IMPACT OF CLIMATE CHANGE AND ADAPTATION STRATEGIES IN BANANA PRODUCTION IN THIRUVANANTHAPURAM DISTRICT

by

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(Admn. No. 2020-11-131)

THESIS

Submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL ECONOMICS

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM – 695 522

KERALA, INDIA

2023

DECLARATION

I, hereby declare that this thesis entitled "**IMPACT OF CLIMATE CHANGE AND ADAPTATION STRATEGIES IN BANANA PRODUCTION IN THIRUVANANTHAPURAM DISTRICT**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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ACKNOWLEDGEMENT

I would like to thank all the people who contributed in some way to the work described in this thesis. First and foremost, I thank my major advisor, ***Sri. T. Paul Lazarus****, Assistant Professor (SS) and Head, Department of Agricultural Economics for accepting me as his student. He gave me intellectual freedom in my work, supported my attendance at various conferences, exposed me to new ideas, and demanded a high standard of work in all my endeavours during my time with him, all of which helped to make my graduation experience rewarding.*

I take this opportunity to thank ***Dr. Aswathy Vijayan****, Assistant Professor ,Department of Agricultural Economics for her valuable suggestions and critical evaluation of this work.*

I am grateful to ***Dr. Brigit Joseph****, Professor and Head, Department of Agricultural Statistics, for her continuous and timely advice in statistical analysis at all the stage of research work.*

My heartfelt gratitude to ***Dr. Archana R. Sathyan*** *, Department of Agricultural Extension, College of Agriculture, Vellayani for her guidance rendered to me in formulating the thesis.*

I profusely thank ***Dr. Durga A. R.****, Assistant Professor and* ***Dr. Thasnimol F.****, Assistant Professor, Department of Agricultural Economics, College of Agriculture, Vellayani, for their valuable support during the course work.*

I gratefully acknowledge Agricultural Officer ***Mrs. Leena S. L.****, Parassala, Thiruvananthapuram and Agricultural Officer* ***Mrs. Ancy****, Chenkal, Thiruvananthapuram, for providing me all the necessary secondary data and also arranging my staying facility during my survey.*

I sincerely thank Directorate of Economics and Statistics, Government of Kerala, Thiruvananthapuram for providing me all the necessary secondary data without which this thesis would not have completed.

*I glad to mention that the response from the farmers and the officials of the local bodies during the field survey has been encouraging. I have great appreciation for their righteousness and readiness to extend any amount of cooperation throughout the survey. I specially thank **Mr. Sreejukumar**, Agricultural Assistant, Parassala and **Mr. Karthik R. S.**, PhD in Agricultural Entomology, College of Agriculture, Vellayani for his willingness to accompanying me to the entire respondents house.*

*I am also thankful to seniors **Venkatrao, Akhila**, my batch mate **Koulath, Arshad** and juniors **Deepak, Yedukrishnan, Sourav, Dhanaswi** and **Anjana** for their selfless help, moral support, encouragement and fulfilment of classroom environment during the course work.*

*I am also thankful to **Lily aunty** and their **family** to support me to the entire journey of my research work. I am glad to thank my roommate **Sushmitha, Abhi, Jeevi, Ameli** and **Vyshu** for their love and support me.*

*I owe a huge debt of gratitude to my parents, **Mrs. Chandrakala Takale** and **Mr. Bhausaheb Takale, aai, aaba**, sister **Dakshata** and brother **Shubham** for their love, support, and blessings, without which I would not have been able to finish my research project.*

I would also like to express my sincere apologies, if I ever failed to mention any names.

Takale Asmita Bhausaheb

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LIST OF ABBREVIATIONS

AIC	Agriculture Insurance Company of India Ltd.
B:C	Benefit Cost Ratio
CACP	Commission on Agricultural Costs and Prices
CAGR	Compounded Annual Growth Rate
CO_2	Carbon Dioxide
CSO	Central Statistical Organisation
CV	Coefficient of Variation
DSSAT	Decision Support System for Agrotechnology Transfer
D-W Test	Durbin Watson Test
et al	Co - workers
FAO	Food and Agricultural Organisation
GDP	Gross Domestic Product
GMST	Global Mean Surface Temperature
GOI	Government of India
GOK	Government of Kerala
G 20	Group of Twenty
IPCC	Intergovernmental Panel on Climate Change
NASA	National Aeronautics and Space Administration
NCRB	National Research Centre for Banana
PCA	Principal Component Analysis
RCP	Representative Concentration Pathway
US	United States
USD	United States Dollars
USDM	United States Drought Monitor
VFPCK	Vegetable and Fruit Promotion Council of Kerala

VIF	Variance Inflation Factor
WMO	World Meteorological Organization

LIST OF SYMBOLS

°C	Degree Celsius
ha	Hectares
ha^{-1}	Per hectare
$acre^{-1}$	Per acre
%	Per cent
% p. a.	Per cent per annum
kg	Kilogram
Kg^{-1}	Per kilogram
L.	Linnaeus
Q_1	1st Quarter (January to March)
Q_2	2nd Quarter (April to June)
Q_3	3rd Quarter (July to September)
Q_4	4th Quarter (October to December)
q^{-1}	Per quintal
m	Meters
mm	Milli meter
m/s	Meters per second
t	Tonnes
mt	Metric tonnes
R^2	Coefficient of multiple determination
₹	Rupees

km	Kilometer
sq km	Square kilometer
$	United States Dollars

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Introduction

CHAPTER I

INTRODUCTION

All global economic sectors face a major threat from climate change. The last decade (2011–2020) was 1.09°C warmer than the decade between 1850 and 1900, and it is likely that we will soon surpass the 1.5°C global warming barrier (Anand, 2021). The temperature of the earth is rising as a result of the unchecked growth of greenhouse gas emissions. The results include shifting seasons, melting glaciers, increased precipitation, and more frequent extreme weather events. Global population and economic growth, along with the growing pace of climate change, pose a danger to food security worldwide. Despite having only 2.4 per cent of the world's land area and four per cent of its water resources, India must support around 17 per cent of the world's people. Of all human endeavours, agriculture is the most weather-dependent and one of the greatest occupation in the world. Higher temperatures eventually cause lower agricultural yields of desired crops while promoting the growth of weeds and pests. The probability of short-term crop failures and long-term production decreases rises with changes in precipitation patterns. Although some crops will experience advantages in specific parts of the world, the overall effects of climate change on agriculture are anticipated to be negative, endangering the security of the world's food supply.

Many panchayats have proposed the idea of carbon neutrality in recent years; one notable example and role model is Meenangadi grama panchayat in Kerala's Wayanad district. Additionally, an inventory of greenhouse gas emissions was created. One of the ground-breaking programmes to support carbon-neutral activities was tree banking, which offered interest-free loans to encourage the planting of more trees. Another example is the Palli grama panchayat in Jammu and Kashmir, which has implemented the same people-centric concept and carried out particular regional activities (Yadav, 2022).

The IPCC issued a warning in August that the observed rise in global surface temperature indicated exceptional warming between 1850 and 2020. By 2100, the difference between the expected emissions reduction and the actual demand might cause a

2.7 ºC increase in temperature. As considering India, which promised to reduce emissions by 33-55 per cent of GDP by 2030, reported that as of the year 2020, it had reached 24 per cent of this objective. Based on commitments made for 2030, the G20 countries, which account for up to 80 per cent of global emissions, are not clearly on a trajectory to attaining net zero (Ananthakrishnan, 2021).

The historical context of climate extremes has provided numerous proofs, including the fact that storms and floods accounted for 79 per cent of all disasters caused by weather climate extremes, causing 54 per cent of fatalities and 84 per cent of economic losses. Droughts, which were particularly severe in Africa in 1975, 1983, and 1984, were responsible for 35 per cent of deaths. According to the World Meteorological Organization (WMO), Hurricane Katrina in 2005 resulted in a significant economic loss of approximately US $ 146.89 billion. Between 1970 and 2012, 2,681 disasters were recorded in Asia, resulting in 9,15,389 fatalities and US $789.8 billion in economic losses (WMO, 2014).

The deadliest calamity to hit Kerala in 2018 was Hurricane Ockhie, which left over 500 people, mostly fishermen, missing and caused 218 deaths in December 2017. Kerala was also subjected to the worst floods in recorded history in August 2018, which claimed 474 lives. The floods and other events have directly disrupted one sixth of Kerala's population. The Western Ghats saw a series of landslides that increased the impact of the deluge (SI, 2020).

Global agricultural production systems are vulnerable to extreme weather events, including floods, droughts, and hailstorms, as well as severe climate change and variability. We live at a time when humanity is becoming more aware of the importance of climate change and its impact on human wellbeing. According to recent estimates, the world's population will increase from 7 billion to more than 9 billion by 2050 (UNDESA, 2009). By 2050, it is anticipated that worldwide agricultural production will need to expand in order to feed the growing population (Alexandratos and Bruinsma, 2012). The difficulty of quickly increasing productivity is made more difficult by the current and anticipated effects of climate change.

Birthal *et al*. (2014) examined variations in temperature and rainfall throughout the years 1969 - 2005 and evaluated their effects on crop yields of significant food crops. According to climate impact forecasts for the year 2100, major changes in temperature and rainfall will result in a 15 per cent decrease in rice yield and a 22 per cent increase in wheat yield. Pulses will be impacted more than cereals, whereas coarse cereals will be less affected. Farmers frequently experience several climatic shocks, but scarcely any research has attempted to quantify how these risks affect crop yields or agricultural production.

The idea of "climate-smart agriculture" is supported by scientific advancements and agronomic techniques, but it disregards a number of conventional risk management techniques. It's critical to create climate-smart practise packages tailored to individual crops and geographic regions that combine scientific advancements with farmer self-risk management techniques (Birthal, 2022).

Tamil Nadu, India, was used to study how climate change affects agricultural productivity in a tropical climate. Over a 39 year period (1971 - 2009) in a panel dataset, it was suggested that rice and sorghum are quite sensitive to variations in rainfall and temperature. Up to a threshold level of rainfall and temperature, rainfall and temperature have a positive and significant influence on rice and sorghum yields. When the temperature and rainfall exceed the threshold, the yield suffers. It's crucial to spend money on new seed varieties that can adapt to temperature and rainfall thresholds (Saravanakumar, 2014).

