUCTION

Human-induced greenhouse gas (GHG) emissions and global climate change, which drive alterations in climate patterns, are heightening the vulnerability of agricultural production systems (Sloat *et al.*, 2020). Coastal regions are particularly vulnerable to the impacts of climate change, with the deltaic areas of Bangladesh being among the most susceptible to climate variability (Kabir *et al.*, 2021). Due to its geographical position, the delta region is expected to experience increased frequency and intensity of climate events such as salinity intrusion, storm surges, cyclones, floods, and droughts (Bhuyan *et al.*, 2024; Hill *et al.*, 2020). These events exert significant pressure on primary crop production, with salinity being one of the most critical stress factors (Bhuyan *et al.*, 2023a,b). Bangladesh's economy is predominantly agriculture-based, with approximately 80% of the population, particularly in rural areas, directly or indirectly engaged in this sector (Bhuyan *et al.*, 2024). Crops are cultivated in three distinct seasons: *Rabi* (October 16–March 15), *Kharif-1* (March 16–June 30), and *Kharif-2* (July 1–October 15). Salinity levels in coastal areas increase as the dry season progresses (Bhuyan *et al.*, 2023b), primarily impacting crops during the *Rabi* season and part of the *Kharif-1* season. As a result, farmers often leave their land fallow between November and May. To enhance cropping intensity and food security, it is essential to bring fallow land under cultivation (Nasim *et al.*, 2021).

Sunflower is one of the promising dry-season crops under saline condition (Sarker *et al.*, 2024). When climatic threats such as drought, salinity, and high temperature make it difficult to grow other dry-season crops, sunflower serves as a decent substitute (Sarker *et al.*, 2024). The demand for sunflower is high due to its oil content, as it contains low cholesterol, which is excellent for health. However, farmers are more interested in growing this oilseed crop to get quality oil at less production cost and high market demand. In the last few years, farmers with medium-high land have been producing sunflower as a climate change adaptation strategy in the coastal zones of Bangladesh (Islam *et al.*, 2022; Sarker *et al.*, 2024).

In Bangladesh's coastal areas, both males and females contributed equally to agricultural activities (Jalal *et al.*, 2021). Men and women across the globe respond differently to various climate effects and disasters (Naz and Saqib, 2021). While these changes impact both, each has different effects. Moreover, women's experiences differ significantly from men's, even within the same household. In recent years, only a limited number of studies have examined the contribution of male and female farmers to climate change adaptation in the south-western coastal areas of Bangladesh (Ahmed & Eklund, 2021; Aryal *et al.*, 2020). Naz & Saqib (2021) focused on the flood vulnerability of both men and women in the Char region (a low-lying coastal area). Additionally, Bhuyan *et al.* (2024) explored farmers' perceptions of climate change and salinity, as well as their adaptation strategies in the south-central coast, but did not specifically address gender-differentiated adaptation approaches. Despite increasing attention to adaptation practices, still now, no research has been conducted for addressing gender based salinity adaptation strategy for sunflower cultivation. Therefore, gender-specific adaptation strategies related to sunflower cultivation and analyze the variables influencing the adaptations plans of male and female farmers to mitigate the impact of salinity in the south-central coastal region of Bangladesh.

MATERIALS AND METHODS

Description of the study area

The south-central coastal region of Bangladesh includes four districts: Patuakhali, Barishal, Jhalokathi, and Borguna. This research was conducted specifically in the saline-affected Borguna district, within Amtali upazila (a small administrative unit of the district) (Figure 1). Amtali upazila occupies an area of 399 square kilometers, located between latitudes 21°51' and 22°18' north and longitudes 90°00' and 90°23' east. Its elevation varies from about 1 to 3 meters above sea level. Agriculture is the main livelihood for the residents (Aryal *et al.*, 2020), with rice and pulses being the key crops grown in the area (Bhuyan *et al.*, 2024).

