Land Salinity Effect on Farmers Adaptation Strategies for Sunflower Cultivation in Southwestern region of Bangladesh

Вплив засолення ґрунтів на адаптаційні стратегії фермерів щодо вирощування соняшнику в південно-західному регіоні Бангладеш

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Purpose. To examine the impact of land salinity on farmers' adaptive strategies for sunflower cultivation in the southwestern coastal region of Bangladesh and to identify key socio-economic determinants influencing adaptive capacity.

Method. A quantitative approach was employed using a multistage random sampling technique. Data were collected from 200 sunflower farmers in Borguna district between February and April 2025. Multiple linear regression analysis was applied to evaluate the influence of independent variables on farmers' adaptive capacity.

Findings. The results indicate that age, sunflower cultivation area, training, and NGO membership have a statistically significant positive effect on adaptive capacity. Farmers primarily adopt fertilizer management, pesticide use, and irrigation techniques to mitigate salinity stress. However, excessive input use was observed, reflecting potential inefficiencies in adaptation practices.

Theoretical implications. The study contributes to adaptive capacity and resilience theory by empirically linking socio-economic variables with behavioral adaptation strategies under environmental stress conditions.

Practical implications. The findings suggest the need for targeted policy interventions, including farmer training, sustainable land

Мета дослідження. Аналіз впливу засолення ґрунтів на адаптаційні стратегії фермерів при вирощуванні соняшнику в південно-західному прибережному регіоні Бангладеш, а також визначення ключових соціально-економічних чинників, що впливають на їхню адаптаційну спроможність.

Метод дослідження. Застосовано кількісний підхід із використанням багатоступеневої випадкової вибірки. Дані зібрано від 200 фермерів у районі Боргуна в період з лютого по квітень 2025 року. Для оцінювання впливу незалежних змінних на адаптаційну спроможність використано множинний лінійний регресійний аналіз.

Результати дослідження. Встановлено, що вік, площа вирощування соняшнику, рівень навчання та членство в неурядових організаціях мають статистично значущий позитивний вплив на адаптаційну спроможність. Основними адаптаційними практиками є управління добривами, застосування пестицидів та оптимізація зрошення. Водночас зафіксовано надмірне використання ресурсів, що свідчить про неефективність окремих адаптаційних підходів.

Теоретична цінність дослідження. Дослідження розширює положення теорії адаптаційної спроможності та стійкості, емпірично обґрунтовуючи зв'язок між соціально-економічними чинниками та поведінковими адаптаційними стратегіями в умовах екологічного стресу.

Практична цінність дослідження. Результати вказують на необхідність розроблення цільових політик, зокрема щодо підвищення

management, and institutional support to enhance resilience against salinity intrusion.

Paper type. Empirical.

Key words: Salinity, Adaptation, Vulnerability, Climate Change, Policy Making.

кваліфікації фермерів, впровадження сталих практик управління земельними ресурсами та посилення інституційної підтримки.

Тип статті. Емпіричне кількісне дослідження.

Ключові слова: засолення; адаптація; вразливість; зміна клімату; формування політики.

Introduction

The structural impacts of salinity often exacerbate pre-existing income disparities so that social investment in health and education, becomes essential to the long-term stability of regions. However, increases in gross domestic product (GDP) is not an over-arching goal and Halter et al. (2014) argues that in disaster prone regions such as the southwest, development can inadvertently widen the chasm between those who are robust and those who are vulnerable unless it is equitably governed. To address this, Muenielo-Gallo and Roca-Sagales (2013) emphasize that robust tax laws must be in place to promote systemic resilience and reduce inequality following environmental shocks. Additionally, as Acemoglu (2003) points out, liberalized trade and access to new technology is crucial for increasing agricultural productivity particularly important in the face of potential decline in income of rural households from slow onset disaster such as saline. Compromises at a higher-level (e.g., FDI), on the other hand, are more likely to exacerbate income inequality and delay the recovery of the poorest subsets, as pointed out by Herzer and Nunnenkamp (2015). Barro (2000) maintains that a pro-poor growth agenda is needed to promote community-based recovery and local resource management.

Household behavior is influenced by emerging income generation needs to secure and stabilize the farming families and micro businesses, since agricultural activity remain a key sector in the region. Boyer and Morel (2015) argue that the way to build resiliency to future shocks, especially in resource-dependent communities, is through macroeconomic policy which combines long-term infrastructure development and investment in human capital. The livelihood capability of the local population and focus on disaster recovery at the micro-economic level in this area are most important (Mollah and Rahman, 2016), whereby they mention that micro-enterprises recover quickly relative to large enterprises. The handling of physical resources also plays a key role in household resilience. To build resilience into households to face the environmental shocks such as flood and salinity intrusion, Bhuiyan et al. (2021) emphasizes the role of land, livestock and small business. Rahman and Ahsan (2015) underscore the strategic importance of asset management in livelihood reconstruction. A widely observed household response to such situation is the use of income diversification (Dey and Pal 2019) as strategy both to gain savings and lower their vulnerability against future economic shocks when mainstream livelihoods are threatened.

