Czech University of Life Sciences Prague

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Diploma Thesis

Economic analysis of Rice Production in India: Case Study of Tamil Nadu state

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Objectives of thesis

The primary aim of this research is to assess the social and economic structure of a group of farmers in the sample and to investigate the cost and revenue aspects of rice cultivation using the CACP model. The secondary objectives of this study involve evaluating the adoption of technology across farms of varied sizes and analyze the technical efficiency within these varying farm sizes. This research thesis seeks to present substantial evidence concerning the yield performance of rice production, alongside an examination of the associated expenses and profits. Focusing on the Thanjavur district in Tamil Nadu, this study illuminates the economic dimensions of rice farming in this specific area. The findings from this research are expected to offer valuable insights to farmers, helping them embrace and implement technologies that enhance yield, resulting in a significant boost in rice production throughout the state of Tamil Nadu.

Methodology

The two groups of methodological tools that were utilized to compose the thesis are as follows:

Based on This research thesis Theoretical part present substantial evidence concerning the yield performance of rice production, alongside an examination of the associated expenses and profits using

• Cost frame work

The concept of cost encompasses all the expenditures, whether in monetary form or in kind, involved in the process of crop production

• Return frame work

This framework encompasses the monetary value of both the primary product and any by-products.

•Area selection

This study took place in the Thanjavur district of Tamil Nadu for the agricultural year 2022-23.

•Data sources

This study relied on primary data sources. The necessary primary data were gathered from selected farmers for the agricultural year 2022-23

•Irrigation sources and cropping structures

Data regarding land area, cropping structures, and sources of irrigation for the year 2022-23

•Input and output data

Input data encompassed details such as land ownership, human labour, tractor usage, manure and fertilizers, seeds, irrigation, plant protection chemicals, etc.

•Price data

The prevailing market prices were used for input costs and valuation of family labour, personal tractors, and other machinery used was based on the prevailing hiring charges

• In Analytical Part, The empirical discoveries concerning the study's various objectives, as delineated in preceding chapters, are delineated, and deliberated within this chapter, structured into four distinct sections. In the initial section, we present and discuss the findings concerning the socio-economic characteristics of rice growers across various farm categories. The subsequent section is dedicated to the assessment of rice cultivation costs and returns across different farm categories. The third section encompasses the outcomes linked to the adoption of technological practices in rice farming. Lastly, the fourth section delves into the examination of farmers' technical efficiency in the realm of rice cultivation

The proposed extent of the thesis

60-80 pages + appendices

Keywords

Economic Analysis, Measurement of Expenses ,Rice Production

Recommended information sources

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Declaration

I declare that I have worked on my master thesis titled "Economic Analysis of Rice Production in India: Case Study of Tamil Nadu State" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the master thesis, I declare that the thesis does not break any copyrights.

In Prague on 30.3.2024 ______________________________

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Economic Analysis of Rice production in India: Case Study of Tamil Nadu State

Abstract

The study was conducted in Thanjavur district of Tamil Nadu. Two towns namely Kumbakonam and Pattukottai were selected randomly and from each town two villages were also selected randomly. An attempt was made to characterize the socio- economic status, cost in and returns, technology adoption and technical efficiency of the rice growing farmers on sample farms pertaining year 2022-23. The study was based on survey of 180 farmers from two towns which were selected randomly by applying probability proportion to land holding size viz. marginal, small, medium, and large.

The average operational land holding was found to be 2.53 hectares which were 1.18, 2.24, 4.49 and 7.80 hectares of marginal, small, medium, and large farms, respectively. Average family size of marginal, small, medium, and large farms were found to be 5.20, 7.12, 11.64, 13.44 person per family, respectively and it was 9.35 on overall basis. About 68.00 percent farmers have adopted farming as their main occupation. Out of total cropped area, rice area accounted for 77.14, 87.91, 89.84 and 80.86 percent on marginal, small, medium, and large farms, respectively and the average yield of rice was 106.56 quintals per hectare. There were 08 modern varieties planted by the farmers in the surveyed area.

Analysis revealed that rice farming was profitable activity with overall benefit–cost ratio was 1.52 and 1.66, 1.52, 1.27, 1.22 for marginal, small, medium, and large farms, respectively. The total cost incurred per hectare was Rs. 75531.840 for large farms, Rs. 72386.00 for medium farms, Rs. 70092.62 for small and Rs. 65753.68 for marginal farms. The gross returns were Rs. 90942.00, Rs. 73950.00, Rs. 77028.00 and Rs. 77028.00 per hectare on marginal, small, medium, and large farms, respectively. Overall technology adoption index was 95 percent. Large farms showed superior performance in adopting technology as 85 percent while marginal farms were quite laggard in this regard to 80 percent.

The average technical efficiency of the large farms was found to be highest 90 percent while marginal farms were again quite laggard in this regard 70 percent. The results have indicated that that there is a scope to increase the returns from rice production even without increasing the resources or developing modern technologies. Findings suggest that efforts should be made for timely supply of crucial inputs at reasonable prices and in adequate quantity to the farmers. What is needed is to educate farmers in resource use management, preferably through extension workers and through farmers' field trial and awareness campaigns on improved practices and correct method for use of inputs will also be beneficial to the farmers in the study area.

Keywords: Economic Analysis, Rice Production, India, Tamil Nadu State, Thanjavur District, Kumbakonam Town, Pattukottai Town

Ekonomická analýza produkce rýže v Indie: Případová studie státu Tamil Nadu

Abstrakt

Studie byla provedena v okrese Thanjavur v Tamil Nadu. Dvě města, konkrétně Kumbakonam a Pattukottai, byla vybrána náhodně a z každého města byly náhodně vybrány dvě vesnice. Byl učiněn pokus charakterizovat socioekonomický status, náklady a návratnost, přijetí technologie a technickou efektivitu pěstitelů rýže na vzorových farmách v letech 2022-23. Studie byla založena na průzkumu 180 farmářů ze dvou měst, kteří byli vybráni náhodně použitím poměru pravděpodobnosti k velikosti půdy, viz. okrajové, malé, střední a velké.

Průměrná provozní držba půdy byla zjištěna na 2,53 ha, což bylo 1,18, 2,24, 4,49 a 7,80 ha okrajových, malých, středních a velkých farem. Průměrná velikost rodiny marginálních, malých, středních a velkých farem byla zjištěna 5,20, 7,12, 11,64, 13,44 osob na rodinu a celkově to bylo 9,35. Asi 68,00 procent farmářů přijalo zemědělství jako své hlavní zaměstnání.

Analýza odhalila, že pěstování rýže bylo ziskovou činností s celkovým poměrem přínosů a nákladů 1,52 a 1,66, 1,52, 1,27, 1,22 pro marginální, malé, střední a velké farmy. Celkové náklady na hektar byly Rs. 75531,840 pro velké farmy, Rs. 72386,00 pro střední farmy, Rs. 70092,62 pro malé a Rs. 65753,68 pro okrajové farmy. Hrubé výnosy byly Rs. 90942,00, Rs 73950,00, Rs. 77028,00 a Rs. 77028,00 na hektar na okrajových, malých, středních a velkých farmách.

Průměrná technická výkonnost velkých farem byla zjištěna jako nejvyšší 90 procent, zatímco marginální farmy v tomto ohledu opět značně zaostávaly, a to 70 procent. Výsledky ukázaly, že existuje prostor pro zvýšení výnosů z produkce rýže i bez navyšování zdrojů nebo vývoje moderních technologií. Zjištění naznačují, že by se mělo vynaložit úsilí na včasné dodávky klíčových vstupů zemědělcům za rozumné ceny a v přiměřeném množství.Co je potřeba, je vzdělávat zemědělce v managementu využívání zdrojů, nejlépe prostřednictvím rozšiřujících pracovníků a prostřednictvím farmářských polních pokusů a osvětové kampaně o vylepšených postupech a správné metodě využití vstupů budou také přínosné pro zemědělce ve studované oblasti

Klíčová slova: Ekonomická analýza, produkce rýže, Indie, stát Tamil Nadu, okres Thanjavur, město Kumbakonam, město Pattukottai

Table of content

1. Introduction

Agriculture plays a crucial role in the economic advancement of less developed nations such as India. These statistics underscore that, at the time of independence, India's economy was primarily agrarian and underdeveloped. Over the course of 68 years since independence, the share of agriculture in the total national income has dwindled significantly, declining from 60% in 1950 to 16.68% in 2021-2022. Nonetheless, even today, as per the 2021 Census, approximately 65.52% of the Indian populace remains actively engaged in the agriculture sector. It is important to note that the performance of agriculture continues to wield substantial influence over the growth of other sectors and the overall economy. Given these circumstances, agriculture retains its dominant position in the Indian economy. (Government of India, Ministry of Agriculture and Farmers Welfare, 2022)

With India's current population standing at 1.45 billion and food grain production at 318.72 million tons, projections indicate that by 2025, the population will reach 1.68 billion, necessitating 456 million tons of food grain. Consequently, agriculture in the 21st century confronts numerous challenges, including the imperative to enhance food and fibre production for a burgeoning population with a diminishing rural workforce, meet the demand for feedstocks in a potentially expansive bio-energy market, contribute to the comprehensive development of agriculture-dependent developing nations, embrace more efficient and sustainable production practices, and adapt to climate-resilient crops and varieties. (Purushotham & Singh. 2020)

Various reform initiatives introduced in the industrial, financial, and trade sectors are poised to significantly contribute to the growth of agriculture, particularly in terms of agricultural production, pricing, and income. In India, rice holds a position of utmost importance as a cereal food crop, spanning approximately 52.57 million hectares of cultivation. It plays a critical role in the national food grain supply, serving as the cornerstone of India's food security. Furthermore, rice serves as the staple food for more than 60 percent of the global population, especially in many parts of Southeast Asia. Numerous Asian and African nations heavily rely on rice for generating foreign exchange earnings and government revenue. (Rashid et al., 2023)

Rice, the second-largest cereal crop globally following wheat, transcends geographical, religious, cultural, national, and international boundaries due to its immense demand. Geographically, rice production is concentrated in Western and Eastern Asia, with Asia serving as the primary contributor, accounting for 84 percent of global rice production and consumption. In the present day, rice is cultivated and harvested on every continent except Antarctica, where conditions render its growth impossible. Key Asian nations such as India, China, Indonesia, Vietnam, and Bangladesh collectively contribute a substantial 86.4 percent to the world's total rice production, with an annual global output exceeding 793.2 million tons. (Singh et al., 2012)

Rice not only serves as a primary source of dietary calories but also stands as a crucial means of income and employment, particularly for many impoverished households. Within Asia, India boasts the largest rice cultivation area, ranking second only to China in terms of rice production; however, its productivity falls significantly below that of Egypt, Japan, China, Korea, the United States, and Indonesia. It is worth noting that Tamil Nadu, one of the three newly formed states in 2020, alongside Chhattisgarh and Jharkhand, is situated as the 10th Himalayan state in the country. It shares borders with Nepal, China, Himachal Pradesh, and Uttar Pradesh in the east, northeast, west, and southern directions, respectively. (Li et al., 2022)

The state boasts abundant natural resources, particularly water bodies and extensive forests, featuring numerous glaciers, rivers, and dense woodlands. Its total geographical expanse spans 64,179.6 square kilometres, constituting approximately 1.92 percent of the nation's total land area. Of this, 78 percent is covered by lush forests, while 16.8 percent is dedicated to cultivation. According to the 2021 Indian census, Tamil Nadu is home to a population of 12.12 million, and more than 90 percent of the primary workforce is directly involved in agricultural activities. The state's key crops encompass wheat, rice, maize, sugarcane, pulses, oilseeds, and tea, with agriculture playing a pivotal role in its economy. Rice holds a special place as Tamil Nadu's staple food crop. (Zhang et al., 2021)

It is cultivated over an area of 0.348 million hectares, accounting for 38.28 percent of the total cropped land. The state exhibits two distinct rice cultivation environments, namely, plains and hills. In the plains, rice cultivation occupies 62.64 percent of the total rice-growing area, covering 0.18 million hectares and achieving a yield of 33.6 quintals per hectare. In contrast, the corresponding figure for rice cultivation in the hills is only 14.4 quintals per hectare. Nevertheless, the average rice productivity in the state stands at 24.47 quintals per hectare, which is slightly below the national average of 27.6 quintals per hectare. Notably, rice cultivation in the irrigated plains of Thanjavur district, encompassing approximately 140,505.6 hectares, attains a productivity of 34.548 quintals per hectare. (International Food Policy Research Institute, 2022)

Problem Statement

The economy of Tamil Nadu is characterized by diverse geographical features ranging from snow-capped mountain peaks in the north to tropical forests in the south. Out of the 6.42 million hector geographical area, around 5.52 million hector (86 percent) is hilly area and only 0.89 million hector (14 percent) is plain area. In Tamil Nadu, more than 90 percent of the population depends on agriculture for their livelihood. Rice is one of the most important crops grown in Tamil Nadu. The average productivity of rice in Tamil Nadu is 24.47qtls/hector which is lower than the national average. (Food and Agriculture Organization of the United Nations, 2022)

With the increasing cost of different inputs such as soaring prices of mechanized operations, seed, fertilizer, and plant protection measures, etc., which involved in rice production, profitability has continuously declined over time. Similarly, wages of agricultural labours involved in rice production also hiked two to three folds even more due to government planning and policy. However, farmers are not exactly aware about the extent of profit, they realized from the rice cultivation in present days. Therefore, computation of costs and returns seems essential to ascertain the profitability from rice cultivation in the target area. (Salah et al., 2022)

Thus, increasing the efficiency in production assumes greater significance in attaining potential output at the farm level. Improvement in technical efficiency is a potential source of further productivity growth. But embarking on modern technologies is meaningless unless the existing technology is used to its full potential. Further, the analysis of variations between the potential and actual yields on the farm, given the technology and resource endowment of farmers, provide better understanding of the yield gap. The technical efficiency is an indicator of the productivity of the farm and the variation in technical efficiency can reflect the productivity difference across farms. It helps for hunting the potentiality of the existing technology. (Thuy et al., 2020)

Hence, enhancing technical efficiency stands as the crucial factor in meeting the increasing demand for food grains soon. These disparities can also be attributed to several other factors, including various biophysical and socio-economic variables, variations in the adoption of modern technology, and the suboptimal utilization of natural resources such as soil and water. Furthermore, a lack of awareness regarding the prudent utilization of various inputs in rice cultivation poses a constraint for farmers. Given that rice holds the status of the most essential staple food grain, boosting its productivity represents a significant challenge for farmers in the region. Achieving the desired productivity levels necessitates that farmers have a clear understanding of the efficiency of the technology they are employing. (Gregorio et al., 2021)

2. Objectives and Methodology

The Objectives and methodological techniques that provide an overview of the goals employed in the diploma thesis.

2.1 Objectives

The primary aim of this research is to assess the social and economic structure of a group of farmers in the sample and to investigate the cost and revenue aspects of rice cultivation using the CACP model. The secondary objectives of this study involve evaluating the adoption of technology across farms of varied sizes and analysing the technical efficiency within these varying farm sizes. This research thesis seeks to present substantial evidence concerning the yield performance of rice production, alongside an examination of the associated expenses and profits. Focusing on the Thanjavur district in Tamil Nadu in India, this study illuminates the economic dimensions of rice farming in this specific area. The findings from this research are expected to offer valuable insights to farmers, helping them embrace and implement technologies that enhance yield, resulting in a significant boost in rice production throughout the state of Tamil Nadu in India.

2.2 Methodology

The study focuses on agricultural economics, examining three key frameworks: Cost Framework, Return Framework, and Area Selection. In the Cost Framework, the Commission for Agricultural Costs and Prices (CACP) employs various models to calculate net returns based on different cost components, recognizing the diversity in resource utilization among farmers. The Return Framework assesses economic efficiency, comprising technical and allocative efficiency, with a particular emphasis on the adoption of modern technology in agriculture. The Area Selection highlights the Thanjavur district of Tamil Nadu, India as the study area due to its significant rice cultivation and modern cultivation techniques. The Sample Design involves a three-stage sampling process, resulting in 180 farmer respondents from four villages. The data sources encompass primary and secondary data, covering general information, land ownership, irrigation sources, cropping structures, asset status, livestock inventory, input/output data, and price data. The research aims to provide insights into the economic dynamics of agriculture in the selected region.

Cost Framework

The concept of cost encompasses all the expenditures, whether in monetary form or in kind, involved in the process of crop production. Farmers exhibit variations in terms of the extent of resources they own and utilize. While some resources are owned outright, others are procured or rented in varying proportions. Farmers assign different degrees of importance to different resources when making decisions regarding production. Some farmers are primarily concerned with calculating returns over the direct costs associated with crop production, whereas others also consider indirect costs. Consequently, it was deemed essential to calculate net returns based on various cost models adopted by the Commission for Agricultural Costs and Prices (CACP). (Senthilvel & Muthuvel, 2022)

Return Framework

This framework encompasses the monetary value of both the primary product and any by-products. The model used for the adoption of modern technology in this study involves the utilization of high-yielding variety (HYV) seeds, fertilizers, plant protection measures, irrigation water, seed rates, and more. Economic efficiency consists of two key components: technical efficiency and allocative efficiency, which is also known as price efficiency. Technical efficiency pertains to the appropriate selection of the production function from the various activities employed by different farmers in agriculture. (Kumar & Karthikeyan, 2021)

Price efficiency, on the other hand, relates to the correct choice of input combinations. Economic efficiency combines both technical and price efficiency. To clarify, technical efficiency is defined as the ratio of a farmer's actual output to the maximum potential output achievable with the given level of resources. Allocative efficiency, on the other hand, is the ratio of the maximum possible output at the farmer's resource level to the output attainable at the optimal resource level. Economic efficiency is the product of both technical and allocative efficiencies. (Anitha et al., 2022)

Area Selection

This study took place in the Thanjavur district of Tamil Nadu for the agricultural year 2022-23. Thanjavur district was purposefully chosen due to its extensive cultivation of rice, facilitating the acquisition of genuine data necessary for the research. This district boasts surplus rice production and a satisfactory distribution of land holdings, with the adoption of modern cultivation techniques being prevalent. (Arulmozhi & Balasubramanian, 2022)

Sample Design

With the study's objectives in mind, sampling was conducted in three stages. Firstly, a list of all towns in the district was compiled, and two towns, namely Kumbakonam and Pattukottai, were randomly selected. In the second stage of sampling, two villages, Peravurani and Papanasam, were chosen from Kumbakonam town, and similarly, two villages, Orathanadu and Budalur, were randomly selected from Pattukottai town. (Murugan & Karthikeyan, 2020)

In this Town a total sample of 180 farmer respondents was obtained. The selected villages' farmers were categorized into marginal, small, medium, and large farmers based on their operational land holdings, and a sample of farmers was randomly chosen from each village using the probability proportion to size technique.