The banana (*Musa paradisiaca* L.) is one of the least expensive, healthiest, and most widely accessible fruits. For millions of people around the world, bananas and plantains are staple foods that offer a more balanced diet than any other fruit or vegetable. Among them are the Robusta, Red Banana, Poovan, Rasthali, Nendran, Virupakshi, Monthan, Karpuravalli, Sakkai, Peyan, Matti, and Dwarf Cavendish, which vary in size, colour, and form. In the majority of southern India, its leaves are used in a wide variety of traditional cuisines for cooking, wrapping, and serving food. In many Hindu and Buddhist ceremonies, they serve decorative and symbolic purposes. Dry banana-leaf thatch is used to make roofs and fences on traditional homes in tropical regions. The stem of a banana is used in clothing production and as a natural craft material. The rhizome, leaves, and flower of the banana have therapeutic qualities.

Due to climate change's increasing air temperature and changing rainfall pattern, banana farming may encounter high temperatures, soil moisture stress, flooding, and water logging (Kumar and Kumar, 2007). Temperature has a significant impact on the pace of fruit growth; hence, using bunch covers to warm the fruit has increased growth. In general, higher temperatures (31-32 ^{o}C) accelerate banana plant maturation and shorten the time it takes for the bunch to grow (Turner *et al*., 2007). Bananas flooded for longer than 48 hours are severely stunted for growth, and after 72–96 hours of rain, mature shoots fail to recover and frequently perish (Stover, 1972). On commercial plantations, bananas need mean annual temperatures between 26 ^{o}C and 30 ^{o}C and 2,000 mm of yearly rainfall (Nelson *et al*., 2006). Strong transport costs for bananas to markets, low prices during the wet season, and high demand for the fruit during the dry season are thought to be the main effects of climate change (Karienye *et al*., 2019).

In India, the area under banana was 8,97,000 ha and the production was 3,25,97,000 mt during 2020. As recent data shows that area under banana was about 9,23,000 ha and production was 3,33,79,000 mt during 2020-21. Since, banana quantity (in Number) consumed in a month by rural people was 4.18 and urban people was 6.69 during 2011- 12 (GOI, 2021). In Kerala, the area under banana cultivation during 2020-21 was 57,694.67 ha and production under banana was 5,44,188 t. It occupied 18.26 per cent in the category of fresh fruits and it has third top position in this plantation crops. About 4.91per cent area has decreased during 2020-21 in banana cultivation than that of 2019-20. As compared to 2021, the area and production under banana was 60,678 ha and 5,48,425 t which was more in the year 2019-20. The productivity of banana during 2021 and 2020 was 9,432 kg ha^{-1} and 9,038 kg ha^{-1}, respectively. Area covered under banana cultivation in Thiruvananthapuram was 3,507 ha during 2019-20 (GOK, 2021). Area covered under banana collective farming during 2020-21 in Thiruvananthapuram was 1,050.8 ha.

Monthly farm price of banana was ₹ 3,375 q^{-1} and ₹ 3,601 q^{-1} for the year 2020-21 and 2019-2020, respectively. The percentage change in monthly farm price of banana in 2020-21 over 2019-20 was -6.29 per cent. The gross area of banana under irrigation was 3,003 ha in Thiruvananthapuram during 2020-21 (GOK, 2022).

Banana is cultivated from sea level to 1,000 m above mean sea level and likes humid, tropical lowlands. It can also be grown up to 1,200 m above sea level, but growth is poorer there. The ideal temperature is 27 °C, and the best soils are those with good fertility and a reliable supply of moisture. The midland and lowlands are where the Thiruvananthapuram district is located. This study was carried out in Kerala's Thiruvananthapuram district, which is vulnerable to climate change and has a large banana farming industry. The study's objectives were as follows:

1. Assessment of impact of climate change on the yield of banana crop in Thiruvananthapuram district

2. Identification and analysis of adaptation strategies practised by the banana farmers.

SCOPE OF THE STUDY

The present study is an attempt to assess the impact of climate change on the yield of banana based on multiple linear regression analysis consisting of climatic weather parameters as independent variables, production of banana as dependent variable using secondary data from 1991-2021 (31 years) of Thiruvananthapuram district. For primary data, two blocks selected based on the highest area and production of banana crop and it has been collected from respondent farmers. The farmers perception on the climate change were collected to identify and to analyse the adaptation strategies practised by the banana farmers. Socio- economic variables influencing the adaptation strategies to suit climate change was determined by binary logistic regression analysis.

LIMITATION OF STUDY

Data regarding climatic parameters were collected from the NASA (National Aeronautics and Space Administration) power access. There is constraint to access accurate data and also time bound master's research programme work. The study is restricted to Thiruvananthapuram district and results cannot be generalized for the entire Kerala state. Primary data has been collected from 100 farmers based on "recall memory method". Therefore, the possibility of some errors can't be ruled out, although care has been taken while collecting data.

PRESENTATION OF THE THESIS

The thesis is divided into five chapters. The present chapter gives the introduction of the research problem, covers the scope, objectives and limitations of the study. The second chapter deals with review of literature, relevant to the study. The third chapter details the study area, the methodological frame work, analytical tools and conceptual issues. The fourth chapter narrates the results obtained and also discusses the results in detail. The fifth and final chapter presents the summary and policy prescriptions based on the study. The references and abstract of the thesis are given at the end.

FUTURE LINE OF WORK

This study focused only on banana crop. Similar studies need to be taken in other agricultural and horticultural crops as well as in other district to bring out the complete picture of impact of climate change on food security. Availability of recent data and inclusion of more relevant variables, impact of climate change can be studied better. As the study is conducted in Kerala region, an attempt can be made in future to conduct similar type of study in the other locations in India. Along with adaptation, the mitigation strategies can also be considered in the future.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

A critical review of the past work is important to have a complete understanding of the topic of research. The review of the previously published works on impact of climate change and adaptation strategies on agriculture was collected and presented under the following headings.

2.1. Studies on climate change and climate extreme events

2.2. Studies on impact of climate change on agriculture

2.3. Studies on adaptation strategies to climate change

2.4. Studies on binary logistic regression

2.1. STUDIES ON CLIMATE CHANGE AND CLIMATE EXTREME EVENTS

The phrases "climate change," "global environmental change," and "global change" are frequently used synonymously to describe the phenomena of sudden changes in the dynamics of the earth system that have been happening at an increasing rate during the past two or more centuries. Inevitable and urgent, climate change has long-term effects on the sustainable growth of all countries. It is well known as a significant environmental issue that affects both natural and human systems on a worldwide scale.

Climate change is an adjustment in the climate's condition that may be detected by variations in the mean or variability of its attributes and that lasts for a long time, usually decades or longer. On longer time scales, an extreme climate event occurs. It can be the result of the aggregation of multiple (severe or non-extreme) meteorological occurrences, such as the season-long drought caused by an accumulation of rainfall days that were somewhat below average (IPCC, 2012).

2.1.1. Categories of Weather and Climate Events

1) Extremes of atmospheric weather and climate variables (temperature, precipitation, wind).

2) Occurrence of extremes in weather or climate variables or are extremes themselves (monsoons, El Nino and other modes of variability, tropical and extra tropical cyclones).

3) Impacts on the natural physical environment (droughts, floods, extreme sea level, waves, and coastal impacts, as well as other physical impacts, including landslides, and sand and dust storms (IPCC, 2012).

The earth's tilt, ocean currents, volcanoes, and continental drift are examples of natural causes of climate extremes. Anthropogenic factors include global CO_2 concentration, ocean acidification, and global mean surface temperature. Reduce susceptibility and exposure while increasing resilience to changing climate. It is a requirement for lowering climate-related hazards through sustainable development to become carbon neutral by 2030 (IPCC, 2012).

In Maharashtra, India, Adhav *et al*. (2021) investigated the socioeconomic vulnerability index to climate change. Using the principle component method, districts were classified as being very, moderately, or less sensitive to climate change depending on the size of the index (PCA). Sangali has the highest socioeconomic vulnerability index exposure (0.62), while Wardha has the lowest (0.38). Maharashtra's core region and water-scarce zone have received significant attention. Crop output is impacted by the lack of precipitation during the growing season.

In accordance with the greenhouse gas concentration pathway scenario, the World Meteorological Organization (WMO) reported that the global mean surface temperature (GMST) rise is anticipated to climb by 2–5 °C by the year 2100. Large and destructive wildfires are fueled by heat waves and heat extremes that are occurring more frequently and intensely around the world due to the warming of the land and surface air temperatures. High temperatures cause the permafrost to thaw as the Arctic rapidly warms. Increased evaporation and transpiration as a result of a warming sea surface change the patterns of precipitation and stream flow, produce more clouds, and increase evaporation. Shifts in rainfall patterns and agricultural seasons will occur as a result of global and regional changes brought on by rising temperatures. There are also more droughts and floods as a result of El Nino episodes (WMO, 2021).

2.2. STUDIES ON IMPACT OF CLIMATE CHANGE ON AGRICULTURE

Agriculture and climate change are internally correlated with each other in various aspects, as climate change is the main cause of biotic and abiotic stresses, which have adverse effects on the agriculture of a region.

The IPCC issued a warning in August 2021 that the observed rise in the global surface temperature during the years 1850 to 2020 showed unprecedented warming. By 2100, the difference between the expected emissions reduction and the actual demand might cause a 2.7 ^{o}C increase in temperature. India reported a 24 per cent success rate on this criterion in 2020 and has pledged to cut emissions intensity of its growth by 33–55 per cent of GDP by 2030 (Ananthakrishnan, 2021).

Susha (2011) investigated the effects of climate change and measures for adaptation in paddy production in the Keralan districts of Alappuzha (Kuttanad) and Thrissur (Kole) in 2010. In the Kuttanad region, the Ricardian Method of analysis revealed that the maximum temperature and rainfall during the first two months of the crop's growth phase had a large positive impact on farm income; however, these variables during the second phase led to a reduction in income. In contrast, the temperature during the second phase of crop growth was found to have a beneficial and considerable impact on Kole lands, albeit indirectly.

Devendra (2012) researched the effects of climate change on Asian agriculture and found that prices will rise; during the next ten years, they will be 15–40 per cent higher in real terms relative to 1997–2006. The price increases are in an upward trend and are a function of increasing demand, inadequate supplies, shortages, and bad weather around the world with climatic changes and events that have been more severe and frequent than have been in the past.

