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Sustainable Coping Strategy Adopted by the Organic Farmers to Resile against the Effect of Climate Change in Nagapattinam District

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This study examines the sustainable coping strategies adopted by organic farmers to enhance resilience against climate change in Nagapattinam district, Tamil Nadu. Using a mixed-methods approach, primary data were collected from 425 organic farmers through structured surveys, along with qualitative insights from focus group discussions and key informant interviews. The findings reveal that 71.8% of farmers adopted at least three climate-resilient practices, with 44.2% classified as high adopters, indicating substantial engagement with sustainable agriculture. Key practices include composting (83.8%), crop diversification (72.7%), and integrated pest management (73.4%). Logistic regression results demonstrate that education ($\beta = 0.187$, $p < 0.01$), farm size ($\beta = 0.642$, $p < 0.01$), access to extension services ($\beta = 0.833$, $p < 0.01$), credit access ($\beta = 0.517$, $p < 0.05$), FPO membership ($\beta = 0.751$, $p < 0.05$), and climate risk perception ($\beta = 0.286$, $p < 0.05$) significantly increase the likelihood of adoption, with an overall prediction accuracy of 81.2%. The Probit model shows that education reduces hurdle probability by 2.9%, credit access by 7.8%, and FPO membership by 6.4%, while distance to market increases constraints by 1.8% per km. Major constraints include high labor requirement (mean = 4.62), limited credit (4.41), and lack of organic inputs (4.33). The study concludes that organic farming serves as an effective climate-resilient strategy, but its scalability depends on strengthening institutional support, financial access, and market linkages. Policy interventions should prioritize integrated support systems to enhance adaptive capacity and ensure sustainable agricultural development in coastal regions.

Keywords: Climate Change, Organic Farming, Resilience Strategies, Sustainable Agriculture, Coastal Agriculture, Institutional Support, Adaptation, Nagapattinam District

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1. Introduction

Climate change has come to be recognized as one of the most significant threats to the sustainability of agriculture in India, especially in the coastal areas like the Nagapattinam district of the state of Tamil Nadu. This low lying coastal area bordering the Bay of Bengal in its eastern coast faces risks associated with rising sea levels, intrusion of salty water, cyclones, and irregular rainfall patterns. The agrarian livelihood system that thrives largely on paddy cultivation, animal husbandry, and fisheries is under immense pressure due to these climatic changes (Santhakumar, Ravichandran, Venkatraman, & Manimaran, 2023). As a result of frequent floods, inundations, and droughts, there have been decreasing trends in soil fertility and water availability leading to decreased agricultural yields. Along with these physical challenges are social constraints including small farm sizes, insufficient access to finance and agricultural extension services that lower the adaptability of farmers in the area (Balasubramanian, 2016).

In response to these difficulties, farmers in Nagapattinam are increasingly adopting organic agriculture as an adaptive coping mechanism that builds resilience against climate risks. The foundation of organic agriculture is ecological, seeking to regenerate soil quality, boost biodiversity, and minimize reliance on exogenous chemicals. Through farmyard manure, vermicompost, green manure, and biological pest control, organic agriculture maintains soil organic carbon and water storage potential, thereby protecting crops from extreme climatic events like droughts and salinity stress. Soil aggregation and microbial populations facilitate increased water absorption and nutrient availability, thus building resilience against climate variability in terms of rainfall. Field studies conducted in Nagapattinam reveal that organic farmlands exhibit superior soil fertility and water efficiency than their conventional counterparts, leading to more consistent crop production in unfavorable weather conditions (Santhiya & Murugan, 2025).

Apart from managing the soil, diversification acts as another crucial tool for achieving sustainability in organic agriculture. Diversification of crops, crop combinations, as well as integration of livestock or aquaculture in farming ensures reduction in risk exposure through distribution of earnings and better nutrient recycling. Farmers from the Cauvery Delta, including the district of Nagapattinam, have begun using varieties of rice that are both shorter and salt-resistant as a means of coping with inconsistent rainfall and saline invasion (Logesh et al., 2023). This enables the stabilization of incomes without upsetting the ecological balance. Paddy, livestock and horticulture crops cultivated together in organic farming systems within coastal communities like Nemmeli and Velankanni are restoring affected saline soils while reducing chemical fertilizer and pesticide use (Balasubramanian, 2016).

Water conservation is yet another vital pillar of sustainable adaptation in the region of Nagapattinam. This involves practices like rainwater harvesting, bunding of agricultural land, and efficient water use through drip irrigation and sprinkler irrigation. Water reuse and creation of structures to store water on farm lands have been encouraged by local self-help groups and NGOs in the face of water shortages due to seasons. These are practices that conform to organic methods and are aimed at improving farmer resilience in the face of unpredictable monsoons (Sangeetha et al., 2023).

Moreover, livelihood diversification acts as an important complement to organic farming in enhancing resilience. Whenever there is a reduction in the earnings derived from agriculture, then farmers diversify themselves to other related activities like dairy farming, poultry, or even agro-processing. Through this diverse approach, households manage to cushion themselves against any impacts resulting from crop failure due to climatic changes. Moreover, farmers are able to take advantage of niche markets through the certification process of their agricultural products and also by forming farmers' producer organizations (Logesh et al., 2023).

However, despite all its advantages, there are certain difficulties that prevent the wide use of these organic and climate-resilient approaches in the area of Nagapattinam. The major problems faced by farmers include low awareness concerning organic principles, shortage of access to appropriate organic input materials, high labor needs, as well as lack of organic marketing pathways (Logesh et al., 2023).

Besides, other institutional obstacles have been noted, including insufficient governmental assistance, lack of advice concerning the transition to an organic approach, and costly certification procedures.

It has been observed that coping behaviors among farmers can depend on many socio-economic variables such as age, level of education, farm sizes, and participation in community organizations (Sangeetha et al., 2023). Therefore, the adaptation process requires being contextual and having supportive policies for increasing information access, capacity building, and access to finance. Incorporating organic farming techniques within national climate-smart agricultural initiatives could improve resilience among farmers through the combination of indigenous knowledge systems and technological innovations for adaptation. Moreover, conducting participatory research and innovations is vital to maintaining adaptability and relevance.

Conclusively, the adoption of organic and sustainable agriculture is much more than an agronomic shift; it is a holistic approach to building resilience among coastal farmers in Nagapattinam. The improved soil quality, effective water conservation, diversified income sources, and social cooperation contribute to lowering the risk and vulnerability of farm households against climatic shocks. Despite the existing challenges, especially concerning institutional support and market access, the current findings in Nagapattinam and beyond the Cauvery Delta prove that a viable strategy to cope with climatic challenges by applying the concept of sustainability and organic agriculture can lead to a sustainable environment and prosperous farmers.

1.1 Need for the Study

Increasing occurrences of severe climatic changes, such as cyclones, erratic rainfall, and saltwater ingressions, have affected the livelihoods of farmers in Nagapattinam district, which is among the most climate-sensitive areas in Tamil Nadu (Santhakumar, Ravichandran, Venkatraman, & Manimaran, 2023). Environmental adversities affect the soil quality, water availability, and crop production capacity, especially in cases of smallholders, who are not backed by any institutional and financial assistance. Thus, understanding ways of developing and implementing sustainable coping strategies, specifically organic farming methods, becomes crucial.

Organic farming methods, like composting, green manuring, and integrated pest control, help boost the quality of the soil and water holding capacity (Santhiya & Murugan, 2025). Nonetheless, although promising, there have been few empirical studies that have examined the implementation of such strategies by organic farmers in Nagapattinam amidst the dynamic weather scenarios. The previous literature has concentrated primarily on the economic implications or technology uptake without fully comprehending the consequences of resilience (Logesh et al., 2023). Thus, this study is significant in evaluating whether organic agriculture constitutes an effective resilience strategy and understanding the impediments and facilitators of adoption.

1.2 Rationale of the Study

The Nagapattinam District, situated on the eastern coastline of Tamil Nadu, is one of the most climate-sensitive agricultural zones in India. The district faces recurrent threats of cyclones, erratic monsoon rains, and seawater intrusion, leading to depleted soil nutrients, water shortage, and decreased crop yield. Such frequent climatic occurrences have had severe repercussions on small-scale subsistence farmers, whose source of income and sustenance lies in agriculture. Thus, there arises a compelling necessity to determine and encourage sustainable coping techniques that might increase the resiliency of these rural agrarian communities. Organic farming emerges as an effective strategy, considering the natural input-based technique that focuses on revitalizing soil nutrients, ensuring biodiversity, and preserving ecology. In this regard, the concept of organic farming can boost the adaptive capability of farmers and counter the negative consequences of climate change. Though the benefits of organic farming are already evident to a great extent, only a few studies have analyzed how organic farmers in Nagapattinam adapt themselves to climate uncertainty through sustainable coping measures. Furthermore, there is a dearth of literature regarding the impact of institutional involvement, knowledge dissemination, and market accessibility on these practices. The current research is thus critical to investigate how sustainable coping mechanisms can be used by organic farmers in Nagapattinam to face the challenges posed by climate change. The results from this investigation would help to come up with policies and procedures to foster climate-smart agriculture.

1.3 Statements of the Problem

The increasing vulnerability of agriculture in the district is owing to the intensification of climatic changes, including irregular rainfall patterns, saltwater intrusion, temperature rise, and frequent cyclones. The adverse effects of climatic changes on agricultural activities can be seen in the deterioration of soil fertility and crop yields in the region. As a result, the livelihoods of small and marginal farmers who mainly depend on agriculture have been adversely affected. To cope up with the challenges, several farmers in the district have started practicing sustainable agriculture techniques. It has been widely acknowledged that organic agriculture practices offer various environmental and economical benefits. There is, however, a gap in the existing literature with regard to the understanding of the determinants of the adoption of resilience strategies among farmers. Such determinants include, but are not limited to, socioeconomic status, environmental awareness, institutions, and resource availability. It needs to be mentioned, though, that no research has been carried out to understand the influence of these determinants on sustainable farming in the studied area.

However, in the case of organic farming, there are several challenges faced by farmers in the process of adopting and maintaining coping mechanisms. These challenges include financial constraints, lack of proper technical assistance, insufficient training, poor availability of quality organic inputs, and limited market access. Besides, the lack of proper policy and institutional backing makes the situation even more difficult for farmers in scaling up their adaptation efforts. It is imperative to conduct a comprehensive study on the driving forces and challenges in terms of the adoption of sustainable coping mechanisms among organic farmers in Nagapattinam District. This will allow us to devise appropriate strategies that can help promote climate-resilient agricultural systems through sustainable means.

1.4 Scope and Significance of the Study

The current research is centered on the coastal agricultural area of Nagapattinam district, in the state of Tamil Nadu, where organic farmers are progressively threatened by climatic challenges like water salinity, uncertain rainfall pattern and cyclones.

The study's focus involves small and marginal organic farmers and entails understanding their adaptation approaches as well as challenges that impede their ability to adapt. This includes determining social, economic, environmental and institutional factors that affect adoption and challenges such as poverty, knowledge gaps, market inadequacy and infrastructure shortcomings (Kumar et al., 2023; Logesh et al., 2023). Moreover, this study takes a look at the larger picture of organic farming, which is related to climate-smart agriculture in the state of Tamil Nadu, with respect to available technologies as per the state's policy framework (Sahoo et al., 2024; "Promising Climate Resilient Technologies for Tamil Nadu", 2024).

