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RESEARCH ARTICLE

Role of farm size in adopting salinity-tolerant paddy varieties: A study in coastal districts of Tamil Nadu

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Abstract

The purpose of this research is to examine the relationship between the causes of salinity, farmers' preferences, and the adoption rates of salt-tolerant rice varieties with an emphasis on how farm size and socioeconomic variables impact these decisions. The study employs an ex-post facto research approach to investigate the cause-and-effect relationship between farm features and the adoption of various salinity-tolerant cultivars. A total of 210 farmers were selected using snowball sampling to evaluate their adoption patterns. The results indicate that marginal farmers predominantly adopt varieties like TPS-5, TRY-3, and KKL(R)-1 due to their adaptability to small-scale farming under salinity stress. Conversely, TRY-1 is more favored by larger farms, while small-scale farmers prefer TRY-5 as a viable salinity-tolerant option. The analysis, conducted using a One-Way ANOVA test, reveals a significant relationship between farm size and variety adoption, with socio-economic factors playing a critical role in shaping these preferences. These findings may assist policymakers and agricultural extension agencies understand the importance of providing farmers with the information, tools, and social support they require to enhance the adoption of specific varieties.

Keywords

causes of adoption index; farm size; salinity tolerant varieties; socio -economic factors; sustainability

Introduction

Rice plants are highly sensitive to salt stress during their critical seedling and reproductive phases, leading to significant reductions in production and grain quality (1). Salinity affects roughly 20% of the world's irrigated fields, posing a major threat to rice production, particularly in Asia, which accounts for more than 90% of the global rice supply (2). The socio-economic consequences are severe in South Asia's rice-growing regions, where salinity exacerbates poverty and worsens food insecurity (3). Globally, salinity impacts approximately 833 million hectares of arable land, devastating rice productivity and degrading grain quality. This presents a critical threat to food security in rice-dependent regions, especially in southern and southeastern Asia, where over 60% of the world's rice is both grown and consumed (4). In Bangladesh's coastal areas, saline intrusion driven by rising sea levels has affected around 1.5 million hectares, reducing rice yields by up to 30% (5). Considering that rice is the staple food for nearly twothirds of the global population, the salinity which impacts roughly 20% of the total rice-growing area, raises serious concerns amid growing population pressures and rising demand (6).

The threat of salinity is acute, especially in the key rice-producing regions like West Bengal, Tamil Nadu, Andhra Pradesh, and Gujarat, where yield losses range from 15% to 50% (7). By 2050, over 1.5 million hectares of India's rice fields, primarily in West Bengal and Odisha, are projected to face severe impacts from rising sea levels and saltwater intrusion (8). According to the World Bank (2021), salinity stress in the Ganges Delta has caused a 20-30% decline in rice yields over the past decade with coastal regions experiencing yield losses of up to 50% in the most severely affected areas. Salinity represents an existential challenge for coastal rice production, with yield losses reaching up to 50% in the most severely affected areas (9).

Salinity poses a growing threat to India's rice production, particularly in West Bengal, Andhra Pradesh, and Tamil Nadu, where yields are reduced by an average of 20-30%, significantly affecting both the quantity and quality of the harvest (10). In the Sundarbans, rice yields have decreased by 30-40% over the past five years, further exacerbating the crisis (11). Climate change has intensified salinity stress, contributing to a 15-25% decline in yields in some regions (12).

Salinity has a divesting economic impact on India's rice farmers, affecting nearly 2 million hectares, resulting in an annual loss of 2-3 million tons of rice (13). The FAO projects that by 2050, coastal districts such as Karaikal and Nagapattinam could experience a 15-20% reduction in rice yields due to increasing salinity levels caused by coastal saltwater intrusion.

Among salinity-tolerant varieties, TRY-1 has shown yield improvements of 20-25% and has been widely adopted across 10,000 hectares in coastal areas (14). TRY-2 enhances yields by 15-20% under moderate to high saline conditions (15), while TRY-3 achieves a 25-30% yield increase, in saline-prone zones (16). Traditional varieties like Pokkali, with a 20-25% yield boost, are grown in approximately 10,000 hectares (17) Vytilla achieves a 15-20% yield increase and is cultivated in over 8,000 hectares (18). KKL-1 and KKL-2 offer an 18-22% yield boost and cover 5,000 hectares (19). ADT-49 enhances yields by 10-15% under low salinity conditions and is cultivated in 6,000 hectares (20). Gangavathy provides a 12-18% yield increase and is adopted in 3,000 hectares (21). Meanwhile Sona improves yields by 10-15% in less saline areas and is cultivated in 4,000 hectares (22). However, comprehensive studies exploring the long-term socio-economic impacts and constraints related to adopting these varieties remain limited, leaving significant gaps in understanding the extent to which farmers are adopting these varieties.

The high cost of seeds and inputs for salinity-tolerant cultivars is a significant barrier, particularly for farmers with small landholdings or limited financial resources who are hesitant to invest due to uncertainty regarding returns (23). Poor adoption rates of salinity-tolerant cultivars in coastal regions is due to a lack of knowledge in salinity adaptation strategies and limited extension services like lack of extension personnel, Demonstrations etc. (24). Farmers in these locations are not well-informed about the benefits and performance of these cultivars, which leads to hesitation in adoption. While several cultivars have been developed for salinity-prone areas, inadequate information distribution from research institutes to farmers continues to impede widespread adoption.