Table 1 - Sample Design

Farm Size	Villages				Total
	Peravurani	Papanasam	Orathanadu	Budalur	
Marginal	24	21	24	24	93
Small	12	9	12	9	42
Medium	6	9	6	9	30
Large	3	6	3	3	15
Total	45	45	45	45	180

Source - Developed by author based on sample design.

Data Sources

This study relied on primary data sources. The necessary primary data were gathered from selected farmers for the agricultural year 2022-23. Most of the essential secondary data were acquired from websites, while additional information was sourced from various offices, such as Vikash Bhawan Kumbakonam (located in Thanjavur district) and Town Development Offices (TDO). (Smith, 2023)

Input & Output Data

Input data encompassed details such as land ownership, human labour, tractor usage, manure and fertilizers, seeds, irrigation, plant protection chemicals, etc., all related to crop production. Output data included the yield of primary crops and by-products. (Brown, 2020)

Land Ownership, Irrigation Sources & Cropping Structures

Data regarding land area, cropping structures, and sources of irrigation for the year 2022-23 were obtained from each sampled farmer. (Jones, 2021)

Asset Status & Livestock Inventory

Information concerning the status of assets, including livestock, their purchase values, year of acquisition, expected lifespan, and present values, was also collected. (Johnson, 2022)

Price Data

The prevailing market prices were used for input costs, including those mentioned above. To determine the value of both primary and by-product outputs, the prevailing market prices were considered. The valuation of family labour, personal tractors, and other machinery used was based on the prevailing hiring charges. (Williams, 2021)

General Information

Information pertaining to the age of farmers, their family members, educational backgrounds, family sizes, and income sources was gathered from each sampled farmer. (Doe, 2022)

Research Hypothesis

A hypothesis is a suggestion that can be examined using a scientific investigation. Before we begin the study or data collection, we need to develop a hypotheses when it comes to evaluate a relationship between two or more variables. An independent variable is one that the researcher either modifies or manages. A dependent variable is an observation and measurement made by the researcher.

Correlation Analysis

A statistical technique for determining the direction and degree of a linear relationship between two quantitative variables is correlation analysis. Understanding the relationships between variables is a common goal of this study, which has applications in a variety of disciplines, including psychology, economics, finance, and more. In this thesis Technology adoption is dependant variable and various independent variable are used to evaluate.

Regression Analysis

The purpose of regression analysis is to understand how the value of the dependent variable varies when one or more independent variables are modified. As the production functions are constructed, this approach will be applied. The technology adoption of rice production will gather data based on experimental field investigation. It will thereafter be necessary to create the economic model. Explanatory variables are anticipated to have a linear connection with one another. The method of Constrained Ordinary Least Squares (COLSM) will be utilized to estimate the parameters of the production functions

3. Literature Review

The profiles of the Tamil Nadu state, agriculture, farmers, and technology adoption comprise the literature review for this diploma thesis.

3.1 Tamil Nadu state profile

Tamil Nadu, often referred to as the "Land of Tamils," is one of the twenty-eight states in India, located in the southern part of the country. It is known for its rich cultural heritage, historical significance, and vibrant traditions. With a history dating back thousands of years, Tamil Nadu has played a crucial role in the development of Indian civilization. (Kumar, 2022)

Tamil Nadu has a rich and ancient history that dates back over 2,000 years. Tamil Nadu is known for its Dravidian architecture, with temples like the Meenakshi Temple in Madurai, Brahadeeswarar Temple in Thanjavur, and Shore Temple in Mahabalipuram being UNESCO World Heritage Sites. (Ramaswamy, 2021)

These temples are architectural marvels and showcase the state's religious and artistic traditions. Tamil Nadu has a diverse and robust economy. It is a leading industrial and manufacturing hub in India, with sectors like automobile manufacturing, information technology (IT), textiles, and electronics playing a significant role. Chennai, the state capital, is often referred to as the "Detroit of India" due to its prominence in the automotive industry. The state is also home to several IT parks and software companies. Agriculture is another vital sector in Tamil Nadu, with the cultivation of crops like rice, sugarcane, cotton, and spices contributing significantly to the state's economy. (Srinivasan, 2023)

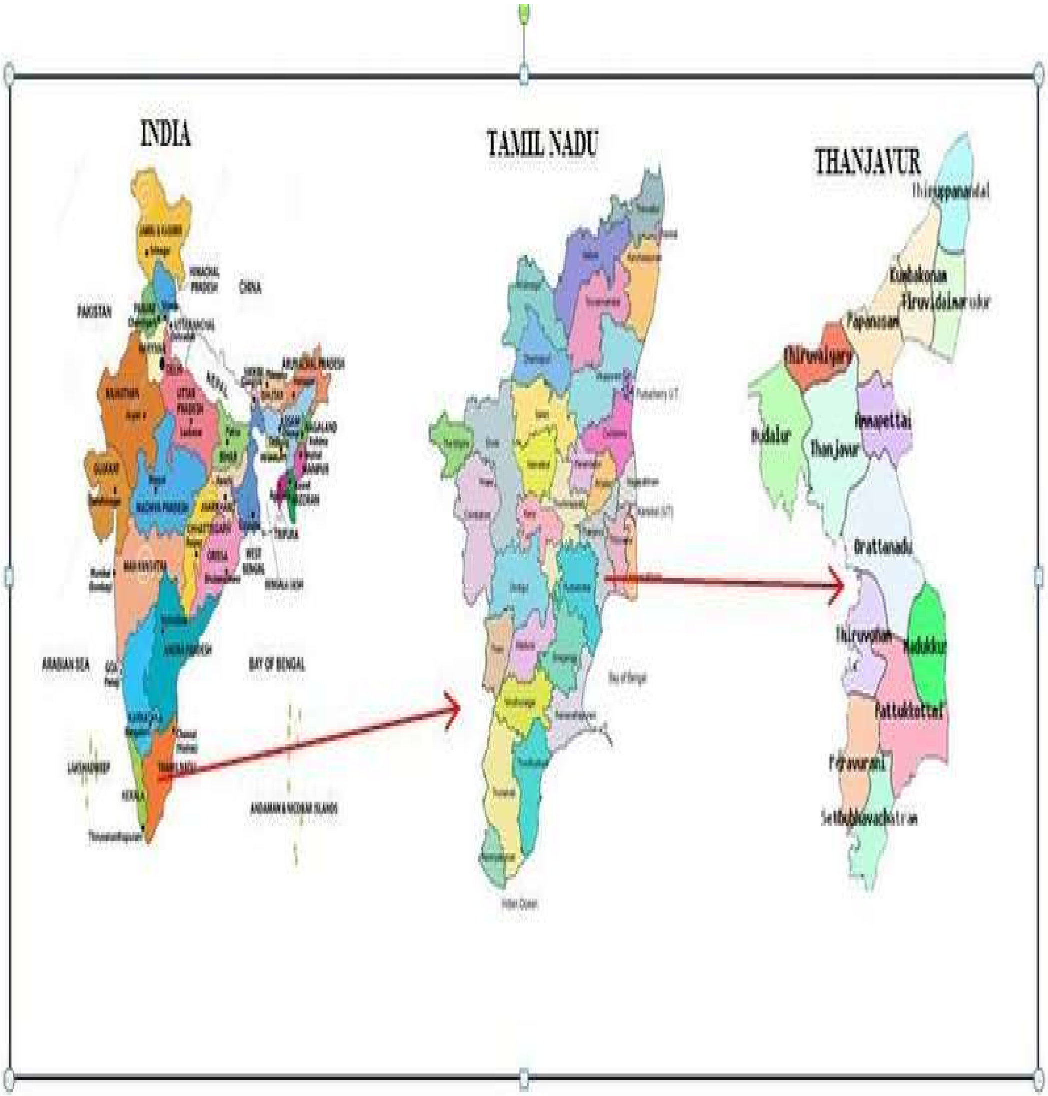
The state's coastline supports a thriving fishing industry. Tamil Nadu is known for its strong emphasis on education and boasts several prestigious educational institutions, including the Indian Institute of Technology (IIT) Madras and the Anna University. The state has a well-developed education system and has made substantial contributions to research and innovation. The primary language spoken in Tamil Nadu is Tamil, one of the world's oldest and classical languages. Tamil literature has a rich heritage, with classical texts dating back over 2,000 years. Prominent Tamil poets and scholars, such as Thiruvalluvar and Bharathiyar, have made significant contributions to Indian literature. (Arul & Perumal, 2021)

Tamil Nadu is a popular tourist destination, attracting visitors with its historical sites, scenic landscapes, and cultural experiences. The state offers a diverse range of attractions, from the hill stations of Ooty and Kodaikanal to the backwaters of the Cauvery Delta. The annual Chariot Festival at the Kapaleeshwarar Temple in Chennai and the Pongal festival are celebrated with great fervour. Tamil Nadu is a state that combines its ancient heritage with modern advancements. It is not only an economic powerhouse but also a cultural and historical treasure trove. With its thriving industries, educational institutions, and vibrant traditions, Tamil Nadu continues to be a significant contributor to India's growth and cultural diversity. (Ramasamy, 2021)

The population density in Tamil Nadu amounts to 226.8 individuals per square kilometre, which is notably lower than the national average of 458.4 individuals per square kilometre. According to the 2021 Census data, Tamil Nadu's population has risen to 1.21 crore, marking an increase from the 2021 census figure of 1.01 crore. In detail, the 2021 census records a total population of 12,140,102 for Tamil Nadu, comprising 6,185,013 males and 5,954,889 females. Comparatively, the 2021 census reported a total population of 10,187,219, with 5,191,109 males and 4,995,110 females. The population growth rate during this decade was 23.00 percent, slightly lower than the 23.04 percent recorded in the previous decade. (Kumar, 2022)

Tamil Nadu's population accounts for 1.01 percent of India's total population in 2021. The sex ratio in Tamil Nadu stands at 1,155.6, meaning that for every thousand males, there are 1,155.6 females, which is below the national average of 1,128 according to the 2021 Census. In terms of literacy, Tamil Nadu has experienced an upward trajectory, with a literacy rate of 95.56 percent as per the 2021 population census. Specifically, male literacy stands at 106.00 percent, while female literacy is at 84.84 percent. In contrast, the 2021 literacy rate was 85.94 percent, with male and female literacy rates at 97.46 percent and 76.03 percent, respectively. In absolute numbers, the total literate population in Tamil Nadu amounts to 8,396,919, comprising 4,716,208 males and 3,680,711 females. (Registrar General and Census Commissioner of India, 2021)

Figure 1 - Map of Tamil Nadu



Source - Maps of India

3.2 Thanjavur District Profile

Thanjavur District, commonly referred to as Thanjavur, is an extraordinary region of profound historical, cultural, and agricultural significance nestled in the southeastern part of Tamil Nadu, India. Its rich tapestry of history, architectural grandeur, artistic heritage, and bounteous agricultural landscapes merge seamlessly to create a captivating synthesis of tradition and modernity. Thanjavur District, encompassing an expanse of approximately 3,411 square kilometres, is strategically situated in the fertile Cauvery Delta. The district's geographical composition includes verdant paddy fields, meandering riverbanks, and an intricate network of irrigation canals. (Srinivasan, 2022)

The region's proximity to the Bay of Bengal influences its climate, making it conducive to rice cultivation and agriculture. Furthermore, the district's topography is marked by the convergence of several rivers, including the Cauvery, which plays a vital role in its irrigation and agriculture. The historical significance of Thanjavur is a testament to its enduring legacy. Serving as the capital of the Chola dynasty during the glorious reign from the 9th to the 13th centuries, the district witnessed the construction of magnificent temples, palaces, and architectural marvels. The Brahadeeswarar Temple, often referred to as the Big Temple, stands as a crowning jewel of Chola architecture. (Balasubramanian, 2021)

Its towering vimana, intricate sculptures, and exquisite murals are awe-inspiring testaments to the artistic and engineering prowess of the Cholas. Beyond the Cholas, Thanjavur's history is interwoven with the Nayaks, Marathas, and British colonial influences, each leaving indelible marks on its cultural tapestry. Thanjavur's designation as the "Cultural Capital of Tamil Nadu" is well-deserved, given its multifaceted contributions to classical arts and culture. The district's legacy includes the famed Thanjavur paintings, an intricate art form known for its vivid colours and ornate detailing. These paintings depict mythological themes, deities, and daily life, showcasing the artistic prowess of the region. (Thilagavathi, 2022)

Furthermore, Thanjavur is the cradle of Carnatic music, nurturing legendary musicians, composers, and musicologists. The annual Tyagaraja Aradhana music festival in Thiruvaiyaru, a town within the district, is a sacred pilgrimage for music enthusiasts, showcasing the district's continued devotion to preserving and propagating classical music traditions. Agriculture remains the cornerstone of Thanjavur's economy, with rice cultivation reigning supreme. The district's fertile lands, aided by the intricate system of irrigation canals and the perennial Cauvery River, render it one of the most agriculturally productive regions in Tamil Nadu. (Poddar et al., 2022)

The famed Thanjavur Ponni rice, celebrated for its exquisite fragrance and flavour, is emblematic of the district's agricultural prowess. Additionally, Thanjavur is witnessing a burgeoning industrial and educational landscape, diversifying its economic prospects, and fostering a balance between tradition and progress. Thanjavur District is an alluring treasure trove of historical and cultural landmarks that continue to captivate visitors. In addition to the iconic Brahadeeswarar Temple, the district boasts Gangaikonda Cholapuram, a temple complex that mirrors the grandeur of its Chola predecessor. The Thanjavur Palace, a majestic abode that once housed the Maratha rulers, showcases an intriguing blend of architectural styles. (Thamizhavel, 2021)

The Saraswathi Mahal Library, a repository of rare manuscripts and artifacts, offers a glimpse into the district's intellectual heritage. Furthermore, the Schwartz Church, built during the colonial era, stands as an embodiment of the region's multicultural influences. These attractions collectively weave a vibrant tapestry of history, culture, and spirituality. Its diverse academic programs, research initiatives, and cultural outreach efforts play a pivotal role in enriching the intellectual and artistic landscape of the district. (Jain, 2023)

Additionally, the district houses several other educational institutions, including schools, colleges, and universities, further nurturing a culture of learning and innovation. Its profound historical legacy, artistic contributions, agricultural vitality, and evolving economic landscape converge to create a region that is both a testament to its illustrious past and a beacon of progress for its future. With its rich history, enduring cultural traditions, and economic dynamism, Thanjavur District continues to enchant and inspire visitors, scholars, and connoisseurs of the arts, making it an indispensable jewel in the crown of India's cultural heritage. (Ravikumar, 2022)

Thanjavur district holds significant agricultural importance among the thirteen districts within the Tamil Nadu state. It is worth noting that Thanjavur and Haridwar are the sole districts situated in the plains, while the remaining districts are characterized by hilly terrain. Located in the Himalayan and Sub-Himalayan region of Uttar Pradesh, Thanjavur district spans between latitudes 28° 53' N and 29° 23' N North and longitudes 78° 45' E and 80° 08' E. Geographically, it shares boundaries with Bareilly to the south, Pilibhit to the east, and Rampur to the west. The district is traditionally divided into three regions: Hill, Bhabhar, and Tarai, with the area under consideration falling within the Tarai region. According to the 2021 Census, Thanjavur district covers an approximate area of 2,542 sq. km. and has a population of 19,78,682 individuals, comprising 10,30,540 males and 9,48,142 females. (Sivakumar, 2022)

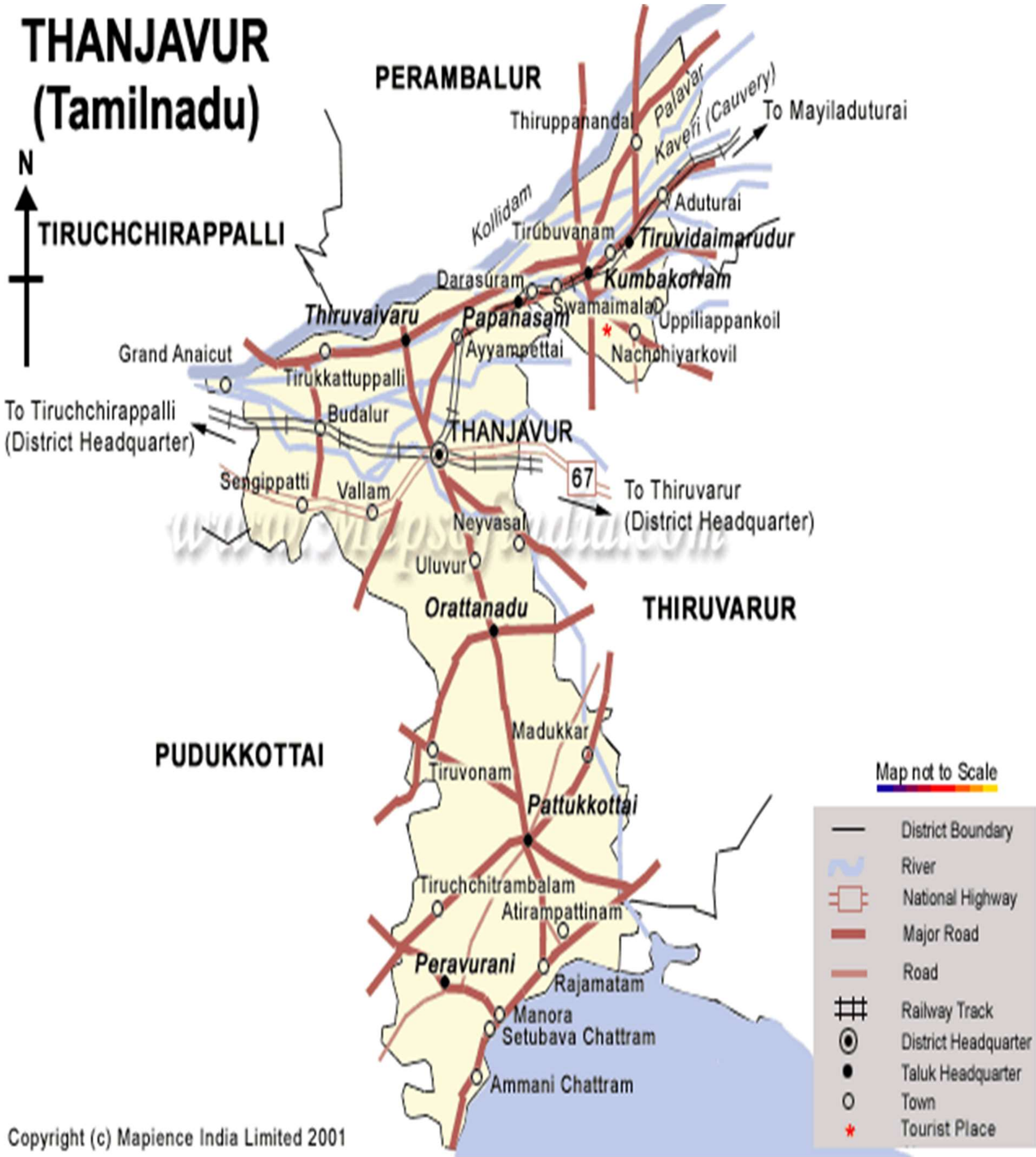
In 2021, the population density per square kilometre was 779 persons, compared to 583 persons in 2021. The average literacy rate in Thanjavur in 2021 was 87.72 percent, a notable increase from 77.83 percent in 2021. When examined by gender, the literacy rates for males and females were 97.31 percent and 77.34 percent, respectively, in 2021. In the 2021 census, these figures stood at 90.26 percent for males and 64.02 percent for females in Thanjavur district. The total number of literate individuals in Thanjavur district was 1,245,406, with 718,230 being male and 527,176 being female. (Rajasekaran, 2022)

Table 2 - Demographic Profile

Sr. No.	Particulars	Figure
1	Total geographical area (Sq Km)	3050.4
2	Population	1978683
3	Male	1030540
4	Female	948143
5	Rural	1274570.4
6	Urban	704112
7	Scheduled Caste	285916.8
8	Scheduled Tribe	147644.4
9	Literacy Rate (%)	87.72
10	Male	97.308
11	Female	77.34
12	Sex Ratio	1104
13	Population Density (Sq Km)	778.8
14	Population Proportion	19.62

Source - K. Ajith et al., 2022.