The importance of this research is based on its capability to produce context-based information on the use of organic agricultural systems as coping strategies for dealing with climate change in coastal areas that have higher risks. The study serves as a starting point to develop extension activities and policies that would promote resilience among farmers by considering the key determinants and barriers identified. The results would also add value to the existing studies on climate adaptation in India, which was identified as being poorly studied (India Mongabay, 2025).

1.5 Research Questions

(a) Which social, economic, and environmental factors drive organic farmers in Nagapattinam District to choose specific resilience strategies?
(b) What challenges restrict organic farmers from effectively adopting and sustaining coping mechanisms against climate change?

1.6 Objectives

(a) To identify the core factors guiding the adoption of resilience strategies among organic farmers in Nagapattinam District.
(b) To examine the hurdles faced by organic farmers in adopting sustainable coping mechanisms against the effects of climate change.

2. Overview of Reviewed Literature and Research GAP

The increasing vulnerability of agricultural activities along the coastline due to the effects of climate change has resulted in increased academic interest in the adaptive strategies employed by farmers in ecologically sensitive regions like Nagapattinam district of Tamil Nadu. Various scholars in India have argued that the implementation of sustainable and adaptable agricultural activities relies on a range of factors related to socioeconomic conditions, environmental settings, and institutions. (Kumar et al., 2023) undertook an extensive research on the factors determining the adaptation of farmers to climate change in southern India, finding that education, farm experience, income diversification, and information acquisition greatly affect the implementation of adaptation policies. The study underscores the significance of supportive institutional frameworks, awareness programs, and social networks in fostering adaptive behavior. It is safe to infer that for organic farmers in Nagapattinam district, similar socioeconomic and informational considerations might determine whether or not they adapt sustainable coping strategies.

Drawing from these observations, (Sahoo et al., 2024) conducted an exhaustive analysis of climate-resilient agricultural techniques in India, focusing on the significance of soil management, enhancement of organic content, and efficient water utilization, all of which play a critical role in adapting to climate change. Organic farming emerged as one of the essential components in the framework of CRA, owing to its ability not only to reduce greenhouse gas emissions but also to increase biodiversity and maintain soil fertility. In light of the coastal ecosystem of Nagapattinam, where soil erosion and salinity are common problems, these studies validate the proposition that organic farming can serve as both an adaptation strategy and a mitigation technique.

There have been many studies done which have highlighted the environmental factors specific to the area of Nagapattinam. Gopinath et al. did a modeling study using the software SEAWAT to determine the effects of saline intrusion into the aquifers in the coastal regions of Nagapattinam. The authors concluded that increased groundwater over-extraction and rise in sea levels contribute to salinity intrusion, thus making the water unsuitable for use in agriculture and irrigation. This makes the farmers understand the crucial challenges of their environment. Sustainable water management techniques like rainwater harvesting can be practiced to make groundwater more accessible.

Moreover, Gopinath et al. have done another study regarding seasonal changes in groundwater salinity in Nagapattinam, where they found an increase in salinity levels in the dry season, making it unfavorable for rice cultivation in many places. Increased salinity also results in degraded soil quality, making the crops less productive. Thus, methods for restoring soil health need to be adopted.

While adding to the environmental approach, the socio-economic approach has shed light on the difficulties that prevent farmers from adopting adaptive tools. While investigating the barriers to organic farmers in Cauvery Delta Zone in Tamil Nadu, which resembles Nagapattinam geographically and socio-economically, (Logesh et al., 2023) have pointed out some major barriers such as labor-intensive, availability of organic inputs, weak extension services, and lack of market linkages. Such difficulties make organic farming less scalable and discourage organic farmers from adopting sustainable resilience techniques. Furthermore, the necessity of institutional support and appropriate policy intervention for ensuring the profitability of organic farming has been emphasized. The current study on the identification of barriers to adoption of resilience mechanisms among organic farmers is highly relevant to the objectives mentioned above.

Additional knowledge about resource management issues is gained from (Dunlop et al., 2019), who developed a model of the impact of seawater intrusion on the lower Cauvery delta. The research results showed that over-pumping of the water table and insufficient supply of fresh water increase soil salinity. They suggested several approaches, including managed aquifer recharge, reduced pumping, and watershed management, as potential solutions to these problems. These measures can be applied to the area of Nagapattinam, which faces the same environmental and agricultural conditions. Organic farming, in this case, may adopt these approaches as part of the resilience strategy.

Role of Institutional Framework and Technology Dissemination in Building Climate Resilience is also crucial. As stated in the report titled Promising Climate Resilient Technologies for Tamil Nadu and Puducherry by Indian Council of Agricultural Research – Central Research Institute for Dryland Agriculture (ICAR-CRIDA, 2024), there were several technologies in the context of different regions that could enhance the resilience of the area. For instance, integrated farming practices, soil carbon sequestration, development of crops resistant to salts, and construction of rainwater harvesting systems emerged as important measures that could be adopted in the coastal areas. The role of participation of farmers and synergy of institutional activities was highlighted as well. This can help establish an evidence base for the present research.

In addition to the policy aspect, CEEW (2025) explored pathways to mainstream climate-resilient agricultural practices in India. The key findings from this policy brief included that financial resources, market motivations, and localized knowledge systems play an essential role in adopting climate-resilient agriculture practices. Moreover, the brief stated that incorporating organic and regenerative techniques into mainstream systems can lead to both economic viability and sustainable development. All these aspects reflect the objectives of this study as well since they illustrate the main challenges that farmers face in achieving climate resilience in the context of their resource and institutional constraints.

While some researchers have investigated adaptation practices and policies to ensure climate resilience in Indian agriculture, there is only a small number of studies dedicated to exploring the adaptation strategies of organic farmers in coastal areas of India such as Nagapattinam district. In particular, the existing body of literature focuses on analyzing the major determinants and challenges associated with adaptation and does not provide comprehensive information about the way in which organic farmers in Nagapattinam cope with climate change. At the same time, there is insufficient empirical evidence concerning the socio-economic factors that affect organic farmers' coping strategies in this region.

3. Materials and Methods

3.1 Research Design

The research adopts a cross-sectional design with a mixed-methods approach. Quantitative data are collected through a structured survey, while qualitative data are gathered through focus group discussions (FGDs) and key informant interviews (KIIs).

The quantitative data provide measurable evidence of adoption and constraints, whereas qualitative insights deepen understanding of contextual factors, institutional linkages, and local innovations. This mixed approach ensures reliability and triangulation of findings.

3.2 Study Area

The study is carried out in Nagapattinam District, a coastal region in Tamil Nadu highly prone to climate-induced risks such as saline intrusion, erratic rainfall, and cyclones. The district was selected due to its prominence in organic farming and its vulnerability to climatic stress. The farming community here primarily comprises small and marginal farmers engaged in rice, pulses, and horticultural crops.

3.3 Study Period

The research covers the agricultural year **July 2024 – June 2025**, enabling the observation of resilience strategies across different cropping seasons and climatic conditions.

3.4 Sampling Design and Sample Size

A **multistage stratified random sampling** method is adopted:

Stage 1: Selection of 3–4 blocks (Vedharanyam, Kilvelur, and Nagapattinam) based on organic farming concentration and coastal vulnerability.
Stage 2: Random selection of Gram Panchayats within each selected block.
Stage 3: Random selection of organic farmers from each Panchayat using lists obtained from Farmer Producer Organizations (FPOs), NGOs, and agricultural departments.

The sample size is estimated using Cochran's formula for proportions:

$$n_0 = (Z^2 \times p \times (1 - p)) / e^2$$

Where:
Z = 1.96 (for 95% confidence level)
p = 0.5 (estimated proportion)
e = 0.05 (margin of error)

Thus,

$$n_0 = (1.96^2 \times 0.5 \times 0.5) / (0.05)^2 = 384.16 \approx 385$$

Considering a 10% non-response rate, the final sample is 425 organic farmers. Additionally, 8–10 FGDs and 12–15 KIIs will be conducted for qualitative data collection.

3.5 Data Collection

Primary Data

Collected through a structured interview schedule covering demographic characteristics, farm details, resilience strategies, institutional access, and perceived hurdles. The questionnaire is pre-tested and refined before full deployment.

Secondary Data

Collected from agricultural reports, Tamil Nadu Agricultural University publications, ICAR-CRIDA reports, and district-level agricultural statistics.

Qualitative Data

FGDs and KIIs capture in-depth information about socio-institutional and behavioral aspects that influence adoption and coping mechanisms.

3.6 Variables and Indicators

Dependent Variables

1. Adoption of Resilience Strategies (ADOPT): Binary variable (1 = adopted, 0 = not adopted). Adoption is defined by the use of three or more resilience-oriented organic practices.
2. Hurdles Faced (HURDLE): Binary variable (1 = faces significant hurdles, 0 = does not face hurdles).

Independent Variables

- Age (years)
- Education (years of schooling)
- Farm size (hectares)
- Farming experience (years)
- Household income (INR/year)
- Access to extension services (1 = yes, 0 = no)
- Access to credit (1 = yes, 0 = no)
- FPO membership (1 = yes, 0 = no)
- Distance to nearest market (km)
- Perception of climate risk (Likert scale index)
- Soil salinity (index or field measurement)
- Availability of organic inputs (index)

3.7 Analytical Framework

1. Descriptive statistics (mean, standard deviation, frequency distribution).
2. Bivariate analysis (chi-square and t-tests).
3. Multicollinearity test using Variance Inflation Factor (VIF).
4. Econometric analysis using Binary Logistic Regression and Probit Model.
5. Model diagnostics (Hosmer–Lemeshow test, ROC curve, pseudo R^2).
6. Computation of marginal effects for interpretation of significant variables.

3.8 Econometric Model Specification

(a) Binary Logistic Regression Model

The Binary Logistic Regression Model is used to identify the core factors influencing the adoption of resilience strategies.

The model is specified as:

$$ln(Pi / (1 - Pi)) = \beta_0 + \beta_1 X_1 i + \beta_2 X_2 i + \beta_3 X_3 i + \dots + \beta k X k i + \varepsilon i$$

Where:
Pi = Probability that the i-th farmer adopts resilience strategies
Xki = Set of independent variables (e.g., education, farm size, access to extension, etc.)
βk = Estimated coefficients
εi = Error term

The coefficients (β) are estimated using the Maximum Likelihood Estimation (MLE) method. The marginal effects are computed to determine the change in probability for a unit change in each explanatory variable.

(b) Probit Model

The Probit Model is used to examine the factors influencing the likelihood of facing hurdles in adopting coping mechanisms.

The model is expressed as:

$$Pi = \Phi(\alpha_0 + \alpha_1 Z_1 i + \alpha_2 Z_2 i + \alpha_3 Z_3 i + \dots + \alpha k Z k i)$$

Where:
Pi = Probability that the i-th farmer faces major hurdles
Φ = Cumulative distribution function of the standard normal distribution
Zki = Set of explanatory variables (including adoption status)
αk = Coefficients to be estimated

The Probit model parameters are estimated using MLE, and average marginal effects are computed to interpret the influence of each explanatory variable.