Objectives

1. To identify the causes driving the adoption of salinity adaptation strategies.
2. To analyse the socio-economic characteristics that influence the extent of adoption of salinity-tolerant varieties.
3. To examine the impact of farm size on the adoption of salinity-tolerant paddy varieties among farmers.

Methodology

Study Area

The study was carried out in the coastal districts of Karaikal and Nagapattinam, specifically targeting six blocks. According to the Central Soil Salinity Research Institute (CSSRI), salinity impacts approximately 25-30% of agricultural land in Karaikal. The most severely affected areas are in the Nagapattinam taluks, where high soil salinity and inadequate drainage systems prevail. To combat the adverse effects of salinity, local farmers predominantly rely on canal irrigation as their primary strategy.

Questionnaire Design

The questionnaire was divided into two comprehensive sections. The first section assessed the adoption of various salinity-tolerant paddy varieties, including TRY-1, TRY-2, TRY-3, TRY-4, TRY-5, Ambai 16, TPS-5, Jyothimattai, Vytilla 1-8, CSR-36, Gangavathy Sona, ADT-49, and the KKL series (KKL(R)-1, KKL(R)-2, KKL(R)-3). Each variety was evaluated with a scoring system where a score of "2" indicates adoption and "1" indicates non-adoption.

The second section examined how agricultural capacity factors influence the adoption of these varieties. It explored the roles of farm size (categorized into Small, Marginal, and Large). This part of the survey aimed to understand how these factors affect farmers' decisions to adopt salinity-tolerant varieties, offering valuable insights into the determinants of agricultural adaptation.

Sample Design and Data Collection

An ex-post facto approach was employed to examine the causal relationships between key variables, due to the uncertainty in the population size, non-probability sampling was used (24). Considering these characteristics, a combination of purposive and snowball sampling strategies was employed. The snowball sampling approach was employed to collect data from farmers, while the purposive sampling strategy was used to determine the region for sample collection. Using snowball sampling approaches, 35 samples were collected from each of the six blocks. A total of 210 samples were collected from the Karaikal and Nagapattinam districts. A pilot survey involving 30 farmers in these and adjoining blocks tested the questionnaire's reliability and relevance, ensuring that the survey was compatible with data processing. A network of grassroots experts, familiar with survey techniques and strong ties to the agricultural community, facilitated the data collection. Each interview session lasted 30-40 minutes.

Data Analysis

Analysis of variance (ANOVA) was employed as a statistical method to evaluate the equality of multiple means by comparing variations among groups to random error within groups (25) Unlike a t-test, ANOVA does not limit the number of means compared. When comparing more than two populations' means for equality, the F-statistic is utilized (26). In many study fields, it is necessary to compare the means of a numerical random variable across several populations. ANOVA is a statistical process for comparing the means of several samples (27). It extends the principles of a t-test for two independent samples to include additional groups.

Hypothesis

The researchers' investigation sought to address the following hypothesis. Farm size has a substantial effect on farmers' adoption of salinity-tolerant rice cultivars.

Null Hypothesis (H_0):There is no significant difference in the adoption of the salinity tolerant varieties based on farm size (Small, Marginal Large)

Alternative Hypothesis (H_1):There is a significant difference in the adoption of the salinity tolerant varieties based on farm size (Small, Marginal, Large Farmer).

Conceptual Framework of the Study (Fig. 1)

Causes of adoption Index

The causes of the adoption index used in this study are based on findings from existing literature. Salinity impairs plant water intake, resulting in dehydration and nutritional imbalances (28) which ultimately leads to low growth and yield, especially in paddy crops. Salinity stress reduces crop yields due to inhibited growth, reduced tailoring, and smaller grain size, especially in paddy fields in regions prone to salinity (29). Additionally, soil degradation due to salinity leads to the accumulation of salts that negatively affect soil structure, reduce fertility, and lower water-holding capacity (30). This degradation significantly hampers crop production, especially in coastal areas where salinity levels are high. Salinity-induced yield reductions pose a serious threat to food security, especially in regions like India where rice is a staple food (31). The negative impacts on paddy yield affect both farmers' livelihoods and the food availability underscoring the need for sustainable solutions, such as salt-tolerant crop varieties. Salinity stress is a key driver for farmers to adopt new agricultural practices, particularly in coastal regions. The increased salinity in soil and water necessitates the introduction of salt-tolerant varieties and improved irrigation practices to mitigate crop loss.

To access the causes of salinity, the study used a Cause of Adoption Index (CAI) (32). A Likert scale of five point continuum for finding out the causes of adoption was followed by a five-point Likert-type modified scalefor