Sampling methods and data collection

An exhaustive list of households cultivating sunflower in the designated villages of coastal area was initially obtained from the Upazila Agriculture Officers (UAOs), Sub-Assistant Agricultural Officers (SAAOs), and local leaders. Data were collected from 100 farmers (50 males and 50 female) through face-to-face interviews using a pre-tested, structured interview schedule. The questionnaire included both open-ended and closed-ended questions (See Supplementary Materials). We used a Global Positioning System (GPS) during the farmers' interview to collect primary data. The data collection used a multistage random sampling method. Previously, several published manuscripts (Aryal *et al.*, 2020; Bhuyan *et al.*, 2024; Islam *et al.*, 2020) utilized the same methodology to gather household information. The questionnaire was designed to collect information on the socio-economic characteristics of the farmers and their adaptation strategies (Supplementary Information). The study was conducted between February and April 2023. The study finds out the sample size utilizing the following Eq. (1) (Kothari, 2014):

$$n = z^2pqN \div e^2(N-1) + z^2pq \quad (1)$$

Where:

N= 1200 (total number of sunflower farmers' in the study area)

Z^2 =1.96 (confidence level (95%) according to (Kothari, 2004))

P=0.5 (proportion of sample)

Q=0.5 (1-p)

E= 0.1 (10% margin of error is considered)

Using the above equation, sample size stood at 92. We surveyed 100 sunflower farmers (including 50 males and 50 female farmers).

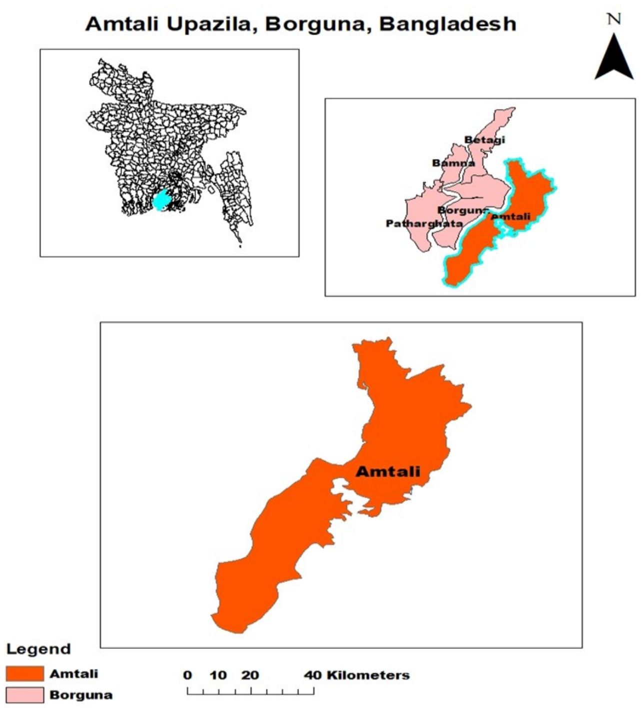

Figure 1. *Geographical location of the study area.*

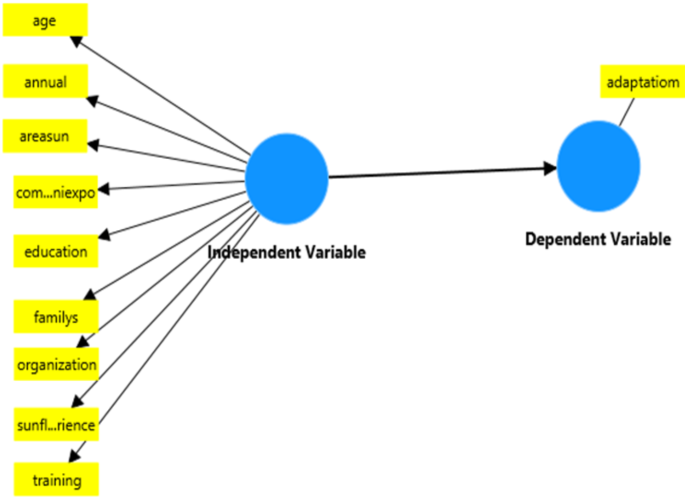

Figure 2. *Conceptual framework of the study area; age = age of the farmers, annual=annual income, areasun=sunflower cultivation area, com= communication exposure, education= education of farmers, family's= family size, organization= organizational participation, sunf= sunflower cultivation experience, training=training experience.*