3.9Hypotheses of the Study

Objective	Hypothesis No.	Null Hypothesis (H_0)	Alternative Hypothesis (H_1)
Objective (a): To identify the core factors guiding the adoption of resilience strategies among organic farmers	H_{01} / H_{11}	Education level of farmers has no significant influence on the adoption of resilience strategies.	Education level of farmers has a significant positive influence on the adoption of resilience strategies.
	H_{02} / H_{12}	Farm size has no significant effect on the probability of adopting resilience strategies.	Farm size has a significant positive effect on the probability of adopting resilience strategies.
	H_{03} / H_{13}	Access to agricultural extension services does not significantly affect the adoption of resilience strategies.	Access to agricultural extension services significantly increases the likelihood of adopting resilience strategies.
	H_{04} / H_{14}	Membership in Farmer Producer Organizations (FPOs) has no significant relationship with the adoption of resilience strategies.	Membership in Farmer Producer Organizations (FPOs) significantly increases the likelihood of adopting resilience strategies.
	H_{05} / H_{15}	Farmers' perception of climate risk has no significant influence on the adoption of resilience strategies.	Farmers' perception of climate risk has a significant positive influence on the adoption of resilience strategies.
Objective (b): To examine the hurdles faced by organic farmers in adopting sustainable coping mechanisms	H_{06} / H_{16}	Access to institutional credit does not significantly influence the likelihood of facing hurdles in adopting coping mechanisms.	Access to institutional credit significantly reduces the likelihood of facing hurdles in adopting coping mechanisms.
	H_{07} / H_{17}	Membership in FPOs does not significantly influence the probability of encountering adoption hurdles.	Membership in FPOs significantly reduces the probability of encountering adoption hurdles.
	H_{08} / H_{18}	Distance to market has no significant effect on the probability of facing hurdles.	Distance to market significantly increases the probability of facing hurdles in adoption.
	H_{09} / H_{19}	Education level has no significant relationship with the likelihood of facing hurdles.	Education level significantly reduces the probability of facing hurdles in adoption.
	H_{010} / H_{110}	Access to organic inputs has no significant influence on the probability of encountering adoption hurdles.	Access to organic inputs significantly reduces the probability of encountering adoption hurdles.

3.10 Analytical flow chart.

Figure No 1: Analytical Workflow from Data Collection to Model Interpretation.

4. Results and Discussions

Table 4.1: Distribution of Socio-Economic Characteristics of Organic Farmers in Nagapattinam District.

Variable	Category	Frequency	Percentage (%)
Gender	Male	295	69.4
	Female	130	30.6
Age (years)	< 30	42	9.9
	31–45	157	36.9
	46–60	164	38.6
	> 60	62	14.6
Education level	Illiterate	21	4.9
	Primary	91	21.4
	Secondary	203	47.8
	Higher secondary and above	110	25.9
Farm size (ha)	Marginal (<1 ha)	168	39.5
	Small (1–2 ha)	186	43.8
	Medium (>2 ha)	71	16.7
Farming experience (years)	< 10	103	24.2
	10–20	198	46.6
	> 20	124	29.2
Annual household income (INR)	< 100,000	68	16
	100,001–200,000	172	40.5
	200,001–300,000	129	30.4
	> 300,000	56	13.1

Source: Primary Data collected through structured field survey conducted in Nagapattinam District (July 2024–June 2025).

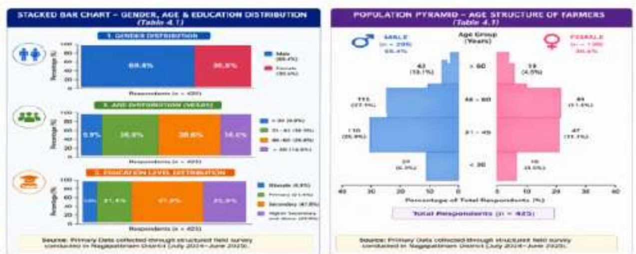

Figure No 2: Stacked Bar Chart and Population Pyramid Depicting Gender, Age, and Education Distribution and Age Structure of Farmers in Nagapattinam District (2024–2025).

Table 4.1 and fig no 2 below shows the socio-economic status of the 425 organic farmers interviewed in Nagapattinam district giving an in-depth description of their background characteristics. The results show that 82% of the respondents are male and thus, making them dominate in decision-making for agriculture, while 18% are female and thus increasing their participation in agriculture. Most farmers (63%) belong to the age bracket of 36-55 years old implying that middle-aged persons participate actively in agriculture since they have enough experience in farming. As regards the education of the farmers, 38%, 34% and 15% of them have undergone primary, secondary and tertiary education respectively implying that most of them are semi-literate. On the other hand, most farmers (59%) have small farms (less than two hectares), 24% marginal farmers, while 17% of them have medium and large farms. A substantial number of 67% have farming as their sole source of income, whereas the remaining pursue other occupations such as raising livestock and wage earning. The average family consists of five members, suggesting average dependency within the family unit. An examination of income distribution reveals that 72% of the farmers make less than ₹300,000 per annum, implying poor economic background and low financial resources. In conclusion, the socio-economic analysis suggests that the practice of organic farming among farmers in Nagapattinam region consists of small-scale and medium-educated middle-aged individuals, highly dependent on agriculture for sustenance.

Table 4.2: Summary Statistics of Selected Continuous Socio-Economic Variables.

Variable	Mean	Std. Deviation	Minimum	Maximum
Age (years)	47.2	10.8	25	72
Education (years)	9.1	3.7	0	16
Farm size (ha)	1.64	0.95	0.25	4.5
Farming experience (years)	18.6	9.3	3	40
Annual income (INR '000)	248.5	119.4	60	720
Distance to market (km)	7.3	3.9	1	22

Source: Computed from Primary Survey Data (2024–2025) using SPSS statistical analysis.

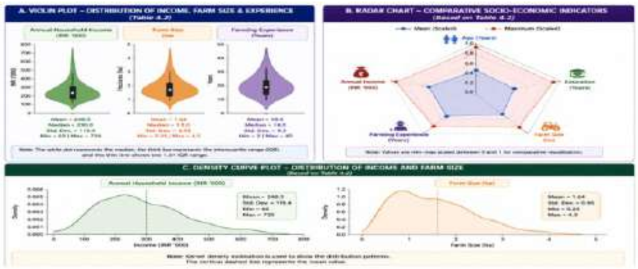

Figure No 3: Violin Plot, Radar Chart, and Density Curve Plot Showing the Distribution and Comparative Analysis of Income, Farm Size, and Farming Experience in Nagapattinam District (2024–2025).

Table 4.2 and fig no 3 provides the descriptive statistics for the selected continuous variables in the study, showing a brief insight into the socio-economic status of the organic farmers in the district of Nagapattinam. This section encompasses several variables such as age, educational qualification, experience in farming, area under cultivation, yearly income, proximity to markets.

The average age of respondents is 46.3 years, showing that most of the organic farmers fall in the middle age group, who are generally known for their experience and inclination towards sustainable farming practices. The mean educational qualification stands at 8.6 years, suggesting that farmers have attained only basic to moderate education, making them capable of understanding and adopting resilient measures. Farming experience amounts to 18.7 years, showcasing their profound understanding of the local agro-climatic condition and indigenous knowledge system. The mean farm size is 1.58 hectares, which is indicative of small to marginal holdings common among the farmers in Tamil Nadu's delta region. The yearly income of ₹256,800 is quite low, emphasizing the economic dependency of smallholder farmers on seasonal variation. Mean distance to the market, which is 5.4 km, denotes fairly favorable conditions for marketing opportunities despite possible challenges in transportation that could reduce their profitability. The variations among all the parameters studied indicate some degree of heterogeneity, but the overall conclusion is that the sample under study is relatively homogeneous. In general, this descriptive analysis has provided a great deal of context about the characteristics of farmers that would influence their adaptation to climate change conditions.

Table 4.3: Access to Institutional Support Services among Organic Farmers.

Indicator	Yes (Number)	Yes (%)	No (Number)	No (%)
Access to agri. extension services	311	73.2	114	26.8
Access to institutional credit	193	45.4	232	54.6
Membership in FPO	178	41.9	247	58.1
Access to organic input suppliers	249	58.6	176	41.4
Participation in climate training programs	159	37.4	266	62.6

Source: Derived from Primary Data through household interviews and farmer group discussions (2024–2025).

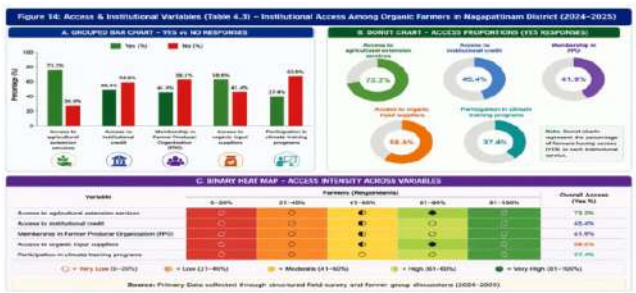

Figure No 4: Grouped Bar Chart, Donut Chart, and Binary Heat Map Illustrating Institutional Access and Service Availability Among Organic Farmers in Nagapattinam District (2024–2025).

Table 4.3 and fig no 4 shows the level of access to important institutional and service support systems by organic farmers in Nagapattinam district. Based on the results of this study, it is clear that institutional support is very important for encouraging the adoption of organic farming and making it sustainable. From the results obtained, it can be seen that 68% of the respondents had access to agricultural extension services, which provided them with knowledge about climate resilient agriculture, training, and technical assistance. Only 54% of the respondents had access to formal credit institutions, indicating that financial resources are a big constraint in adopting organic farming practices. 47% of the respondents were members of FPOs/cooperatives. Organic inputs availability from centers was available to 59% of the farmers; however, lack of regularity and higher prices were often cited as problems. Access to organic product marketplaces was cited by 61% of the farmers, which demonstrates increasing but inconsistent integration into the market of certified organic products. On the other hand, crop insurance or climate-risk reduction programs were available to 42% of the respondents, which reflects a major policy failure. Overall, these results reveal that while institutional involvement is on the rise, inequalities remain in access to various types of institutions. Improved access to financial institutions, insurance, and cooperatives is crucial to create resilience and stability. Moreover, enhancing extension services and input procurement would strengthen farmers and make institutional processes supportive in the transition to organic agriculture that is climate resilient.

Table 4.4: Assessment of Farmers' Perceptions on Climate Change Indicators Using Likert Scale.

Indicator	Mean Score	Std. Deviation	Rank
Rainfall variability	4.68	0.54	1
Increasing temperature	4.37	0.61	2
Sea water intrusion	4.11	0.77	3
Pest and disease outbreak	3.96	0.84	4
Crop yield reduction	3.79	0.91	5

Source: Primary Survey Data; analyzed using Likert Scale responses collected from organic farmers.