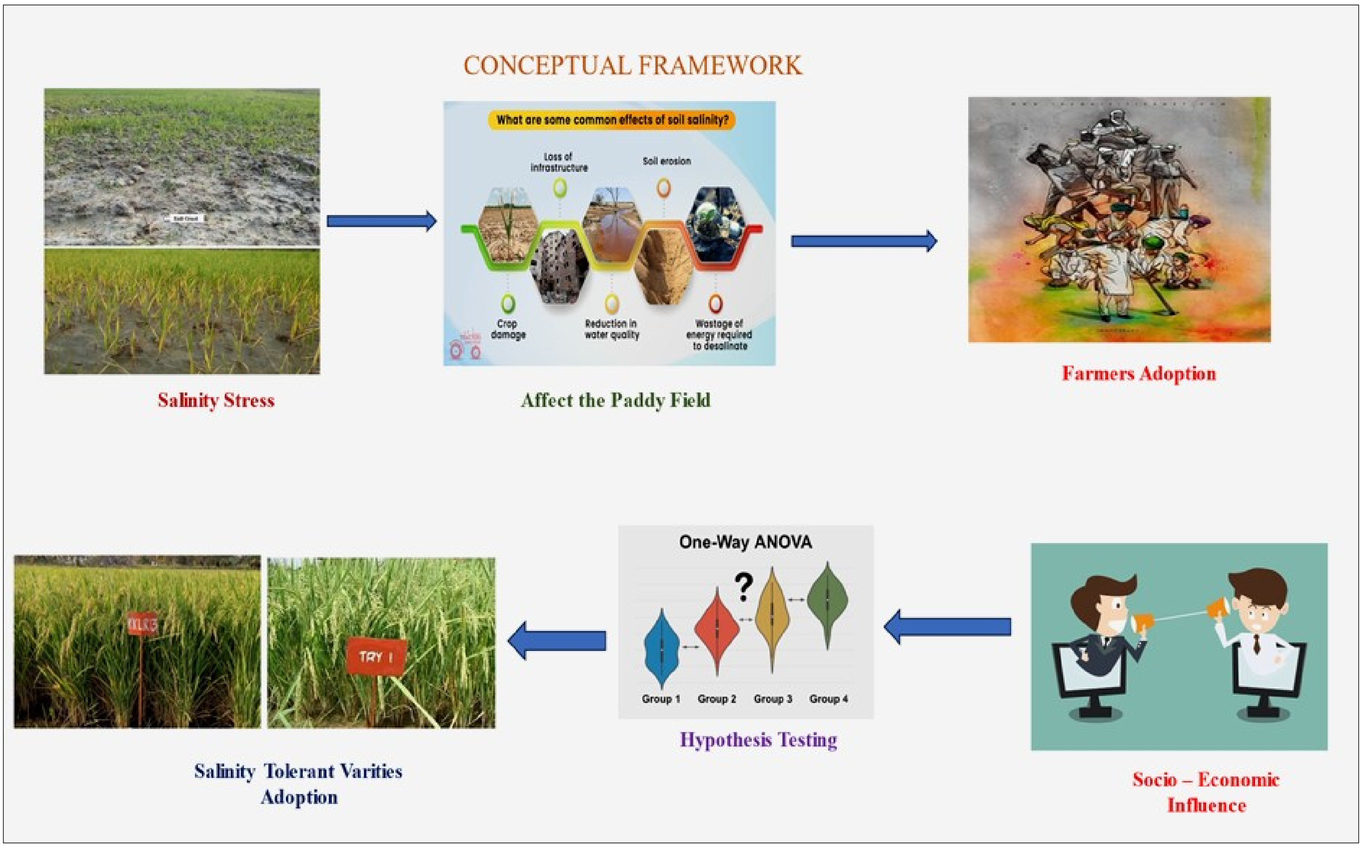

Fig. 1. Conceptual framework of the Study.

each statement, with the following degrees of freedom: strongly agree, agree, undecided, disagree and strongly disagree. A score of 5 (Strongly agree), 4 (Agree), 3 (Undecided), 2 (Disagree) and 1 (Strongly Disagree) were assigned against the rating scale.

The CAI was designed to quantify the importance of various factors driving the adoption of salinity-tolerant varieties. The total score for each respondent varies from 60-300, where 60 indicates the lowest number of causes and 300 indicates the highest number of causes for adoption of climate adaptation strategies. The causes for adoption were ranked based on the percentage of CAI Score. (33)

$$CAI\ (\%) = \frac{\text{OISCA}}{\text{HPISCA}}$$

$$\text{OISCA} = \text{Nas} \times 5 + \text{N ag} \times 4 + \text{Nod} \times 3 + \text{ND} \times 2 + \text{ND} \times 1$$

Where, OISCA-Observed Index score for causes of Adoption, HPISCA-Highest Possible Index score for causes for causes of Adoption, N as-Number of Respondents pointed as a Strongly Agree, Na-Number of Respondents pointed as a Agree, N ud-Number of Respondents pointed as Undecided, Nda-Number of Respondents pointed as a Disagree and Nsd-Number of Respondents pointed as a Strongly Disagree.

Results

Causes of Adoption Index

A significant number of farmers (85%) in the affected regions report a marked reduction in yield, a finding consistent with the previous study (34). Their research emphasizes that salinity stress severely disrupts soil structure and water availability in paddy fields, leading to substantial yield losses. Additionally, 71% of farmers identified an increase in production costs as a major challenge. The economic burden salinity imposes on rice cultivation is substantial, noting that it not only diminishes yields but also escalates costs. Farmers are forced to invest heavily in soil amendments, salt-tolerant seeds, and alternative irrigation methods to combat the effects of salinity, consistent with the findings (35). Moreover, 55% of farmers face nutrient deficiencies, a problem discussed previously (36). Their study revealed that salinity stress hampers the uptake of essential nutrients like potassium, calcium, and magnesium, resulting in nutrient imbalances that further compound yield reductions. Lastly, Climate change exacerbates salinity stress in coastal paddy fields with rising sea levels and increased storm surges leading to greater saltwater intrusion, significantly threatening paddy cultivation without substantial interventions (37), as shown in Fig. 2.