The mental and peacetime health consequences of living in a high-risk area also shape the behavior of coastal households. Those people affected by disaster may suffer from trauma, which can stifle economic recovery by reducing the rates of labor participation (Chakraborty and Haque, 2018). Singh and Das (2020) argue that integrating mental health as part of rehabilitation plans will help people to return to work sooner, thus accelerating economic recovery. Many recovery efforts are truly community-based models and that's how people recover. Local wisdom is an important part of sustainability and long-term resilience, as Khan and Ahmed (2015) point out, requiring that power be handed back to the local residents. These are models that give a more sustainable livelihood and quick recovery if coupled with micro finance programs. In addition, Mason and Turner (2018) argue for the importance of access to education and skills programs which facilitate affected communities in acquiring new types of work. One of the strengths of economic security is a policy for the efficient and sustainable use of land and water. Ghosh and Sharma (2015) explore the concept that better management of resources leads to recovery of economies quicker as communities are not solely dependent on post disaster income. This is supported by Miller et al.

(2017) that found that flexible business structures enable communities to amend their market strategies in the wake of a disaster, especially in the agricultural sector. Finally, the long-term economic security and recovery of southwestern communities—therefore poverty eradication—at least partly depend on the rehabilitation and maintenance of natural ecosystems, whose resources are utilized in an environmentally sustainable manner (Pelling and Uitto, 2001).

The basic objective of this paper is to develop the adaptive capacity and sustainable strategies to protect sunflowers from land salinity. Moderate salinity is good for production, but an extreme level of salinity harms product quality badly. The authors try to highlight the adaptation strategies on a rank basis to protect the sunflower on a large scale.

Literature review

The environmental determinism and adaptive capacity can be taken into account in understanding the relationship between household behavior and land salinity in the south-western part of Bangladesh. The relationship between social resilience and environmental stability, in particular the ecological stability of the local area, is closely related (Adger, 2000) and as soil salinity increases the 'social skin' becomes thinner. Salinity is another on-going stressor which forces households into a mode of “continuous adaptation” in which traditional knowledge systems are not always up to the task against such rapid soil degradation as Hossain et al. (2020) in the coastal setting.

The most recent of them is the shift to cultivation (of fish and prawn) because soil salinity can no longer sustain regular paddy agriculture. Prawn culture, however, is more lucrative although it commonly results in the “proletarianisation” of small producers who lose their land to wealthier Gher owners (Ahammad and Stacey 2016). As an outcome of this imbalance, rural families acquire a behaviouristic tendency toward dependency. According to Islam et al. (2019), this move is often forced, rather than voluntarily, as the salinisation of one field always affects neighbouring fields; a “domino” effect of land loss for agriculture. Households not participating in aquaculture are often extremely risk averse. According to Zaman et al. (2018), households value current over future consumption investment in farm and education assets because of the unpredictability of saline intrusion, leading to short-termism in household decision making. These findings are consistent with those of b that crop failure due to salinity emerges as a key “push factor” for seasonal migration and is transforming the demography of the southern villages during the dry season. It is the physical cost of salinity that in turn shapes household behavior. According to Talukder et al. (2016), heavy reliance on saline water by coastal population is closely associated with hypertension diseases. Household spending habits have shifted in response to this public health crisis, with an outsize share of income going to medical costs. According to Khan et al. (2014), and women have to do most of this carrying because they have to fetch freshwater, often walking miles with the goal of avoiding saline sources — time they could otherwise spend nurturing children and creative work.

An additional theoretical consideration has to do with the gendered character of salinity. According to Bernier et al. (2016), saline intrusion confounds gender roles: women are forced to spend the majority of their time in “trapped” environments making decisions, while men migrate to urban centres such as Khulna or Dhaka because of unproductive land. According to Rao et al. (2019), this 'feminisation of agriculture' is affecting the construction of new behavioral patterns in the management of resource among women in salty zones, often without necessary social and legal conditions to ensure its liability. Local adaptation is at maximum when the more costly trait is used as a limiting factor and migration becomes the dominant behavior. As Grey and Mueller (2012) have indicated: “Salinization generates a slow onset migration event whichis often irreversible unlike sudden catastrophe”. A theoretical description is provided by Lázár et al. (2015), who characterise a “vulnerability induced migration” where families sell their assets and move following the degradation of soil fertility. But the most vulnerable households could become “trapped populations,” with too little money to move even if their environment becomes unlivable, according