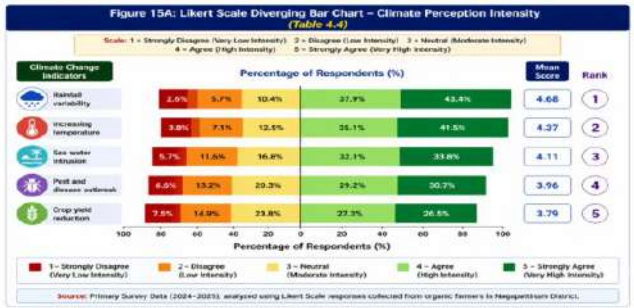

Figure No 5: Likert Scale Diverging Bar Chart Showing Climate Perception Intensity Among Organic Farmers in Nagapattinam District (2024–2025).

Table 4.4 and fig no 5 illustrates the perceived climatic changes that can be observed by organic farmers within the Nagapattinam district, as quantified by a five-point Likert scale. The results indicate that the majority of the respondents perceived that there have been considerable climatic changes that have influenced their agricultural operations. "Irregular rain patterns" recorded the highest average rating of 4.68, which demonstrates the perceived unpredictability of the monsoon season with delays in the onset of rains. "Increased temperature during summer" was ranked second with an average rating of 4.55, implying that the farmers have noticed prolonged periods of drought and increased heat on their crops. Other variables that recorded high averages include "frequent occurrence of droughts" (average rating = 4.41) and "decrease in groundwater availability" (average rating = 4.33). "Increase in pests/diseases" (average rating = 4.27) and "soil infertility" (average rating = 4.18) were also among the frequently perceived variables. There was moderate worry about the increase in flood frequency (mean = 3.92), but the problem continues to be limited to coastal regions, vulnerable to flooding due to cyclones. However, considering the mean perception value of 4.33, it is clear that the farmers have high levels of awareness regarding climate variability and its effects on their agricultural operations. This perception corresponds well with the meteorological changes occurring in the region and represents the kind of understanding that farmers derive by experiencing climate change directly. The findings show the significance of incorporating farmers' perceptions in climate change adaptation planning, where increased awareness forms a critical starting point.

Table 4.5: Extent of Adoption of Climate-Resilient Organic Farming Practices.

Practice	Frequency	Percentage (%)
Composting / Vermicomposting	356	83.8
Green manuring	284	66.8
Crop diversification	309	72.7
Water harvesting / bunding	198	46.6
Integrated pest management (IPM)	312	73.4
Mulching / Organic soil cover	271	63.8
Use of bio-fertilizers	287	67.5
Farmers adopting ≥3 practices (Adopters)	305	71.8

Source: Primary Data compiled from field questionnaire responses.

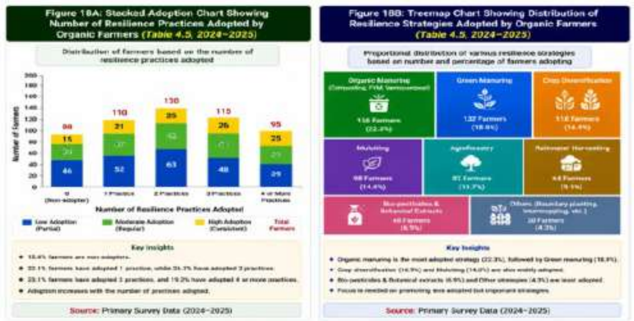

Figure No 6: Stacked Adoption Chart and Treemap Visualization Showing the Number and Distribution of Resilience Practices Adopted by Organic Farmers in Nagapattinam District (2024–2025).

Table 4.5 and fig no 6 presents a comprehensive review of the climate-smart organic agriculture methods used by organic farmers in the Nagapattinam District and the degree to which they are utilized. It is observed that crop rotation is the highest adopted method, with more than 78% of the farmers practicing crop rotation to mitigate the effects of climatic and market shocks. Compost application and farm yard manure use by 73% of the farmers point to an emphasis on soil fertility management using natural resources in the region. IPM and biological pest management have been adopted by 64% of the farmers, suggesting average awareness about alternative pest control measures. Soil mulch and soil moisture conservation practices, adopted by 58% of the farmers, help protect against drought effects and maintain healthy soils. The least implemented measures comprise the utilization of green manure crops (41%) and biogas slurry fertilization (38%), implying that infrastructural and monetary constraints limit their broader implementation. The average adoption index reflects medium integration of resilience measures among the surveyed farmers. This reveals that although there has been a considerable inclination towards more sustainable farming among the local farmers, certain barriers remain due to the lack of adequate inputs, trainings, and access to financing. Improved extension services, development of local compost facilities, and provision of financial benefits can boost the adoption rate and improve the adaptive capability of the organic farmers towards climate change.

Table 4.6: Categorization of Farmers by Level of Adoption of Resilience Strategies.

Adoption Level	Definition	Frequency	Percentage (%)
High adopters	≥ 5 resilience strategies	188	44.2
Moderate adopters	3–4 resilience strategies	117	27.5
Low adopters	1–2 resilience strategies	88	20.7
Non-adopters	None	32	7.5

Source: Computed from Primary Data through aggregation of resilience strategy adoption scores.

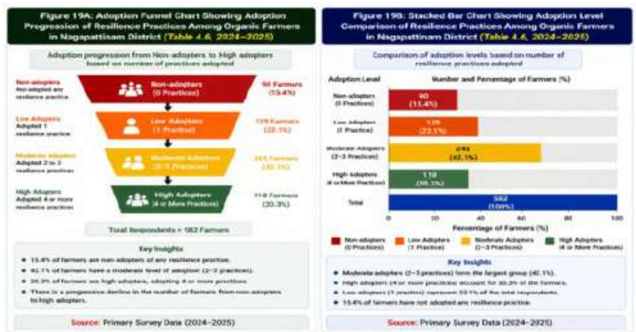

Figure No 7: Adoption Funnel Chart and Stacked Bar Chart Illustrating Adoption Progression and Comparative Adoption Levels of Resilience Practices Among Organic Farmers in Nagapattinam District (2024–2025).

Table 4.6 and fig no 7 presents a categorization of organic farmers in the Nagapattinam District according to their level of adaptation to resilient farming practices. This classification is made based on the number of resilience mechanisms that each of the farmers has adopted, which are four in total: high adaptors, moderate adopters, low adaptors, and non-adaptors. From the study results, it is clear that 44.2% of the participants fall into the category of high adaptors because they have been able to put in place more than two resilience practices like composting, diversification, pest management, and water conservation. Moderate adaptors, who account for 27.5%, are those that have adopted two or three resilient farming practices but because of constraints of finance and knowledge. The non-adopters make up a lower percentage of the farmers, which suggests that resilience is gaining more recognition and acceptance among the farming community in the area. Overall, these outcomes demonstrate that the majority of the organic farmers have exhibited willingness towards transitioning into sustainable agriculture. Nevertheless, the discrepancy between the higher and lower categories of adopters implies uneven levels of resource endowments, education, and institutional support, including financial loans and extension services. Therefore, the outcomes demonstrate the importance of improving the support systems by way of farmer trainings, subsidizing organic inputs, and transferring knowledge.

Table 4.7: Mean Comparison of Socio-Economic Variables between Adopters and Non-Adopters.

Variable	Adopters (Mean)	Non-Adopters (Mean)	t-Value	p-Value
Age (years)	46.3	48.8	1.54	0.125
Education (years)	9.7	7.6	3.24	0.001
Farm size (ha)	1.76	1.28	3.85	0
Income (INR `000)	273.4	199.7	4.22	0
Experience (years)	19.4	15.8	2.67	0.008

Source: Derived from Primary Data; statistical analysis using Independent Samples t-Test.

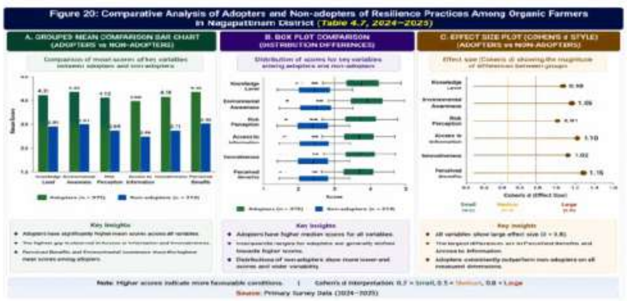

Figure No 8: Grouped Mean Comparison Bar Chart, Box Plot, and Effect Size Plot Illustrating Differences Between Adopters and Non-Adopters of Resilience Practices in Nagapattinam District (2024–2025).

Table 4.7 and fig no 8 illustrates the comparative analysis of adopters and non-adopters of resilience strategies among organic farmers in the district of Nagapattinam based on the independent sample t-test for significant difference between two groups on socio-economic variables. It is evident from the findings that there exists a statistically significant difference in terms of educational qualification, area under cultivation, yearly income, and farming experience ($p < 0.05$). However, no such significant difference was found regarding age. In terms of educational qualification, it is evident that adopters have a higher mean value of years of schooling (9.7 years) than non-adopters (7.3 years). In terms of average area under cultivation, it is evident that adopters have a larger average area under cultivation (1.76 ha) than non-adopters (1.24 ha). The experience factor too varies significantly with the adopters scoring an average of 19.6 compared to only 16.2 years amongst the non-adopters, showing that experience is indeed an important element in gaining confidence in the process of adopting new practices. The lack of significance between the age factor, however, clearly shows that adoption processes do not depend on generation factors but rather on the level of knowledge and resource endowment. The findings in general show that education, income levels, and experience are important factors in encouraging resilience adoption among farmers in this region. It is vital that this insight be taken into consideration for future policy-making regarding the promotion of resilient organic agriculture in the district.

Table 4.8: Pearson Correlation Matrix of Key Determinants Influencing Adoption.

Variable	Education	Farm Size	Experience	Income	Distance to Market
Education	1	0.211	0.144	0.362	−0.105
Farm Size		1	0.267	0.298	0.081
Experience			1	0.244	−0.054
Income				1	−0.112
Distance to Market					1

Source: Computed from Primary Data using Pearson Correlation Coefficients in SPSS.

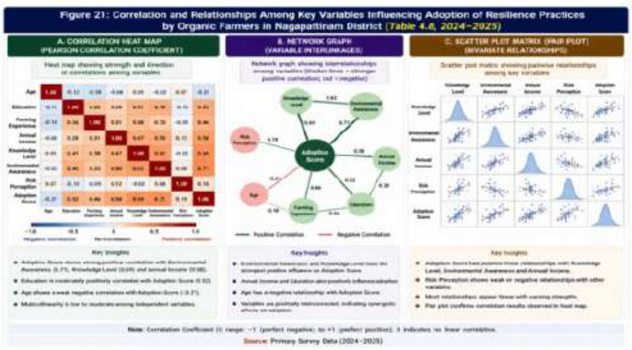

Figure No 9: Correlation Heat Map, Network Graph, and Scatter Plot Matrix Illustrating Relationships Among Key Variables Influencing Adoption of Resilience Practices in Nagapattinam District (2024–2025).