Correlation of Profile Characteristics of Paddy Growers with the Extent of Adoption of various Salinity Tolerant Varieties

The correlation and association of profile characteristics are shown in Table 1. Experience in Salinity Adaptation (r = 0.476) shows the strongest positive correlation with the adoption of salinity-tolerant varieties. Farmers with more experience dealing with salinity issues are much more likely to adopt these varieties.

Annual Income (r = 0.458) also shows a strong positive correlation between income and the adoption of salinity-tolerant varieties. Lower-income farmers are more likely to adopt these varieties, possibly because they cannot afford the potentially higher costs of new seed varieties or can take the risk of trying new crops.

Mass Media Participation (r = 0.437) shows a strong correlation, suggesting that farmers who engage more with mass media are more likely to adopt salinity-tolerant varieties. Media exposure likely increases awareness about these varieties and their benefits.

Information Sources (r = 0.266) and Extension Participation (r = 0.208) both show positive correlations, indicating that farmers with access to more information sources and those who participate in extension programs are more likely to adopt salinity-tolerant varieties. This highlights the importance of information dissemination in promoting adoption.

Saltwater Inundation (r = 0.266) shows a positive

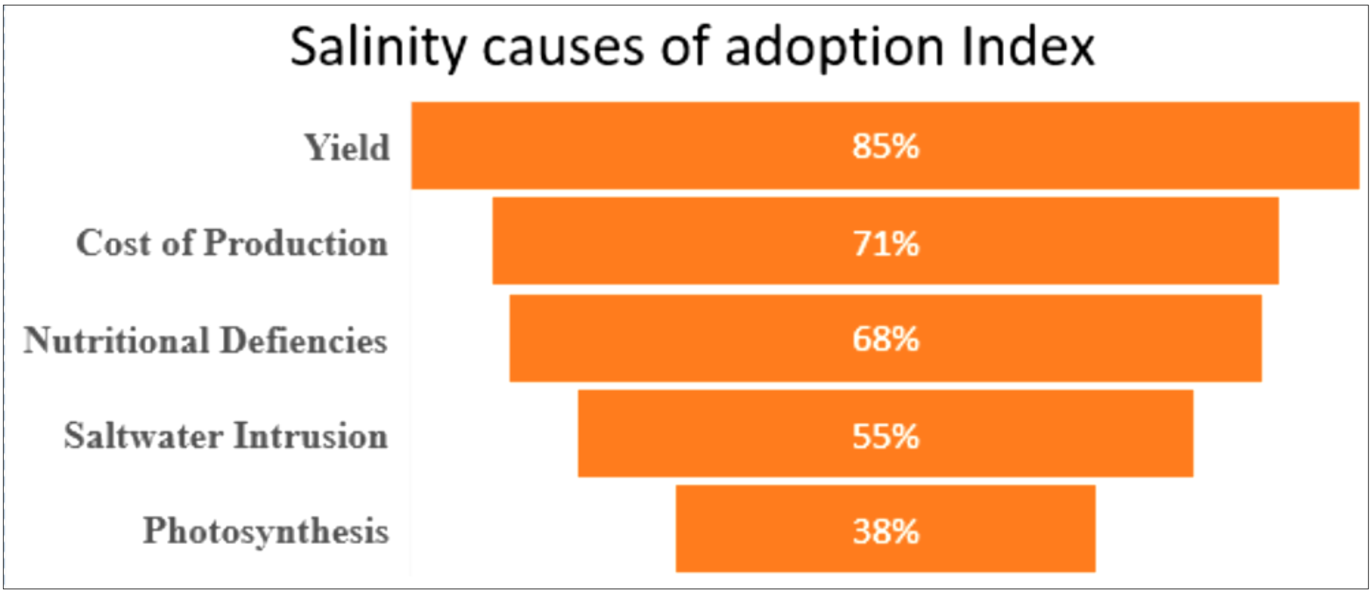

Fig. 2. Causes of Adoption Index.

Table1. Correlation of Profile Characteristics of Farmers.

S.no	Variable	"r" Value
X1.	Age	0.235**
X2.	Gender	0.118(NS)
X3.	Education	0.169*
X4.	Farm Size	0.256**
X5	Farmers Occupation	0.253**
X6.	Experience in Salinity Adaptation	0.476**
X7.	Annual Income	0.458**
X8.	Extension Participation	0.208**
X9.	Information Sources	0.266**
X10.	Social Participation	0.141(NS)
X11.	Farmer Progressiveness	0.111(NS)
X12.	Decision Making Behavior	0.123(NS)
X13.	Risk taking choosing on Adaptation	0.196**
X14.	Saltwater Inundation	0.266**
X15.	Mass Media Participation	0.437**

*-Significant @ 5% ** -Significant @1% **NS**- Non-Significant.

correlation, suggesting that farmers experiencing more saltwater problems are more likely to adopt salinity-tolerant varieties, which is logical given their greater need for these crops.

Farm Size (r = 0.256) and Farmer's Occupation (r = 0.253) both show similar levels of positive correlation. Marginal farms and certain types of farming occupations are associated with higher adoption rates of salinity-tolerant varieties.