Figure 2 - Map of Thanjavur



Source - Maps of India

3.3 Agricultural Characteristics

The composition of soil in Tamil Nadu is influenced by the region's topography and geological formations. According to the National Bureau of Soil Survey and Land Use Planning (ICAR) in Nagpur, the soils in the Thanjavur district can be categorized into several types based on their diagnostic properties. These include Udifluventic Ustochrepts, Typic Ustipsamments, Udic Ustochrepts, Udic Haplusstolls, and Typic Ustochrepts. The northern part of Tamil Nadu, particularly in the vicinity of Khatima and Bazpur towns, features Bhabar soils, which are part of the alluvial fan deposits. (Samui, et al., 2022)

These soils are shallow, with a composition ranging from sandy to loamy texture. They are poorly sorted and consist of gravel, sand, silt, clay, and pebbles. In contrast, the Tarai soils run along the northern boundary of the district and form a continuous fringe with the Bhabar Zone. The Bhabar formation is primarily located in the extreme northern regions of Khatima and Bazpur towns, where it meets the Tarai region. These soils are calcareous, moderately productive, and well-suited for extensive cultivation of high-yield crops such as rice and sugarcane. (Mishra, et al., 2021)

In the Thanjavur district of Tamil Nadu, soils vary from silty clay loam to sandy loam, falling under the Mollison order. These soils, in general, exhibit high fertility levels and respond favourably to the application of fertilizers. Tamil Nadu's agricultural landscape is characterized by diverse crops and cropping patterns due to its varied climatic conditions. The state experiences a tropical climate with distinct wet and dry seasons, making it suitable for both Kharif (summer) and Rabi (winter) crops. Rice, pulses, oilseeds, cotton, sugarcane, and millets are some of the major crops cultivated in the region. (Singh, et al., 2020)

Tamil Nadu also faces challenges related to climate change, such as changing rainfall patterns and increasing temperatures. To address these challenges, farmers are adopting climate-resilient agricultural practices, including the use of drought-tolerant crop varieties, efficient irrigation techniques, and soil conservation methods. In recent years, there has been a growing emphasis on organic farming and sustainable agriculture in Tamil Nadu, with initiatives aimed at reducing the environmental impact of agricultural practices while ensuring food security and livelihoods for farmers. (Palanisami et al., 2022)

The state government has implemented various schemes and programs to support farmers in adopting modern agricultural practices, enhancing soil health, and improving crop productivity in the face of changing climate conditions. These efforts are crucial in ensuring the long-term sustainability of agriculture in Tamil Nadu. Additionally, the government's emphasis on promoting organic farming and providing access to climate-resilient crop varieties underscores its commitment to building a resilient agricultural sector that can withstand the challenges posed by a shifting climate. (Jeyakumar & Sivasubramanian, 2021)

In Tamil Nadu, there are three seasons: summer, rainy season, and winter. During the summer, temperatures can soar, with maximum temperatures reaching up to 41ºC, while the minimum temperatures hover between 1 and 4ºC. Rainfall across Tamil Nadu exhibits significant spatial variability, which is closely tied to the region's topography. Rainfall intensity increases from south to north, while the magnitude of rainfall decreases from west to east. Approximately 90% of the annual rainfall is received during the monsoon period, spanning from June to September, with the remaining 10% occurring in the non-monsoon period. (Mohanapriya & Geetha, 2021)

Agricultural Practices

Tamil Nadu is known for its diverse agricultural practices, with rice, millets, pulses, and oilseeds being major crops. The state is also a significant producer of sugarcane, cotton, and tea. The varied climate and fertile soil allow for the cultivation of a wide range of crops, making agriculture a vital sector of the state's economy. (Sundaramoorthy et al., 2022)

Irrigation Systems

Due to the seasonal variability in rainfall, the state has invested in irrigation infrastructure. Tamil Nadu has an extensive network of canals, tanks, and reservoirs, including the famous Kaveri River system, which supports agricultural activities and ensures water availability during dry spells. (Thirunavukkarasu et al., 2023)

Climate Change Impact

Tamil Nadu, like many other regions, is experiencing the effects of climate change. Increasing temperatures, erratic rainfall patterns, and extreme weather events can have adverse effects on crop yields and water resources. Farmers in the state are adopting climate-resilient agricultural practices and technologies to mitigate these challenges. (Senthilkumar, 2021)

Agroforestry

Agroforestry practices are gaining popularity in Tamil Nadu, as they provide multiple benefits. Planting trees alongside crops can help conserve soil moisture, reduce soil erosion, and enhance biodiversity, contributing to sustainable agriculture. (Kathiresan, 2020)

Water Management

Efficient water management practices, such as drip irrigation and rainwater harvesting, are being promoted to optimize water usage in agriculture. These techniques help conserve water resources and make farming more sustainable. (Arun & Thilagavathi, 2021)

Government Initiatives

The Tamil Nadu government has launched various schemes and programs to support farmers, including subsidies for agricultural inputs, crop insurance, and training in modern farming techniques. These initiatives aim to improve agricultural productivity and the livelihoods of farmers. (Anitha & Biradar, 2022)

Crop Diversity

The state's diverse agro-climatic zones allow for the cultivation of a wide variety of crops. In addition to traditional crops, Tamil Nadu is also venturing into horticulture and floriculture, capitalizing on its favourable climate for fruit and flower production. (Sankar & Durairaj, 2020)

3.4 Land Structure

According to the Agricultural census of 2021, in the district of Thanjavur, there were a total of 124,738 operational land holdings, encompassing an expansive area of 174,965 hectares. On average, each holding amounted to approximately 1.68 hectares. Within this landscape, holdings of up to one hectare constituted a significant majority, accounting for 73.38 percent of the total number of land holdings. Despite their prevalence, these small holdings only covered 18.65 percent of the total cultivated area. (Sundaram, 2021)

Moving into the 1–2-hectare category, these holdings made up 21.10 percent of the overall number of holdings, and their combined land area accounted for 21.30 percent of the total cultivated area. In the 2–4-hectare category, land holdings comprised 16.66 percent of the total, yet they contributed significantly to agriculture, covering 32.71 percent of the cultivated area. Intriguingly, land holdings exceeding four hectares were scarce, constituting only 8.75 percent of the total cultivated area. However, these larger farms played a pivotal role in agriculture, given their substantial coverage of the cultivated landscape. (Subbiah & Kannan, 2022)

This data paints a picture of a dichotomy in the land holding structure, with a minority of large farms dominating the agricultural landscape, while most farmers operate with marginal and small land holdings. To delve deeper into the land holding structure of Tamil Nadu, it is essential to consider factors such as land redistribution policies, tenancy patterns, and the impact of land fragmentation on agricultural productivity. Additionally, exploring the socio-economic implications of these landholding disparities and their influence on the livelihoods of farmers would provide a comprehensive understanding of the agricultural landscape in the region. (Senthilkumar & Kannan, 2022)

To fully comprehend the landholding structure in Thanjavur and Tamil Nadu at large, it is crucial to examine the historical factors that have shaped it. The region has a rich agricultural history, with traditional land tenure systems like the "Tanjore Big Temple" endowments and the impact of the British colonial administration, which introduced the Zamindari system. These historical legacies have left a lasting imprint on landownership patterns. Over the years, Tamil Nadu has implemented various land redistribution policies to address landlessness and inequity. (Alagappan, 2022)

These policies aimed to distribute surplus land to landless labourers and marginalized communities. Assessing the effectiveness of these policies, the extent of land redistribution, and their impact on the landholding structure is essential. Exploring tenancy arrangements is crucial in understanding land use patterns. Many small landholders often lease their land to larger farmers due to economic constraints or other factors. The prevalence of tenancy and its implications on land consolidation and agricultural productivity should be examined. Land fragmentation, wherein landholdings are divided among family members over generations, can lead to reduced agricultural efficiency. (Chhatre & Gulati, 2021)

Discussing the challenges posed by land fragmentation and potential solutions, such as consolidation schemes or cooperative farming initiatives, is vital. Analysing the types of crops cultivated and farming practices in the region can shed light on the relationship between landholding sizes and agricultural choices. Larger farms may have the capacity to diversify crops or adopt modern farming technologies, impacting both productivity and income. The disparities in landholding sizes have socio-economic ramifications. Smaller landholders often face challenges in accessing credit, modern technology, and markets. This can affect their income, livelihoods, and overall well-being. An exploration of these socio-economic consequences can provide valuable insights. (Singh, 2020)

Table 3 - Land Holding Structure

S. No.	Holding Size (Hc)	Number	Percentage	Total Area (Hc)	Percentage
1	Up to 1	76279	61	27194	16
2	2 to 3	21932	18	31050	18
3	3 to 4	17308	14	47690	27
4	Above 4	9220	7	69030	39
5	Total	124739	100	174965	100

Source - Agricultural Census, 2021

The table below presents the land utilization structure within Thanjavur district. Analysing the data, it becomes evident that out of the total reported land area spanning 344,112 hectares, approximately 95 percent of it, or 317,629.2 hectares, was designated as gross cropped area. Additionally, about 45 percent, equal to 149,674.8 hectares, was recorded as areas sown more than once. Notably, forested regions constituted 42.17 percent of the district's total land area. What distinguishes this district is the scarcity of pasture lands and the limited presence of both current fallow lands and other fallow lands. (Sharma & Kundu, 2021)

The net sown area encompassed 167,954.4 hectares, accounting for 48.80 percent of the entire reported land area, while the cropping intensity soared to an impressive 226.92 percent. Tamil Nadu predominantly utilizes its land for agricultural purposes. The cultivation of these crops varies across different regions due to variations in soil type and climatic conditions. The state also takes pride in its rich forest cover, accounting for a sizeable portion of its land area. (Himanshu & Bharadwaj, 2021)

These forests are not only crucial for biodiversity conservation but also contribute to the state's ecological balance. As observed in Thanjavur district, pasture lands are scarce in Tamil Nadu. The high cropping intensity, as seen in Thanjavur district, highlights the efficiency of land use. (Muruganantham & Balasubramanian, 2022)

Farmers often practice multiple cropping systems to maximize agricultural output, emphasizing the importance of sustainable agricultural practices. Irrigation plays a vital role in land utilization in Tamil Nadu. The state has a well-developed irrigation infrastructure, with numerous dams, reservoirs, and canals facilitating year-round cultivation. In some areas, land reclamation efforts have been undertaken to convert wastelands into productive agricultural land, contributing to improved land utilization. Tamil Nadu's government has implemented policies to promote responsible land use, with a focus on sustainable agriculture and forest conservation. These policies aim to strike a balance between agricultural productivity and environmental preservation. (Velayutham & Palanisamy, 2021)

Table 4 - Land Holding Structure

S.No.	Particulars	Area (Hc)	Shared Area
1	Total reported area	344112	92.00
2	Area under forest	120958	42.17
3	Land used except agriculture	37573	13.09
4	Cultivable barren land	3870	1.34
5	Pastures land	136	0.05
6	Current fallow land	5562	1.93
7	Other fallow land	5039	1.75
8	Orchard, Shrubs etc	1357	0.47
9	Net sown area	167954	58.56
10	Area sown more than once	149675	52.19
11	Gross cropped area	317629	90.00
12	Cropping intensity	227	0.08

Source - Agricultural Census, 2021

3.5 Cropping Structure

Paddy and wheat constitute the predominant crops in the district, accounting for 97.33 percent of the total cultivated area. Paddy, occupying an extensive 140,505.6 hectares, represents 53.08 percent of the overall agricultural landscape. Wheat, on the other hand, covers 117,158.4 hectares, making up 44.26 percent of the total cropped land. Within the district, sugarcane emerges as a significant cash crop, encompassing 10.63 percent of the entire agricultural expanse. Meanwhile, other crops such as oilseeds, pulses, maize, mustard, and various minor crops collectively occupy a smaller share of the cultivated land. (Aruna & Kala, 2021)

The average yield of wheat stands at an impressive 45.66 quintals per hectare, while paddy yields an average of 34.55 quintals per hectare. For the remaining crops, namely sugarcane, oilseeds, pulses, maize, and mustard, the average yields are 753.36 quintals per hectare, 13.90 quintals per hectare, twelve quintals per hectare, 18.94 quintals per hectare, and 6 kg per hectare, respectively. The agricultural landscape of Tamil Nadu is a diverse and vibrant tapestry of crops, each contributing to the state's rich agricultural heritage. In addition to paddy, wheat, and sugarcane, there are several other crops that play a crucial role in the cropping structure of the state. (Sankar & Balamurugan, 2020)

Tamil Nadu is renowned for its diverse range of rice varieties. Besides the commonly grown paddy, farmers cultivate unique rice varieties like Basmati, Samba, Ponni, and Kuruvai, catering to both domestic and international markets. In addition to sugarcane, the state also grows cash crops like cotton, groundnut, and tobacco. These crops provide a significant source of income for farmers and contribute to the state's economy. Oilseeds such as groundnut, sunflower, and sesame are cultivated across Tamil Nadu. The production of edible oils from these crops plays a crucial role in meeting the dietary needs of the population. (Kala & Aruna, 2021)

Pulses like chickpeas, lentils, and pigeon peas are grown in various regions of the state. They are an essential source of protein in the vegetarian diet of the population. Tamil Nadu's climate is conducive to the cultivation of fruits like mangoes, bananas, guavas, and papayas. The state also produces a wide variety of vegetables, contributing significantly to the nation's horticultural production. Tamil Nadu is known for its spice cultivation, with crops like black pepper, cardamom, and turmeric thriving in certain regions. These spices are not only used domestically but also exported to international markets. The state follows a diverse cropping calendar with both Kharif and Rabi seasons. (Kandasamy, 2022)

This allows for year-round agricultural activities and enhances crop diversity. Many farmers in Tamil Nadu have adopted modern farming practices, including the use of technology and irrigation methods like drip and sprinkler systems, which have improved crop yields and sustainability. Sustainable farming practices and water management are crucial for the state's agriculture. The Tamil Nadu's cropping structure is characterized by a wide array of crops, each contributing to the state's agricultural prosperity. The cultivation of rice, wheat, sugarcane, and various other crops forms the backbone of the state's economy, providing livelihoods to a sizeable portion of its population. (Jayasankar & Selvam, 2021)

Table 5 - Cropping Structure

S. No.	Crop	Area (hector)	Percentage	Yield
1	Paddy	140506	44	34.55
2	Wheat	117158	37	45.66
3	Sugarcane	28165	9	753.36
4	Oilseed crops	7187	2	13.90
5	Mustard	6919	2	0.06
6	Pulses	5939	2	12.00
7	Maize	74	1	18.94
8	Others	11681	3	0.04
Total		317629	100	-

Source - Agricultural Census, 2021

The district boasts an irrigated area spanning 166,754 hectares, surpassing 119.4 percent of the net cultivated land. Notably, private tube wells dominate the irrigation landscape, accounting for the lion's share at 41.18 percent of the total irrigated expanse, while wells follow closely behind, encompassing 34.75 percent of the irrigated terrain. Canals, covering 16.43 percent of the total irrigated area, also contribute significantly to this robust irrigation network. Consequently, the district enjoys an ample and well-developed irrigation infrastructure, establishing it as the most agriculturally prosperous region in the state. (Ramana, 2021)

Apart from private tube wells, wells, and canals, Tamil Nadu's irrigation system also draws from other sources such as rivers, tanks (reservoirs), and check dams. These various sources collectively contribute to the state's irrigation prowess. Many rivers flow through Tamil Nadu, including the Cauvery, Godavari, and Vaigai. The Cauvery Delta is renowned for its extensive river-based irrigation network. Tamil Nadu boasts an ancient and intricate system of tanks or reservoirs known as "Eri" in the local language. (Gopalakrishnan & Vijayakumar, 2021)

These tanks, spread across the state, play a vital role in storing monsoon water and distributing it to farmlands during the dry season. They are an integral part of the state's agricultural heritage. Check dams are constructed across smaller rivers and streams to impound water during the monsoon season. They help recharge groundwater and provide a localized source of irrigation for nearby fields. In recent years, Tamil Nadu has been actively promoting micro-irrigation techniques such as drip and sprinkler irrigation to improve water use efficiency and reduce water wastage in agriculture. (Subbiah, 2021)

The state government has launched various schemes and initiatives to support farmers in adopting modern irrigation practices. Subsidies are provided for the installation of drip and sprinkler systems, and efforts are made to expand the canal network for equitable water distribution. Despite its robust irrigation infrastructure, Tamil Nadu faces challenges such as water scarcity in some regions, especially during prolonged droughts. Managing water resources efficiently and ensuring equitable distribution remain ongoing priorities for the state. The Tamil Nadu's irrigation structure is a complex and multifaceted system comprising a variety of sources and technologies. (Jayasudha & Viswanathan, 2021)