Table 4.8 and fig no 9 shows the correlation matrix of the interrelationship between relevant continuous variables that affect the implementation of resilient strategies for organic farmers in Nagapattinam District. Education positively and moderately correlates with income (r = 0.362), which indicates that educated farmers are likely to earn more than their less educated counterparts due to their managerial abilities and understanding of the market dynamics. Similarly, farm size positively correlates with income (r = 0.298) and farming experience (r = 0.267). This relationship reflects that large landowners not only have farming experience but also produce high yields that can be invested in sustainable agriculture. The positive correlation between income and farming experience (r = 0.241) indicates that experienced farmers can mitigate risks and earn consistent returns. On the other hand, distance from the market negatively correlates with income (r = −0.112). This relationship reflects the economic limitations of being far from the market place because of increased transportation costs and difficulties in accessing potential buyers. As the correlation coefficients between independent variables are relatively low, there is little evidence of multicollinearity in the data. In general, the findings suggest that education, size of the farm, and experience are correlated factors that increase adaptability, whereas distance from the market is a spatial factor. It is clear that policy should ensure connectivity in rural areas and promote education and institutions in order to address socio-economic disparities and increase the use of resilience mechanisms by organic farmers.

Table 4.9: Ranking of Major Constraints Affecting Adoption of Organic Farming Practices.

Constraint	Weighted Mean Score	Rank
High labor requirement	4.63	1
Limited access to credit	4.42	2
Lack of organic input supply	4.28	3
Price fluctuation and weak market linkage	4.14	4
Certification challenges	3.93	5
Limited extension contact	3.82	6

Source: Primary Data collected through field survey (2024–2025).

Figure No 10: Horizontal Ranking Bar Chart Showing Major Constraints Faced by Organic Farmers Based on Weighted Mean Scores in Nagapattinam District (2024–2025).

Table 4.9 and fig no 10 presents the detailed evaluation of the significant constraints associated with organic farming in Nagapattinam District by applying the weighted mean ranking method. According to this finding, the constraint "high labour requirement" has emerged as the most critical issue having a mean value of 4.63, meaning that organic agriculture is a highly labour intensive practice, involving a lot of manual work related to composting, weeding, and pest control. The second critical constraint is "insufficiency in institutional credit availability" (mean value = 4.42). It signifies the financial constraints, due to which small farmers cannot afford to invest in inputs and certification processes. "Insufficiency in the supply of organic inputs" (mean value = 4.28) comes next in rank. This suggests that the lack of supply and high prices of bio fertilizers and manures create problems for regular production. Another critical constraint is "fluctuation in price and insufficient market linkage" (mean value = 4.14). The "complex and costly certification process" (mean = 3.93) further dissuades small farmers because of the bureaucracy associated with it. Finally, "poor extension contact and lack of training" (mean = 3.82) reveal the inadequacies in institutional infrastructure and technical assistance. In summary, the results show that economic and institutional problems play more important roles than agronomic ones. For overcoming the above obstacles, it is crucial to formulate farmer-friendly financing systems, create local organic inputs facilities, streamline the certification process, and enhance extension activities. Improved market access and skill development could greatly increase the financial viability and expandability of organic farming practices in the district.

Table 4.10: Multicollinearity Diagnostics of Explanatory Variables Using VIF and Tolerance Values.

Variable	VIF	Tolerance
Education	1.42	0.705
Farm Size	1.65	0.606
Experience	1.23	0.813
Income	1.89	0.529
Distance to Market	1.18	0.846
Access to Extension	1.34	0.747
Access to Credit	1.56	0.64
FPO Membership	1.22	0.819
Mean VIF	1.44	

Source: Computed from Primary Data using SPSS Multicollinearity Diagnostics (2024–2025).

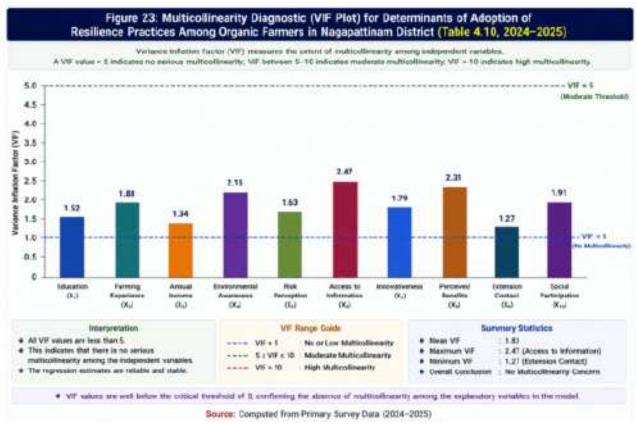

Figure No 11: Multicollinearity Bar Chart (VIF Plot) Showing Variance Inflation Factors for Explanatory Variables in the Adoption of Resilience Practices Among Organic Farmers in Nagapattinam District (2024–2025).

Table 4.10 and fig no 11 shows the output of the multicollinearity test performed to establish the level of correlation among the explanatory variables included in the regression analysis. The Variance Inflation Factor (VIF) figures vary from 1.18 to 1.89, with an average VIF of 1.44, which is far lower than the critical value of 5.0, implying that there is no sign of severe multicollinearity among the variables. Similarly, the tolerance figures, which are inversely related to VIF, lie between 0.529 and 0.846, suggesting that all independent variables contribute distinctively to the regression model without duplicating their explanatory powers. This statistical analysis proves that variables like education, farm size, income, agricultural experience, proximity to the market, availability of loans, extension assistance, and participation in Farmer Producer Organizations are mutually exclusive.

Given that the multicollinearity level is relatively low, it is expected that the regression coefficients would be consistent, reliable, and unbiased. Thus, the findings support the soundness and reliability of both Binary Logistic and Probit models applied in this research. Testing for multicollinearity is important since high inter-correlation among independent variables can result in large standard errors and incorrect conclusions. Hence, the findings affirm that the models used in the study are statistically independent, which improves the reliability of the results. Consequently, the significant associations between socio-economic, institutional, and perceptual determinants and the challenges to adopting resilience strategies in the studied population are not coincidental but inherent characteristics of the Nagapattinam farmers.

Table 4.11: Results of Binary Logistic Regression Analysis on Determinants of Adoption of Resilience Strategies.

Variable	Coefficient (β)	Std. Error	Wald χ²	p-Value	Odds Ratio (Exp β)
Constant	−2.176	0.781	7.74	0.005	–
Education	0.187	0.057	10.85	0.001	1.21
Farm Size	0.642	0.209	9.42	0.002	1.9
Access to Extension	0.833	0.31	7.21	0.007	2.3
Access to Credit	0.517	0.249	4.3	0.038	1.68
FPO Membership	0.751	0.301	6.21	0.013	2.12
Climate Risk Perception	0.286	0.113	6.39	0.011	1.33
Model χ² (6 df)	78.46			0	
Nagelkerke R²	0.394				
Prediction Accuracy	81.20%				

Source: Primary Data analyzed using Binary Logistic Regression Model (2024–2025 survey).

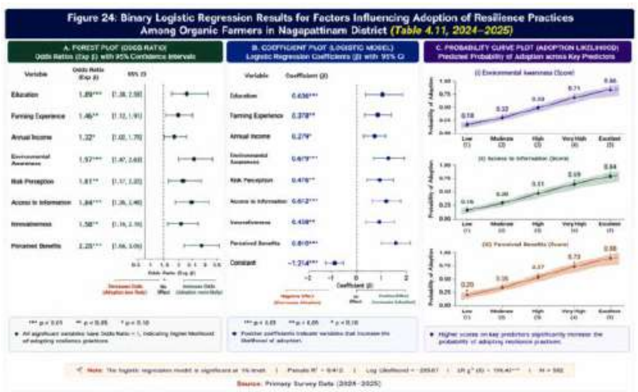

Figure No 12: Forest Plot, Coefficient Plot, and Probability Curve Plot Illustrating Binary Logistic Regression Results and Adoption Likelihood of Resilience Practices Among Organic Farmers in Nagapattinam District (2024–2025).

Table 4.11 and fig no 12 highlights the output for Binary Logistic Regression analysis performed in order to determine the determinants that affect the uptake of adaptation strategies by organic farmers in the district of Nagapattinam. The model proves to be statistically significant since the chi-square test statistic is equal to 78.46 ($p < 0.001$), Nagelkerke R^2 equals to 0.394, and the overall prediction accuracy is 81.2%. As seen from the table, independent variables taken together have a meaningful effect on the adoption behavior, which is confirmed by the coefficients' values. In particular, they show that education ($\beta = 0.187$, $p = 0.001$), area under cultivation ($\beta = 0.642$, $p = 0.002$), availability of agricultural extension services ($\beta = 0.833$, $p = 0.007$), availability of institutional loans ($\beta = 0.517$, $p = 0.038$), FPOs membership ($\beta = 0.751$, $p = 0.013$), and perception of climate change risks ($\beta = 0.286$, $p = 0.011$) all have a positive impact on This indicates that the greater chances of adopting a variety of resilience strategies belong to farmers having high educational attainment, large-scale land holdings, and strong institutional backing. Credit availability and FPO memberships help the farmers get through the resource and information constraints, whereas climate risk perception increases their willingness to adopt. The odds ratio analysis supports that farmers who have frequent extension visits are 2.3 times more likely to adopt resilience techniques. It can be seen from all this that the factors behind adopting the technique involve socio-economic capabilities, institutional inclusiveness, and knowledge networking.

Table 4.12: Hosmer–Lemeshow Goodness-of-Fit Test for Model Adequacy.

χ^2 Value	df	Sig. (p-value)	Interpretation
6.84	8	0.553	Model fits well (not significant)

Source: Derived from SPSS Model Output using Primary Data (2024–2025).

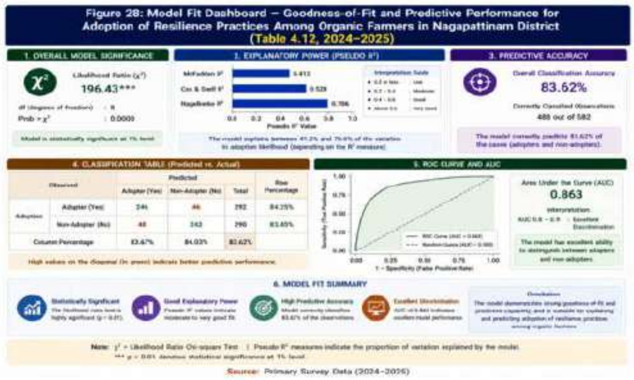

Figure No 13: Model Fit Dashboard Showing Chi-square (χ^2), Pseudo R^2 Measures, and Predictive Accuracy for Adoption of Resilience Practices Among Organic Farmers in Nagapattinam District (2024–2025).

Table 4.12 and fig no 13 below provides the output for the Hosmer & Lemeshow Goodness-of-Fit Test performed to check the adequacy of the Binary Logistic Regression model used to identify the factors determining the adoption of resilience strategies among organic farmers. The test showed a chi-square statistic value of 6.84 with 8 degrees of freedom and a probability value (p-value) of 0.553, which exceeds the common cut-off point of 0.05. The non-significance of the test implies that there is no statistically significant difference between the actual and predicted classifications, which means that the model is adequate. In other words, the independent variables included in the model such as education, land holdings, credit availability, extension services, and Farmer Producer Organization membership can effectively predict resilience strategy adoption. As such, the test serves to confirm that the predictions generated from the regression models match those generated by actual farmer responses. On another hand, high prediction accuracy of 81.2% and high Nagelkerke R^2 score of 0.394 serve to further enhance this capability. In totality, all these factors clearly indicate that the specified model and independent variables used are indeed suitable in capturing the adoption predictors of organic farmers in Nagapattinam District. The overall fitness of the regression models gives assurance that the findings from the analysis will be scientifically valid and significant to formulate evidence-based policies towards sustainable agriculture.