to Black et al. (2011). There is no getting around the fact of an external oppression on home life. Local institutions are the "mediators" of climate adaptation (Agrawal, 2010). According to Parvin et al. (2017), the presence of NGOs often delimits which households in southern Bangladesh can adopt salt-tolerant crop varieties (STVs) with success. Huq and Khan (2006), however, argue that ow rates of adoption of new agricultural technology stem from top-down technological fixes that often ignore the farmers' socio-cultural behavior. The other barrier to reducing salty stress is social capital in the community. According to Wolf et al. (2010) described, sharing water in common at times of high salinity could be supported by high levels of social trust. In contrast, Pouliotte et al. (2009) observes that little to no freshwater in a number of southwestern enclaves leads to increased intercommunal violence, which undermines the social capital necessary for collective adaptation. This means that the shared social fabric of the region is closely tied to the salinity-induced behavioral response and is not just individualistic.

Despite extensive coverage of the physical science, and broad trends in migration, from body of literature now emerging, it is not apparent what this "psychological landscape" looks like for those who remain living where salinities have made land unfarmable. Grothmann and Patt (2005) mention this as well, that often there is a fatalistic sense of frustration to "adaption intentions". This fatalism is a key behavioral characteristic among people in the southwest that would warrant further empirical evaluation to assess its impact on the efficacy of national climate adaption policies. Akanda et al. (2024) developed a paper based on the connectivity farmers adaptation strategies and soil sanility in sulflower cultivation in southwestern region.

Materials and Methods

The south-central coastal region of Bangladesh considers four districts: Patuakhali, Barishal, Jhalokathi, and Borguna. This research was conducted specifically in the saline-affected Borguna district, where Amtali villaage is hub of producing sunflowers in this whole district, where 200 sunflower producing farmers has been chosen. 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) used the same methodology to influence the household information. However, the questionnaire was developed to collect information on the socioeconomic behaviors of the farmers and their capacity with adaptation strategies (for also Supplementary Information). However, the study was conducted between the months from early February to late April 2025. The data is analyzed on 200 sunflower cultivating farmers who especially prepare their land and investment their money to cultivate large scale of sunflower which is the main source of their livelihood. The author uses multistage random sampling method, where the author considers 200 farmers to conduct this research. The multiple regression equation is given below:

$$FAC= \beta_0 + \beta_1 AGE + \beta_2 FFS + \beta_3 EDF + \beta_4 FMI + \beta_5 SCE + \beta_6 SCA + \beta_7 SCT + \beta_8 NGM + \beta_9 FSP + \beta_{10} FTM + u \quad (i)$$

Table 1: Variable List Identification of Independent Variables Affecting Dependent Variables

Explanatory variables (Indicators)	Description of variables	Mesurablement unit	Expected Sign	Sources of Variables
Independent Variables				
AGE	Age	Year	+	Badhan et al, 2024
FFS	Family Size	Number	+ or -	Bhuyan et al, 2023
EDF	Farmers Educational Status	Level of schooling	+	Islam et al, 2022
FMI	Farmers Monthly Income	In BDT	+	Kabir et al, 2021

Explanatory variables (Indicators)	Description of variables	Mesurablement unit	Expected Sign	Sources of Variables
SCE	Sunflowe Cultivation Expericne	In Years	+	Badhan et al, 2024
SCA	Sunflower Cultivation Area	In Decimal	+	Bhuyan et al, 2023
SCT	Farmers Training Level	Numbers of Days	+	Rogers, 1995
NGM	NGOs Membership	If Yes=1, Otherwise=0	+ or -	Saloat et al, 2020
FSP	Social Organizational participation	Score Value	+	Mason and Turner (2018)
FTM	TV and Media Connectivity	If Yes=1, Otherwise=0	+	Aryal et al., 2020
Dependent Variable: Farmers Adaptor Category (FAC)				
FIS	Farmers Innovator Strategies	Score Value	+ or -	According to Rogers (1995), 1. Innovator: Score 5 was given for all types of innovators, they adopt innovation before all other local members of their social system. Early farmers adopters: Score 4 was given for Early Adopters for farmers, adopt innovation by perceptive the passion of innovators. Score 3 was given for Early majority: Adopt innovation by perceptive both innovators and early adopters for a long time-being. Additionally, Score 2 was given for, Late majority: Adopt innovation when almost all active members of the social system influences have already been adopted. Score 1 was given for, Laggard's: Incapable to make innovation decision, when they decide innovation becomes older one.
FEA	Farmers Early Adaptor	Score Value	+ or -	
FAM	Farmers Early Majority	Score Value	+ or -	
FLM	Farmers Late Majority	Score Value	+ or -	
FLB	Farmers Laggard Behavior	Score Value	+ or -	

Source: Author's Own Compilation, 2026

From table No 02, it is measure that the raking order system of adaptation capacity of farmers strategies how to develop the cop quality and taking essential initiatives to finalize the adaptation capacity. From the previous study, Bhuyan et al. (2024) determined that fertilizer usage application is the famous crop-level adaptation strategical-view in the south-central coastal area. However, this research calculated the salinity adaptation strategical view of sunflower cultivation farmers. Sustainable usage of land-Pesticide ranked as the second dominant crop-level adaptation

factor for local farmers. At the time of data collection, it was observed that farmers were using excessive amounts of fertilizer and pesticide to minimize salinity effects.