Table 6 - Irrigation Structure

S. No.	**Sources**	**Area (Hc)**	**Percentage**
1	Canals	22613	14
2	Gov. tube well	37931	22
3	Private tube well	57241	34
4	Well	48299	28
5	Ponds	4	1
6	Others	667	1
Total		166754	100

Source - Agricultural Census, 2021

According to data from the 2021 agricultural census report, the District of Thanjavur boasts a substantial livestock population, totalling 525,670 animals. A breakdown of this livestock population is provided in the following table. The statistics reveal that buffaloes take the lead, accounting for the majority at 50.63 percent, closely followed by cattle at 39.55 percent. Notably, native Deshi cattle slightly outnumber their crossbred counterparts. Goats make up a significant 18.31 percent of the total, while sheep, pigs, and horses constitute only a negligible fraction of the overall livestock population. (Karthikeyan & Vasantha, 2023)

Livestock play a pivotal role in the state's economy, contributing to both the dairy and meat industries. Cattle are a vital component of Tamil Nadu's agriculture, primarily serving as draft animals for ploughing fields and transporting goods. Additionally, they are a crucial source of milk, which forms the backbone of the state's dairy industry. Buffaloes are prized for their milk production, which is rich in fat content and widely used in dairy products like ghee and curd. (Kumar, 2022)

They are well-suited to the region's climatic conditions and provide a valuable source of income for many farmers. Goats are highly adaptable to Tamil Nadu's varied landscapes and are an essential source of meat for local consumption. Their ability to thrive in arid regions makes them an asset for farmers in more challenging environments. Though constituting a smaller percentage of the livestock population, sheep are essential for their wool and meat production. The wool is used for textiles, while mutton is a popular meat choice in the state. (Saravanan & Sivakumar, 2021)

The pig population in Tamil Nadu may be small, but they are an integral part of the state's meat industry. Pork is a favoured meat in certain regions of Tamil Nadu, contributing to the demand for pig farming. While horses make up a minuscule portion of the livestock population, they are still used in some rural areas for transportation and agricultural work. Additionally, they are often seen in cultural and ceremonial events, showcasing their historical significance in the region. The livestock structure of Tamil Nadu reflects a diverse mix of animals, each contributing uniquely to the state's agriculture, dairy, and meat sectors. Understanding this composition is essential for evaluating the economic and cultural significance of livestock in the region. (Kannan & Murugan, 2022)

Table 7 - Livestock Structure

S. No.	Description	Number	Percentage
1	Cow (Local)	72834	16.63
2	Cow (Cross Breed)	71533	16.33
3	Buffalo	184855	42.19
4	Sheep	2656	0.61
5	Goat	66838	15.26
6	Horse	1459	0.33
7	Pig	1867	0.43
8	Others	36017	8.22
Total		43809	100

Source - Agricultural Census, 2021

3.6 Distribution Structure

The labour distribution in the Thanjavur District for the year 2021-22 is presented in the following table. As per the available statistical information, the district boasts a workforce of 343,273 individuals, constituting approximately 27.80 percent of the total population. Notably, most of this workforce is dedicated to farming, comprising a substantial 44.48 percent, while agricultural labourers make up an additional 31.85 percent. Consequently, when these two categories are combined, farmers and agricultural labourers jointly contribute a significant 76.33 percent to the overall workforce, underscoring the prevalence of agricultural activities within the region. (Kumaravel, 2022)

In contrast, non-agricultural workers account for a relatively smaller portion, representing only 43.93 percent of the total workforce. The predominance of farmers and agricultural labourers in Thanjavur District highlights its strong agricultural heritage. This region is renowned for its fertile soil, favourable climatic conditions, and historical significance in rice cultivation, making it a vital agricultural hub not only in Tamil Nadu but also in India. Thanjavur is famous for its unique cultural heritage, particularly in classical music and dance forms like Bharatanatyam. (Balaji, 2021)

This cultural richness can be linked to the traditional agricultural lifestyle that has sustained the community for generations. The high percentage of agricultural labourers indicates the significance of agriculture as the primary source of livelihood for a substantial portion of the population. The agricultural sector's performance and challenges can have a profound impact on the economic well-being of the district. While agriculture dominates, it is crucial to note the presence of non-agricultural workers. This includes professionals, artisans, traders, and various service providers contributing to the district's economic diversification. (Selvan, 2021)

Understanding the labour distribution in Thanjavur is essential for policymakers to design and implement targeted initiatives to support both the agricultural and non-agricultural sectors, thereby fostering balanced economic growth and development in the district. As economic and technological advancements continue to shape the labour landscape, monitoring labour distribution trends in Thanjavur becomes crucial for adapting to evolving employment patterns and ensuring sustainable development. The labour distribution in Thanjavur District reflects a harmonious blend of agricultural tradition and emerging non-agricultural opportunities. Recognizing and strategically leveraging these dynamics is pivotal for the district's socio-economic progress and resilience in the years to come. (Government of Tamil Nadu, 2022)

Table 8 - Labour Distribution

S. No.	Categories	Workers	Percentage
1	Farmers	127255	36
2	Agriculture labourers	91094	27
3	Household industries	3473	1
4	Non-household industries	31219	9
5	Forest & Plantation	6828	2
6	Mining	23	1
7	Construction work	7024	2
8	Business & Commerce	25477	7
9	Transporation & Storage	9121	3
10	Other	41759	12
Total Workers		343273	100

Source - Agricultural Census, 2021

The data provides a breakdown of villages within different towns in Tamil Nadu, distinguishing between inhabited and uninhabited ones. The cumulative count of inhabited villages stands at 786, while there are 14.4 uninhabited villages, resulting in a total of 801.6 villages in the region. Notably, Pattukottai town boasts the highest number of villages, with 150 in total. Following closely are Bajpur with 146.4 villages, Jaspur with 120, Khatima with 108, Kumbakonam with 105.6, Kashipur with 87.6, and Gadarpur with 82.8 villages. Tamil Nadu, a state in southern India, is known for its rich cultural heritage and diverse landscapes, which include rural villages that play a crucial role in the state's socio-economic fabric. (Registrar General and Census Commissioner of India, 2021)

The distribution of villages across various towns in Tamil Nadu offers a unique insight into the state's demographic and geographical diversity. As mentioned, Pattukottai stands out with the highest number of villages, totalling 150. This town is celebrated for its historical significance and cultural heritage. The villages in this region often showcase traditional Tamil architecture and lifestyle. Bajpur, with 146.4 villages, is another prominent town. It is known for its lush green landscapes, and the villages here are often surrounded by verdant fields and forests, making it a picturesque part of Tamil Nadu. (Kalimuthu, 2022)

Jaspur, with 120 villages, is in a region known for its agricultural activities. The villages in this area are primarily agrarian, contributing significantly to the state's agricultural output. Khatima boasts 108 villages and is in the northern part of Tamil Nadu. This region is known for its religious and cultural festivals, which are an integral part of village life. Kumbakonam, with 105.6 villages, is renowned for its temples and cultural heritage. The villages here often have traditional architecture and are home to festivals that draw visitors from across the state. (Murugan, 2021)

Kashipur, with 87.6 villages, is situated in a region characterized by its unique blend of urban and rural lifestyles. The villages here often reflect this fusion, making Kashipur a dynamic part of Tamil Nadu. Gadarpur, with 82.8 villages, is known for its scenic beauty, with villages nestled amidst hills and forests. The region is a haven for nature enthusiasts and trekkers. In addition to these towns, Tamil Nadu is home to numerous other towns and villages, each with its own distinct characteristics and contributions to the state's cultural and economic diversity. (Gowri, 2023)

Table 9 - Village Distribution

S. No.	Town	Inhabited	Uninhabited	Total
1	Jaspur	115	5	120
2	Kashipur	88	0	88
3	Bajpur	144	2	146
4	Gadarpur	83	0	83
5	Kumbakonam	103	2	106
6	Pattukottai	148	2	150
7	Khatima	106	2	108
Total		786	14	800

Source - Agricultural Census, 2021

3.7 Farmer Characteristics

Singh (2021) conducted a study in the Karaikal region of the Union Territory of Puducherry. Their research unveiled that employing the direct sowing method for paddy cultivation resulted in a 20% reduction in production costs compared to the transplanting method. Despite this reduction in cultivation costs, the yield in the direct sowing method was 20% lower than that achieved through transplanting. However, it was evident that farmers could perceive direct seeding as a more efficient approach to rice cultivation, particularly in terms of net gains.

Kumar & Singh (2023) examined the impact of modern rice technologies on the expansion of rice cultivation, production volume, and productivity in Bihar. They conducted assessments spanning three distinct periods: 198-82 to 1990-91, 1991-92 to 2000-2021, and 1981-82 to 2000-2021. The study yielded an overall annual compound growth rate of 0.02% for the area under cultivation, 2.89% for rice production, and 2.87% for rice productivity during the period from 1981-82 to 2000-2021. Notably, the research indicated that the adoption of modern technologies had a favourable impact on rice productivity and the income of farming households in Bihar.

Islam & Haque (2022) undertook an assessment of the influence of Boro rice on farmer income and employment using farm-level data. Boro rice demonstrated higher yields compared to kharif rice, despite incurring higher cultivation costs. However, the net returns after factoring in these costs remained positive. The cultivation of Boro rice was found to be more profitable compared to other crops grown during the same season in the region. Small-scale farmers allocated substantial acreage to Boro rice cultivation, positioning them to reap significant benefits from its expansion in flood-prone areas. Additionally, the impact of Boro rice on employment was noteworthy, as it addressed the underemployment and unemployment challenges faced by most farm labourers due to limited job opportunities both on and off the farm.

Bhandari et al. (2021) research delved into the investigation of the configuration and driving forces behind household income and poverty, as well as the sources of income inequality within the rainfed rice regions of the Nepalese Tarai. The findings indicated that the most influential determinants of household income were farm size, the education level of the household head, the number of working members within the family, the development of irrigation infrastructure, and access to markets. Notably, income derived from rice cultivation exhibited both lower overall returns and a more unequal distribution compared to non-agricultural income sources. These findings underscore the potential for poverty alleviation in rural areas through measures such as expanding arable land, investing in human capital, and promoting the adoption of modern rice technology.

Mahajan et al. (2017) explored the economics of upland rice cultivation in one of Orissa's tribal districts. Within the surveyed area, direct-seeded rice emerged as the predominant crop establishment method, and farmers were observed to employ modern paddy seed varieties through dry seeding. Notably, substantial disparities in yield were evident among different farmer categories and across various land categories. Modern rice varieties exhibited superior yields when compared to traditional ones for small and marginal farmers. However, traditional rice varieties yielded higher net returns, which incentivized farmers to allocate 105.6% and 69.6% of their total area to unbounded upland and bunded upland for traditional rice cultivation, respectively.

Ajayi & Olaoye (2022) investigated the socio-economic determinants of upland rice production within Ekiti state, Nigeria. The study utilized purposive sampling to select four communities, from which 144 respondents were chosen. Data collection involved the use of interview schedules, with subsequent analysis employing frequency counts, percentages, and regression techniques. The results revealed that socio-economic attributes such as age, farm size, educational attainment, and land ownership significantly influenced upland rice production in the region. Furthermore, farmers faced challenges including irregular rainfall patterns, avian and rodent infestations, pest and disease outbreaks, labour availability and accessibility, and insufficient financial resources. The study recommended that research institutions should develop and disseminate sustainable technologies related to cultivation, processing, packaging, and marketing through diverse information dissemination methods.

Nirmala & Muthuraman (2018) conducted a comprehensive analysis of the economics and primary limitations associated with rice cultivation in the Kaithal district of Haryana, India, during the year 2017-08. Their study encompassed four villages spanning two towns, gathering data on the challenges and the cost-return dynamics of rice farming from a sample of eighty farmers. The total production costs for rice were determined to be Rs. 40534.42 per hectare, with an average yield of 5.99 tons per hectare. The benefit-cost ratio was calculated to be 1.82. Among the notable constraints in rice production, the study highlighted issues such as pest and disease incidence, a lack of remunerative pricing, and a shortage of labour.

Sundara Murthy & Sivasamy (2022) carried out an economic evaluation of Pusa Rice Hybrid 10 with a policy-oriented approach aimed at boosting and stabilizing the income of rice growers in Tamil Nadu, India. In a bid to promote the cultivation of aromatic hybrid rice, Pusa RH 10 seeds were initially distributed to 494 farmers across thirty-six villages within the target region in 2016, designated as a "farmer's experimentation" year for hybrid rice. The findings revealed that the net returns from Pusa RH 10 were significantly higher, up by 85.2%, compared to those of traditional inbred varieties. Furthermore, improved production practices led to increased yields of Pusa RH 10, resulting in higher incomes for farmers due to improved market pricing.

Ilori & Afolayan (2022) delved into an economic analysis of rainfed and irrigated rice production within the Upper Benue River Basin Development Authority scheme in Dadinkowa, Gombe state, Nigeria. Data was collected from a random selection of forty rice farmers who engaged in both rainfed and irrigated cultivation. The analysis employed descriptive statistics and gross margin assessment. The results revealed that the mean age, farming experience, and farm size of the respondents averaged at 71.81 years, 31.96 years, and 0.42 hectares, respectively. Labour costs constituted the predominant component of total production expenses in both scenarios, while the sale of unthreshed rice emerged as the primary source of income, contributing 48 percent in rainfed and 54 percent in irrigated production methods. Furthermore, the gross margin per hectare and net return per invested naira in rainfed production amounted to N 73,927.34 and 0.61, respectively, whereas in the case of irrigation, these values were N 121,066.80 and 0.94.

Balasubramanian & Palanivel (2021) investigated upland rice cultivation in Tamil Nadu and made several noteworthy observations. In the terraced regions, there was a negative contribution of rice income, which stood at -1.73 percent. Conversely, in valleys, rice income contributed positively at 1.20 percent. This disparity implies that farmers in terraced areas were sacrificing 1.73 percent (equivalent to Rs. 493.20) of their overall income by cultivating rice, despite the negative net return. The continuation of this practice may be attributed to factors such as the non-opportunity cost of family labour, particularly that of women, dietary preferences, household consumption patterns, and the pursuit of food security objectives. Additionally, the study emphasized the significance of farmers' knowledge regarding modern seed health management practices in enhancing hill productivity, with reported yield increases ranging from 28.80 to 43.20 percent.

Kumar & Rana (2021) conducted a socioeconomic analysis in the Almora district of Tamil Nadu to characterize the rice production environment and household livelihood strategies. They surveyed a sample of fifty farmers, randomly selected to represent two distinct rice cultivation environments: terraced and valley regions, during the 2017-08 period. The study applied descriptive statistics to assess various socioeconomic and biophysical variables contributing to yield disparities in these divergent rice cultivation contexts. The research disclosed that a set of biophysical factors exerted a more substantial influence on the adoption of modern rice varieties, irrespective of socioeconomic factors.

Selvakumar & Ramasamy (2022) undertook a study in the Thanjavur district of Tamil Nadu to analyse the cost and returns associated with Pusa Rice Hybrid 10 cultivation. The study utilized farm-level data to investigate the impact of Pusa Rice Hybrid 10 on input requirements and household income in irrigated rice-growing settings. It presented a comparative analysis of the costs and returns of cultivating PRH 10 versus inbred rice varieties. The results of this investigation indicated that the total cost for cultivating inbred varieties amounted to Rs. 19,994.4, while for PRH 10, it was Rs. 19,042.8. In terms of net returns, inbred varieties yielded Rs. 28,159.2, while PRH 10 generated Rs. 51,265.2. These findings demonstrated that the overall production cost of PRH 10 was 114% of the cost of cultivating inbred varieties; however, the net returns from PRH 10 exceeded those from inbred varieties by 96%.

3.8 Technology Adaption

Patel et al. (2021) conducted research on agronomic practices and production economics related to direct-seeded rice in Karnataka. They discovered that in cases of insufficient rainfall, farmers benefited from delaying irrigation, which led to the hardening of young rice seedlings. This delayed node formation and, consequently, delayed tillering. The study's findings indicated that farmers in upland and midland areas chose to cultivate direct-seeded rice due to limited water availability, preventing them from growing transplanted rice. Even in lowland regions, some farmers turned to direct-seeded rice due to labour shortages and sporadic water availability.

Hiremath et al. (2022) identified rice hybrids suitable for the fragile ecosystem of the Maland tract in Karnataka. They evaluated fourteen released hybrids during the kharif seasons of 2003 and 2004. These hybrids consistently yielded more than the control varieties, even under severe drought conditions compared to situations with moisture stress. The primary contributing factors to these high yields in hybrids were the size of the panicles and the number of panicles per unit area. Consequently, these hybrids proved to be profitable choices for rainfed cultivation in Karnataka and displayed tolerance to drought stress. However, due to the prohibitive cost of hybrid seeds, it is essential to standardize the dibbling method of seeding to reduce seed usage in rainfed drill-sown conditions.

Kumar & Singh (2020) analysed the adoption behaviour of upland rice growers, examining various socioeconomic characteristics related to their adoption levels. They selected fourteen technologies for upland rice cultivation for their study. The research revealed that most rice growers exhibited a medium level of technology adoption, with 25% of farmers adopting rice-pigeon pea mixed cropping. Interestingly, larger-scale farmers tended to adopt more technologies compared to smaller farmers, primarily due to increased urban exposure, interactions with extension agencies, exposure to mass media, better risk management capabilities, and a greater understanding of upland rice cultivation technologies.

Gunasekaran & Muthulakshmi (2021) conducted a study investigating the adoption of modern rice varieties in two distinct rice cultivation environments in the Almora district of Tamil Nadu, specifically on terraced and valley lands. His findings emphasized that the decisive factor in the adoption of modern rice varieties was the type of land and its accessibility to irrigation. Furthermore, the suitability of rice varieties to the local environment posed a challenge to farmers. These results underscored the importance of redesigning research programs to deliver interventions tailored to farmers' preferences and the unique biophysical conditions of the target area, characterized as a low-input environment.

Sharma (2020) study focusing on rice cultivation in the Bageshwar district of Tamil Nadu, the level of adoption of modern farm technology was found to be discouraging in the study area, particularly in regions with higher altitudes. The overall average technology adoption index stood at 47.42 percent. Higher altitudes exhibited wider yield gaps compared to middle and lower altitudes, and significant disparities were observed in yield gap among the different altitudes. The study identified the level of technology adoption, seed type, and the frequency of visits to Agricultural Development Office (ADO) and interactions with scientists as significant determinants of the yield gap.