Ravi and Mustaffa (2013) examined impact, adaptation, and mitigation options. For climate-resilient banana production, the cucumber mosaic virus illness and the severe leaf spot disease were identified in Jalgaon, a traditional banana-growing region in Maharashtra state, India. Climate change may be responsible for the development of these new diseases. The negative effects of climate change will be mitigated through adaptation measures such as change in farming practices like change varieties, altering planting and harvest dates and cropping patterns, crop rotation and the adoption of technology like rainwater harvesting, modernising irrigation infrastructure.

Using the DSSAT 4.5 model, Safia (2015) assessed how anticipated climate change scenarios will affect tomato growth and yield (RCP 2.6, 4.5, 6.0, and 8.5). The findings also revealed that the minimum temperature will have a significant adverse effect on the yield. Although the impact of increasing atmospheric CO_2 is likely to have some positive effects on yield, they are likely to be small in comparison to the detrimental effects of rising temperatures. Tomato (Anagha) yield will be significantly reduced as a result of climate change.

Salau *et al*. (2016) used data collected between 1998 and 2012 from Ondo State, Nigeria, to investigate the consequences of changes in significant climate variables such as temperature, rainfall, and relative humidity on the production of an important crop commodity called banana. The results suggested that excessive rainfall and hot temperatures can decrease banana productivity, while low rainfall and low temperatures combined with low humidity also result in low banana yield.

George (2017) reported the effects of climate change on Kerala's high range landscapes, particularly Wayanad, and their agroforestry systems. The district's monsoon rainfall was found to be declining over time, but temperatures rose at the same time, according to variables. During 1991-2015, the area of crops such as arecanut, coconut, rubber and banana increased considerably whereas the area of rice, ginger and pepper has declined due to rainfall variability. Climate has played a major role in shifting productivity of crops and cropping patterns of a region. Using Principle Component Analysis (PCA), about 15 per cent change in the overall shift of agricultural practices driven by climate change.

The economic effects of climate change on crop growing in Bangladesh were explored by Hossain *et al*. (2018). The findings showed that Bangladesh's net crop income is highly dependent on the weather, particularly seasonal temperatures. For the farms located in locations with adequate irrigation facilities, a favourable impact of the temperature rise on net crop income was noted. According to estimates, Bangladesh's net crop income per hectare will increase by around US $4 to US $15 for every 1 mm/month increase in rainfall and 10°C increase in temperature.

According to time series data from 1981 to 2017, Chandrarekha (2019) observed a pattern of climatic change. Climate factors like maximum temperature, minimum temperature, and rainfall in Uttar Pardesh, Maharashtra, and Tamil Nadu, were used to explain the sugarcane yields of 11 per cent, 1.9 per cent, and 12 per cent, respectively. The results showed that there was no significant relationship between climatic factors and rainfall in Tamil Nadu and Uttar Pradesh, but that there was a positive significant relationship in Maharashtra.

Kumar and Kaur (2019) used daily meteorological data of temperature and rainfall by district from 1986 to 2015 to study seasonal patterns in climate variables and their impact on rice and wheat yields in Punjab. Both the rice and wheat growing seasons show a notable increase in the average temperature. Over the past 30 years, there has been a seven per cent yearly decline in rainfall during the rice-growing season. By 2080, there will be a significant reduction in wheat yield (6.51 %) and rice yield (8.10 %).

The effects of climate change on Sicily, a tiny Mediterranean region in southern Europe, were investigated by Migliore *et al*. (2019). The Ricardian analysis method makes use of a production function as the underpinning and calculates effects by modifying a few input factors, such as temperature and precipitation. Contrary to the sharp decline in profitability of grapevine and citrus trees, the estimated average net revenue of olive trees is nearly the same as in the reference period. Crops responded to weather fluctuations in diverse ways from 1961 to 1990.

In 2019, Varma and Bebber evaluated how climate change may affect banana yields globally. A changing climate since 1961 has raised annual yields for 27 nations, which produce 86 per cent of the world's dessert bananas, by an average of 1.37 t ha^{-1}. Under the climate scenarios, however, worldwide yield gains could be muted or eliminated, falling to 0.59 t ha^{-1} and 0.19 t ha^{-1} by 2050, respectively, due to decreased yields in the top producers and exporters.

Benny (2020) investigated the financial effects of harsh weather on cardamom production in Kerala's Idukki district. Numerous people died as a result of major landslides and erosion brought on by 2018's abundant rain, as well as significant damage to homes and farmland. Cardamom yields were projected to be 901.21 kg ha^{-1} and 889.57 kg ha^{-1}, respectively, but there was a significant loss of 404.25 kg ha^{-1} in Santhanpara gramapanchayat and 349.61 kg ha^{-1} in Senapathy gramapanchayat. It was discovered that farmers lost 42.09 per cent of the anticipated production owing to inclement weather, and the harvested yield of cardamom was only 518.49 kg ha^{-1}.

Esfandiari *et al*. (2020) conducted research among 360 rice farmers in the basins of the Kamfiruz district, reported that the most significant negative effects of climate change on rice production are the fall in rice yield, the rise in irrigation costs, and the reduction in planting area.

Significant effects on crop output, biodiversity, water availability, and food security are caused by climate change and climate variability. Changes in rainfall patterns are more important to agriculture than differences in yearly temperature changes, particularly in regions where a lack of rainfall is a warning sign for crop yield (Nihal, 2020).

The economic effects of climate change on 16 important US fisheries were analysed by Moore *et al.* (2021). Based on the anticipated changes in thermally accessible habitat, the analysis uses a two-stage inverse demand model to assess the impacts on consumer welfare of expected increases or decreases in commercial landings for 16 US fisheries from 2021 to 2100. Rising sea temperatures are predicted to have a favourable impact on landings for some species, such as blue crab, white shrimp, California market squid, and summer flounder, while having a detrimental impact for others, such as Dungeness crab, Florida stone crab, yellow fin sole, and chum salmon.

The effect of globalisation-induced shifts in climatic conditions on Vietnamese agriculture was explored by Nguyen *et al*. (2022). The 10-year panel of household data primarily focuses on the production of 20 crops across seven areas in Vietnam and was subjected to the two-step Hsiao approach. The Ricardian model's panel data point to diverse climate influences across seasons and geographies. The majority of areas experience losses as a result of rising seasonal temperatures, with springtime temperatures being the exception. The consequences of rising temperatures can be lessened by increasing summer precipitation.

Based on panel data (1979 - 2011) from China's primary rice-producing regions, Wang *et al*. (2018) observed the impact of climate change on the country's rice production. Panel data analysis revealed that the four main climate factors affecting rice output in China were lowest temperature (T min.), maximum temperature (T max.), temperature differential (TD), and precipitation (RP). Climate change has actually contributed negatively to the rise in China's rice output as the real lowest temperatures and precipitation in the country's primary rice-growing regions decreased while the maximum temperatures and temperature difference increased over the sample period.

Shimada (2022) examined the effects of climate-related natural disasters in Africa, including droughts, floods, storms, and rainstorms. Panel data regression model analysis from 1961 to 2011 was used in the research. The findings indicated that natural disasters brought on by climate change had an adverse impact on Africa's agricultural production, poverty, and armed conflicts.

In order to determine how climate change may affect rice and wheat yields, Kumar and Kaur (2019) built a panel data set with 150 observations spanning 30 years and five districts. The effects of time-invariant variables (soil qualities, elevation) and farmers' autonomous responses (changes in variety planting dates, input use) in response to yearly variations in weather variables were documented by the panel data approach.

The U.S. Drought Monitor (USDM) reported the effects of drought on agricultural yields and farm revenue in the United States between 2001 and 2013 in Kuwayama *et al*. (2019). According to the findings, drought has a negative, statistically significant impact on crop yields, causing decreases in corn and soybean production of 0.1 to 1.2 per cent in dry land counties and 0.1 to 0.5 per cent in irrigated counties. Using panel data models with fixed effects, an empirical method was used to take advantage of the geographical and temporal volatility in drought conditions and agricultural outcomes at the county level.

2.3. STUDIES ON ADAPTATION STRATEGIES TO CLIMATE CHANGE

Intercropping should be used as an alternate farming method rather than relying just on coffee, according to Joy's (2004) suggestion that diversification of agriculture is one of the ways Wayanad coffee growers can increase their profits. The coffee growers will receive more cash as a result. Vanilla, medicinal plants, and other intercrops could be grown in coffee gardens to generate additional revenue.

Dhaka *et al*. (2010) analysed farmers' perception and adaptation strategies to climate change in Bundi district of Rajasthan. Analyzing adaptations made by all respondents revealed that an integrated farming system was considered to be one of the most important adaptations in response to climatic vagaries. To cope with climate variability, farmers have developed a wide range of management practices such as pre-monsoon dry seeding, stubble mulching, crop rotations and intercropping. Some of the respondent farmers adopted zero tillage technology of wheat showing in rice - wheat cropping system to same time and to make best use of residual moisture of rice field.

Ranjitkar *et al.* (2016) conducted research on suitability analysis and projected climate change impact on Banana and Coffee production zones in Nepal. The Government of Nepal has identified opportunities in agricultural commercialization, responding to a growing internal demand and expansion of export markets to reduce the immense trade deficit. The multi-model suggested that climate change will reduce the suitable growing area for coffee by about 72 per cent across the selected emission scenarios up to 2050. Impacts are low for banana growing, with a reduction in suitability by about 16 per cent by 2050.

The impact of climate change on the economics of major cereal production in the Bihar district of Samastipur was disclosed by Ranjeet (2020). Farmers are positively and significantly impacted by their farming experience and availability of knowledge about climate change. The decision to use adaptation measures is positively and strongly correlated with other factors like education, farm size, and ownership of implements and machinery. In order to prevent the negative effects of climate change on cereal crops, notably maize and wheat, the majority of the farmers proposed soil and water conservation methods. These activities include land levelling, changing the crop calendar, crop diversification, reduced tillage, etc.

Sonone (2016) studied impact of climate change on yield of sorghum and paddy crop for year 2001-2015 in Akola, Washim, Gondhia, Bhandara districts. He suggested that use of new crop varieties of sorghum and paddy crop with heat and drought tolerance, need to increase more irrigation facilities, crop rotation to increase food production.