Data analysis

The data analysis was performed using SPSS 23 statistical software. Descriptive statistics, including mean, standard deviation, and observed range, were applied to assess the socioeconomic conditions of sunflower farmers. Correlation analysis identified associations between dependent and independent variables, while linear regression was used to evaluate the influence of farmers' socioeconomic characteristics on their adaptation strategies. Regression analysis is widely utilized in climate change adaptation studies to explore the statistical relationships between variables. Additionally, a stepwise regression model was implemented to pinpoint the unique contribution of each independent variable to the dependent variable. To estimate farmers' motivation for cultivating sunflowers, the subsequent multiple regression equation was used (Eq. 2):

$$Y_i=\alpha+\beta X_i+\varepsilon_i \qquad (2)$$

Where,
Y = Motivation of farmer's (Obtained score)
X1= Age of the farmers (Year)
X2=Annual income (Tk.)
X3= Sunflower cultivation area (Decimal)
X4= Communication exposure (Frequency of contact)
X5= Education of farmers (Year of schooling)
X6= Family size (Number)
X7= Organizational participation (Obtained score)
X8= Sunflower Cultivation experience (Years)
X9= Training experience (Days)
$\acute{\varepsilon}_{i\,s}$ are random error components which are independently and normally distributed with mean zero and variance σ^2

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

Table 1 presents various socioeconomic characteristics of the farmers. The variables inserted in the analysis were male and female farmers age, family size, education level, annual family income, experience (Sunflower cultivation), area (sunflower cultivation), training experience, communication exposure, membership and adaptation Strategies. Farmers interviewed

Table 1. Socio-economic characteristics of respondents.

Variables	Mean		Standard deviation		Observed Range		Unit of measurement
	Male	Female	Male	Female	Male	Female	
(I) Independent Variables Age	47.78	35.10	11.86	6.25	24-70	22-45	Year
Family Size	5.14	5.14	1.17	1.17	3-8	3-8	Number
Education	4.10	3.86	2.90	2.35	0-16	0-10	Level of schooling
Annual income	76.62	31.56	22.89	10.08	39-121	11-50	'000' Taka
Experience (Sunflower cultivation)	3.04	2.66	1.37	1.46	1-5	1-5	No of years
Area (sunflower cultivation)	0.85	0.80	0.33	0.35	0.35-1.53	0.22-1.53	Decimal
Training experience	0.26	0.38	0.44	0.49	0-1	0-1	No of days
Communication exposure	76.62	11.88	22.89	2.11	11-17	6-16	Score
Membership	2.10	2.10	0.99	0.99	0-4	0-1	Score
(II) Dependent Variable Adaptation Strategies Five adopter categories 1.Innovator 2. Early adopter 3. Early Majority 4. Late Majority 5. Laggard's	21.50	10.36	9.78	2.56	5-32	5-32	On the basis of innovativeness of the farmers, the adopters in a social system have been classified into five categories (Rogers, 1995): 1. Innovator: Score 5 was given for innovators, they adopt innovation before all other members of their social system. Early adopters: Score 4 was given for Early Adopters, adopt innovation by observing the success of innovators. Score 3 was given for Early majority: Adopt innovation by observing both innovators and early adopters for a long time. Score 2 was given for, Late majority: Adopt innovation when almost all members of the social system have already adopted. Score 1 was given for, Laggard's: Unable to make innovation decision, when they decide innovation becomes older one.

ranged in age from 22 to 70 years. The average age of male sunflower farmers in the study area was 47, while the average age for female farmers was 35.10 years. In both groups, family size varied between 3 and 8 members, as the majority of the participants came from the same households. Education was recognized as a crucial variable for evaluating the development status of the region (Feinstein & Mach, 2020). Moreover, high education is assumed to impact the adoption against climate variability and change suggestively. Our findings show that the educational level of the farmers ranged from 0 to 16 years for male farmers and 0 to 10 years for female farmers. Notably, male farmers had higher educational attainment, with up to 16 years of schooling, compared to female farmers, who achieved a maximum of 10 years. The average income of male and female sunflower farmers was 76.62 thousand takas (637 USD) and 31.56 thousand takas (263 USD), respectively. The minimum income observed among male farmers was 39 thousand takas (327 USD), while female farmers earned as little as 11 thousand takas (92 USD). This is mainly caused by women not being directly involved in household income. Experience in crop cultivation is crucial for adopting various crop-level adaptation strategies (Bhuyan *et al.*, 2024). Both male and female farmers had between 1 and 5 years of experience in sunflower cultivation. This relatively limited experience is due to *boro* rice (dry season rice) and fallow being the dominant cropping practices during the dry season in the study area (Bhuyan *et al.*, 2024). The area allocated for sunflower cultivation was 0.85 decimals for male members and 0.80 decimals for female members. This is because, in Bangladesh, female members consider their husband's property as their own. Training programs improve farmers' capacity to manage the negative effects of salinity on crop production (Kumar *et al.*, 2020). This study revealed that both male and female farmers received between 0 and 1 day of training experience. Farmers should facilitate training programs to enhance crop production in salinity-prone coastal regions.