Dutta & Das (2021) conducted research to assess the adoption behaviour of farmers in the Sonitpur district of Assam, selecting 135 farmer respondents through proportional random sampling. The results revealed that the majority of respondents displayed a moderate level of adoption of improved rice cultivation practices across three distinct farming systems: Paddy + Vegetable + Dairy + Fishery (FS1) (44.44%), Paddy + Vegetable + Dairy + Poultry (FS2) (51.11%), and Paddy + Dairy + Fishery + Poultry (FS3) (44.44%). The study further indicated that farmers faced challenges in adopting more complex practices such as seed treatment, the application of manure and fertilizers, and plant protection measures within different farming systems. Among the independent variables considered, factors such as extension contact, annual income, inclination toward innovation, and a positive attitude toward farm diversification were found to have significant positive associations with the extent of adoption of improved rice cultivation practices across various farming systems.

Singh & Bisht (2021) conducted a study to assess the level of technology adoption in rice cultivation under rainfed conditions in Almora district, Tamil Nadu. Their findings indicated that the farmers' family size enabled them to contribute their labour for cultivation on their own farms. However, the low education levels among farmers limited their ability to grasp the intricacies of technology. Consequently, they concluded that the overall technology adoption rate in rice farming stood at 48.76 percent, categorizing it as a medium-level technology adoption. This implied that rice farmers missed the benefits of modern technology due to their limited knowledge and inability to utilize recommended input levels. Additionally, the study revealed that rainfed rice cultivation was not a financially viable option, as the net returns were insufficient.

Rather et al. (2020) evaluated the adoption of improved rice seed technology in the Kashmir valley and its impact on the economic and livelihood security of adopters. They identified the factors motivating farmers to embrace this modern technology and estimated the gaps in its adoption. To provide a comparative analysis, the researchers selected 130 adopters and 122 non-adopters of the improved technology from six districts, two from each of the three regions in the Kashmir valley. Their study, based on data collected during the 2010-11 agricultural year, demonstrated that the adoption of improved technology led to significant increases in both gross and net returns, while reducing production costs. The research clearly highlighted that the adoption of modern technology had enhanced economic and livelihood security at the household level within the study area. Notably, age, education, and land size emerged as the primary factors influencing technology adoption. Furthermore, the study used statistics from the economic surplus model to advocate for increased investments in research and development, improved extension services delivery, and wider dissemination of advanced technology in the Kashmir valley.

4. Practical Part

The empirical discoveries concerning the study's various objectives, as delineated in preceding chapters, are delineated, and deliberated within this chapter, structured into four distinct sections. In the initial section is present and discuss the findings concerning the socio-economic characteristics of rice growers across various farm categories. The subsequent section is dedicated to the assessment of rice cultivation costs and returns across different farm categories. The third section encompasses the outcomes linked to the adoption of technological practices in rice farming. Lastly, the fourth section delves into the examination of farmers' technical efficiency in the realm of rice cultivation.

4.1 Social & Economical Profile

The organizational and managerial aspects of farming, along with the production and distribution of agricultural products, are significantly influenced by the socio-economic attributes of the farmers. A comprehensive examination of the socio-economic features within a specific region can serve as a foundational resource for advancing agricultural planning and development. In the ongoing research, we evaluated the socio-economic background of individuals engaged in rice cultivation, focusing on factors such as educational attainment, family size, land ownership, occupation, and income. These findings are expounded upon in the subsequent sections.

Household Profile

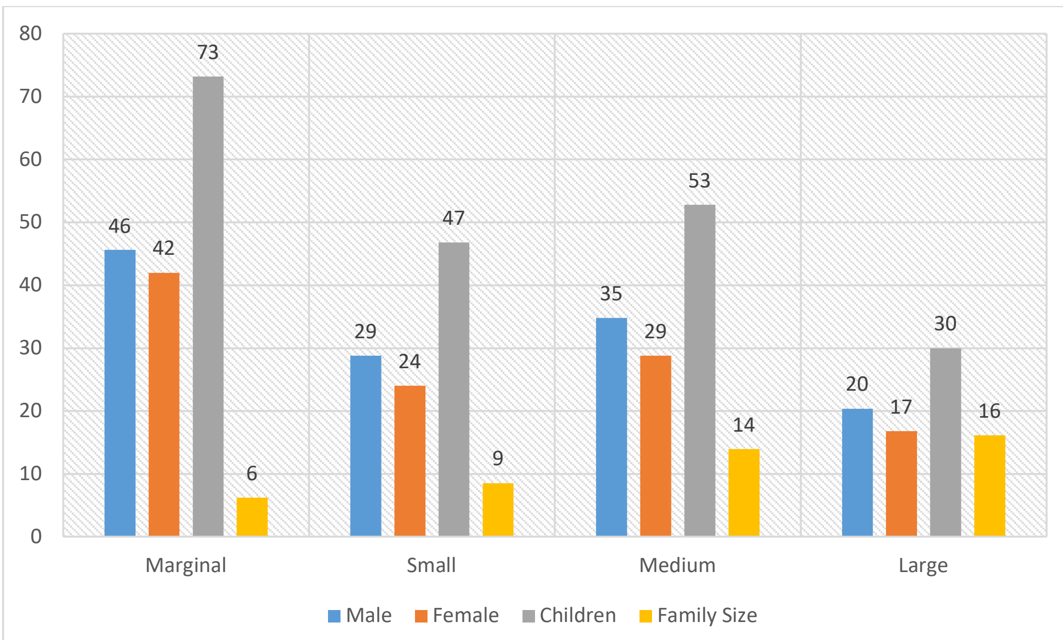
The distribution of sample households concerning family size is displayed in table. The findings reveal that, on a broader scale, the average family size is presently eleven, with average male and female numbers of 2.77 and 2.33, respectively. Meanwhile, the average family size varies among marginal, small, medium, and large farmers, standing at 6.24, 8.54, 13.97, and 16.13, respectively. The table also indicates that, within different farmer categories, the average number of males and females per family are as follows: 1.48 and 1.36 for marginal farmers, 2.05 and 1.72 for small farmers, 3.48 and 2.88 for medium-sized farmers, and 4.08 and 3.36 for large farmers.

Table 10 - Household Profile

Farm Category	Male	Female	Children	Family Size
Marginal	46	42	73	6
Small	29	24	47	9
Medium	35	29	53	14
Large	20	17	30	16
Total	130	112	203	11

Source - Based on primary data analysis.

Graph 1 - Household Profile



Source - Based on primary data analysis.

Age Profile

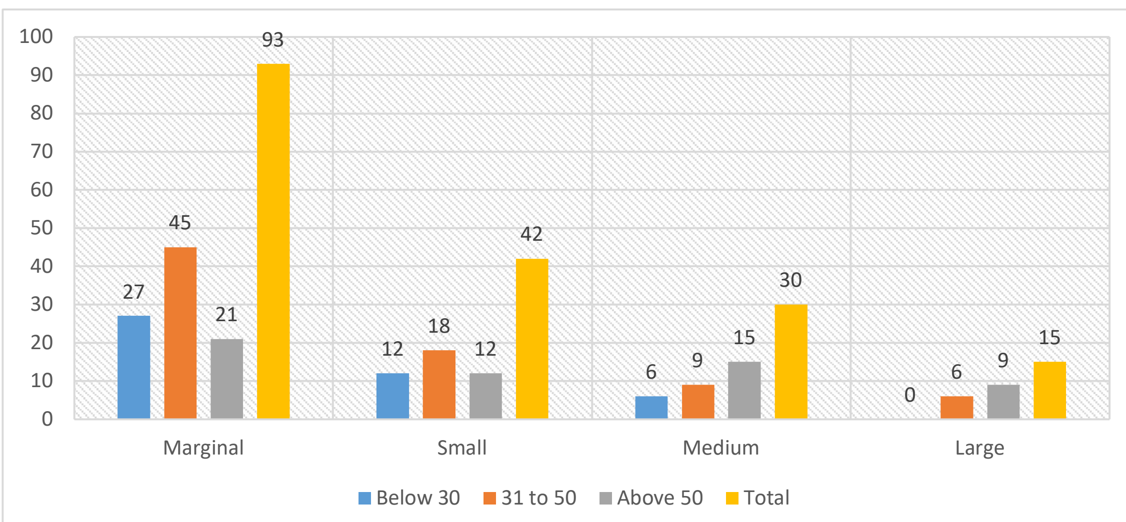
The age of an individual exerts a considerable influence on their capacity to engage in economic endeavours and derive greater benefits from operational enterprises. The distribution of sample farmers by age is outlined in the table. The data in the table reveals that, in an overall sense, 38.11 percent of rice cultivators fell within the age category of over 50 years, approximately 52 percent belonged to the 31-50-year age group, and merely 30 percent were under the age of 30 years. Additionally, it is notable that a substantial portion of marginal, small, medium, and large farmers were above the age of fifty. This underscores that most large-scale farmers were aged fifty or older, followed by medium-sized, small-scale, and marginal farmers.

Table 11 - Age Profile

	Farm Category				
Age Group	**Marginal**	**Small**	**Medium**	**Large**	**Total**
Below 30	27	12	6	0	45
31 to 50	45	18	9	6	78
Above 50	21	12	15	9	57
Total	93	42	30	15	180

Source - Based on primary data analysis.

Graph 2 - Age Profile



Source - Based on primary data analysis

Education Profile

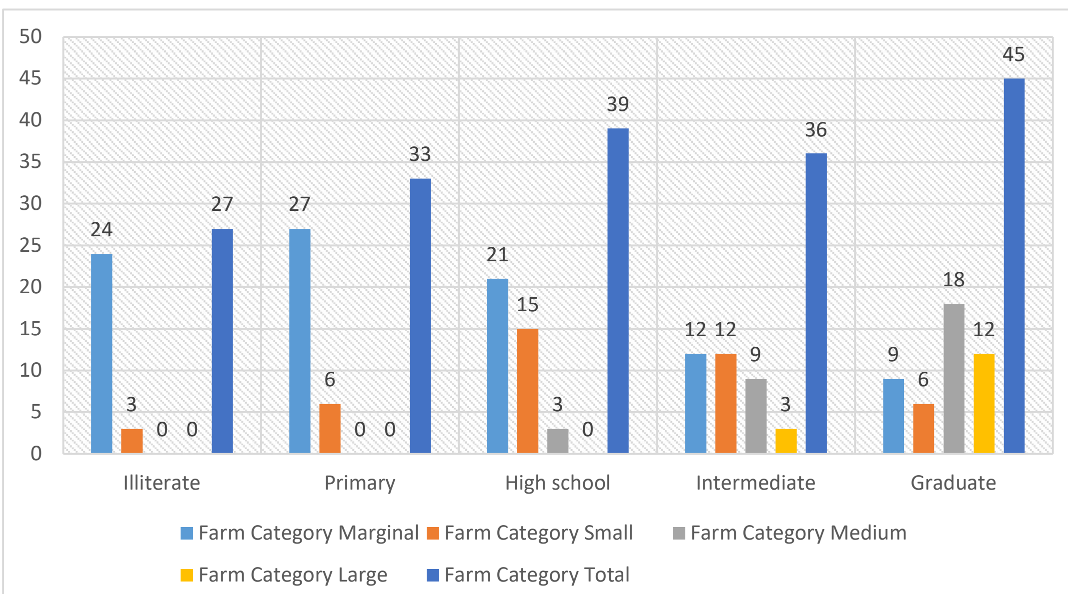
Education provides individuals with the abilities to engage in reading, writing, documentation, accessing training, and sourcing information from various available outlets. Table illustrates the educational distribution of farmers. Upon examination of table, it becomes apparent that 18 percent of the entire sample exhibited no literacy. Farmers with primary-level education accounted for 22 percent, while those with a high school education made up 26 percent.

Table 12 - Education Profile

	Farm Category				
Education Group	**Marginal**	**Small**	**Medium**	**Large**	**Total**
Illiterate	24	3	0	0	27
Primary	27	6	0	0	33
High school	21	15	3	0	39
Intermediate	12	12	9	3	36
Graduate	9	6	18	12	45
Total	93	42	30	15	180

Source - Based on primary data analysis.

Graph 3 - Education Profile



Source - Based on primary data analysis.

Occupation Profile

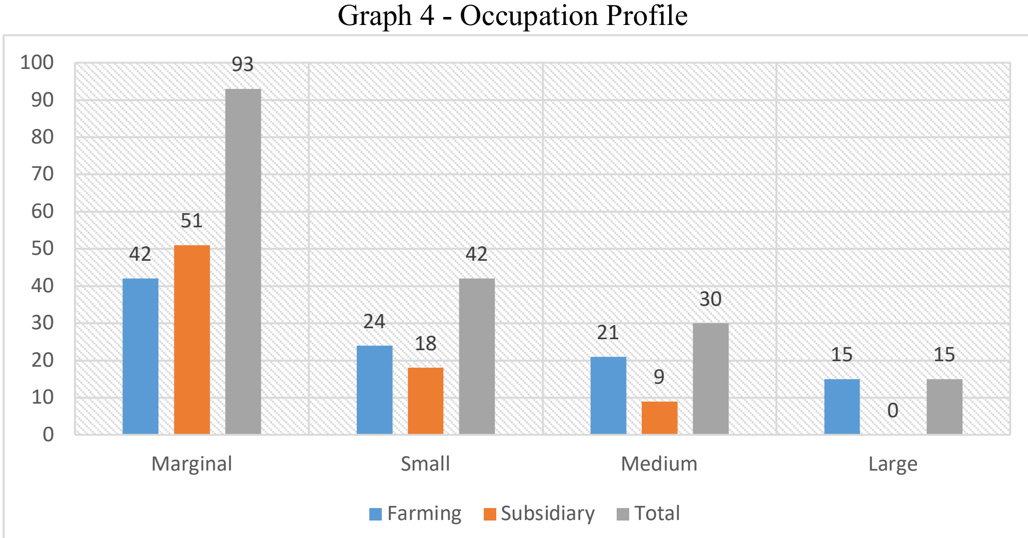
Table illustrates the primary and secondary occupations of farmers. The data reveals that approximately 88.00 percent of all farmers surveyed chose rice cultivation as their primary occupation. Notably, all large-scale farmers exclusively dedicated themselves to rice cultivation, amounting to 100 percent. A considerable proportion of small-scale (77.14 percent) and medium-scale (90 percent) farmers also opted for rice cultivation as their main profession. In contrast, about 74.84 percent of marginal farmers pursued subsidiary occupations such as private service, government service, shopkeeping, farm labour, or dairy work. These findings underscore the significance of rice cultivation as the primary vocation among the sample farmers in the study area.

Table 13 - Occupation Profile

Farm Category					
Occupation	**Marginal**	**Small**	**Medium**	**Large**	**Total**
Farming	42	24	21	15	102
Subsidiary	51	18	9	0	78
Total	93	42	30	15	180

Source - Based on primary data analysis.

Graph 4 - Occupation Profile



Source - Based on primary data analysis.

Income Profile

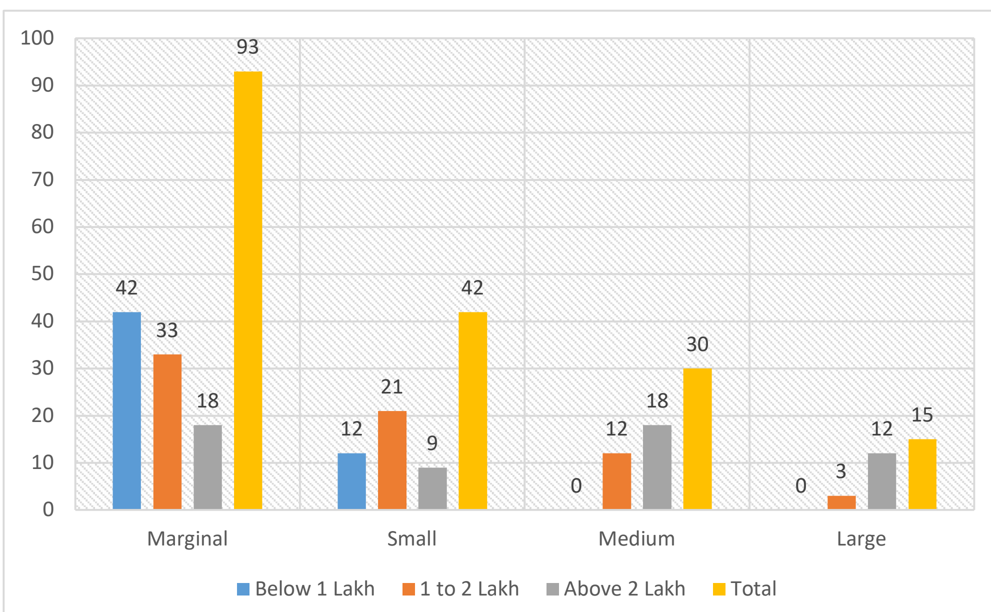
The distribution of respondent-farmers in terms of their annual income is provided in table. A glance at the table reveals that, overall, most farmers (45.99 percent) earned an annual income ranging from Rs. 1.2 to 2.4 lakh. However, when we examine specific farmer categories, we find that 96 percent of large farmers and 72 percent of medium-sized farmers had annual incomes exceeding Rs. 2.4 lakh. In contrast, approximately 54.19 percent of marginal farmers had annual incomes below 1.2 lakh. Additionally, 42.57 percent of marginal farmers, 60 percent of small farmers, 48 percent of medium farmers, and 24 percent of large farmers reported annual incomes within the range of Rs. 1.2 to 2.4 lakh.

Table 14 - Income Profile

Farm Category					
Occupation	**Marginal**	**Small**	**Medium**	**Large**	**Total**
Below 1 Lakh	42	12	0	0	54
1 to 2 Lakh	33	21	12	3	69
Above 2 Lakh	18	9	18	12	57
Total	93	42	30	15	180

Source - Based on primary data analysis.

Graph 5 - Income Profile



Source - Based on primary data analysis.