Extent of Adoption of Salinity Tolerant Varieties

It was observed that Table 2. and Fig. 3 show that KKL(R) 3 had the lowest adoption rate among the listed varieties, with only 14.80 per cent of farmers choosing to adopt it, while a significant 85.20 per cent of them were non-adopters. The low adoption rate could be due to a lack of awareness or the perception that the variety is ineffective in local conditions.

TPS-5 stands out as one of the most popular varieties, with 68.00 per cent of farmers adopting it, indicating its recognized benefits, likely due to strong performance under saline conditions. TRY-1 is also widely adopted, with 59.50 per cent of farmers using it. While this is a notable adoption rate, it is slightly lower than TPS-5, suggesting that although TRY-1 is beneficial, there may be specific factors limiting its adoption for some farmers. The 36.19 per cent non-adoption rate hints at challenges related to adaptability or farmer preferences.

Table 2. Extent of Adoption of salinity tolerant varieties.

Sl. No.	Varieties	Adopters		Non- adopters		Total	
		No.	%	No.	%	No.	%
1.	KKL(R) 3	31	14.8	179	85.2	210	100
2.	TPS-5	143	68.00	67	31.9	210	100
3.	TRY-1	124	59.50	76	36.19	210	100
4.	TRY-2	20	9.50	190	90.50	210	100
5.	TRY-3	128	60.50	82	39.00	210	100
6.	TRY-4	41	19.50	169	80.50	210	100
7.	TRY-5	116	55.00	94	44.76	210	100
8.	KKL-1	133	63.30	77	36.67	210	100
9.	KKL-2	27	2.90	183	87.10	210	100
10.	Pokkali	54	25.70	156	74.30	210	100
11.	Vytilla 1-8	50	23.80	160	76.20	210	100
12.	Jyothi	19	9.00	191	91.00	210	100
13.	ADT-49	104	49.00	106	50.50	210	100

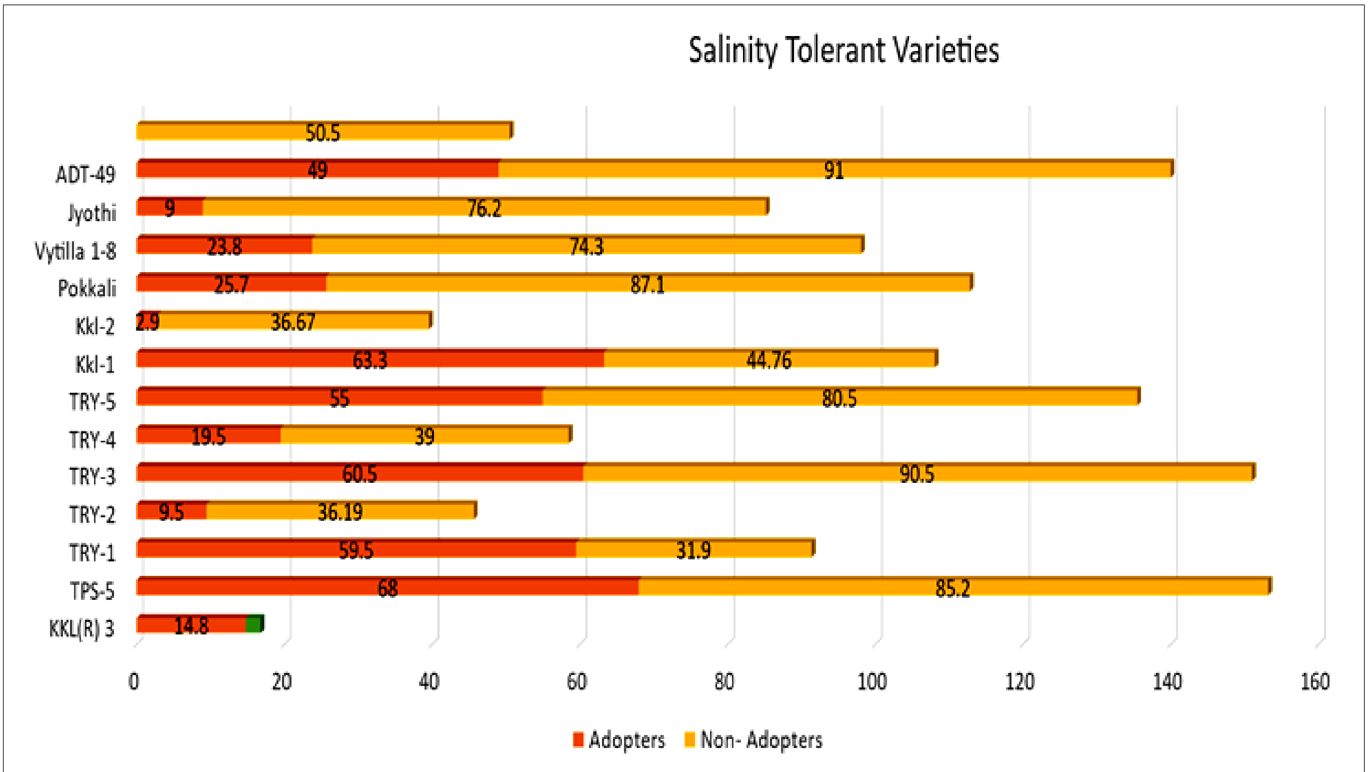

Fig. 3. Extent of Adoption of Salinity Tolerant Varieties.