Amogh (2017) conducted his study on economic impact of climate change and adaptation strategies in Black pepper cultivation in Kerala. Secondary data regarding area production, productivity and climatic variables were collected for Idukki and Wayanad districts from 1987-2016. Adaptation measures to conserve water such as rain water harvesting system, mulching, spraying 1 per cent lime solution, moisture conservation tillage and growing drought tolerant varieties (Paniyur-5, Paniyur-6 and Paniyur-7) helps to reduce the risk of drought.

Rattan (2017) analysed climate change impacting on agrarian economy in Western Himalayas. He observed that impact of changes in climatic conditions on cropping patterns, livestock composition, crop-livestock productivity, insect-pest and diseases, the affordability of cost of adaptation, returns and livelihood of the farmers in the selected district; documented and validated the adaptation measures for the affected district and screening of the available crop-livestock concerning technologies. The awareness with respect to symptoms of climate change was reported by 49 per cent of the farmers. As many as 47 per cent of farmers could explain about the impact and causes of climate change and 37 per cent of the farmers could reveal about the climate change adaptation strategies. The policy recommends promotion of high yielding cultivars especially in maize crop, availability of increased area under food grains, optimum livestock and proper strategies for crop diversification planning in the study area.

Elum *et al*. (2018) examined the effects of climate variability and insurance adoption on the net returns of crops across selected provinces of South Africa. It was inferred from the study that farmers with insurance coverage had higher net revenue. In addition, rainfall positively affects net revenue until it peaks (excessive rainfall) and then assumes a diminishing effect. It was further revealed that the adoption of insurance is significantly influenced by rainfall, length of farming experience and level of irrigated farming. It was implied from the study that people would more likely buy insurance with increasing occurrence of flooding caused by excessive rainfall. However, farmers may choose not to participate in the insurance market due to various factors such as cost constraint or trusting in their knowledge of agronomic practices for climate adaption.

Adaptation is a key part of Kerala State Action Plan on Climate Change and it is about taking action now to protect State from the challenges caused by a changing climate. Addressed negative consequences of climate change and thus reduce risk associated with it. It also envisaged that climate change strategies need to be integrated into the development planning process in the State (GOK, 2020).

Dupdal *et al.* (2022) carried out a study in Vijayapura and Bagalkot districts of Karnataka to assess the adoption of improved technologies by dryland farmers to mitigate effects of climate change. The unpredictable variation in climate especially rainfall and temperature, frequent crop failures, sinking water level in bore wells and open wells and increased emergence of pest and diseases resulted in decreased crop yields. The farmers in the region sustained crop yields by adopting climate resilience indigenous and modern scientific technologies like manipulating sowing dates, mixed farming, crop diversification, alternate cropping systems and drought tolerant varieties.

Gbemavo *et al.* (2022) evaluated rice farmers' perceptions on the manifestations of the climate change and identify efficient strategies and determinants of adoption of these strategies in the Republic of Benin. The disruption of agricultural calendar and the reduction in rice yield were perceived as the main impacts of climate change in rice production. The practice of adaptation strategies was influenced positively by the household size, land size, education level, use of improved varieties and the location in climatic zones, training in rice production and negatively by membership to rice farmers association, access to extension services.

2.4. STUDIES ON BINARY LOGIT REGRESSION

Binary logistic regression is a type of regression analysis that is used to estimate the relationship between a dichotomous dependent variable and dichotomous-, interval-, and ratio-level independent variables. This method was chosen because it is a standard method of analysis when the outcome variable is binary or dichotomous to predict categorical variables such as yes/ no, pass/ fail. Dichotomous or dummy variables are usually coded 1, indicating "success" or "yes," and 0, indicating "failure" or "no."

Huong *et al.* (2017) studied farmers' perception, awareness and adaptation to climate change evidence from northwest Vietnam. The most frequent adaptation to climate change was changing crop varieties, while water management was one of the less popular primary adaptation strategies. These findings show that household-level adaptation strategies typically do not incorporate advanced management technology but rather are restricted to straightforward, low-cost strategies like switching crops or crop varieties and finding additional income from non-farm activities. Only a small percentage of farmers have adopted advanced adaptation strategies, such as altering crop varieties, varying crop rotations, and deploying effective water management technology.

Maya *et al.* (2019) analyzed determinants of Aman rice farmers' choice of adaptation strategies to climate change and weather in Khulna district, Bangladesh during 1948 to 2013. A binary logistic regression model determined the factors that have a significant influence on the adaptation practices of rice farmers. The response variable takes a value of 1 if farmers adopt a specific adaptation in response to the negative effects of climate change and 0 they did not practice any adaptation measures. Family size, annual income, farmer-to-farmer extension and access to subsidies have a positive and significant impact on rice farmers’ adaptation strategies to climate and weather change effects.

Ojo *et al*. (2019) revealed in their study on effect of Cassava production on rural household food security status in Kwara State, Nigeria. Cassava output, age, marital status, family size, farm size, access to finance, farm revenue, and off-farm income were all significant at varying levels of probability in influencing food insecurity, according to the results of the logistic regression in terms of the p-values. The odd ratio result, however, showed that the households' level of food security was not improved by cassava production or revenue from farms or other sources. On the other hand, higher farm size and financing availability improved the likelihood of food security.

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

This chapter focuses on the methodological framework regarding research and explains about the research design followed to draw inferences. An appropriate design of research methodology is very important for a systematic analysis of the research problem and to arrive at meaningful conclusions. The basic terms and concepts involved in the study are also presented in this chapter. Contents of this chapter are presented under following sub headings:

3.1. Description of the study area

3.2. Sources of data

3.3. Variables and their measurement

3.4. Analytical framework

3.1. DESCRIPTION OF THE STUDY AREA

The study was conducted in Thiruvananthapuram district of Kerala as it is the one of the climate change hotspot in Kerala, with a high degree of vulnerability to calamities like heavy rainfall, forest fires and floods (GOK, 2014).

3.1.1. Thiruvananthapuram District

Thiruvananthapuram the Southernmost district of the coastal State of Kerala in South India came into existence on 1st November 1956. Being capital of Kerala often known as "God's own country", Thiruvananthapuram is also called "God's own capital". The district has an area of 2192 sq km which forms 5.64 per cent of the total area of the state consisting of 11 blocks, 4 municipalities and one corporation. The district is part of South Kerala coast and is divided into three sub micro regions. Geographically district can be divided as highland, midland and lowland regions. Thiruvananthapuram lies within North Latitude 8^0 17' and 8^0 51' and East Longitude 76^0 41' and 77^0 17'. District has a sea coast which is about 75 km long and also suited for backwater fishing due to the presence of continuous stretch of lakes and backwaters. The forest reserves (1,304 sq km) favourably affect the climate and more rain in the district. The part “Agasthyarkoodam” mountain which is the second highest peak in the Western Ghats lies in the district. The history of the District is intertwined with the history of the princely State of Travancore. with 3 major rivers Neyyar, Vamanapuram River and Karamanayar and also have several fresh water lakes and more than 300 ponds. The Neyyar irrigation project started in 1959 for irrigating an area of 116.65 sq km, Neyyar reservoir is the major source for irrigation project. Mahatma Gandhi referred this city as “Evergreen city of India”. The city is ranked among best cities to live in India (KSLUB, 2013).

3.1.2. Nemom Block

It is surrounded by Thirumala in the north, Thiruvallam in the west, Balarampuram in the south-east and Kovalam in the south. Area under the block was about 134.59 sq km. It lies within 8^{0} 27´ North and 76^{0} 59´ East. The literacy per cent of panchayath was 90.54 per cent. During 2019-20, it had the second largest area and production under banana which was 559.8 ha and 4,313.05 t (GOK, 2021). It is situated 17 km way from Thiruvananthapuram city.

3.1.3. Parassala Block

Parassala block is 54 km away from the southern peninsular tip of India, Cape Comorin (Kanyakumari). It is situated 34 km south of state capital Thiruvananthapuram in Kerala, bordering Tamil Nadu situated at 8^{o} 44´ North and 77^{o} 02´ East. Parassala has heavy rains during June - August due to the south west monsoon. Winter starts from December continues up to February. Annual average rainfall is 3,100 mm and average maximum temperature is 32 ^{o}C. The literacy per cent of panchayat is 82 per cent. The total population of the block was 33,556 according to 2011 census. During 2019-20, it was the first largest area and production under banana which was 656.72 ha and 6,810.11 t (GOK, 2021). Vinod Sahadevan Nair, who won place in the Limca Book of Records and grown