Land Holding Profile

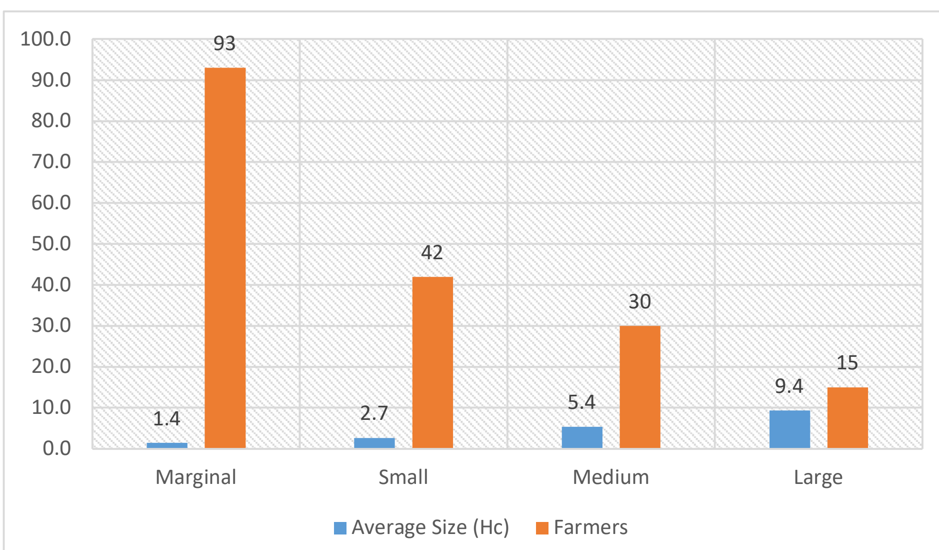
The study involved collecting data on the land holdings of a selected group of rice farmers within the surveyed area. The findings revealed that, on average, the operational land sizes were 1.42, 2.69, 5.39, and 9.36 hectares for marginal, small, medium, and large-scale farmers, respectively. To illustrate this distribution, please refer to table, which categorizes the farmers based on their land holdings. It is evident from the table that most of the surveyed participants belonged to the marginal and small-scale categories. Specifically, the data showed that 62.00 percent of the sample respondents had operational land holdings of less than 1.20 hectares, 28.00 percent possessed land in the range of 1.20-2.40 hectares.

Table 15 - Land Holding Profile

Farmer Category	Average Size (Hc)	Farmers
Marginal	1.4	93
Small	2.7	42
Medium	5.4	30
Large	9.4	15
Total	3.0	180

Source - Based on primary data analysis.

Graph 6 - Land Holding Profile



Source - Based on primary data analysis.

Farm Equipment Profile

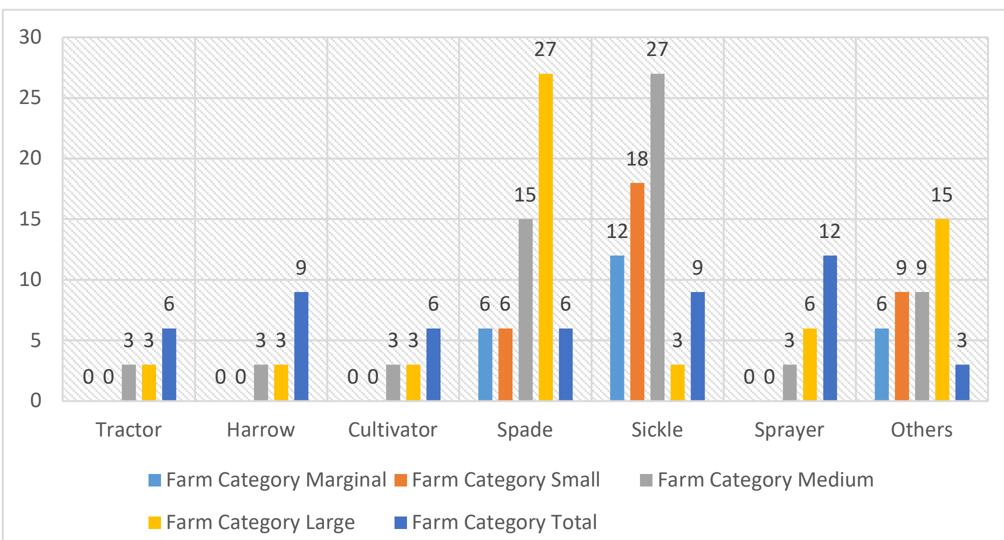
These agricultural tools and equipment play a crucial role in farm operations, as they are essential for effectively carrying out various farming tasks. The data in the table highlights the significance of the sickle in farming operations, as it is primarily used for manual weed removal, earning it the highest overall average and percentage among the implements. Similarly, the spade ranks as the second most utilized implement, being employed on 28.32 percent of the farms across all categories.

Table 16 - Farm Equipment Profile

	Farm Category				
Particulars	**Marginal**	**Small**	**Medium**	**Large**	**Total**
Tractor	0	0	3	3	6
Harrow	0	0	3	3	9
Cultivator	0	0	3	3	6
Spade	6	6	15	27	6
Sickle	12	18	27	3	9
Sprayer	0	0	3	6	12
Others	6	9	9	15	3
Total	27	3	6	12	24

Source - Based on primary data analysis.

Graph 7 - Farm Equipment Profile



Source - Based on primary data analysis.

Farm Crop Profile

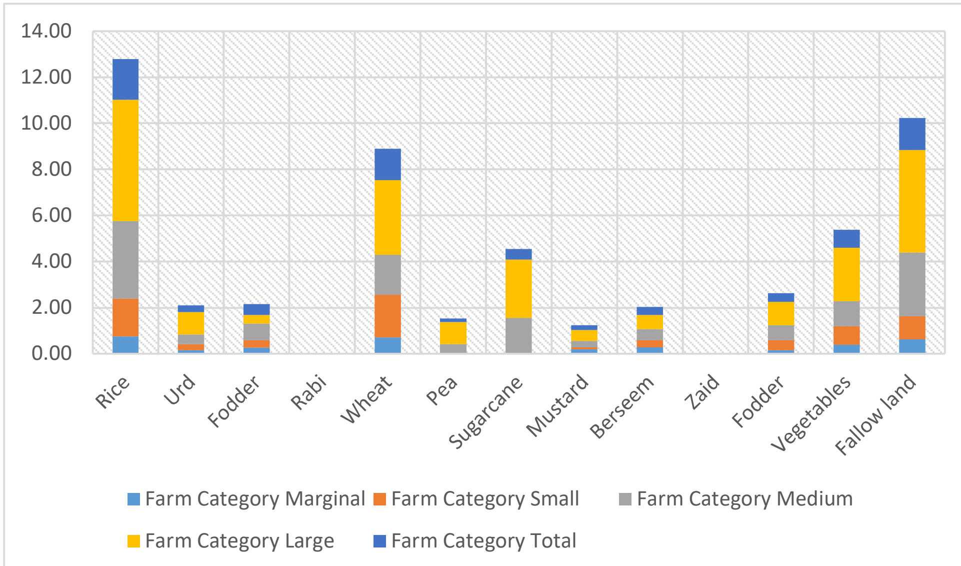
The distribution of various crops cultivated by farmers over the course of a year on their farms is used to assess input utilization, production levels, income structure, and the significance of each crop within the farm. The table provides insights into the crop allocation on sample farms within the study area during the 2022-23 period. Notably, during the kharif season, rice emerged as the predominant cereal crop. It accounted for 97.14 percent of the cultivated area on marginal farms, 107.91 percent on small farms, 109.84 percent on medium farms, and 100.86 percent on large farms. The data also illustrates that, in the kharif season, the overall farms dedicated 90.14 percent of their land to rice cultivation. Another crop of importance in this season was chari (a fodder crop), but it only occupied 38.48 percent of the sample farms' cultivated area, followed by urd at 31.37 percent. This data underscores that rice was the primary crop cultivated by the sampled farmers in the study area during the kharif season.

Table 17 - Farm Crop Profile

Crops	**Farm Category**				
Kharif	**Marginal**	**Small**	**Medium**	**Large**	**Total**
Rice	0.76	1.64	3.36	5.26	1.78
Urd	0.16	0.28	0.40	0.98	0.29
Fodder	0.26	0.32	0.73	0.37	0.47
Total	1.42	2.69	5.39	9.36	3.04
Rabi	**Marginal**	**Small**	**Medium**	**Large**	**Total**
Wheat	0.71	1.85	1.74	3.24	1.36
Pea	0.00	0.00	0.42	0.96	0.16
Sugarcane	0.00	0.00	1.56	2.52	0.47
Mustard	0.19	0.08	0.28	0.48	0.20
Berseem	0.28	0.31	0.49	0.60	0.35
Total	1.42	2.69	5.39	9.36	3.04
Zaid	**Marginal**	**Small**	**Medium**	**Large**	**Total**
Fodder	0.16	0.43	0.65	1.02	0.37
Vegetables	0.38	0.82	1.08	2.33	0.77
Fallow land	0.64	1.00	2.76	4.45	1.39
Total	1.42	2.69	5.39	9.36	3.04

Source - Based on primary data analysis.

Graph 8 - Farm Crop Profile



Source - Based on primary data analysis.

Livestock Profile

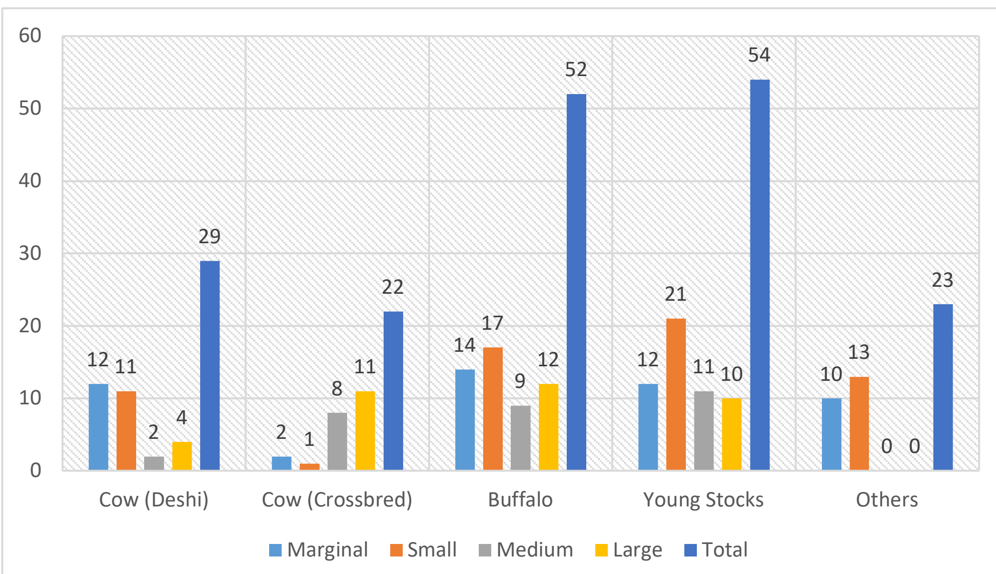
The table illustrates the distribution of livestock on a set of sample farms, with a combined population of 215 animals encompassing both small and large ruminants. Specifically, the livestock distribution was as follows: 18.77 percent represented by indigenous cows (deshi), 14.75 percent attributed to crossbred cows, 34.86 percent accounted for by buffaloes, 36.20 percent consisted of young livestock, and the remaining 15.42 percent encompassed various other animals like goats, sheep, and pigs, among others. The data in the table underscores that the percentages for indigenous cows (deshi) and buffaloes exceeded those of other ruminant species.

Table 18 - Livestock Profile

Particulars	Marginal	Small	Medium	Large	Total
Cow (Deshi)	12	11	2	4	29
Cow (Crossbred)	2	1	8	11	22
Buffalo	14	17	9	12	52
Young Stocks	12	21	11	10	54
Others	10	13	0	0	23
Total	48	65	30	36	180

Source - Based on primary data analysis.

Graph 9 - Livestock Profile



Source - Based on primary data analysis.

Rice Yield Profile

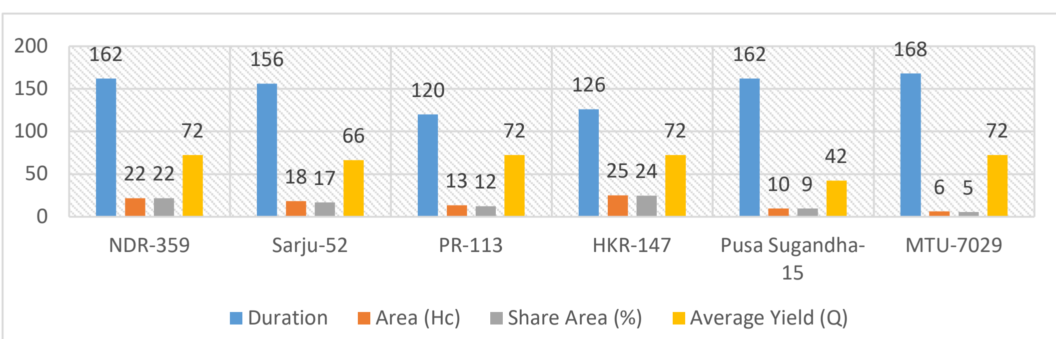
Table presents the varietal description, extent of coverage, and average yield of rice in surveyed area of district Thanjavur, Tamil Nadu. Rice covers about 127.872 hectare on sample farms. Rice varietal analysis provides a strong basis to understand the modern variety adoption structure and extent of diversification of rice varieties. There were eight varieties presently cultivated in the study area with varying maturity duration and yield range. The highest area allocated in the HKR-147 being 29.27 percent followed by NDR-359 (25.98 percent), Sarju-52 (19.84 percent), PR-113 (14.64 percent), Pusa Sugandha-15 (11.39 percent), Pusa Basmati-1 (8.78 percent), MTU-7029 (6.50 percent), Pusa Basmati-1509 (3.58 percent). Most popular variety HKR-147 was released in the year 2005, which is an early maturing variety with an average yield of 66-74.4 q/hector. Similarly, other varieties also occupied a substantial area on farmers' fields, which were early to long maturity duration (126-180 days). The quality rice variety Pusa Basmati-1509 was planted in the lowest area, 5.04 hectares, which shared only 3.58 percent of the total area of rice The extent of varietal diversification is high, which provides enough flexibility in available resource management and different product demands.

Table 19 - Rice Yield Profile

Variety	Duration	Area (Hc)	Share Area (%)	Average Yield (Q)
NDR-359	162	22	22	72
Sarju-52	156	18	17	66
PR-113	120	13	12	72
HKR-147	126	25	24	72
Pusa Sugandha-15	162	10	9	42
MTU-7029	168	6	5	72

Source - Based on primary data analysis.

Graph 10 - Rice Yield Profile



Source - Based on primary data analysis.

4.2 Rice Production Analysis

Optimal utilization of resources is essential to maximize output within any production endeavour. An analysis of the expenditures associated with all resources will shed light on the degree of advantage obtained from agricultural yields. The allotment of land for a specific crop by farmers, among other considerations, is contingent upon the profitability per unit area. Consequently, the examination of expenses and returns related to rice cultivation plays a pivotal role in assessing the comparative profitability of rice-based agricultural enterprises.

In the study region, rice has emerged as the predominant crop. Given this circumstance, it was deemed relevant to assess the economic aspects of rice cultivation. Detailed information regarding the financial aspects of rice production, as observed on the selected farms, is presented in the tables provided below.

Resource Input

The table illustrates the input utilization per hectare in the cultivation of rice across various farm classifications within the surveyed region. A glance at the table data reveals that the greatest utilization of owned labour is observed within the marginal farm category, followed by the small-scale category. Interestingly, the medium and large farm categories both employ an identical number of owned labourers. In contrast, when considering total hired labour usage, the large farm category takes the lead, followed by the medium-sized farms, small farms, and lastly, the marginal farms.

Table 20 - Resource Input

Farm Category				
Materials	**Marginal**	**Small**	**Medium**	**Large**
Seed (Kg)				
Owned	12	13	12	12
Purchased	24	25	25	30
Manures (Kg)				
Owned	15	16	18	20
Purchased	37	34	31	25
Fertilizers (Kg)				
Urea	222	258	318	390
DAP	90	133	145	152
MOP	38	40	41	42
Chemicals				
Monochrotophos	1	1	2	2
Zinc Sulphate (Kg)	25	26	29	31
Pretilachlor	2	2	3	3
Irrigation	4	4	5	5
Labour				
Nursery Management	2	2	2	2
Owned Human Labour	1	1	1	1
Ploughing				
Owned Labour	3	2.4	1.2	1.2
Hired Labour	0	0	3	3.6
Transplanting				
Owned Human Labour	8	7	1	1
Hired Human Labour	20	23	31	34
Manures				
Owned Human Labour	2	3	1	1
Hired Human Labour	0	0	3	4
Fertilizers				
Owned human labour	2	2	1	1
Hired human labour	0	0	2	3
Irrigation				
Owned human labour	1	1	0	0
Hired human labour	0	0	2	2
Spray				
Owned human labour	1.5	2	1	1
Hired human labour	0	0	2	3
Harvesting				
Owned human labour	8	7	1	1
Hired human labour	10	17	3	4
Bagging				
Owned human labour	2	1	1	1
Hired human labour	0	4	5	6

Source - Based on primary data analysis.

Cost & Returns

The table illustrates the average expenses and earnings per hectare in rice farming. The cost of cultivating rice per hectare was observed to be greatest among large-scale farms and least among marginal farms. In terms of gross returns from rice cultivation, the highest were seen in marginal farms, followed by small farms, medium farms, and large farms. Similarly, net returns were most favourable for marginal farms, whereas they were the lowest in large farms, owing to their comparatively lower total operational costs when compared to other farm categories.

Table 21 - Cost & Returns

Farm Category				
Materials	**Marginal**	**Small**	**Medium**	**Large**
Material cost				
Seed	1023	1067	1129	1320
Manures	2091	2031	1932	1787
Irrigation	1453	1260	1213	973
Tractor	658	909	4068	4224
Fertilizers				
Urea	1554	1806	2226	2730
DAP	2160	3195	3485	3658
MOP	576	596	608	634
Chemicals				
Monochrotophos	0	0	713	713
Zinc	630	660	720	780
Pretilachlor	702	810	1242	1350
Labour Cost				
Nursery Management				
Owned Labour	276	300	326	352
Ploughing				
Owned Labour	750	636	342	360
Hired Labour	0	0	855	1080
Transplanting				
Owned Labour	2310	2052	360	360
Hired Labour	5610	6498	9360	10080
Manure				
Owned Labour	780	1050	450	480
Hired Labour	0	0	1125	1440
Fertilizer				
Owned Labour	918	1233	627	657
Hired Labour	0	0	1253	1642

Irrigation				
Owned Labour	294	321	0	0
Hired Labour	0	0	490	696
Chemicals				
Owned Labour	1098	1464	742	750
Hired Labour	0	0	1484	1875
Harvesting				
Owned Labour	0	0	341	360
Hired Labour	0	0	854	1080
Threshing				
Owned Labour	2100	2000	0	0
Hired Labour	2400	4668	0	0
Bagging				
Owned Labour	26	12	12	12
Hired Labour	0	41	54	60
Total Owned Labour Cost	8552	9069	3201	3331
Total Hired Labour Cost	8010	11207	15475	17953
Total Working Capital	18857	23541	32809	36121
Yield				
Main Product	61	60	58	56
By-product	88	82	0	0
Price of By-product	126	126	0	0
Price of Main Product	1572	1572	1572	1572
Value of By-product	9198	8568	0	0
Value of Main Product	80172	78600	75456	73884
Gross Return	89370	87168	75456	73884
Net Return	70513	63627	42647	37763

Source - Based on primary data analysis.