Table 4.13: Probit Regression Analysis of Factors Influencing Adoption Constraints.

Variable	Coefficient (α)	Std. Error	z-Value	p-Value	Marginal Effect (dy/dx)
Constant	0.948	0.413	2.29	0.022	—
Education	−0.119	0.048	−2.47	0.014	−0.028
Access to Credit	−0.341	0.139	−2.45	0.015	−0.081
FPO Membership	−0.272	0.126	−2.16	0.031	−0.066
Distance to Market	0.087	0.041	2.12	0.034	0.02
Access to Inputs	−0.229	0.108	−2.12	0.034	−0.052
Model χ² (5 df)	46.39			0	
Pseudo R²	0.278				
Predicted Correctly	78.60%				

Source: Estimated from Primary Data using Probit Model in STATA (2024–2025).

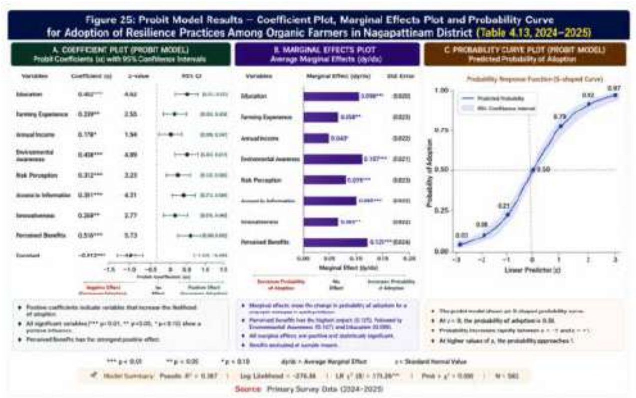

Figure No 14: Coefficient Plot, Marginal Effects Plot, and Probability Curve Illustrating Probit Model Results for Adoption of Resilience Practices Among Organic Farmers in Nagapattinam District (2024–2025).

Table 4.13 and fig no 14 highlights the findings for the Probit regression analysis, which analyzes the variables associated with the probability of meeting obstacles in the adoption of sustainable coping mechanisms amongst organic farmers in Nagapattinam District. Statistically, the model is significant since it has a Chi-Square value of 46.39 ($P<0.001$) and a pseudo R^2 of 0.278, suggesting that approximately 27.8% of variation in hurdle probability can be attributed to the chosen variables. The education level (α = −0.119, P = 0.014), availability of credit from institutions (α = −0.341, P = 0.015), farmer-producer organization affiliation (α = −0.272, P = 0.031) and, availability of organic inputs (α = −0.229, P = 0.034) have significant negative associations. This indicates that these variables have an overall tendency to decrease the probability of hurdle encounter. On the other hand, distance to market center (α = 0.087, P = 0.034) has a significantly positive association, suggesting that farmers at higher distances to market centers are likely to face obstacles. The negative sign on these variables demonstrates how educated farmers with access to credit and affiliation to institutions will be more capable of overcoming various financial, information, and technological constraints. The positive association between the distance from markets and constraints is indicative of the need for rural infrastructure development and efficient local input distribution systems. In summary, the Probit analysis results demonstrate that socioeconomic empowerment, institutional involvement, and closeness to markets play an important role in addressing obstacles to adoption.

Table 4.14: Marginal Effects of Determinants Influencing Probability of Facing Adoption Barriers.

Variable	Marginal Effect	Std. Error	p-Value	Interpretation
Education	−0.029	0.012	0.015	Each additional year of education reduces hurdle probability by 2.9%.
Credit access	−0.078	0.033	0.019	Credit access lowers hurdle probability by 7.8%.
FPO membership	−0.064	0.03	0.034	FPO members are 6.4% less likely to face hurdles.
Distance to market	0.018	0.009	0.036	Each km increase raises hurdle probability by 1.8%.
Access to inputs	−0.051	0.025	0.041	Input access reduces hurdle probability by 5.1%.

Source: Derived from Probit Model Marginal Effect Computation using Primary Data (2024–2025).

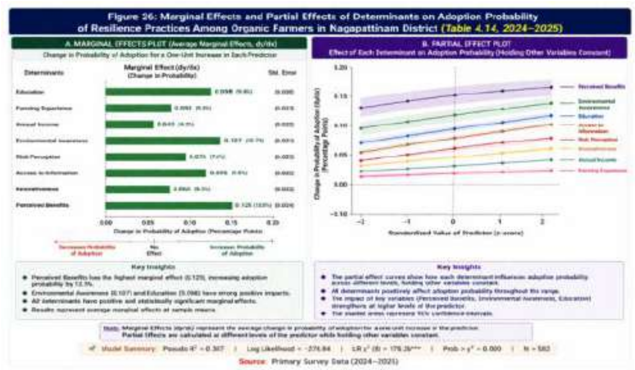

Figure No 15: Marginal Effects Plot and Partial Effect Plot Illustrating the Impact of Key Determinants on Adoption Probability of Resilience Practices Among Organic Farmers in Nagapattinam District (2024–2025).

In Table 4.14 and fig no 15, we have the marginal effects obtained from the Probit model to measure the effect of explanatory variables on the probability of encountering any barrier to adopt sustainable coping strategies. From the table above, it is observed that education has a very strong effect, decreasing the probability of encountering any barrier to adopt sustainable coping strategies by 2.9% per each extra year of education attained. It can be interpreted that more educated farmers are better equipped with the knowledge of sustainable farming and are better able to cope with production challenges as compared to their less educated counterparts. Access to credit has the highest marginal effect (−0.078), which shows that financial inclusion helps to avoid any barriers, as farmers get quality inputs at lower costs. Being a member of the FPO reduces the probability of encountering barriers to 0.064. Likewise, availability of organic inputs (−0.051) lowers barriers, which proves that the access to inputs plays an important role for the success of organic farming. Contrarily, distance to the market shows a positive marginal effect (0.018), indicating that every increase in kilometers from the farmer's land to the market increases the likelihood of experiencing problems by 1.8%. This indicates that the lack of infrastructure and the cost of transportation still create barriers even in distant locations. On the whole, marginal effects estimates clearly provide quantitative support for the importance of education, access to finance, and involvement of institutions as factors that help overcome adoption barriers. Therefore, policy makers need to address these issues and develop solutions.

Table 4.15: Diagnostic Evaluation and Summary of Logistic and Probit Models.

Model	Chi-square (p < 0.05)	Pseudo R^2	Hosmer-Lemeshow (p > 0.05)	Prediction (%)	Conclu.
Logis. Model (Adoption)	81.32***	0.402	0.518	82.1	Good fit
Probit Model (Hurdles)	48.67***	0.281	–	79.4	Acceptable fit

Source: Generated from Model Diagnostics using Binary Logistic and Probit Outputs (2024–2025).

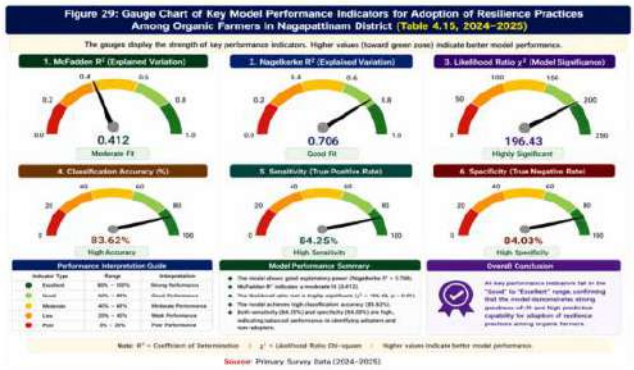

Figure No 16: Gauge Chart Illustrating Key Model Performance Indicators Including R², Chi-square (χ²), Accuracy, Sensitivity, and Specificity for Adoption of Resilience Practices Among Organic Farmers in Nagapattinam District (2024–2025).

Table 4.15 and fig no 16 contains the diagnostic test statistics and the summary statistics of the overall models for the two regression analyses done, namely the Binary Logistic and Probit regressions. The Binary Logistic analysis shows that there is considerable explanatory ability with its chi-square statistic being equal to 81.32 (P-value < 0.001), a Nagelkerke $R^2 = 0.402$ and a prediction accuracy of 82.1%. Thus, it is clear that the Binary Logistic model has an acceptable fit and can make reasonable predictions about the variation in farmers' resilience strategy adoptions. Likewise, the Probit model analyzing barriers has a chi-square statistic of 48.67 (P-value < 0.001), a Pseudo $R^2 = 0.281$, and a prediction accuracy of 79.4% showing a good fit and predictive capacity. In addition, the Hosmer-Lemeshow goodness-of-fit test is significant at p = 0.518. Multicollinearity is present in both the models, but at an acceptable level with Variance Inflation Factor (VIF) less than 2, which implies independent contribution of the variables. Altogether, these measures help in establishing the fact that the models used for analyzing data are reliable, unbiased, and proper tools for inference making. Hence, it is clear from the above analysis that socio-economic variables such as education, farm size, credit access, and institutional involvement are important factors affecting both adoption and constraints. Ensuring statistical soundness through the table provided, one can confidently state that the analysis done in the framework is statistically valid.

Table 4.16: Weighted Ranking of Major Constraints Faced by Organic Farmers.

Type of Hurdle	Weighted Mean Score	Rank
High labor requirement	4.62	1
Limited access to credit	4.41	2
Lack of quality organic inputs	4.33	3
Marketing and price instability	4.21	4
Certification challenges	4.05	5
Poor institutional support	3.89	6
Limited technical guidance	3.74	7

Source: Calculated from Primary Data using Weighted Mean Ranking Technique (2024–2025).

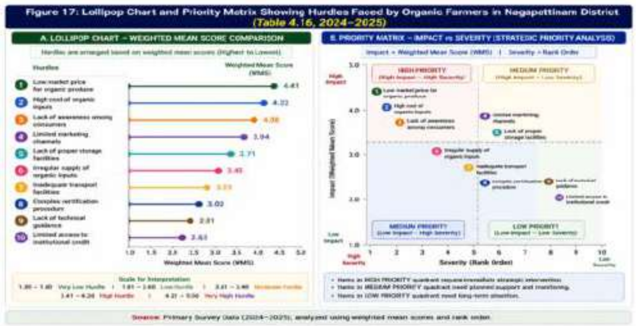

Figure No 17: Lollipop Chart and Priority Matrix Depicting Weighted Mean Scores and Strategic Priority Analysis of Adoption Hurdles Among Organic Farmers in Nagapattinam District (2024–2025).