TRY-2, on the other hand, has a strikingly low adoption rate of only 9.50 per cent, with a staggering 90.50 per cent of farmers not adopting it, making it one of the least favoured varieties. The low adoption rate may be attributed to TRY-2 being poorly suited to the region's salinity levels, or farmers may simply be unaware of its potential benefits.

TRY-3 had a relatively high adoption rate, with 60.50 per cent of farmers incorporating it into their farming practices, indicating that this variety has been well-received. TRY-4, much like TRY-2, shows a low adoption rate of 19.50 per cent, with 80.50 per cent of farmers being non-adopters. This low adoption rate may be due to issues such as low yields, cultivation difficulties, or doubts about its efficacy in managing salinity when compared to other varieties.

TRY-5 has a moderately high adoption rate of 55.00 per cent, while 44.76 per cent of farmers have yet to adopt it. Despite its relative acceptance, TRY-5 still faces competition from other varieties or scepticisms regarding its performance.

KKL-1, with a solid adoption rate of 63.30 per cent, indicates widespread acceptance, though 36.6 per cent of farmers remain hesitant. Its relatively high adoption suggests that KKL-1 offers tangible benefits in managing salinity or increasing yields, making it a favourable choice for many.

KKL-2 shows a significantly low adoption rate of just 2.90 per cent, with 87.10 per cent of farmers choosing not to adopt it. This low adoption suggests that KKL-2 is either underperforming or has not been adequately promoted among farmers.

Pokkali, a well-known salt-tolerant variety traditionally cultivated in coastal regions, has a moderate adoption rate of 25.70 per cent, with 74.30 per cent opting not to adopt it. Its relatively low adoption may be due to regional preferences, the availability of better alternatives, or difficulties in adapting Kokkali to non-traditional areas.

Similarly, Vitelli 1-8 shows a comparable adoption rate to Kokkali, with 23.80 per cent of farmers adopting it and 76.20 per cent not. While the Vitelli varieties are known to farmers, they are not as widely embraced, possibly due to regional suitability or competition from more popular varieties, such as TPS-5 or TRY-3.

Jyothimattai has one of the lowest adoption rates, with only 9.00 per cent of farmers adopting it and 91.00 per cent being non-adopters. This extremely low adoption could stem from a lack of awareness, poor performance in local conditions, or stiff competition from more favoured varieties.

ADT-49 has an adoption rate of 49.00 per cent, nearly matching its non-adoption rate of 50.50 per cent. This indicates that while ADT-49 has its supporters, it faces significant competition from other varieties, limiting its overall adoption as shown in Fig. 3.

Adoption of Salinity Tolerant Varieties through Influences on the Farm Sizes

Hypothesis Testing

Table 3 provides an in-depth analysis of five crop varieties TPS-5, KKL-R1, TRY-1, TRY-3, and TRY-5, evaluated across three distinct farm sizes: Marginal, Small, and Large. The data included key metrics such as sample size (N), mean yield, standard deviation, and standard error, revealing important insights into how different varieties perform under varying farm scales. TPS-5 yields the highest mean yield on marginal farms (1.92), followed by small (1.7) and large farms (1.6). This indicates that TPS-5 may be particularly well-suited for smaller holdings, potentially due to the more intensive management strategies that can be implemented on such farms.

Table 3. Adoption of salinity tolerant varieties through influences on the farm sizes:.

S.No	Variety	Farm Size	N	Mean	Std Dev	Std error
1.	TPS-5	Marginal	91	1.92*	0.269	0.033
		Small	63	1.7	0.203	0.022
		Large	56	1.6	0.234	0.031
		Total	210	1.74	0.235	0.016
2.	KKL(R)-1	Small	64	0.97	0.278	0.034
		Marginal	90	1.11*	0.318	0.034
		Large	56	0.98	0.25	0.033
		Total	210	1.04	0.276	0.019
3.	TRY-1	Marginal	65	1.1	0.343	0.043
		Small	56	1.05	0.231	0.025
		Large	89	1.23*	0.426	0.057
		Total	210	1.13	0.333	0.023
4.	TRY-3	Marginal	94	1.92	0.269	0.033
		Small	60	1.7	0.203	0.022
		Large	56	1.65	0.221	0.03
		Total	210	1.75	0.236	0.016
5.	TRY-5	Marginal	63	1.26	0.402	0.05
		Small	91	1.34	0.475	0.05
		Large	56	1.18	0.333	0.045
		Total	210	1.27	0.405	0.028

* >0.05 (Test statistics) Indicates the significant values influence by the Farm

KKL-R1, however, follows a different trend, with marginal farms again showing the highest mean yield (1.11), but small (0.97) and large (0.98) farms yield similar results. The generally lower yields for KKL-R1 suggest that it may not be as productive as TPS-5, regardless of farm size.TRY-1 presents a notable contrast, as large farms show the highest mean yield (1.23), followed by marginal farms (1.1) and small farms (1.05). This pattern suggests that TRY-1 benefits from economies of scale and might require larger plots or more resources to achieve optimal yields.

TRY-3, much like TPS-5, performs best on marginal farms (1.92), with small farms (1.7) and large farms (1.65) following closely behind. This consistency in performance across both varieties points to the potential for higher productivity on smaller farms. For TRY-5, small farms exhibit the highest mean yield (1.34), with marginal farms (1.26) and large farms (1.18) lagging slightly behind. This suggests that TRY-5 is particularly well-suited for small-scale agricultural systems.