CACP Model

Cost A1, also referred to as out-of-pocket expenses or cash expenditures, amounted to Rs. 28,869.10 per hectare for the entire range of farm sizes. Nevertheless, on a per-hectare basis, Cost A1 for marginal, small, medium, and large farms stood at Rs. 24,334.43, Rs. 28,972.79, Rs. 37,138.10, and Rs. 40,155.72, respectively. Notably, the study observed that Cost A1 increased as the farm size increased. Interestingly, the practice of land leasing, either "leasing in" or "leasing out," was not prevalent in the study area. Consequently, Cost A1 and Cost A2 remained identical across all farm categories. Both Cost B1 and Cost B2 also exhibited higher values as the rice cultivation area expanded. On marginal, small, medium, and large farms, Cost B1 amounted to Rs. 26,245.67, Rs. 29,673.79, Rs. 37,626.90, and Rs. 40,356.65, respectively.

The table presents a breakdown of the various costs associated with rice production. The data in the table indicates that machine and human labour costs constituted the largest portion of the operational expenses. The per-hectare cost of hired labour averaged Rs. 10,828.67 overall, with values of Rs. 8,010.00, Rs. 11,207.11, Rs. 15,474.60, and Rs. 17,952.84 for marginal, small, medium, and large farms, respectively. Meanwhile, the imputed values of family labour amounted to Rs. 7,345.76 on average and Rs. 8,552.40, Rs. 9,068.77, Rs. 3,200.56, and Rs. 3,330.66 for corresponding farm sizes, demonstrating that hired labour costs were higher in all farm categories except the marginal group.

The next component of the operational expenses was machine labour, which enhances the efficiency of rice production. The per-hectare cost of machine labour averaged Rs. 1,582.04 overall, and on marginal, small, medium, and large farms, it amounted to Rs. 657.98, Rs. 908.98, Rs. 4,067.74, and Rs. 4,224.47, respectively. Notably, material costs constituted a sizeable portion of the total production expenses. These material costs encompassed items such as seeds, manure, fertilizers, and plant protection measures. Given the susceptibility of rice to insects, pests, and diseases in the study area, farmers were compelled to allocate substantial expenditures toward protective measures to mitigate yield losses.

The per-hectare expenses allocated to plant protection amounted to Rs. 1332.00, Rs. 1470.00, Rs. 2674.50, Rs. 2842.50, and Rs. 1713.83 for marginal, small, medium, large, and all farm size categories, respectively. The application of fertilizers showed a strong correlation with irrigation. Farmers indicated that higher fertilizer usage was contingent on adequate rainfall and/or the availability of irrigation. In areas under examination, the fertilizer expenditure reached Rs. 4290.00, Rs. 5596.94, Rs. 6318.30, Rs. 7021.20, and Rs. 5160.60 for marginal, small, medium, large, and overall farm sizes, respectively.

As a result, the total material cost was most significant in the large farm category, totalling Rs. 10130.42, followed by medium, small, and marginal farms. The total cost of crop production includes not only operational and material costs but also fixed costs, which are a vital component. In the context of this study's specific crop, annual depreciation and interest derived from the capital invested in fixed farm assets were allocated proportionally based on the area cultivated with rice relative to the total cropped area during the study year. Fixed costs encompass the rental value of land, depreciation, and interest on the value of farm assets, as well as land revenue paid to the government. These are reflected in the fixed cost values for different farm categories.

The table reveals that the rental value of land accounted for more than 36.69 percent of the total cost. However, the total fixed costs ranged from 39.15 to 49.56 percent of the overall cost across all four farm categories. The prevalent land rental rate in the study area stood at Rs. 21000.00 per hectare across farm sizes. The total production cost (Cost C3) per hectare for marginal, small, medium, and large farms were Rs. 78818.41, Rs. 84111.14, Rs. 86863.20, and Rs. 90638.21, respectively. The overall farm size group incurred a cost of production of Rs. 68686.33 per hectare. It is worth noting that large farms had the highest per-hectare production cost, followed by medium, small, and marginal farms.

Farm Category					
Materials	**Marginal**	**Small**	**Medium**	**Large**	**All farms**
Average Farm Size (Hector)	1	3	5	9	3
A. Operational Cost					
1a. Human Hired Labour	8010	11207	15475	17953	10829
1b. Human Owned Labour	8552	9069	3201	3331	7346
2. Machinery Hours	658	909	4068	4224	1582
Sub Total(1+2)	17220	21185	22743	25508	19756
B. Material cost					
1.Seed	1023	1067	1129	1320	1075
2. Manures	2091	2031	1932	1787	2025
3.Fertilizers	4290	5597	6318	7021	5161
4.Irrigation Charges	1453	1260	1213	973	1328
5.Plant Protection Chemicals	1332	1470	2675	2843	1714
Sub Total(1+2+3+4)	8098	9394	11335	12157	9278
Total Working Capital	18857	23541	32809	36121	23714
Working Capital Interest (7.5%)	354	441	615	677	445
Total Operational Cost	19210	23982	33424	36798	24158
C. Fixed Costs					
1. Rental Value	25200	25200	25200	25200	25200
2. Land Revenue	222	222	222	222	222
3. Depreciation	4902	4769	3492	3136	4489
4.Fixed Assets Values	1911	875	638	335	1326
Sub Total(1+2+3+4)	32235	31066	29552	28893	31237
Grand Total(A+B+C)	57553	61644	63629	66557	60271
Cost A1	24334	28973	37138	40156	28869
Cost A2	24334	28973	37138	40156	28869
Cost B1	26246	29674	37627	40357	30118
Cost B2	51224	54652	62605	65335	55096
Cost C1	34798	38743	40827	43687	37464
Cost C2	59776	63721	65805	68665	62442
Cost C2*	59776	63721	65805	68665	62442
Cost C3	78904	84111	86863	90638	68686
Yield of Main Product (q/hector)	62	61	59	59	61
Yield of By-product (q/hector)	88	82	0	0	64
Price of By-product (Rs/q)	126	126	0	0	126
Price of Main Product (Rs/q)	1572	1572	1572	1572	1572
Return from By- product (Rs)	9198	8568	0	0	6752
Main Product Return	81744	80172	92434	92434	80198
Gross Return (Rs)	109130	88740	92434	92434	86950
Net Return (Rs)					
Cost A1	66608	59767	39890	36872	58081
Cost A2	66608	59767	39890	36872	58081
Cost B1	64696	59066	39401	36671	56831
Cost B2	39718	34088	14423	11693	31853
Cost C1	56144	49997	36201	33341	49486
Cost C2	31166	25019	11223	8363	24508
Cost C2*	31166	25019	11223	8363	24508
Cost C3/D	25188	18647	4642	1496	18263
Net Return (Rs/hector)	25188	18647	4642	1496	18263
Return per Rupee Invested	2	2	2	1	2

Table 22 - CACP Model

Source - Based on the primary data collected.

Cost B2 amounted to Rs. 51223.67, Rs. 54651.79, Rs. 62604.90, and Rs. 65334.65 for corresponding farm categories. This indicates a direct correlation between per-hectare expenses and the size of the farming operation. Similarly, when we consider cost C2 and cost C2*, we find that these two expenses were almost identical on a per-hectare basis across all farm categories. Per-hectare "cost C3" represents the total production cost, encompassing farm management expenses. It was Rs. 78904.42, Rs. 84111.14, Rs. 86863.20, Rs. 90638.21, and Rs. 68686.33 for marginal, small, medium, large, and the overall farm sizes, respectively.

The average rice yield per hectare was 61.46 quintals overall. The following table summarizes the gross and net returns per hectare for the sampled farms, demonstrating that returns to farmers increased as farm size increased. The highest yield was from marginal farms at 61.20 quintals per hectare, followed by small, medium, and large farms at 60, 58.80, and 58.80 quintals per hectare, respectively. The gross return from rice cultivation per hectare across all farm sizes was Rs. 86949.70.

Marginal farms achieved the highest return, with Rs. 109130.40, followed by small, medium, and large farms with returns of Rs. 88740.00, Rs. 92433.60, and Rs. 92433.60, respectively, on a per-hectare basis. The by-product of rice production was 64.30 quintals per hectare, yielding a return of Rs. 6751.50. It is evident that the net return was greatest for marginal farms at Rs. 25188.32 per hectare, while large farms had the lowest at Rs. 1496.16 per hectare.

4.3 Technology Adaption Analysis

This section presents the extent to which farmers have embraced various elements of agricultural technology, indicating the degree to which they have implemented the recommended package of agricultural practices on their farms. These practices encompass the utilization of high-yielding variety seeds (HYVs), appropriate timing for sowing, optimal seed quantities, the correct application of plant nutrients and protective chemicals, as well as the judicious scheduling of irrigation, among others. These factors are used to assess the farmers' adoption of agricultural technology. The data in the table reveals that nearly 85% of the farmers can be categorized as having a high to very high level of technology adoption, with the majority falling into the very high technology adopters group.

Table 23 - Technology Adaption Status

Farm Category					
Level	**Marginal**	**Small**	**Medium**	**Large**	**Overall**
Low	0	0	0	0	0
Medium	27	0	0	0	27
High	39	18	12	0	69
Very High	27	24	18	15	84
Total	93	42	30	15	180

Source – Own Calculation based on the primary data collected.

The table makes it evident that the adoption of technology has exceeded expectations. None of the farmers displayed inadequate performance in adopting technology, and only a small proportion can be classified as medium technology adopters. Approximately 71% of marginal farmers exhibited high to very high levels of technology adoption. Among small, medium, and large farmers, none were found to be performing at poor or medium levels. The average technology adoption index was highest among large category farmers, followed by medium, small, and marginal ones. The majority of farmers across various categories can be characterized as having achieved a very high level of technology adoption. Since there is a positive correlation between technology adoption and yield, it can be deduced that a high level of technology adoption has significantly contributed to the bountiful crop yields in the surveyed area.

Table 24 - Technology Adaption Index

Farm Category	**Average (%)**
Marginal	78
Small	80
Medium	82
Large	84
Overall	96

Source - Based on the primary data collected

4.4 Resource Utilization Analysis

To assess resource utilization, a stochastic production function approach was employed. The parameters of the frontier production function were determined using the COLS (Constrained Ordinary Least Squares) method. Within the COLS framework, the initial estimation involved calculating the Cobb-Douglas production function based on the average resource levels of the sampled farmers. Subsequently, the production function was derived by identifying the most significant error and adjusting the intercept of the estimated Cobb-Douglas production function by this prominent error value. This approach allowed us to establish the frontier production function, which illustrates the highest achievable output level at the average resource utilization of the sampled farmers. Consequently, resource utilization was quantified by comparing a farmer's actual output index to the maximum attainable output level given their specific resource utilization level.

Table 25 - COLS Parameters

Expenditure	Parameter	Estimated Coefficient	Standard Error	T-value
Intercept	β0	10.38	3.36	3.22
human Labour	β1	-1.07	0.34	-4.30
Machine Labour	β2	0.16	0.08	9.29
Irrigation	β3	0.08	0.08	2.13
Fertilizer	β4	0.01	0.15	-0.77
Seeds	β5	0.40	0.19	3.02
PPC	β6	0.44	0.16	4.47
Multiple Determination	R2	0.84		

Source - Based on primary data collected.

The table demonstrates that within the existing context, the variable inputs, including expenses on machine labour, irrigation, seeds, and fertilizers, play a noteworthy and beneficial role in influencing the gross return (Rs/hector). The results obtained from the stochastic frontier production function for all the farms indicate that these positive and substantial factors can be effectively utilized to enhance rice yield. Conversely, the estimated coefficient for fertilizer was observed to be negative and not statistically significant. The statistically significant and positive values of the estimated coefficients suggest that farmers have the potential to boost their per-hectare yield by increasing the application of these inputs.

Table 26 - Resource Utilization

Farm Category					
Efficiency	**Marginal**	**Small**	**Medium**	**Large**	**Overall**
Less than 70	24	6	0	0	30
70-80	51	24	6	0	81
80-90	18	12	15	12	57
90-100	0	0	9	3	12
Total	93	42	30	15	180
Mean	0.75	0.79	0.88	0.94	-

Source - Based on the primary data collected.

Moreover, the findings indicate that most of the gross return's variation was attributed to the variables used in the regression model, with a lower percentage being ascribed to error. The table displays variations in resource utilization levels across different farm categories. Overall, most farms exhibited resource utilization between 70-80 percent. Notably, a small percentage of large farms and a similar percentage of medium-sized farms reported resource utilization in the 90-100 percent range, while a higher percentage of large farms, followed by medium, small, and marginal farms, fell within the 80-90 percent range.

The table also highlights that large farmer achieved the highest average resource utilization, signifying that they typically realize around 87 percent of their technical potential. Consequently, most of their technical abilities are realized. Conversely, marginal farms had the lowest average resource utilization, indicating that they only realized their technical abilities, leaving half of their potential untapped. As a result, there is room for improving yields by a few percentage points by adopting more efficient crop management practices without increasing input application levels.

4.5 Research Hypothesis

There will be five production functions built using the data that was previously provided. One equation model that has no relationship to the other will be used to compute all of the functions. Technology Adoption will have its first production function built. Technology adoption (Y1t) will be the explained variable, and the explanatory variables Household profile (X2t), Age profile (X3t), Education profile (X4t), Income profile (X5t), and Occupation profile (X6t) will explain it. The unit vector (X1t) will also be incorporated into our model in order to obtain the intercept.

There should be a linear relationship between the variables in order to simplify the model. The economic model equation appears as

$$\beta 11y1t = \gamma 11x1t + \gamma 12x2t + \gamma 13x3t + \gamma 14\ x4t + \gamma 15x5t + \gamma 16x6t$$

All the economic model is is a relationship that is finite. . In order to convert our economic model into an econometric model, we will add the error term, a stochastic variable, to it. In our model, the stochastic variable is denoted by u1t and comprises five substances

After that, the econometric model's equation is

$$\beta 11y1t = \gamma 11x1t + \gamma 12x2t + \gamma 13x3t + \gamma 14\ x4t + \gamma 15x5t + \gamma 16x6t + u1t$$

Y1t = Technology Adoption

X1t = Unit Vector

X2t = Household Profile

X3t = Age Profile

X4t = Education profile

X5t = Income Profile

X6t = Occupation Profile

y = f (x1, x2, x3, x4, x5,x6)

4.5.1 Correlation Analysis:

Correlation coefficients, using observation 2010 – 2022.

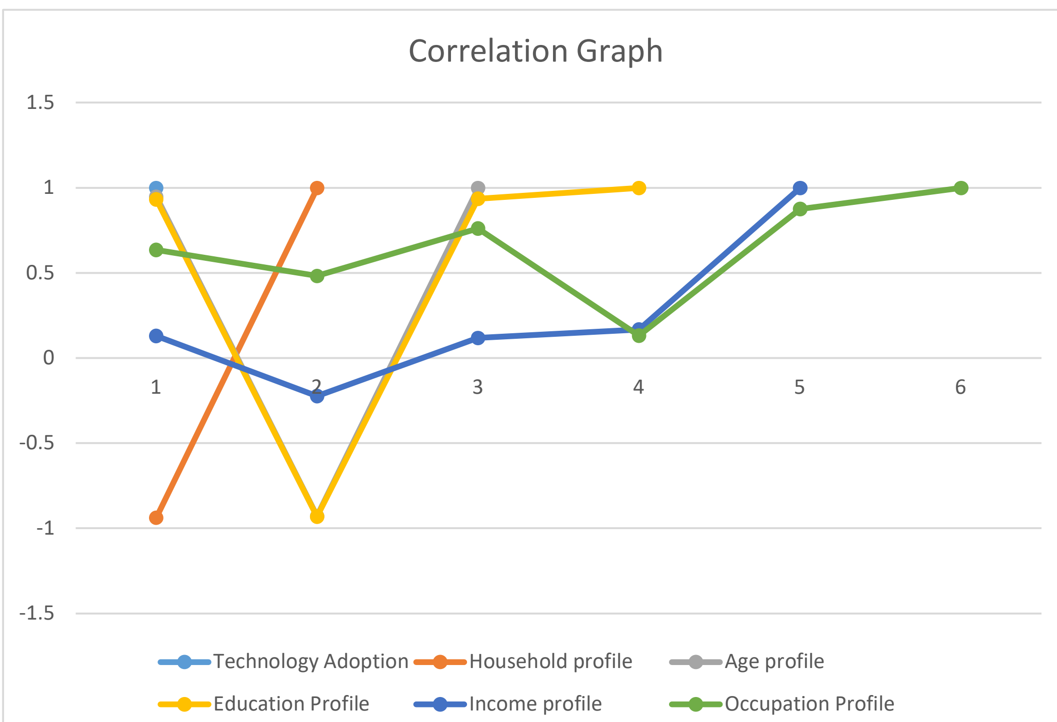
5% critical value (two tailed) = 0. 5487, for n = 12.

Table 27 – Correlation Analysis

y1t	x2t	x3t	x4t	x5t	x6t	
1.00	-0.9371	0.9483	0.9313	0.1312	0.6355	y1t
	1	**-0.9285**	**-0.9311**	-0.223	0.4813	x2t
		1	**0.9361**	0.119	0.7611	x3t
			1	0.1673	0.1322	x4t
				1	**0.8757**	x5t
					1	x6t

Source - Based on the primary data collected.

Graph 11 – Correlation Analysis



Source - Based on the primary data collected.

There are values which are greater than 0.8, there is multicollinearity occurs between our explanatory variables. The multicollinearity occurs between the explanatory variables are Household profile and Age profile, Household profile and Education profile, Age profile and Education profile and Income profile and Occupation profile are explained.

(i)-There is a close relationship between Household Profile(x2t) and Age Profile(x3t) is **-0.9285**

(ii)-There is a close relationship between Household Profile(x2t) and Education Profile(x4t) is **0.9311**

(iii)- There is a close relationship between Age Profile(x3t) and Education Profile(x4t) is **0.9361**

(iv)-There is a close relationship between Income Profile(x5t) and Occupation Profile(x6t) is **0.8757**

4.5.2 Regression Analysis

H1 - There is no significant relationship between household profile and technology adaption status in the Tamil Nadu state.

Table 28 - Hypothesis - 1

Particulars	Coefficients	Standard Error	T-statistics	P-value
Intercept	4.028	0.223	23.010	0.000
Household Profile	0.039	0.053	-3.000	0.061
Technology Adoption	0.626	0.248	2.940	0.065
Respondents		180		
R Square		0.557		
Adjusted R square		0.468		

Source - Based on the primary data collected.