Sunflower related work distribution

We observed the variations of different activities for male and female farmers, from land preparation to the marketing of sunflower (Figure 3). A maximum number of male farmers were involved in land preparation (90%). This is because the land is

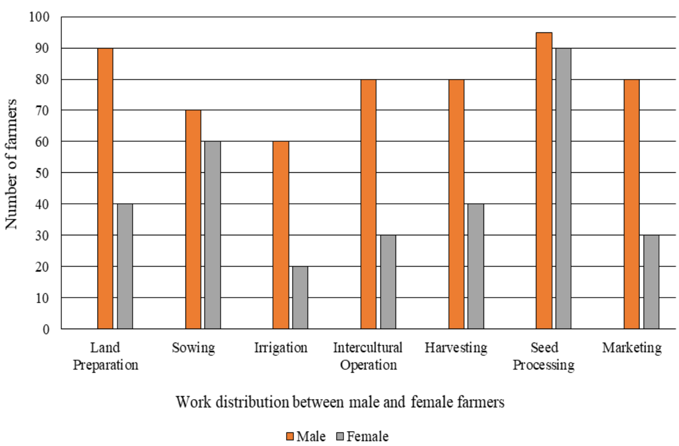

Figure 3. *Frequency of work distribution.*

prepared using a tractor machine or manually, which is difficult to conduct by females or physically demanding persons. Therefore, male members mainly involve themselves in this, although sometimes female members need to do this in case of male farmers' absence. Approximately 70% of male sunflower farmers were engaged in sowing, while 60% of female farmers participated in seed sowing-related activities. However, it was observed that a major portion of female farmers indulged in seed processing activities (>60%) because women mainly prefer work that can be completed from home. It is noticeable that female farmers, minimum participation was observed in the irrigation sector (20%). This may be because they mainly hire male labor to irrigate land through machine irrigation, and females are not involved in machine irrigation. Furthermore, significant variation was observed in the areas of intercultural operations, harvesting, and marketing. After harvest, several tasks are required, such as cleaning the seeds and separating them from the bunch. While male farmers assist women in these tasks, women's participation is highest in the seed processing sector.

Rank order of the adaptation strategies

Table 2 shows that the main adaptation strategies for the highest proportion of male and female farmers were the application of fertilizer and pesticides. Previously, Bhuyan *et al.* (2024) observed that fertilizer application is the dominant crop-level adaptation strategy in the south-central coastal area. However, this study evaluated the salinity adaptation strategies of sunflower cultivation for male and female farmers separately. Pesticide ranked as the second dominant crop-level adaptation strategy. During data collection, it was observed that both male and female farmers were using excessive amounts of fertilizer and pesticide to minimize salinity effects. Unnecessary fertilizer application particularly causes an increase in salinity, pollutes the environment, and upsurges the cost of production (Bhuyan *et al.*, 2024). In addition, pesticides are also responsible for environmental pollution and are discrete to adaptation against salinity stress (Khouni *et al.*, 2023). So, indigenous knowledge is sometimes not sufficient to alleviate climate change impacts. Therefore, farmers require training for capacity building (Kumar *et al.*, 2020). For male farmers, planting in highlands was the third most preferred adaptation strategy, with improved irrigation ranked fourth, followed by well digging in fifth place. Changes in land use patterns ranked sixth, the use of organic fertilizer seventh, mixed cropping eighth, crop rotation ninth, crop diversification tenth, crop management eleventh, reduced tillage and deep ploughing in twelfth place. On the other hand, for female farmers, plantation in highlands ranked third, followed by change in land use patterns ranked fourth, crop rotation ranked fifth and crop diversification ranked sixth. Overall, it is noticeable that male farmers practiced twelve adaptation strategies, while female farmers took six. This is due to the traditional culture of Bangladesh, which discourages most women from engaging in outside work, leading them to focus more on internal tasks.

Table 2. Rank order of the adaptation strategies.