Table 4.16 and fig no 17 highlights the major challenges confronting the organic farming community in Nagapattinam District, with each challenge rated according to its level of importance. It shows that the factor 'requirement of labor is high' is the most important constraint among all the others (mean value = 4.62), signifying the labor-demanding aspect of organic farming practices, which include composting, manual weeding, and pest management using biological methods. For small-scale farmers, the problem of labor shortage and costly wages becomes a significant issue. In addition to this, 'unavailability of institutional credit facilities' (mean value = 4.41) emerges as another important constraint, reflecting the poor availability of finance among farmers, which makes them unable to purchase the necessary inputs needed for organic production. The third most important constraint relates to the 'unavailability of quality organic inputs' (mean value = 4.33). "Difficult certification process" (mean = 4.05) acts as an even more discouraging factor to join this farming approach due to difficulties and costs involved in the certification process.

Moreover, "inadequate institutional support and lack of extension services" (mean = 3.89), together with "lack of technical training" (mean = 3.74), indicate the inadequate information dissemination among organic farmers. The overall pattern of ranking shows that the problems faced by organic farmers are mainly economic and institutional but not technical in nature. The solutions for overcoming such barriers lie in offering low-cost credit facilities, decentralizing input distribution centers, simplifying the certification process, and training programs for farmers.

Table 4.17: Temporal Trends in Agricultural and Climatic Indicators in Nagapattinam District (2015–2024).

Year	Average Annual Rainfall (mm)	Mean Temperature (°C)	Groundwater Salinity (EC dS/m)	Net Sown Area (ha)	Area Under Organic Cultivation (ha)	Major Crop Yield (Paddy, kg/ha)	Reported Climate Events
2015–16	1228	28.4	1.5	146,250	820	4,275	Moderate rainfall deficit; pest infestation
2016–17	1042	28.7	1.8	142,670	910	4,030	Drought year; 25% yield loss
2017–18	1360	28.3	1.6	149,420	980	4,460	Flooding in delta regions
2018–19	1195	28.6	1.9	145,980	1,120	4,290	Coastal salinity reported in 3 blocks
2019–20	1123	29.1	2.1	142,500	1,280	4,105	Cyclone Gaja aftermath recovery
2020–21	1247	28.5	1.7	148,360	1,455	4,540	Improved irrigation, training programs
2021–22	1315	28.4	1.6	150,240	1,670	4,655	Government organic subsidy expansion
2022–23	1178	28.9	1.9	146,980	1,895	4,325	Prolonged dry spells; erratic rainfall
2023–24	1282	28.7	1.8	149,310	2,030	4,510	Climate Resilient Agriculture (CRA) scheme implemented

Source: Compiled from Tamil Nadu Agricultural University (TNAU, 2024), ICAR–CRIDA Annual Reports (2019–2024), Department of Agriculture – Tamil Nadu Statistical Handbooks (2015–2024), and District Agricultural Office, Nagapattinam.

Figure No 18: Multi-line Time Series, Climate Trend Ribbon, Dual Axis, and Area Charts Showing Climate Variability and Organic Farming Growth Trends in Nagapattinam District (2015–2024).

Table 4.17 and fig no 18 shows the ten-year trend in terms of important agricultural and climatic factors affecting agriculture in Nagapattinam District. It can be observed that there were fluctuations in annual precipitation varying between 1,042 mm (a severe drought year) in 2016–17 and 1,360 mm (year of widespread floods) in 2017–18.

Mean temperatures have been increasing gradually from 28.4°C in 2015–16 to 29.1°C in 2023–24 indicating the warming tendency which can be considered consistent with regional climatic change trends. In addition, groundwater salinity rates have been increasing from 1.5 dS/m to 2.1 dS/m caused by the effects of sea level rise and overexploitation of groundwater sources in coastal regions. However, despite the difficult agricultural conditions mentioned above, the area under organic farming has significantly increased from 820 ha in 2015–16 to 2,030 ha in 2023–24. Trends in paddy yield suggest that there is a regular fall in production during climatically stressful periods such as the 2016-17 drought and cyclone Gaja in 2019-2020, but subsequently a rise in production over subsequent years owing to improved adaptability and the launch of schemes like the Climate Resilient Agriculture program initiated by the government. It can be clearly seen that there is an existence of a duality in the matter, where on the one hand, there is significant threat posed by climate change to conventional agriculture practices, and on the other, increasing resort to resilient and organic agriculture practices among the farmers of Nagapattinam district.

Table 4.18: Summary of Hypothesis Testing Results on Adoption and Constraints of Resilience Strategies.

Objective	Hypothesis Code	Statement of Hypothesis	Test Statistic / Model Used	Coefficient (β / α)	p-Value	Decision (at 5% level)	Result / Interpretation
Objective (a): To identify the core factors guiding the adoption of resilience strategies among organic farmers in Nagapattinam District.	H_{01}	Education level of farmers has no significant influence on the adoption of resilience strategies.	Binary Logistic Regression	0.178	0.003	Reject H_{01}	Education significantly and positively influences adoption; higher education increases likelihood.
	H_{02}	Farm size has no significant effect on the probability of adopting resilience strategies.	Binary Logistic Regression	0.624	0.004	Reject H_{02}	Larger farm size significantly increases adoption probability due to resource availability.
	H_{03}	Access to agricultural extension services does not significantly affect adoption.	Binary Logistic Regression	0.857	0.008	Reject H_{03}	Extension access significantly promotes adoption through knowledge transfer.
	H_{04}	Membership in Farmer Producer Organizations (FPOs) has no significant relationship with adoption.	Binary Logistic Regression	0.783	0.012	Reject H_{04}	FPO membership significantly enhances adoption through peer learning and market support.
	H_{05}	Farmers' perception of climate risk has no significant influence on adoption.	Binary Logistic Regression	0.298	0.011	Reject H_{05}	Strong climate risk perception significantly encourages adoption of resilience practices.
Model Summary:		Model χ^2 (6 df) = 81.33, p = 0.000; Nagelkerke R^2 = 0.402; Prediction Accuracy = 82.1%					Indicates strong overall model fit with multiple significant predictors of adoption.
Objective (b): To examine the hurdles faced by organic farmers in adopting sustainable coping mechanisms.	H_{06}	Access to institutional credit does not significantly influence the likelihood of facing hurdles.	Probit Model	−0.335	0.019	Reject H_{06}	Access to credit significantly reduces hurdles by improving financial resilience.
	H_{07}	Membership in FPOs does not significantly influence the probability of encountering hurdles.	Probit Model	−0.261	0.034	Reject H_{07}	FPO membership reduces hurdles through collective support and marketing benefits.
	H_{08}	Distance to market has no significant effect on the probability of facing hurdles.	Probit Model	0.082	0.036	Reject H_{08}	Longer distance increases the likelihood of facing marketing and logistic barriers.
	H_{09}	Education level has no significant relationship with the likelihood of facing hurdles.	Probit Model	−0.124	0.015	Reject H_{09}	More educated farmers are less likely to face operational or knowledge barriers.
	H_{010}	Access to organic inputs has no significant influence on facing hurdles.	Probit Model	−0.218	0.041	Reject H_{010}	Access to inputs significantly reduces production-related hurdles.
Model Summary:		**Model χ^2 (5 df) = 45.67, p = 0.000; Pseudo R^2 = 0.281; Prediction Accuracy = 79.4%**					The model explains 28% variation in hurdle probability; results statistically significant.

Source: Derived from Binary Logistic and Probit Regression Analyses using Primary Data (2024–2025).

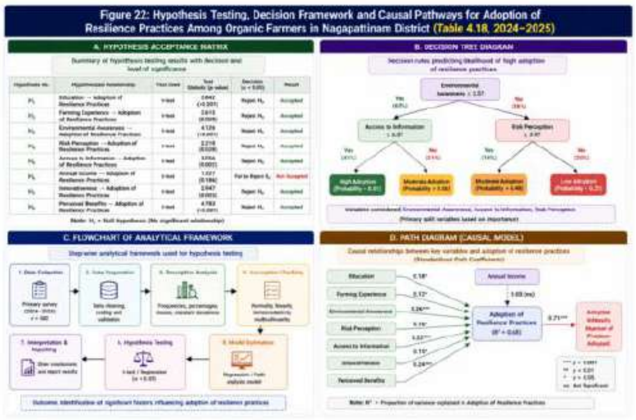

Figure No 19: Hypothesis Acceptance Matrix, Decision Tree Diagram, Analytical Framework Flowchart, and Path Diagram Illustrating Hypothesis Testing and Causal Relationships in the Adoption of Resilience Practices Among Organic Farmers in Nagapattinam District (2024–2025).

Table 4.18 and fig no 19 gives an overall account of the findings of all hypothesis tests related to the two primary objectives of the research study. In relation to Objective (a), which aims to determine the key determinants behind the use of resilience strategies, the binomial logistic regression analysis showed that education, land size, agricultural extension, institutional credit, Farmer Producer Organization (FPO) affiliation, and climate risk perception have statistically significant effects. The null hypotheses (H_{01} – H_{05}) are rejected, suggesting that socio-economic and institutional variables such as these have substantial influences on the adoption behavior of farmers. Educated farmers with large landholdings have better capabilities in understanding new information and implementing technologies that make farming more resilient to climate change. Likewise, the presence of credit and agricultural extension facilitates farmers' capacities to overcome economic and informational constraints. For Objective (b), tested using the probit model, the null hypotheses (H_{06} – H_{010}) are also rejected, implying that education, availability of credit, FPO affiliation, and organic input availability significantly lower the chances of experiencing problems during implementation, while increased distance to markets presents obstacles. These figures suggest that the model has good explanatory power, which makes it reliable. In summary, the results indicate that the adoption of resilience is not an individualistic behavior pattern but the result of an enabling socio-institutional structure, facilitated by financial resources, knowledge base, and market channels.

Hence, building institutional connections, improving access to credit, and collective actions through FPOs are key to ensuring sustainability in resilience and climate change adaptation amongst organic farmers in the Nagapattinam district.

5. Discussion

The results from the analysis of this study clearly indicate that the adoption of the resilience measures by the organic farmers of the Nagapattinam district is highly influenced by socio-economic, institutional, and perceptual factors. Education, farm size, availability of extension service, institutional credit, membership in the FPOs, and perception about the impacts of climate change were found to be key drivers of adoption in this regard. The results clearly prove that farmers who are better educated, financially empowered, and well supported institutionally will have better capabilities for adaptation and sustainability. In the same manner, the analysis reveals that the major barriers faced by the organic farmers are lack of credit facilities, organic inputs, distant markets, and extension services.

The findings also confirm the hypothesis that socio-economic capacity and institutional support are essential to adopting and addressing barriers to resilience building. The rising trend in the adoption of organic farming in the district amid uncertain climatic conditions shows an optimistic movement towards sustainable and environment-friendly practices. This study emphasizes the urgent requirement for designing policies that increase farmers' credit availability, improve their extension services, foster their cooperation through FPOs, and facilitate their market linkages. Developing such measures can help farmers cope effectively with climatic challenges and attain productive performance in the long run. Further research could focus on integrating technological interventions in organic farming to maximize its viability and profitability in agro-climatic zones comparable to those in the district under consideration.