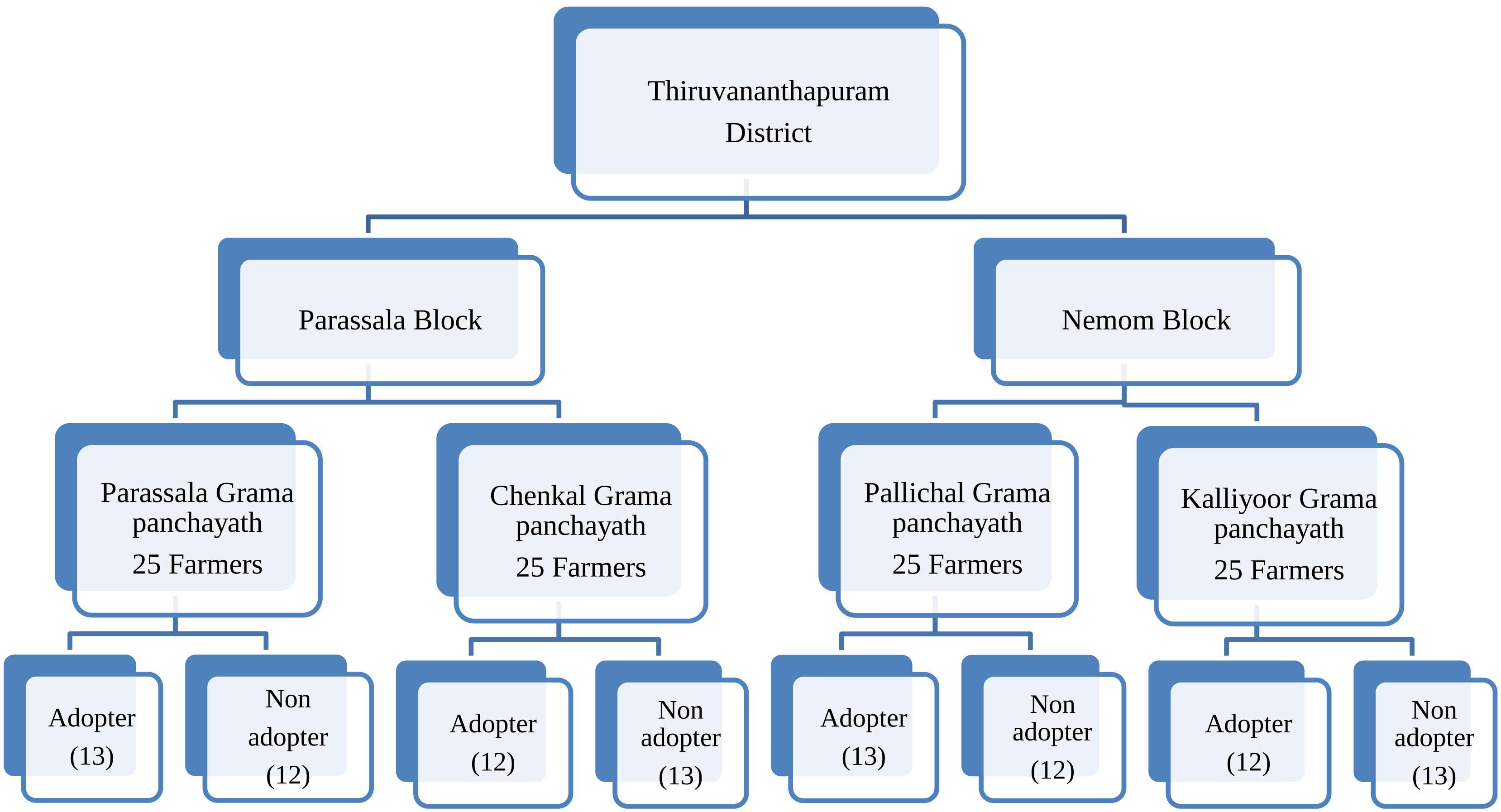

Figure 1: Diagrammatic representation of sampling frame.

400 different kinds of bananas in Parassala and honoured by National Research Centre for Banana (NCRB) (Nagarajan, 2022).

Chenkal is situated 9 km away from Neyyatinkara town. One of the leading banana producing panchayat in Neyyatinkara tehsil. During the last decade, most of reclaimed fallow lands were converted for banana cultivation.

3.2. Sources of Data

The study was based on both primary and secondary data.

3.2.1. Primary Data

Primary data was confined to Thiruvananthapuram district as it was purposively selected for study as vulnerable to climate change. Selection of the blocks and panchayaths for the study was made based on the data obtained from the office of Directorate of Economics and Statistics, Thiruvanathapuram. Two blocks with maximum area under banana cultivation were selected purposively. From each block, two panchayaths having maximum area under banana were selected. Thus, Pallichal panchayath and Kalliyoor panchayath of Nemom block (559.8 ha) and Parassala panchayath and Chenkal panchayath of Parassala block (510.75 ha) were selected for the study. The farmers were categorized into two groups. Group I (adopters) which included farmers who followed adaptation practices to suit the climate change continuously for the past three years and Group II (non adopters) included farmers who did not follow the adaptation practices continuously for the past three years and have casual approach towards adaptation. From each Panchayath 25 farmers belonging to Group I and 25 farmers belonging to Group II were selected. So, total sample size of the respondents was 100.

3.2.2. Secondary Data

From 1991 to 2021, secondary data on monthly averages of temperature, precipitation, relative humidity, and wind speed were gathered from the NASA power data access website (https://power.larc.nasa.gov/data-access-viewer). The Directorate of Economics and Statistics, Vikas Bhavan, Thiruvananthapuram, provided data on area, production, and productivity under banana from 1991 to 2021 for the previous 31 years.

3.3. VARIABLES AND THEIR MEASUREMENT

3.3.1. Cost of sucker

Cost of nendran banana suckers was considered at the purchase market price which was ₹ 11 per sucker.

3.3.2. Cost of Human Labour

It includes cost of hired labour and imputed value of family labour on the basis of wages paid per day work.

3.3.2.1. Cost of Hired Labour

Hired labour charges were calculated on the basis of wages paid per day work. The prevailing wage rate in the area was ₹ 950 for men and ₹ 750 women labourers in banana cultivation. Male labourers are preferred for banana cultivation because of the need of heavier physical strength to do cultivation practices.

3.3.2.2. Cost of Family Labour

The family labours value was imputed on the basis of wages of attached farm labour and number of men used. Women labour was evaluated based on the charges paid to women which was less compared to men.

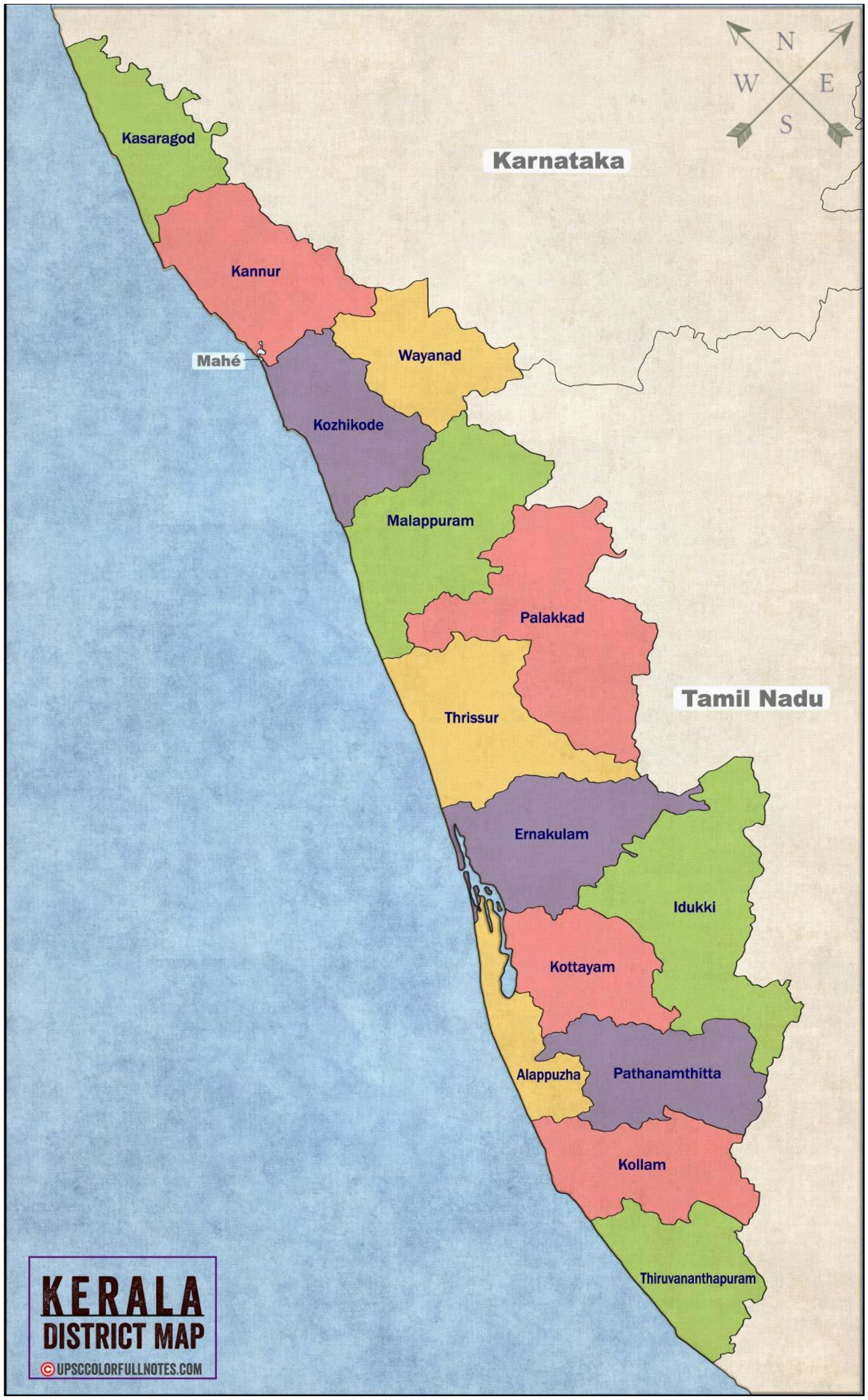

Figure 2. Political map of Kerala state

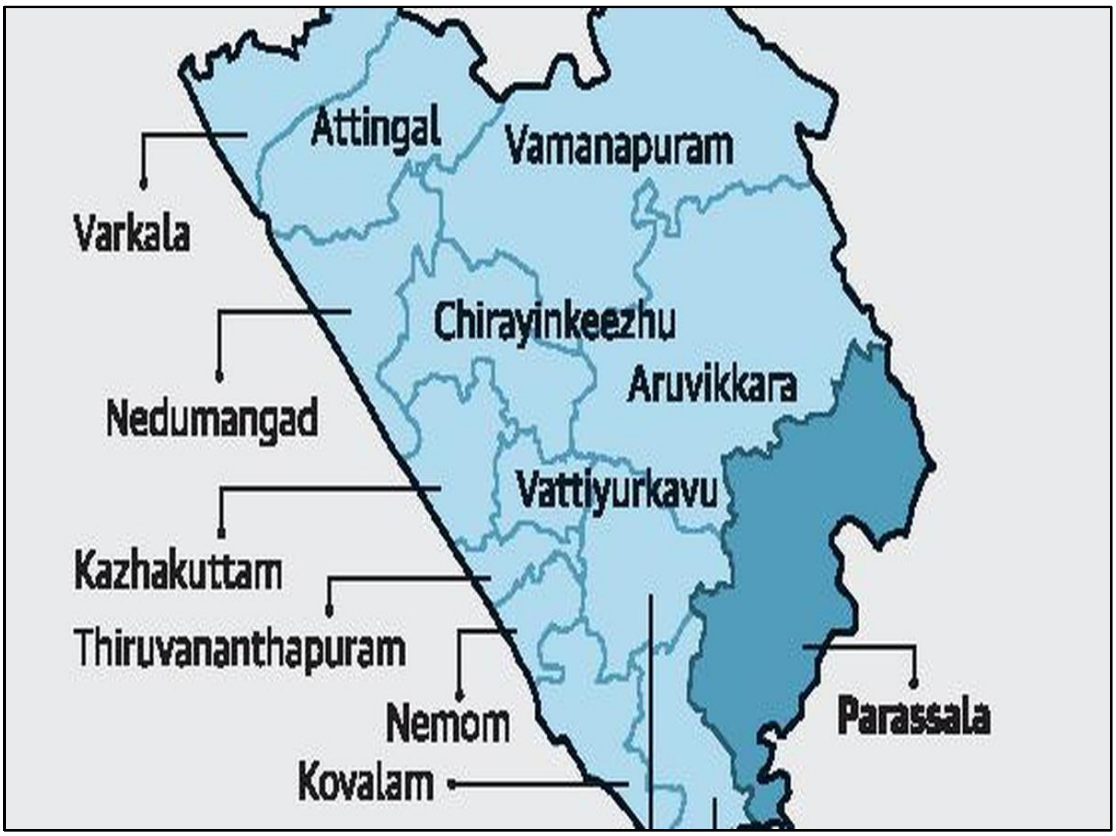

Figure 3. Political map of Thiruvananthapuram district

3.3.2.3. Cost of Machine Labour

Hired machine labour cost was calculated on the basis of the prevailing rent for machine on hour basis, which was 950 hr^{-1}. Depreciation of owned machineries was worked out using straight line method and was accounted in cost of cultivation.