Interestingly, marginal farms show greater standard deviations across all varieties, indicating more variability in yield outcomes. This could be due to a wider range of management practices or varying environmental conditions often associated with smaller land plots.

Salinity Tolerant Varieties Adoption to Access Robust Test of Equality Means & Levene Statistics

Hypothesis Testing

As observed in Table 4, the ANOVA results, particularly Levine's test, offer valuable insights into the homogeneity of variances across different farm sizes small, marginal, and large when evaluating the adoption of salinity-tolerant paddy varieties. Levine's test assesses the equality of variances, and a significant p-value (typically less than 0.05) suggests that variances differ significantly across groups. Ensuring homogeneity of variances is essential for making accurate inferences about the factors influencing the adoption of these varieties across different farm sizes.

The Welch and Brown-Forsythe tests, known for their robustness are more reliable than traditional ANOVA when dealing with unequal variances. These tests ensure valid comparisons between groups, such as when evaluating the adoption rates of various varieties across farm sizes, even in the presence of unequal variance distributions. For instance, the adoption of TPS-5 significantly varies across different farm sizes, as indicated by significant p-values (Welch F = 0.385, p = 0.042; Brown-Forsythe F = 0.378, p = 0.041; Levene's Statistic = 3.218, p = 0.042). This suggests that farm size plays a critical role in the adoption of this variety, with marginal farmers showing consistent adoption patterns. This finding corroborates the work of (38) who discovered that marginal farmers in saline-prone regions preferred TPS-5 due to its superior yield performance under saline conditions.

Similarly, the adoption of KKL(R)-1 also demonstrates significant variation across farm sizes (Welch F = 0.803, p = 0.042; Brown-Forsythe F = 0.803, p = 0.041; Levine's Statistic = 4.665, p = 0.010). The significant p-values highlight that farm size is an influential factor, particularly with marginal farmers showing equal variance in adoption. This aligns with the previous study (39), which reported that KKL(R)-1 significantly improved productivity for marginal farmers in saline soil environments.

TRY-1 exhibits notable differences in adoption across farm sizes (Welch F = 2.795, p = 0.020; Brown-Forsythe F = 2.469, p = 0.025; Levene's Statistic = 11.775, p = 0.000), indicating a strong variance in adoption patterns. This supports the finding of the study (39), which observed widespread adoption of TRY-1 among farmers with larger landholdings, particularly due to its superior grain quality and suitability for saline-prone areas.

The adoption of TRY-3 also varies significantly based on farm size (Welch F = 0.204, p = 0.015; Brown-Forsythe F = 0.188, p = 0.017; Levene's Statistic = 5.883, p = 0.003). Marginal farmers demonstrate consistent adoption patterns, which is in line with (37) on the adoption of salinity-tolerant varieties like TRY-3, particularly among small and marginal farmers in Karaikal District.

TRY-5, also shows significant variation in adoption rates across farm sizes (Welch F = 1.274, p = 0.030; Brown-

Table 4. Salinity tolerant varieties adoption to access Robust test of Equality Means& Levene statistics:

S.No	Variety	Test	Statistics (F)	P Values
		Welch	0.068	0.935
1.	KKLR 3	Brown Forsythe	0.067	0.935
		Levene Statistics	0.271	0.763
		Welch	0.385	0.042*
2.	TPS-5	Brown Forsythe	0.378	0.041*
		Levene Statistics	3.218	0.042*
		Welch	1.147	0.321
3.	Jyothimattai	Brown Forsythe	1.233	0.294
		Levene Statistics	4.665	0.476
		Welch	0.803	0.032*
4.	KKL(R)-1	Brown-Forsythe	0.731	0.035*
		Levene Statistics	4.665	0.010*
		Welch	0.068	0.935
5.	Gangavathy Sona	Brown-Forsythe	0.067	0.935
		Levene Statistics	0.271	0.763
		Welch	2.795	0.020*
6.	TRY-1	Brown-Forsythe	2.469	0.025*
		Levene Statistics	11.775	0.000*
		Welch	1.508	0.226
7.	TRY-2	Brown-Forsythe	1.252	0.289
		Levene Statistics	0.774	0.463
		Welch	0.204	0.015*
8.	TRY-3	Brown-Forsythe	0.188	0.017*
		Levene Statistics	5.883	0.003*
		Welch	0.364	0.696
9.	TRY-4	Brown-Forsythe	0.379	0.685
		Levene Statistics	1.479	0.230
		Welch	1.274	0.030*
10.	TRY-5	Brown-Forsythe	1.314	0.029*
		Levene Statistics	3.103	0.047*
		Welch	0.803	0.451
11.	KKL(R) 2	Brown-Forsythe	0.731	0.483
		Levene Statistics	2.393	0.094
		Welch	0.068	0.935
12.	ADT49	Brown-Forsythe	0.067	0.935
		Levene Statistics	0.697	0.499

P = >0.05 Indicates the significant values influence by the Farm size.

Forsythe F = 1.314, p = 0.029; Levene's Statistic = 3.103, p = 0.047), with small farmers especially inclined toward its adoption. This is likely due to its early maturation, water scarcity tolerance, and salinity resistance, echoing the findings of (38) who identified TRY-5 as a preferred variety for small farmers for these very reasons. In contrast, varieties such as KKL(R)-3, TRY-2, Vytilla 1-8, Pokkali, ADT-49, Jyothimattai, and GangavathySona exhibit no significant p -values, indicating uniform adoption patterns across farm sizes, with little variance in adoption rates.