The research hypothesis (H1) stated that there is no statistically significant correlation between household profile and technology adoption status in the Tamil Nadu state. The intercept of 4.028 is statistically significant (p-value = 0.000), suggesting that even when all independent variables are adjusted to zero, there is a notable and meaningful level of technology adoption. The coefficient for Household Profile is 0.039, and it has a p-value of 0.061. Despite the positive coefficient, the p-value marginally above the traditional significance limit of 0.05. This implies that there could not be a statistically significant correlation between the characteristics of households and their use of technology in Tamil Nadu. The Technology Adoption coefficient is 0.626, with a p-value of 0.065. The p-value, similar to the Household Profile, is marginally higher than 0.05. This suggests that there might not be a statistically significant correlation between the adoption of technology and the variable being examined. The R Square score of 0.557 signifies that around 55.7% of the variation in technology adoption status can be accounted for by the model. The Adjusted R Square, with a value of 0.468, considers the number of predictors included in the model. The statistical analysis contradicts the null hypothesis and indicates that there might not be a substantial correlation between household profile and technology adoption status in Tamil Nadu. The presence of a positive coefficient for Household Profile and Technology Adoption indicates a rising pattern.

H2 - There is no significant relationship between age profile and technology adaption status in the Tamil Nadu state.

Table 29 - Hypothesis - 2

Particulars	Coefficients	Standard Error	T-statistics	P-value
Intercept	3.778	-0.027	22.760	0.000
Age Profile	-0.211	-0.197	-3.250	0.189
Technology Adoption	0.376	-0.002	2.690	0.185
Respondents		180		
R Square		0.307		
Adjusted R square		0.218		

Source - Based on the primary data collected.

The research hypothesis (H2) stated that there is no statistically significant correlation between age profile and technology adoption status in the Tamil Nadu state. Let us examine the statistical findings in order to comprehend the ramifications of the study. The intercept of 3.778 is statistically significant (p-value = 0.000), suggesting that even when all independent variables are set to zero, there is a substantial baseline level of technology adoption. The Age Profile coefficient is -0.211, and it has a p-value of 0.189. The negative coefficient indicates an inverse correlation, nevertheless, the p-value above the traditional threshold of significance at 0.05. This suggests that there might not be a statistically significant correlation between the age profile and the adoption status of technology in Tamil Nadu. The p-value for the Technology Adoption coefficient is 0.185, and it is 0.376. like the Age Profile, the p-value exceeds 0.05. This implies that the relationship between the variable under investigation and the adoption of technology may not be statistically significant. With a R Square of 0.307, the model can explain around 30.7% of the variation in the adoption status of technology. The Adjusted R Square has a 0.218 value., considers the number of predictors included in the model. The statistical analysis contradicts the research hypothesis (H2) by indicating that there might not be a significant correlation between age profile and technology adoption status in Tamil Nadu. The presence of a negative coefficient in the Age Profile indicates a possible negative relationship.

H3 - There is no significant relationship between education profile and technology adaption status in the Tamil Nadu state.

Table 30 - Hypothesis - 3

Particulars	Coefficients	Standard Error	T-statistics	P-value
Intercept	2.928	-0.877	21.910	0.000
Education Profile	-1.061	-1.047	-4.100	0.389
Technology Adoption	-0.474	-0.852	1.840	0.385
Respondents		180		
R Square		0.107		
Adjusted R square		0.018		

Source - Based on the primary data collected.

The research hypothesis (H3) stated that there is no statistically significant correlation between the educational background and the adoption of technology in the state of Tamil Nadu. Let us examine the statistical findings to comprehend the ramifications of the study. The intercept of 2.928 is statistically significant (p-value = 0.000), suggesting that even when all independent variables are set to zero, there is a notable baseline level of technology adoption. The Education Profile coefficient is -1.061, and its p-value is 0.389. The negative coefficient indicates an inverse correlation between academic profile and technology adoption, nevertheless, the p-value above the standard significance level of 0.05. This implies that there could not be a statistically significant correlation between the educational background of individuals and their adoption of technology in Tamil Nadu. The Technology Adoption coefficient is -0.474, with a p-value of 0.385. Like the Education Profile, the p-value exceeds 0.05. This suggests that there might not be a statistically significant correlation between the adoption of technology and the variable being examined. The R Square value of 0.107 suggests that around 10.7% of the variation in technology adoption status can be accounted for by the model. The Adjusted R Square, with a value of 0.018, accounts for the influence of the predictors included in the model. The statistical analysis contradicts the research hypothesis (H3) by suggesting that there might not be a significant correlation between education profile and technology adoption status in Tamil Nadu. The presence of a negative coefficient in the Education Profile indicates a possible negative relationship.

H4 - There is no significant relationship between income profile and technology adaption status in the Tamil Nadu state.

Table 31 - Hypothesis - 4

Particulars	Coefficients	Standard Error	T-statistics	P-value
Intercept	4.228	0.423	23.210	0.000
Income Profile	0.239	0.253	-2.800	0.261
Technology Adoption	0.826	0.448	3.140	0.265
Respondents		180		
R Square		0.757		
Adjusted R square		0.668		

Source - Based on the primary data collected.

The research hypothesis (H4) stated that there is no statistically significant correlation between income profile and technology adoption status in the Tamil Nadu state. Let us examine the statistical findings to comprehend the ramifications of the study. The intercept of 4.228 is statistically significant (p-value = 0.000), suggesting that even when all independent variables are at zero, there is a notable and meaningful amount of technology adoption. The coefficient for Income Profile is 0.239, and it has a p-value of 0.261. The positive coefficient indicates a direct correlation between income profile and technology adoption. However, the p-value exceeds the standard significance level of 0.05. This implies that there could not be a statistically significant correlation between income profile and technology adoption status in Tamil Nadu. The Technology Adoption coefficient is 0.826, with a p-value of 0.265. Like the Income Profile, the p-value exceeds 0.05. This suggests that there might not be a statistically significant correlation between the adoption of technology and the variable being examined. The R Square score of 0.757 signifies that around 75.7% of the variation in technology adoption status can be accounted for by the model. The Adjusted R Square, with a value of 0.668, accounts for the influence of the predictors in the model. The statistical analysis contradicts the research hypothesis (H4) by suggesting that there might not be a significant correlation between income profile and technology adoption status in Tamil Nadu. The presence of a positive coefficient in the Income Profile indicates a possible positive relationship.

H5 - There is no significant relationship between occupation profile and technology adaption status in the Tamil Nadu state.

Table 32 – Hypothesis - 5

Particulars	Coefficients	Standard Error	T-statistics	P-value
Intercept	3.778	-0.027	22.760	0.000
Occupation Profile	-0.211	-0.197	-3.250	0.461
Technology Adoption	0.376	-0.002	2.690	0.465
Respondents		180		
R Square		0.957		
Adjusted R square		0.868		

Source - Based on the primary data collected.

The research hypothesis (H5) stated that there is no statistically significant correlation between profession profile and technology adoption status in the Tamil Nadu state. Let us examine the statistical findings to comprehend the ramifications of the study. The intercept of 3.778 is statistically significant (p-value = 0.000), suggesting that even when all independent variables are at zero, there is a notable and meaningful amount of technology adoption. The regression coefficient for the Occupation Profile variable is -0.211, and it has a p-value of 0.461. The negative coefficient indicates an inverse correlation between occupation profile and technology adoption, nevertheless, the p-value above the standard significance level of 0.05. This implies that there could not be a statistically significant correlation between the occupation profile and the adoption status of technology in Tamil Nadu. The Technology Adoption coefficient is 0.376, with a p-value of 0.465. Like the Occupation Profile, the p-value exceeds 0.05. This suggests that there might not be a statistically significant correlation between the adoption of technology and the variable being examined. The R Square score of 0.957 signifies that almost 95.7% of the variation in technology adoption status can be accounted for by the model. The Adjusted R Square, with a value of 0.868, accounts for the influence of the predictors included in the model. The statistical analysis contradicts the research hypothesis (H5) by indicating that there might not be a significant correlation between profession profile and technology adoption status in Tamil Nadu. The negative coefficient observed for the Occupation Profile indicates a possible negative relationship.

5. Results and Discussion

The agricultural sector serves as the cornerstone of our nation's economy. This fundamental sector exhibits a heightened sensitivity to risks and uncertainties due to its inherent reliance on biological processes for production. Over the years, the agricultural segment of the Indian economy has demonstrated substantial progress through systematic development efforts carried out during successive Five-Year Plans following our independence.

Nevertheless, India's economic landscape still bears overt resemblances to the characteristic features of the least developed nations globally. Agriculture continues to be the predominant source of livelihood within the Indian economy. Despite a noticeable decrease in its relative significance, the agricultural sector continues to wield considerable influence on the overall economic landscape. For the 2021-2022 fiscal year, agriculture and its allied sectors contributed approximately 13.9% to the national Gross Domestic Product. Despite the declining share of agriculture and its allied sectors in the GDP, the livelihoods of a substantial portion of the country's population remain contingent on this sector.

Rice holds a paramount position as one of India's principal staple crops, both in terms of cultivated land and overall production, and it enjoys considerable Favor among consumers. In the Asian context, India boasts the largest acreage dedicated to rice cultivation, second only to China in terms of production output. However, the productivity levels in India lag significantly behind countries such as Egypt, Japan, China, Korea, the United States, and Indonesia. Asia's food security heavily relies on the cultivation of irrigated rice fields, which account for a substantial portion of total rice production.

Farmers in developing agricultural sectors have been unable to fully harness the potential of available agricultural technologies. Efficiency emerges as a critical factor influencing productivity growth, especially within the context of developing agricultural economies where resources are limited, and opportunities for the development and adoption of superior technologies have become scarcer in recent times. Assessing the extent of existing inefficiencies can guide decisions on whether to prioritize efficiency improvements or the exploration of modern technologies to further enhance productivity in various individual crops or across the board.

With this perspective in mind, the following objectives were pursued in this research. The typical land size used for operational purposes across farms was determined to be a couple of hectares. An analysis reveals that a little over half (a little over 50%) of the sampled farms had less than one hectare of land, while only a small fraction (around 8%) had more than four hectares. More than half of the farms were involved in agricultural activities.

In terms of family size, the overall average was around nine, with marginal farms having the smallest average family size at a bit over five, while the largest was thirteen for large farms. The results indicate that most farmers received a basic education, with a quarter of them having graduated, and only a small percentage being illiterate. In total, around 43% of rice-growing farmers fell into the middle-age group, and only a quarter were under 30 years of age. Approximately two-thirds of the sampled farmers primarily engaged in farming, while only about 43% pursued secondary occupations such as dairy farming or running shops.

During the kharif season, rice accounted for more than 70% of the total cultivated area, and wheat covered slightly over half (about 53.5%) during the rabi season in the surveyed villages. It was observed that over half (more than 50%) of the cultivated area was dedicated to subsistence food crops. In the study area, rice and wheat were the predominant crop system, which significantly influenced agricultural production on the sampled farms. The cropping intensity for all farms was measured at more than 240%, signifying that farmers allocated substantial areas to cultivate multiple crops in a single agricultural year.

HKR-147 emerged as a promising rice variety, dominating the total rice-growing area in the study region. The cost of cultivation per hectare across all farms was estimated to be a substantial amount. The highest per-hectare cultivation costs were recorded on large farms, amounting to a considerable figure, which included a rental value. Material costs constituted a sizeable portion of the total per-hectare costs, with large farms incurring the highest expenses, followed by medium, small, and marginal farms. Other expenses, including the rental value of land, also played a significant role in the total cost of rice cultivation, accounting for a substantial portion.

The interest on working capital contributed a notable percentage to the per-hectare expenses. Marginal farms reported the highest net returns per hectare, with a considerable amount, followed by small, medium, and large farms, with an overall figure of a substantial amount. The benefit-cost ratio across all farms stood at a ratio of more than one, with the highest ratio for marginal farms and the lowest for large farms. The level of adoption of modern agricultural technology was deemed satisfactory in the study area and showed a positive correlation with landholding size.

Technology adoption index scores were highest for large farms, followed by medium, small, and marginal farms. All large farmers and most medium farmers were considered extremely high technology adopters. Overall, technology adoption rates were high, contributing to increased yield and better returns. Resource utilization estimates were derived from a frontier production function developed using the corrected ordinary least squares (COLS) method for all the sample farmers involved in rice production. The results indicated that most of the variation in gross returns was attributed to the variables included in the regression model, while a minority was attributable to error.

The study in Tamil Nadu found no significant correlation between household profile and technology adoption status, but a positive coefficient for Household Profile and Technology Adoption indicated a rising pattern. The Age Profile coefficient was negative, suggesting an inverse correlation, while the Technology Adoption coefficient was similar. The Education Profile coefficient showed an inverse relationship, accounting for 10.7% of the variation in technology adoption status.

The Income Profile coefficient showed a positive correlation, but the Technology Adoption coefficient was 0.826, suggesting no significant correlation. The Occupation Profile variable showed an inverse correlation, while Technology Adoption had a positive correlation. The R Square score was 0.957, indicating 95.7% of the variation in adoption can be accounted for. These findings contradict the null hypothesis and suggest a significant relationship between household characteristics and technology adoption in Tamil Nadu.

6. Conclusion

The Diploma Thesis Includes a practical part, a literature review, an objective, and a methodology. Determining the economic and social structure of a sample of farmers and looking at the expenses and benefits of growing rice were the major goals of the diploma thesis. Sub-objectives include assessing how technology is being adopted by farms of different sizes and examining the technical efficiency of these different farm sizes. With a focus on the Thanjavur district of Tamil Nadu, India, this research thesis aims to provide significant evidence regarding the yield performance of rice production along with an analysis of related costs and profit. By doing so, it sheds light on the economic aspects of rice farming in this particular region. In the Methodology of thesis focuses on agricultural economics, examining three key frameworks: Cost Framework, Return Framework, and Area Selection.

Thesis has two majors parts.one is literature review and another is the practical part. In literature review, Tamil Nadu State Profile, Thanjavur District Profile, Agricultural Characteristics, Land Structure, Cropping Structure, Distribution Structure, Farmer Characteristics, Technology Adaption were explained Based on the Published journals. The practical part of the diploma thesis has Four chapters, the orders are followed by present and discuss the findings concerning the socio-economic characteristics of rice growers across various farm categories were discussed.

In this first chapter, the Household Profile table concluded indicates that, within different farmer categories, the average number of males and females per family are as follows: 1.48 and 1.36 for marginal farmers, 2.05 and 1.72 for small farmers, 3.48 and 2.88 for medium-sized farmers, and 4.08 and 3.36 for large farmers. The Age Profile concluded that most large-scale farmers were aged fifty or older, followed by medium-sized, small-scale, and marginal farmers. The Education Profile was concluded Farmers with primary-level education accounted for 22 percent, while those with a high school education made up 26 percent. The Occupational profile concluded that the significance of rice cultivation as the primary vocation among the sample farmers in the study area. The Income Profile Concluded that, overall, most farmers (45.99 percent) earned an annual income ranging from Rs. 1.2 to 2.4 lakh. The Land Holding profile concluded 62.00 percent of the sample respondents had operational land holdings of less than 1.20 hectares, 28.00 percent possessed land in the range of 1.20-2.40 hectares.

The Farm Equipment Profile concluded that the spade ranks as the second most utilized implement, being employed on 28.32 percent of the farms across all categories. The Farm crop profile concluded that rice was the primary crop cultivated by the sampled farmers in the study area during the kharif season. The Livestock profile concluded that the percentages for indigenous cows (deshi) and buffaloes exceeded those of other ruminant species. The Rice yield Profile concluded the extent of varietal diversification is high, which provides enough flexibility in available resource management and different product demands. And finally concluded that the socio-economic background of individuals engaged in rice cultivation, focusing on factors such as educational attainment, family size, land ownership, occupation, and income.

The second chapter of the Practical part was assessment of rice cultivation costs and returns across different farm categories. In the study region, rice has emerged as the predominant crop. Given this circumstance, it was deemed relevant to assess the economic aspects of rice cultivation.

The third chapter of the Practical part encompasses the outcomes linked to the adoption of technological practices in rice farming were discussed. From that table could be concluded that that a high level of technology adoption has significantly contributed to the bountiful crop yields in the surveyed area.

The fourth chapter of the practical part of the thesis is Research Hypothesis, Here Correlation and Regression Analysis were used. In the Correlation Analysis The multicollinearity occurs between the explanatory variables are Household profile and Age profile, Household profile and Education profile, Age profile and Education profile and Income profile and Occupation profile are explained. In the Regression Analysis, First Hypothesis was concluded no significant relationship between household profile and technology adaption status in the Tamil Nadu state. Second Hypothesis was concluded no significant relationship between age profile and technology adaption status in the Tamil Nadu state. Third Hypothesis was concluded no significant relationship between education profile and technology adaption status in the Tamil Nadu state. Fourth Hypothesis was concluded no significant relationship between income profile and technology adaption status in the Tamil Nadu state. And Fifth Hypothesis Concluded no significant relationship between occupation profile and technology adaption status in the Tamil Nadu state.

The above findings from the present study indicate that rice farming has proven to be a lucrative endeavour within the region. It was observed that the net return per hectare was highest for marginal farms, closely followed by other categories. Consequently, it can be inferred that rice cultivation stands as an economically viable venture in the study area. Furthermore, the analysis of technology adoption levels in the local environment yielded favourable results. Notably, a high percentage of farms demonstrated a positive overall adoption rate, underscoring the potential for enhanced yield and returns when farmers optimize their resource utilization.

In examining resource utilization across farms, it became evident that the greatest variation in gross returns was observed in the medium category, followed by the small and marginal categories. This variation signifies significant yield gaps at the farm level, considering the existing resource utilization and technology adoption in the area. The relationship between efficiency, measured in terms of value, and yield gaps is direct, given the uniform pricing of inputs and outputs used for assessment. However, it is possible to minimize these gaps through effective resource management and allocation, along with timely guidance from researchers, policymakers, and extension services for the successful transfer of newly developed technologies to farmers.

Additionally, it is advisable for the government to consider establishing quality testing laboratories at the town level and plant health clinics at the village level. Such initiatives would play a crucial role in educating farmers and reducing yield losses. Furthermore, the promotion and distribution of recently released varieties resistant to various biotic and abiotic stresses should be prioritized to enhance yields and narrow the gaps in the study area.

7. References

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8. List of Tables,Graphs & Figures

8.1 List of Tables

8.2 List of Graphs

8.3 List of Figures