3.3.3. Cost of Manures, Fertilizers and Micro Nutrients

Manures used on the farm were accounted based on the price prevailing in the locality. Manures and other fertilizers purchased from the market were accounted at the purchased price.

3.3.4. Cost of Plant Protection Chemicals

Purchased price of pesticides, insecticides and fungicides was used in accounting cost of these inputs in total cost.

3.3.5. Cost of Adaptation Practices

In order to adapt to the climate change, farmers follow various adaptation practices. Cost of materials required for each adaptation practice were worked out and summed up to get the total cost of each adaptation practice. Premium for crop insurance was the amount paid to the insurance authority to insure the crop. In Kerala state crop insurance, the premium was ₹ 3 per plant and VFPCK charging ₹ 3 per plant. The propping material such as plastic thread, bamboo was used for tying, was evaluated at purchasing rate.

3.3.6. Land Revenue

Land revenue paid was considered at the actual payment made in the study area. It was ₹ 200 per acre per year.

3.3.7. Depreciation

It was used to account for the wear and tear of implements and machinery used. Annual rate of depreciation was worked out for each implement using straight line method and then cumulated to get the total annual depreciation allowance of all implements.

$$\text{Depreciation} = \frac{\text{Purchased value} - \text{Present value}}{\text{Expected Value}}$$

(Reddy *et al*., 2016)

3.3.8. Interest on Working Capital

Working capital forms the part of paid out cost. Interest on this working capital was calculated at the rate of 7 per cent per annum. Because, this was the rate at which farmers obtained crop loans from financial institutions.

3.3.9. Interest on Fixed Capital

Equipment and asset values make up fixed capital. Similar to how interest on working capital is computed, interest on fixed capital was also calculated. Given that commercial banks typically lend long-term loans at a rate of 11 per cent annually, interest on fixed capital (excluding land) was computed at this rate.

3.3.10. Rental Value of Leased in Land

It is the rent paid to the leased in land. The farmers cultivate their crop throughout the year, so rental value of the leased in land was calculated as the rent paid per year.

3.3.11. Rental Value of Owned Land

Rental value of owned land was computed by taking the rent of land prevalent in the study area.

3.3.12. Miscellaneous Cost

The cost involved in replacing damaged, pest infested and disease infected suckers and charge for transportation were included as all miscellaneous charges.

3.4. ANALYTICAL FRAMEWORK

3.4.1. Compound Annual Growth Rate and Coefficient of Variation

To determine the growth trend and variability, CAGR and coefficient of variation were calculated for the factors related to area, production, productivity, and climate. Compound Annual Growth Rate of independent variable is the rate of change per unit time, usually a year. It is expressed in the per cent and gives a general trend in growth of variable over specified time period. It was calculated using following formula:

$Y = ab^t e_t$ (Gujarati, 2004)

Where,

Y= Dependent variable for which area/ production/ productivity of banana/ climatic variables

a= Intercept

b= Co-efficient of independent variables

t= Number of years

e= Error term

taking the logarithm on both the sides it takes the linear form

$\log Y = \log a + t \log b$

The Compound Annual Growth Rate (CAGR) is calculated as:

CAGR(%) = [Antilog (log b) – 1] * 100

The significance of the regression coefficient was tested using the Student's t- test as

$$t = b_i / SE(b_i)$$

Where, b_i = regression co-efficient

SE (b_i) = standard error of regression co-efficient b_i

t = calculated t- value

Coefficient of Variation (CV)

To study the variability in area, production and productivity of banana in Thiruvananthapuram district over thirty one years, coefficient of variation was used.

$$CV = \frac{\text{Standard deviation (SD)}}{\text{Mean}} \times 100$$

$$SD = \sqrt{\frac{\sum_{i=1}^{N}(X_i - \bar{X})^2}{N-1}}$$

Where,

SD = sample standard deviation

N = total number of observations

X_i = the observed value of sample

$\bar{X}$ = mean value of observation (Reddy *et al*., 2016)

3.4.2. Multiple linear regression model

The impact of climate change on banana production was quantified by using multiple linear regression model for Thiruvananthapuram district. Log values of the quarterly data on climatic variables such as temperature, rainfall, relative humidity and wind speed for a period of 31 years from 1991 to 2021 were taken as independent variables. Log value of production of banana from 1991 to 2021 was taken as the dependent variable. In multiple linear regression, there are two or more independent variables to predict the outcome, and the relationship between the dependent variable and model is represented by the following equation:

$$Y_t = \beta_1+\beta_2Q_1T_t +\beta_3Q_2T_t+ \beta_4Q_4T_t + \beta_5Q_1R_t+ \beta_6Q_3R_t + \beta_7Q_4R_t+ \beta_8Q_1RH_t+ \beta_9Q_2RH_t+ \beta_{10}Q_3RH_t + \beta_{11}Q_2WS_t+ \beta_{12}Q_4WS_t+ u_i$$

Y_t = Banana production during t^{th} period.

Q_1T_t = Temperature during January to March during t^{th} period.

Q_2T_t = Temperature during April to June during t^{th} period.

Q_4T_t = Temperature during October to December during t^{th} period.

Q_1R_t = Rainfall during January to March during t^{th} period.

Q_3R_t = Rainfall during July to September during t^{th} period.

Q_4R_t = Rainfall during October to December during t^{th} period.

Q_1RH_t = Relative Humidity during January to March during t^{th} period.

Q_2RH_t = Relative Humidity during April to June during t^{th} period.

Q_3RH_t = Relative Humidity during July to September during t^{th} period.

Q_2WS_t = Wind Speed during April to June during t^{th} period.

Q_4WS_t = Wind Speed during October to December during t^{th} period.

β_1 = The y- intercept

$\beta_2, \beta_3, \beta_4, \beta_5, \ldots \beta_{12}$ = Slope of the independent variables

u_i = Random error or stochastic component

(Koutsoyiannis, 2004)

The term ‘linear’ is used because in multiple linear regression we assume that dependent variable is directly related to a linear combination of the independent variables.

Data consists of thirty one years of observations for Thiruvananthapuram district. Natural logarithm was taken for both dependent and independent variable to avoid too much fluctuation in the results.

Statistical package STATA version SE 14.1 was used to analyse the secondary data. To decide how much is the impact of climate change on the production of banana, multiple linear regression was used. Preferred model is having explanatory variables which are showing significant results and other variables omitted from the model. The averages, percentages and estimates of growth trends were also used in analysis.

The Coefficient of multiple determination (R^2) shows the percentage of the total variation of Y explained by the regression plane, that is, by changes in independent variables. The value of R^2 lies between 0 to 1. The higher R^2 the greater the percentage of the variation of Y explained by the regression plane to the sample observations. The R^2 close to 1, the goodness of fit.

Observed F^* value was compared with the theoretical value of $F_{0.01}$ with υ_1 = K and υ_2 = (n- K) degrees of freedom. If $F^* > F_{0.01}$, then the overall multiple linear regression model is a good fit.

Variance (Variance Inflation Factor) was used to check the multicollinearity in the function. It was calculated using formula:

$VIF = 1/1-R^2$

Where,

VIF = Variance Inflation Factor.

R^2 = Coefficient of multiple determination.

If the VIF value is equal to or more than 10, then the particular independent variable is considered to have high multicollinearity with one of the other independent variables.

Durbin – Watson test was carried out to check the autocorrelation using the formula:

$d = 2 (1 - \rho)$

Where,

d = Durbin – Watson value.

ρ = Correlation coefficient of error term.

If d value is equal to 2 then, the model is said to have no autocorrelation.

3.4.3. Percentages and Averages

The socio economic characteristics of the respondent farmers such as age, education, gender, family size, land holding, area under banana crop, occupation and cropping pattern and cost of cultivation were analyzed using percentages and averages.

3.4.4. Binary logistic regression

Binary logistic regression model analysis is a uni or multi variate technique which estimates the probability that a characteristic is present by predicting a binary dependent outcome from a set of explanatory variables. It is generally used to model binary response data. Consider a non linear regression model where the variance of the response variable is a function of its mean. This was worked out using STATA package SE 14 version.

To know the socio economic variables influencing the adoption of adaptation practices, binary logistic regression was fitted. Model is specified as follow:

$Y = f(X_1, X_2, X_3, X_4, X_5)$

Where,

Y = Takes value 1 for adopters and 0 for non adopters.

X_1 = Area under banana cultivation (ha).

X_2 = Income (₹).

X_3 = Age of respondents (years).

X_4 = Education status of respondents (code given to each education level).

X_5 = Occupation (Code given to agriculture as main and others as subsidiary).

Another alternative to interpret the results of a logistic regression is to use Partial elasticity calculations to illustrate the percentage impact of various factors on the probability of different adaptation measures.

It was calculated using formula:

$$\Pr(Y = 1) = \frac{e^{(\bar{x}_k \beta)}}{1 + e^{(\bar{x}_k \beta)}} \qquad \text{(Gujarati, 2004)}$$

Where,

Y = 1 is for adopter and 0 is for non adopter.

e = 2.71828 (natural logarithm base).