Discussion

The research gaps highlight that existing studies on the adoption of salinity-tolerant varieties primarily focus on technical efficiency and yield benefits, while insufficient attention is given to behavioural, socio-economic, and psychological factors. Variables such as farmers' attitudes, risk orientation, and decision-making processes are understudied, and their impact on the adoption process remains unclear. Moreover, the role of information dissemination through extension services, mass media, and agricultural cooperatives in influencing farmers' decisions has not been adequately explored. Many farmers remain unaware of new varieties, and there is limited research on the effectiveness of various communication channels in raising awareness. The influence of social participation through farmer cooperatives or women's groups on adoption decisions is also underexplored. This research is the first of its kind to introduce the influence of farm size on the adoption of salinity-tolerant varieties, asserting that socio-economic factors play a pivotal role in shaping farmers' preferences. The underlying causes of adoption are key drivers influencing the selection of these varieties, with this research integrating multiple components to provide a holistic analysis.

The hypothesis testing revealed significant findings. For instance, Welch F = 0.385, p= 0.042*; Brown-Forsythe F = 0.378, p = 0.041*; and Levene's Statistic = 3.218, p = 0.042 indicate that farm size significantly affects adoption. Marginal farmers, who face a higher incidence of pest and disease problems (as indicated by an adoption index of 65%), are particularly drawn to the TPS-5 variety. This variety boasts medium amylose content, soft gel consistency, and moderate pest resistance, making it an appealing choice for marginal farmers seeking versatile and resilient crops. Therefore, the alternate hypothesis (H1) is accepted, and the null hypothesis (H0) is rejected.

Similarly, Welch F = 0.803, p = 0.042*; Brown-Forsythe F = 0.803, p = 0.041*; and Levene's Statistic = 4.665, p = 0.010 suggesting that farm size significantly influences adoption, with marginal farmers showing consistent variance. Socio-economic factors such as farmers' salinity adaptation experience and causes of yield reduction (85%) further drive their preferences. The KKL(R)-1 variety, with a medium duration and yield potential of 3.5 to 4.5 tons per hectare, is particularly suited for moderate-to-high salinity soils and is favoured for its excellent cooking quality and disease resistance. Consequently, the alternate hypothesis (H1) is accepted, and the null hypothesis (H0) is rejected.

Moreover, the hypothesis results (Welch F = 2.795, p= 0.020*; Brown-Forsythe F = 2.469, p = 0.025*; and Levene's Statistic = 11.775, p = 0.000) show a strong correlation between farm size and variety adoption. TRY-1, known for tolerating salinity levels up to 8 ds/m and yielding 3.5 to 4.0 tons per hectare, is highly sought after by larger farmers for its resilience and moderate yield under challenging conditions. The socio-economic factors, including salinity-induced yield reduction and saltwater inundation (r = 0.266), play a critical role in driving this preference. Hence, the alternate hypothesis (H1) is accepted.

Finally, the results (Welch F = 0.204, p= 0.015*; Brown-Forsythe F = 0.188, p = 0.017; and Levene's Statistic = 5.883, p = 0.003) indicate that farm size has a significant impact on adoption, with a focus on reducing production costs (73%) and adapting to saline soils. TRY-3, which can withstand salinity levels up to 7.0 dS/m and yield 4.0 to 5.0 tons per hectare, emerges as the preferred variety for marginal farmers due to its adaptability and strong performance. As a result, the alternate hypothesis (H1) is accepted.

Furthermore, Welch F = 1.274, p = 0.030*; Brown-Forsythe F = 1.314, P = 0.029*; and Levene's Statistic = 3.103, p = 0.047 support the conclusion that farm size significantly influences adoption. The TRY-5 variety, known for its high yield (5 to 6 tons per hectare) under saline conditions and its superior grain quality, is especially popular among small farmers. Its versatility and resilience make it an attractive option, leading to the acceptance of the alternate hypothesis (H1) and the rejection of the null hypothesis (H0).

Conclusion

The adoption of salinity-tolerant paddy varieties is significantly influenced by farm size, as revealed through hypothesis testing via ANOVA. Varieties such as TPS-5, KKLR (1), and TRY-3 are predominantly embraced by marginal farmers, while TRY-1 is favoured by larger landholders, and TRY-5 is preferred by small-scale farmers. The selection of these varieties is shaped by a combination of socio-economic determinants, including risk tolerance, decision-making skills, experience with saline conditions, and exposure to mass media. These factors contribute to strategic decision-making that promotes agricultural sustainability, particularly in Tamil Nadu, where rice remains the cornerstone of the population's diet. By cultivating these resilient, salinity-tolerant varieties, farmers ensure enhanced yields, fortifying both food security and nutritional sufficiency. This practice not only protects their livelihoods but also supports the broader goal of sustainable agriculture. In doing so, farmers help bolster the resilience of the agrarian sector in the face of salinity-induced challenges. This balance between innovation and tradition is crucial for maintaining agricultural productivity and ensuring long -term food security in the region.

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All author contributions are useful to conducting this research.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used the Quilbot AI tool in order to better the Pronunciation of English words. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the contents of the publication.

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