S. No.	Adaptation strategies taken by male farmers	Number of farmers	Rank
1	Application of fertilizer	50	I
2	Application of pesticides	50	II
4	Improved Irrigation	45	III
5	Digging wells	37	IV
6	Change in land use patterns	34	V
7	Use of organic fertilizer	32	VI
8	Mixed cropping	30	VII
9	Crop rotation	29	VIII
10	Crop diversification	28	IX
v11	Crop management	23	X
12	Reduced tillage and deep ploughing	20	XI
S. No.	**Adaptation strategies taken by female farmers**	**Number of farmers**	Rank
1	Application of fertilizer	49	I
2	Application of pesticides	48	II
3	Plantation in highlands	45	III
4	Changing land use patterns	24	IV
5	Crop rotation	20	V
6	Crop diversification	18	VI

Table 3. Bivariate analysis between independent and dependent variables.

Independent variables	Gender			
	Male (n=50)		Female (n=50)	
	Pearson Correlation	P-value	Pearson Correlation	P-value
Age	0.634	0.000**	0.532	0.000**
Family Size	0.339	0.016*	0.145	0.314NS
Education	-4.15	0.003**	-0.215	0.134NS
Annual income	0.179	0.214NS	0.131	0.364NS
Sunflower cultivation experience	0.387	0.006**	0.099	0.496NS
Area under sunflower cultivation	0.086	.554NS	0.465	0.001**
Training experience	0.426	0.002**	0.490	0.000**
Communication exposure	0.565	0.000***	0.411	0.003**
Organizational participation	0.179	0.214NS	0.162	0.262NS

**=Significant at 0.01 level, NS=Not significant, *=Significant at 0.05 level; Source: Author's own calculation using SPSS from field survey data, 2023.

Table 4. Multiple linear regression analysis depicting contribution of independent variables to farmer's adaptation strategies to sunflower cultivation.

Gender	Independent Variables	B	S.E	β	t	sig	R	R^2	F	p
Male	Age	.296	.119	.359	2.490	.017*	.754	.569	9.468	.000
	Family Size	.814	.909	.098	.895	.376				
	Education	-.016	.454	-.005	-.035	.972				
	Experience (Sunflower cultivation)	.688	.843	.096	.816	.419				
	Training experience	4.927	2.407	.223	2.047	.047*				
	Communication exposure	1.896	.764	.308	2.483	.017*				
Female	Age	.159	.159	.387	3.765	.000**	.754	.568	14.807	.000
	Area (sunflower cultivation)	1.820	1.820	.255	2.453	.018**				
	Training experience	1.396	1.396	.267	2.537	.015**				
	Communication exposure	.332	.332	.274	2.695	.010**				

**=Significant at 0.01 level, *=Significant at 0 .05 level.

Analysis between independent and dependent variables

To identify the association between independent and dependent variables, we first considered nine independent variables (Table 3). Bivariate analysis revealed that six variables for male farmers had a significant relationship with the dependent variable, and four variables for female farmers had a relationship with adaptation strategies to salinity problems.

We entered the independent variables, which had a relationship with the dependent variables, into the regression models. According to the regression analysis, among the five variables, male farmers, age, training experience, and communication exposure ($p<0.01$) were significantly connected to how farmers adapt to the effects of soil salinity on sunflower cultivation (Table 4). Older farmers have perceived changes in various climate change factors and are taking adaptation plans accordingly. Our result is opposite from that of Ahmed *et al.* (2022), who found that age has a negative relationship with the adaptation approaches. Furthermore, training improves farmers' capacity building and helps them adapt to salinity and other climatic hazards (Bhuyan et *al.*, 2024). Moreover, regular communication with extension agents helps the male farmers update new varieties and technologies, increasing farm productivity under adverse climatic conditions.

For female farmers, age also has a significant relationship

Table 5. Stepwise regression model related to farmers (male and female) adaptation strategies to salinity effect.