$\bar{X}_k$ = mean of k^{th} independent variable.

β = respective regression coefficient of the independent variable.

The odds of an event are the probability that the event occurs divided by the probability that the event does not occur. The coefficient represents the log-odds ratio. The 'log' part of the log-odds ratio is just the logarithm of the odds ratio, as a logistic regression uses a logarithmic function to solve the regression problem. It is much easier to just use the odds ratio, so we must take the exponential of the log-odds ratio to get the odds ratio.

Odds ratio was calculated using formula:

Odds ratio = $e^{\beta i}$

Where,

e = 2.71828

β_i = regression coefficient of the i^{th} independent variable.

Interpretation of odds ratio: When logistic regression is performed, the exponent of regression coefficient is named as odds ratio associated with a one unit increase in the adaptation.

OR= 1 indicates adaptation does not affect odds of outcome.

OR <1 indicates adaptation associated with lower odds of outcome.

OR >1 indicates adaptation associated with higher odds of outcome.

(Szumilas, 2010)

3.4.5. Cost of Cultivation

The cost of cultivation of a crop is considered three different levels viz. Cost A, Cost B and Cost C which is followed by the Commission on Agricultural Costs and Prices (CACP). It constitutes total of costs incurred by the respondent famer on the various inputs used in the production of particular crop product. In this study, cost of cultivation and returns were analysed by using aforesaid cost concepts for banana crop.

CACP cost concepts

Cost A_1

Actual paid-out costs by owner cultivator, inclusive of both cash and kind expenditure, which includes cost of following items.

1. Hired labour- Human Labour, bullock labour and machine labour
2. Cost of suckers
3. Cost of manures and fertilizers and soil ameliorants
4. Cost of plant protection chemicals
5. Cost of adaptation strategies used
6. Land revenue
7. Depreciation on capital assets
8. Interest on working capital
9. Miscellaneous cost

Cost A_2

It includes sum of the Cost A_1 and rental value of leased in land.

Cost B

It includes Cost A_2, imputed rental value of owned land and imputed interest on owned fixed capital excluding land.

Cost C

It is the total cost of cultivation, which includes all cost items. The value of family labour is to be imputed and added in Cost B to work out Cost C. (CSO, 2008)

3.5.3. Returns

3.5.3.1. Gross returns

Gross returns was worked out as the total value of product at the prevailing market price.

Gross returns = Quantity of product * unit price

3.5.3.2. Net returns

Net returns was derived by deducting the total cost from the gross returns.

Net returns= Gross returns - cost of cultivation

3.5.4 Benefit-Cost Ratio

It was calculated as the ratio of the total benefits to total expenditure incurred for production of Nendran banana.

B:C ratio = Gross returns/cost of cultivation

(Raju and Rao, 2015)

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

Data collected from the respondent farmers during survey are tabulated and analysed to get meaningful conclusions. Results were obtained by considering the objectives of the study and inferences are given in this chapter.

4.1. Socio economic status of respondents

4.2. Status of banana production in Thiruvananthapuram

4.3. Climate change and its impact on banana production

4.4. Adaptation strategies followed by the banana farmers

4.5. Economics of banana cultivation

4.1. SOCIO ECONOMIC STATUS OF RESPONDENTS

From the primary data collected, socio economic status of the farmers was analysed and discussed in detail in the following sub headings. The components of socio economic status of respondents includes age wise distribution of respondents, based on family size, educational status, gender, major occupation, size of holding, type of mixed crops grown, and area under banana.

4.1.1. Age of Respondents

Age wise distribution of farmers is presented in table 1. Out of 100 respondents, 62 were in the age group of 45-60 years, which was 62 per cent of the sample respondents. This shows the involvement of middle adult hood age group in farming. Only seven farmers (7 per cent of total respondents) were above 60 years of age. Out of 100 respondents, there were 6 youth farmers and 25 adulthood farmers which were 6 per cent and 25 per cent of the sample respondents respectively.

Average age of the respondents was 48.69 years. Average age of adopter and non adopter farmers was 49.82 years and 47.56 years, respectively.

Table 1. Distribution of respondents based on age.

Sl. No.	**Particulars**	**Age (years)**				**Total**	**Average age (years)**
		<30	**30-45**	**45-60**	**>60**		
1	Adopters	2 (4)	13 (26)	31 (62)	4 (8)	50 (100)	49.82
2	Non-adopters	4 (8)	12 (24)	31 (62)	3 (6)	50 (100)	47.56
3	Total	6 (6)	25 (25)	62 (62)	7 (7)	100 (100)	48.69

Note: Figures in parentheses indicate percentage to respective totals.

4.1.2. Education status

The education status of the respondent farmers waspresented in table 2. It indicated that 100 per cent of total sample farmers were literates, among which 44 per cent have attained education up to pre degree level. Out of 50 adopter farmers, 6 per cent attained primary education, 48 per cent attained high school, 42 per cent attained pre degree and 4 per cent attained graduation. Among 50 non adopters, 24 per cent attained primary education, 24 per cent attained high school, 46 per cent attained pre degree and 6 per cent attained graduation. The education status of the respondent farmers is presented in table 2.

Table 2. Distribution of respondents based on educational status.

Sl. No.	**Particulars**	**Education**				**Total**
		Primary	**High school**	**Pre degree**	**Graduation**	
1	Adopters	3 (6)	24 (48)	21 (42)	2 (4)	50 (100)
2	Non-adopters	12 (24)	12 (24)	23 (46)	3 (6)	50 (100)
3	Total	15 (15)	36 (36)	44 (44)	5 (5)	100 (100)

Note: Figures in parentheses indicate percentage to respective total.

4.1.3. Family Size

Respondents were categorized into three groups according to their family size as small family (less than four members), medium family (four to six members) and large family (more than six members) and results are shown in table 3. Majority 78 per cent of the farmers belonged to medium size family. In the case of adopters, 82 per cent belonged to medium size family. In the case of non adopter farmers, 74 per cent people came under the medium size family. Sixteen per cent of adopter farmers and 22 per cent of non adopter farmers living in small family with less than four members. Large family size consisted of 2 per cent of adopter farmers and 4 per cent of non adopter farmers.

Table 3. Distribution of respondents based on family size.

Sl. No.	Particulars	Family Size			No. of respondents
		<4	4-6	>6	
1	Adopters	8 (16)	41 (82)	1 (2)	50 (100)
2	Non-adopters	11 (22)	37 (74)	2 (4)	50 (100)
3	Total	19 (19)	78 (78)	3 (3)	100 (100)

Note: Figures in parentheses indicate percentage to respective totals.

4.1.4. Gender

Gender wise distribution of the respondents is presented in table 4. From, the results it is understood that 91 per cent of the sample farmers were male and only nine per cent of the sample farmers were female who have taken up banana farming. Number of male was more in adopters (92 %) of the respondents compared to non adopters (90 %).

Table 4. Distribution of respondents based on gender.

Sl. No.	Particulars	Gender		No. of respondents
		Male	Female	
1	Adopters	46 (92)	4 (8)	50 (100)
2	Non-adopters	45 (90)	5(10)	50 (100)
3	Total	91 (91)	9 (9)	100 (100)

Note: Figures in parentheses indicate percentage to respective total.

4.1.5. Occupational status

Details on main and subsidiary occupation of the respondents were presented in table 5. Agriculture was the primary and main occupation for 84 per cent of sample. Among the respondents who took agriculture as a subsidiary occupation, 9 per cent depended on service sector such as teachers and 7 per cent depended on own business such as shop owners as main occupation.

Table 5. Distribution of respondents based on occupation.

Sl. No.	Particulars	Agriculture as main	Agriculture as subsidiary		No. of respondents
			Service	Own business	
1	Adopters	39 (78)	6 (12)	5 (10)	50 (100)
2	Non-adopters	45 (90)	3 (6)	2 (4)	50 (100)
3	Total	84 (84)	9 (9)	7 (7)	100 (100)

Note: Figures in parentheses indicate percentage to respective total.

4.1.6. Size of land holding

Farmers were categorized into 4 groups based on their size of land holdings and results are presented in table 6. Land holding size was classified as less than 0.2 ha, 0.2 to 0.4 ha, 0.4 to1 ha and more than 1 ha. Only eight per cent of adopter farmers had less than 0.2 ha. The land holding of 30 per cent of adopter farmers and 28 per cent non adopter farmers ranged from 0.2 to 0.4 ha. Fifty per cent adopter farmers and 38 per cent non adopter farmers had 0.4 to1 ha of land holdings. Among the total respondents, 12 per cent of farmers had area more than 1 ha of land holdings. Average land holding of adopter farmers was 0.64 ha and it was 0.97 ha for non adopter farmers. The average size of land holding of farmers was 0.8 ha.

Table 6. Distribution of respondents based on size of land holding.

Sl. No.	Particulars	Land holding category (ha)				Total	Average size of land holding (ha)
		<0.2	0.2-0.4	0.4 -1	>1.00		
1	Adopters	4 (8)	15 (30)	25 (50)	6 (12)	50	0.64
2	Non-adopters	0 (0)	14 (28)	19 (38)	17 (34)	50	0.97
3	Total	4 (4)	29 (29)	44 (44)	23 (23)	100	0.8
4	Average size of holding (ha)	0.15	0.33	0.77	1.50	0.80	

Note: Figures in parentheses indicate percentage to respective total.

4.1.7. Types of mixed crops grown with banana as main crop

Types of mixed crops grown with banana as main crop by respondents was analyzed and is presented in table 7. Crop diversification was the method practised by farmers to cope up with the climate change and to reduce the level of burden. First highest position was occupied by cucumber for adopter (80 %) and non adopter (28 %) farmers. Second position was occupied by cowpea for adopters (74 %) and non adopters (42 %). In the study area, most of the people were cultivating cowpea as an intercrop at an early stage of banana cultivation, due to sufficient availability of sunlight. Crop period of cowpea was on an average 60-70 days. After the harvest plant residues were used as green manure as well as mulch. Third position was occupied by amaranthus in the study area. Most of the farmers cultivated tuber crops like arrowroot, vegetables such as yard long bean, amaranthus, okra, bitter gourd and snake gourd, etc. as intercrops, three months after planting. Adopter farmers have given more stress to crop diversification than non adopter farmers, they were practicing crop diversification as adaptation strategy.