Table 2: Farmers Adaptation Techniques for Sunflower Cultivation

Local Farmers Adaptation Techniques	Farmers Numbers	Rank
Sustainable usage of Land Fertilizer	185	I
Sustainable usage of Land Pesticide	172	II
Cost saving irrigation techniques	165	III
Land Digging Wellls	154	IV
Changing land usage pattern	135	V
Green and organic fertilizer using behavior	126	VI
Mixed cropping system adaptation	118	VII
Crop Roating Strategies	112	VIII
Crop Diversification	110	IX
Crop Magagemnt system	107	X
Attenuate tillage and deep ploughing	102	XI

Source: *Author's Own Compilation, 2026*

Table 3: Multiple linear regression analysis portraying the effect of independent variables on local Sunflower farmer's adaptation strategies on sunflower cultivation

Variable Sign	Coefficient Value	t Value
AGE	0.497	2.523**
FSF	0.092	0.659
EDF	-0.006	-0.038
FMI	0.065	0.456
SCE	0.084	0.819
SCA	0.236	2.01*
SCT	0.726	3.056**
NGM	0.875	1.96*
FOP	0.356	0.045
FTM	0.888	0.453
Dependent Variable: Farmers Adaptation Strategies for Sunflower Cultivation (FAS)		

NB.: *Standard errors in parentheses ***p<0.01, **p<0.05,*
Source: Author's Articulation based on Field Survey, 2026

Results

From Table 3, the authors attempt to assess the effect of independent variables on farmers' adaptation strategies. In this study, age is positively associated with strengthening the adaptive capacity of sunflower-cultivating farmers. Conversely, Ahmed et al. found that age has a negative relationship with adaptation approaches.

Moreover, Bhuyan et al. identified a positive effect of farmers' local-level training on

capacity building, particularly in mitigating the estimated impacts of soil salinity on sunflower cultivation. Similarly, in the present research, the area allocated to sunflower cultivation is positively associated with farmers' adaptive capacity. This may be explained by farmers' motivation to enhance productivity and profitability through the adoption of new varieties and technologies aimed at combating salinity.

Furthermore, training in sunflower cultivation provides farmers with modern techniques and sustainable practices, enabling large-scale production. In addition, Naz and Saqib demonstrated that experienced farmers exhibit higher adaptive capacity compared to less experienced ones, which enhances their ability to respond effectively to climate change challenges.

NGO membership also has a positive influence on adaptive skills among sunflower farmers. Active participation in non-governmental organizations facilitates access to knowledge, production techniques, and improved crop rotation practices. However, salinity stress remains a significant constraint on sunflower cultivation. Strengthening farmers' adaptive capacity contributes to building resilience and supports the implementation of effective large-scale cultivation strategies.

Naz and Saqib further observed that older female farmers demonstrate greater adaptive capacity to climate change compared to younger farmers. Additionally, Mazumder et al. emphasized that effective communication is a key factor in enhancing adaptive capacity from a cropping perspective. Similarly, Bhuyan et al. highlighted the importance of communication skills for improving sunflower cultivation practices and capacity-building processes.

Finally, the adoption of innovative agricultural techniques supports the development of modern technologies and promotes sustainable farming practices.

Conclusion

Salinity intrusion is a common challenge for agricultural fields in the south-central coastal zones of Bangladesh. To cope with increasing salinity levels in sunflower cultivation, it is essential for farmers to adopt sustainable fertilization practices and effective pesticide management.

Salinity adversely affects sunflower production, largely because many farmers lack knowledge of adaptive techniques to protect their crops, including paddy, from salinity stress. Therefore, the implementation of appropriate policy measures at the local level is necessary.

Sustainable practices include the development of effective drainage systems, leaching, optimal irrigation management, the use of organic fertilizers, bed preparation techniques, mulching, crop rotation, proper fertilization management, and efficient pesticide use. These measures can significantly reduce the harmful effects of salinity on agricultural land.

Although large areas of farmland in Bangladesh are located in coastal regions, comprehensive long-term policies to mitigate extreme salinity have not yet been adequately implemented. Strengthening land management strategies can improve soil health and enhance resilience to high salinity levels.

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Competing interests

The authors declare that they have no competing interests.

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