Gender	Predictor Variables	R^2	Adjus.R^2	S.E. of the estimate	R^2change	F change	Sig F Change
Male	Age	.402	.390	7.64385	.402	32.278	.000
	Communication exposure	.504	.483	7.03533	.102	9.663	.003
	Training experience	.551	.522	6.76300	.047	4.861	.033
Female	Age	.283	.268	2.19187	.283	18.924	.000
	Communication exposure	.424	.400	1.98455	.142	11.553	.001
	Training experience	.511	.479	1.84965	.086	8.106	.007
	Area for sunflower	.568	.530	1.75636	.058	6.016	.018

($p<0.05$) for female farmers' adaptation strategies against soil salinity effects (Table 4). Naz & Saqib (2021) observed that older female farmers' adaption capacity against climate change is greater than younger farmers. Area of sunflower cultivation) has a positive influence ($p<0.05$) on female farmers' adaptation strategies. In the last few years, sunflower cultivation in the south-central coastal areas has increased due to a shorter lifecycle than *boro* rice and more adaptive capacity against salinity (Bhuyan *et al*., 2024). Naz & Saqib (2021) found that farmers' adaptation strategies also increase with increasing sunflower cultivation area. Training experience was also a significant factor ($p<0.05$) for female farmers' adaptation strategies for sunflower cultivation. Usually, no gender-specific training is conducted for farmers in Bangladesh (Medendorp *et al*., 2022). Since male and female farmers' agricultural activities differ (Naz & Saqib, 2021), the Bangladesh government should focus on providing gender-specific training facilities. Opportunities for training will enhance the female farmers' farm-level adaptation strategies to salinity effects. Consistent with male farmers, communication exposure was significantly associated ($p < 0.05$) with female farmers' adaptation strategies. This aligns with findings by Mazumder *et al.* (2022), who observed that good communication skills help farmers familiarize themselves with new adaptation approaches. In most cases, farmers tend to emulate the practices of other farmers without direct communication with agricultural extension officers (Bhuyan *et al*., 2024). Thus, it is essential for farmers to establish regular communication with agricultural extension agents to stay informed about innovative agricultural technologies.

Moreover, we applied a stepwise regression model to determine the unique contribution of independent variables to the dependent variables (Table 5). The results show that for male farmers, age accounts for 40.2% of the total variation in salinity adaptation when cultivating sunflowers, while communication exposure and training experience contribute an additional 10.2% and 4.7% of the variation, respectively. For female farmers, age explains 28.3% of the total variation in salinity adaptation, while communication exposure, training experience, and the area of sunflower cultivation account for 14.2%, 8.6%, and 5.8% of the variation, respectively.

Conclusion

Salinity intrusion is a common challenge for agriculture in the south-central coastal zones of Bangladesh. To cope with changing salinity conditions in sunflower cultivation, male farmers have adopted twelve adaptation strategies, while female farmers have adopted six, the most common of which involve applying fertilizers and pesticides. These key adaptation measures need improvement to better address salinity issues and reduce production costs. These strategies are based on the farmers' own experiences and skills. Factors that influence household decisions to adapt to salinity on foremost adaptation decisions were analyzed in the current study. Linear regression analysis revealed that age, communication exposure, and training experience positively contributed to male farmers' adaptation strategies to salinity. For female farmers, four variables, namely, age, training, communication exposure, and area of sunflower cultivation, were found to positively impact their adaptation approaches. However, to advance crop production in saline-prone coastal areas, training programs should be tailored to specific age groups and genders to enhance farmers' capacity and productivity. Additionally, efforts should be made to strengthen farmers' communication skills with agricultural extension agents. Therefore, the outcomes of this study can help policymakers develop farm-level adaptation strategies in the coastal regions of Bangladesh. Moreover, this study does not address the perceptions of male and female farmers regarding salinity stress at various stages of major crops and its impact on their livelihoods. Future research should focus on this issue.

DECLARATIONS

Author contributions

Conceptualization: A.B and M.I.B.; Methodology: A.B; Software and validation: A.B. and M.H.S.; Formal analysis and investigation: A.B., M.I.B., and M.H.S.; Resources: A.B and M.I.B.; Data curation: A.B and M.I.B.; Writing—original draft preparation: A.B and M.I.B.; Writing—review and editing: A.B, M.I.B., S.M, and M.G.R.A; Visualization: A.B, M.I.B., and S.M.; Supervision: M.G.R.A.; Project administration: A.B.; Funding acquisition: A.B. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest: The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Ethics approval: The study received approval from the Ethics Committee of Patuakhali Science and Technology University (PSTU), with Reference Number PSTU/IEC/2022/46(1). Before participation, respondents were fully informed about the study's objectives. All data were collected exclusively for research purposes, without any personal interest involved.

Consent for publication: All co-authors gave their consent to publish this paper in AAES.

Data availability: Data will be made available on request.

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