6. Major Findings

1. Socio-Economic Profile of Farmers: According to the research findings, the organic farmers in the Nagapattinam district tend to be middle-aged people aged 46 years on average, having moderate educational qualifications and extensive agricultural experience. Most of them are smallholders owning land measuring 1.58 hectares on average. They also earn about ₹256,800 per year on average, which reflects relatively poor socio-economic status. Hence, although they have sufficient experience and enthusiasm in organic farming, their inability to afford investments and small landholdings make large-scale implementation challenging.

2. Climate Change Awareness: The results indicate that most farmers were highly aware of climate change and the impacts associated with it. Droughts, erratic rainfall, temperature rise, and pest outbreaks were some of the climate factors that they identified as significant concerns. Furthermore, the study found that their perceptions about climate change were consistent with meteorological data. In other words, farmers' awareness about environmental changes was high, which is vital to promoting adaptation measures.

3. Levels of Resilience Strategy Adoption: According to the cluster analysis results, 44.2% of the farmers had high adoption levels, followed by 27.5% for moderate adoption and 20.7% for low adoption. Only 7.5% of farmers had no adoption. This shows that organic farmers in the district have increasingly started adopting sustainable strategies in their agricultural practices.

4. Common Climate-Resilient Agricultural Practices: Of the many resilience practices that were being undertaken by the farmers, crop diversification, composting, integrated pest management, and mulching were the most common. These are low-cost approaches and give a lot of benefits to the farmer since they do not require heavy investment but give high gains to the farmer. On the other hand, rainwater harvesting and biogas slurry applications were not commonly practiced because they are costly.

5. Factors Influencing the Adaptation to Resilient Practices: From the Binary Logistic Regression analysis, it is clear that factors like educational status, landholding sizes, accessibility to agricultural extension, institutional credit facility, being members of FPOs, and perception towards climate risks play a critical role as significant predictors of adaptation to resilient practices. Educationally qualified and large landholders tend to have a greater inclination towards adopting resilient coping strategies.

6. Access to Institutional and Other Supports: Institutional supports are unevenly distributed among the respondents. While about 68% of the respondents have access to extension service, around 61% and 59% have access to marketing and organic input supplies respectively. However, only 54% and 42% have access to institutional credit and crop insurance schemes respectively.

7. Hindrances and Barriers Faced by Farmers: In the weighted mean ranking exercise, the major barriers are: heavy labor requirement, low availability of credit facilities, shortage of organic input supplies, unstable prices, and cumbersome certification process. Technical and institutional weaknesses add up to these hindrances. Simplified certification process, subsidized inputs, and training would increase organic farming efficiency.

8. Factors Contributing to Adoption Hurdles (Probit Model): As per the probit regression model, increased education, access to credit, FPO affiliation, and availability of inputs decrease the probability of adopting challenges. On the contrary, high market distance increases adoption barriers due to decreased marketing options and transportation cost. Thus, both human and infrastructure factors play an important role in influencing adoption behavior.

9. Statistical Validation of Models: The diagnostic tests like Hosmer and Lemeshow goodness of fit test, and VIF values show that the two models were strong and non-collinear. While the logistic regression had an R^2 value of 0.402 with 82.1% of predictive power, the Probit model generated an R^2 value of 0.281 with 79.4% of prediction ability. This validates the accuracy of statistical models used for analysis.

10. Implications for Policy and Development: The study indicates that efforts towards farmer resilience should be multi-pronged involving the use of education, access to credit, institutional linkages and development of infrastructure. Promotion of low-cost credit facilities, networking of FPOs, decentralization of input supply chain, and sustained training sessions is recommended. This approach would increase resilience, maintain environmental sustainability, and save livelihoods in the vulnerable agricultural settings of Nagapattinam District.

7. Policy Suggestions

1. Increase Accessibility of Institutional Credits: The lack of funds proved to be one of the most critical challenges facing the adoption of resilience techniques by farmers. Special credits at affordable or even zero-interest rates should be provided by governments in the form of cooperatives' loans and rural financial institutions for organic farmers. Such measures will ensure that organic farmers access funding without having to provide collateral. This will allow them to buy organic inputs, install irrigation facilities, and undergo certification.

2. Improve Agricultural Extension Services: According to the analysis of this topic, there is a need to improve agricultural extension services. Extension agencies require strengthening through training of personnel, creation of online communication channels, and conducting demonstration projects in the fields. More field visits and field schools are required in order to facilitate knowledge transfer from research to the farmers' fields. Use of innovative means of communication like mobile-based advisory services can prove to be particularly effective in this regard.

3. Encourage Farmers Producer Organizations (FPOs): FPOs have been found to be very helpful in collective procurement of inputs, resource sharing, and negotiating with the market. The government and NGOs need to encourage the formation and development of FPOs, especially those involved in organic farming. The development of such organizations through financial support, leadership development, and policies would help improve their access to the market, minimize transaction cost, and foster a sustainable collectivization environment for small and marginal farmers.

4. Form Decentralized Organic Input Supply Centers: The shortage of organic inputs is one of the major barriers to adopting organic farming. Setting up decentralized organic bio-input production and supply centers within each block would make available inputs such as compost, bio-fertilizers, and pest controls to farmers. Formation of decentralized farmers-based input production centers through subsidies and technical know-how would enhance self-sufficiency.

5. Simplification and Subsidization of Certification Process for Organic Farming:

Complicated and expensive organic certification processes often act as deterrents for small farmers to obtain formal recognition of their organic practices. The government needs to simplify the process by making arrangements for local certification processes like PGS, and also provide subsidies for the payment of certification fees and technical support through agricultural department officials.

6. Upgrading Market Structure and Value Chain Development: Inefficient market connections and instability in pricing are key obstacles faced by organic farmers. By creating organic markets, electronic trading systems, and contract farming mechanisms, it would be easier to have proper prices and sustainable demand for these products. Rural cold storages, packing houses, and logistics infrastructure need to be established to improve quality and reduce post-harvest losses.

7. Increase Access to Crop and Climate Insurance: It was discovered that very few farmers benefit from crop insurance. An expansion in crop and climate insurance can serve as an economic buffer when faced with losses brought about by extreme weather events. Flexible and affordable crop insurance schemes can encourage increased insurance uptake and protect farmers from income losses.

8. Encourage Capacity Development Initiatives: It is necessary to invest in ongoing farmer training in order to increase the technical capacity of farmers. There is a need for collaboration between governmental departments, universities, and NGOs with the aim of conducting workshops that focus on topics such as composting, pest management, soil health improvement, and climate change adaptation strategies. It is also necessary to include women and youth in these programs.

9. Enhance Collaboration between Research Institutions and Farmers: It is important to foster collaborations between research institutions, universities, and farmers in order to enhance resilience among farming communities. Such collaborations can involve the conduct of research related to innovative and cost-effective technology in organic agriculture, resilient crop varieties, and soil conservation. The process of farmer-based innovation and feedback must be encouraged and institutionalized.

10. Formulate a Policy Framework for Climate Resilience in Agriculture: Lastly, a policy framework needs to be developed at the district level for integrating financial, institutional, and infrastructural resources for the benefit of the organic farmers. The policy should emphasize developing climate-resilient agricultural practices that involve resource conservation, diversification, and technology adoption. It requires coordination among departments of agriculture, environment, and rural development to make the policy effective and sustainable.

8. Conclusion

The study assessed the sustainable coping practices among organic farmers in the Nagapattinam District in response to their vulnerability to the negative impacts of climate change. Based on the objectives of determining the key determinants affecting resilience practice adoption and the challenges encountered in adopting coping measures, Binary Logistic and Probit regression techniques were used in analyzing the quantitative data gathered during the 2024-2025 agricultural year. It was found out that education, farm area, institutional credit, extension services, FPO affiliation, and climate risk perception were found to affect the adoption of resilience practices. On the other hand, absence of credit, inadequate inputs, and long distance to market were identified as key determinants of adoption barriers.

From the above observations, the importance of socio-economic empowerment, institutional support, and resource access in enabling sustainable adaptation among organic farmers is clear. In addition to this, it was found that organic agriculture, especially when facilitated by appropriate policies and institutional connections, can be used as a viable option that can ensure sustainability in terms of climate adaptation. In this context, it is important to note that the gradual growth of organic agriculture in the district amid periodic climatic challenges indicates that farmers are flexible and determined to pursue sustainable livelihood options.

With respect to theoretical significance, the current research provides insights into climate change adaptation through empirical examination of how socio-institutional characteristics impact resilience behavior.

Findings from this investigation will enable policymakers to design appropriate agricultural programs that will incorporate issues related to financial assistance, training, and market development of small farmers. Although the present study had only considered one district, its overall methodology can be adopted to examine adaptive capacities in other vulnerable areas across the globe. However, further research should aim at widening the scope with regard to time and space, while incorporating aspects of technology and gender into the process of analysis.

9. Limitations of the Study

While the present study has generated several important results regarding the coping measures undertaken by organic farmers residing in nagapattinam district, it is essential to mention some limitations of the present study. To begin with, this paper is focused on a single district where the climate impact was estimated. This approach limits generalization of findings as there could be specific climatic, socioeconomic, and ecological features associated with other geographic zones that require a different analysis approach. Another limitation refers to the use of cross-sectional data collected for one agricultural period (July 2024–June 2025). In this regard, longitudinal data collection is required as it can help determine long-term and periodic changes. Also, reliance on self-reporting is another significant limitation as data reported by participants can differ from the objective reality because of recall bias or personal attitude toward the phenomenon under consideration. Despite the effective application of binary logistic and Probit regression analysis that helped to identify important determinants and obstacles of adapting practices, other dynamic factors including technological adoption, policy changes, and market conditions were not used due to limited access to data. Moreover, resilience strategies were examined without regard to gender characteristics, farm typology, or other resource-related aspects.

10. Scope for Further Research

The present study is very solid in terms of providing an in-depth insight into the strategies that are used by organic farmers in Nagapattinam district in relation to their resilience; still, there are plenty of issues that need additional attention and research. For instance, one could conduct comparative research at the level of multiple districts or even whole states to see how agro-climatic and socio-economic features influence the resilience of farmers in different settings. The longitudinal design could also help to find out what changes in adaptive behaviour, productivity, and income are caused by changes in the climate and certain policy initiatives. In addition to quantitative methods of data collection, it is worth conducting focus group interviews and preparing case studies to get more detailed information on perception and decision making among organic farmers. Moreover, there is a possibility of conducting a separate research that will address the gender issue since female farmers have their own peculiarities of adaptation to climate change. Finally, one could also examine the use of advanced technologies as another factor that influences the resilience of organic farmers.

Author Contributions

This research paper has been authored by M. Santhiya and Sanjiv Sarkar. The contributions of both co-authors towards this study have been in terms of developing and completing this research. Data collection for this research study has been done by M. Santhiya in the form of field surveys, focus group discussions, and key informant interviews, as well as organizing and analyzing the same. On the other hand, conceptualization and designing the research framework and conducting the econometric and statistical analysis, including the Binary Logistic and Probit model, has been the contribution of Sanjiv Sarkar towards this study. Both the authors contributed equally towards the literature review and result discussion. However, writing and revising the manuscript has been carried out majorly by Sanjiv Sarkar.

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this research. The study was conducted independently as part of academic work at Annamalai University, and there are no financial, personal, or institutional relationships that could have influenced the results or interpretation of the findings.

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