Table 7. Distribution of respondents based on types of crops grown with banana as main crop.

Sl. No.	Crop	No. of adopters	No. of non adopters
1	Amaranthus	22 (44)	10 (20)
2	Snake gourd	8 (16)	11 (22)
3	Cowpea	37 (74)	21(42)
4	Okra	10 (20)	9 (18)
5	Cucumber	40 (80)	14 (28)
6	Bitter gourd	2 (4)	5 (10)
7	Tapioca	21 (42)	7 (14)
8	Turmeric	7 (14)	5 (10)
9	Arrowroot	22 (44)	3 (6)

Note: Figures in parentheses indicate percentage to total farmers under respective category.

4.1.8. Operational area under Banana

Area under banana cultivated by selected respondents is shown in table 8. At the aggregate level about 38 per cent of respondents had 0.2 to 0.4 ha of area under banana. In case of adopters, 44 per cent of respondents came in this category and it was 32 per cent for non adopters. Out of the total 100 respondents, 38 per cent had 0.4 to 1 ha of area under banana which consist of 28 per cent of adopters and 48 per cent of non adopters. Average operational area under banana for total respondents was 0.55 ha, and it was 0.51 ha and 0.59 ha for adopters and non adopters, respectively. Average banana area under the classes of less than 0.2 ha and more than 1 ha were 0.14 ha and 1.4 ha, respectively.

Table 8. Distribution of respondents based on operational area under banana.

Sl. No.	Particulars	Operational area under banana crop (ha)					Average operational area (ha)
		<0.2	0.2-0.4	0.4-1	>1	Total	
1	Adopters	9 (18)	22 (44)	14 (28)	5 (10)	50 (100)	0.51
2	Non-adopters	9 (18)	16 (32)	24 (48)	5 (10)	50 (100)	0.59
3	Total	18 (18)	38 (38)	38 (38)	10 (10)	100 (100)	0.55
4	Average operational area (ha)	0.14	0.3	0.68	1.4	-	-

Note: Figures in parentheses indicate percentage to respective total.

4. 2. STATUS OF BANANA PRODUCTION IN THIRUVANANTHAPURAM

The status of banana production in Thiruvananthapuram district can be understood by analyzing the area, production and productivity under banana using data for the period 1991-2021 (31 years). The CAGR and Coefficient of Variation (CV) were calculated to understand the rate of growth and variability over the period of time and is given in table 9. Positive growth in area (5.35 % p. a.) and production (2.86 % p. a.) were observed in spite of negative trend in productivity (-2.36 % p. a.). It is graphically represented in figure 4. The productivity was found to be declining over years. This can be attributed to the decrease in efficiency of production due to insufficient input usage and lack of scientific management practices. The data on area, production, and productivity under banana from 1991 to 2021 (31 years) were collected from the Directorate of Economics and Statistics, Vikas Bhavan, Thiruvananthapuram.

Table 9. CAGR and Coefficient of Variation (CV) of area, production and productivity of banana in Thiruvananthapuram (1991-2021).

Sl. No.	**Particulars**	**Area (ha)**	**Production (t)**	**Productivity (kg ha^{-1})**
1	CAGR (% p. a.)	5.35*** (10.19)	2.86*** (7.04)	-2.36*** (-5.41)
2	Standard Deviation	878.93	5488.64	3000.92
3	Mean	2059.12	16827.10	9174.26
4	Coefficent of Variation (CV) (%)	42.68	32.62	32.71

Note: Figures in parentheses indicate t-value.

*** significant at 1 per cent level

The CAGRs for area, production, and productivity of bananas in Kolhapur district were estimated to be 7.72, 6.08, and -1.29 percent per annum, respectively, for the period from 2003-04 to 2012-13. It was reported in a study by Bondar *et al*., (2015) while studying the economics of banana production in Kolhapur district of Maharashtra.

Coefficient of Variation (CV) was high in area as compared to that in production and productivity of banana in Thiruvananthapuram and Coefficient of Variation (CV) for area, production and productivity were 42.68, 32.62 and 32.71 per cent, respectively (Plate 1).

Plate 1: Banana cultivation in Thiruvananthapuram district

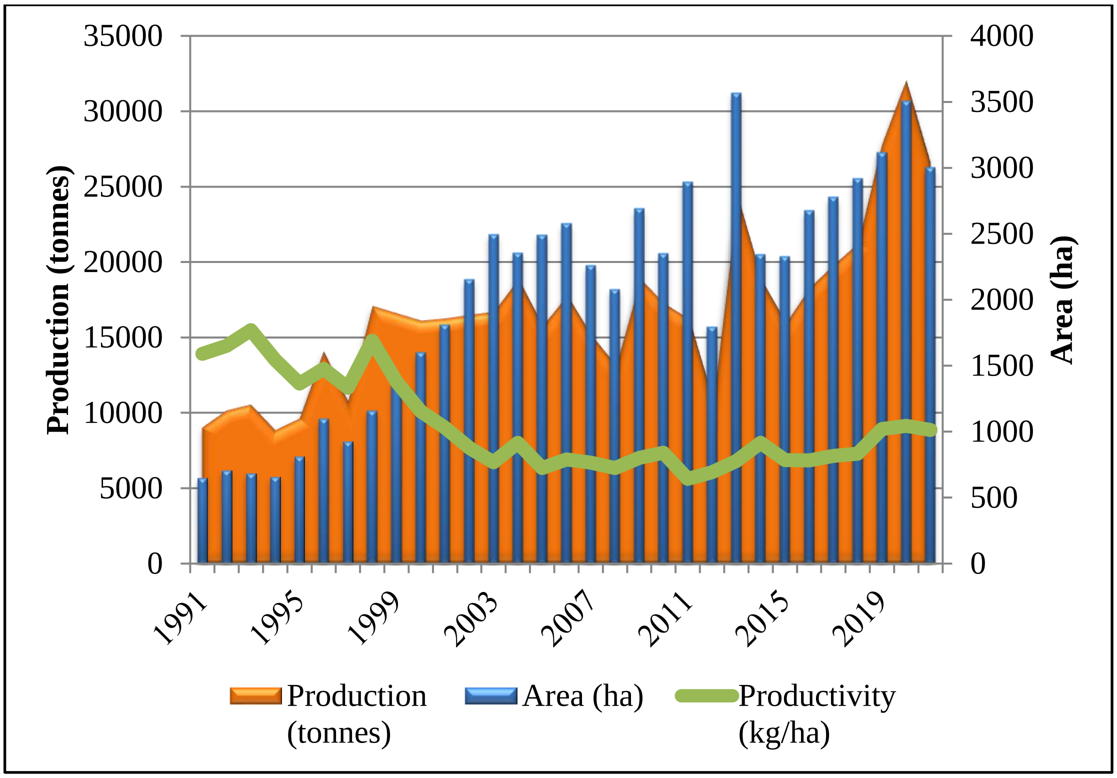

Figure 4. Trend in area, production and productivity of banana in Thiruvananthapuram district (1991-2021)

4.3. CLIMATE CHANGE AND ITS IMPACT ON BANANA PRODUCTION

4.3.1. Climate Change

The data on major climatic variables such as maximum temperature, minimum temperature, rainfall, relative humidity, wind speed were analysed using mean, Coefficient of Variation (CV) and CAGR and results are given in table 10. From 1991 to 2021 (31 years), secondary data on monthly averages of temperature, precipitation, relative humidity, and wind speed were gathered from the NASA (National Aeronautics and Space Administration) power data access website (https://power.larc.nasa.gov/data-access-viewer). By entering the latitude and longitude of the area, the weather data was downloaded.

Table 10. CAGR and Coefficient of Variation (CV) of weather parameters in Thiruvananthapuram (1991-2021)

Sl. No.	Particulars	Mean	Coefficient of Variation (%)	Compound Annual Growth Rate (% p. a.)
1	Minimum Temperature (^{o}C)	19.73	3.24	0.13** (2.15)
2	Maximum temperature (^{o}C)	36.65	1.96	0.02 (0.60)
3	Rainfall (mm)	1748.07	19.52	0.04 (0.08)
4	Relative Humidity (%)	80.09	1.64	0.03 (0.98)
5	Wind Speed (m/s)	4.15	4.47	-0.24 ***(-2.92)

Note: Figures in parentheses indicate t-value.

** Significant at 5 per cent level

*** Significant at 1 per cent level

In Thiruvananthapuram district, average maximum temperature, average minimum temperature, average rainfall, average relative humidity and average wind speed were

35.65 °C, 19.73 °C, 1748.07 mm, 80.09 per cent and 4.15 m/s respectively. Among all the weather parameters, Coefficient of Variation (CV) was the highest for rainfall i.e., 19.52 per cent. All weather parameters have positive growth rate except wind speed (-0.24 % p. a. significant at 1 % level of significance). Positive trend of minimum temperature was 0.13 per cent per annum significant at 5 per cent level of significance. It is graphically represented in figures 5, 6 and 7.

4.3.2. Impact of climate change on banana production

The impact of climate change on banana production was quantified by using multiple linear regression model for Thiruvananthapuram district. Log values of the quarterly data on climatic variables such as temperature, rainfall, relative humidity and wind speed for a period of 31 years from 1991 to 2021 were taken as independent variables. Log value of production of banana from 1991 to 2021 was taken as the dependent variable. Multiple linear regression was used with production as a function of climatic variables and estimates are represented in table 11.

Table 11 shows that Q_4 (October to December) temperature was positively significant at 1 per cent level of significance. This means that increased temperature during this period resulted in increased production of banana in the district. Also Q_4 (October to December) rainfall was positively significant at 5 per cent level of significance. This means that increase in rainfall during this period resulted in increased production of banana in the district. This means that one per cent increase in temperature during Q_4 will increase the production by 13.9 per cent and one per cent increase in rainfall during Q_4 will increase the production of banana by 0.42 per cent due to optimum temperature and rainfall. Q_4 is the important growth stage in banana. For those who planted in Q_2 (April- June), Q_4 coincided with flowering, pollination and fruit formation. It was also reported that optimum temperature for balanced growth and development of banana is around 27 ^{o}C (Robinson and Sauco, 2010) which coincides with 27.69 ^{o}C, the average temperature in this district.

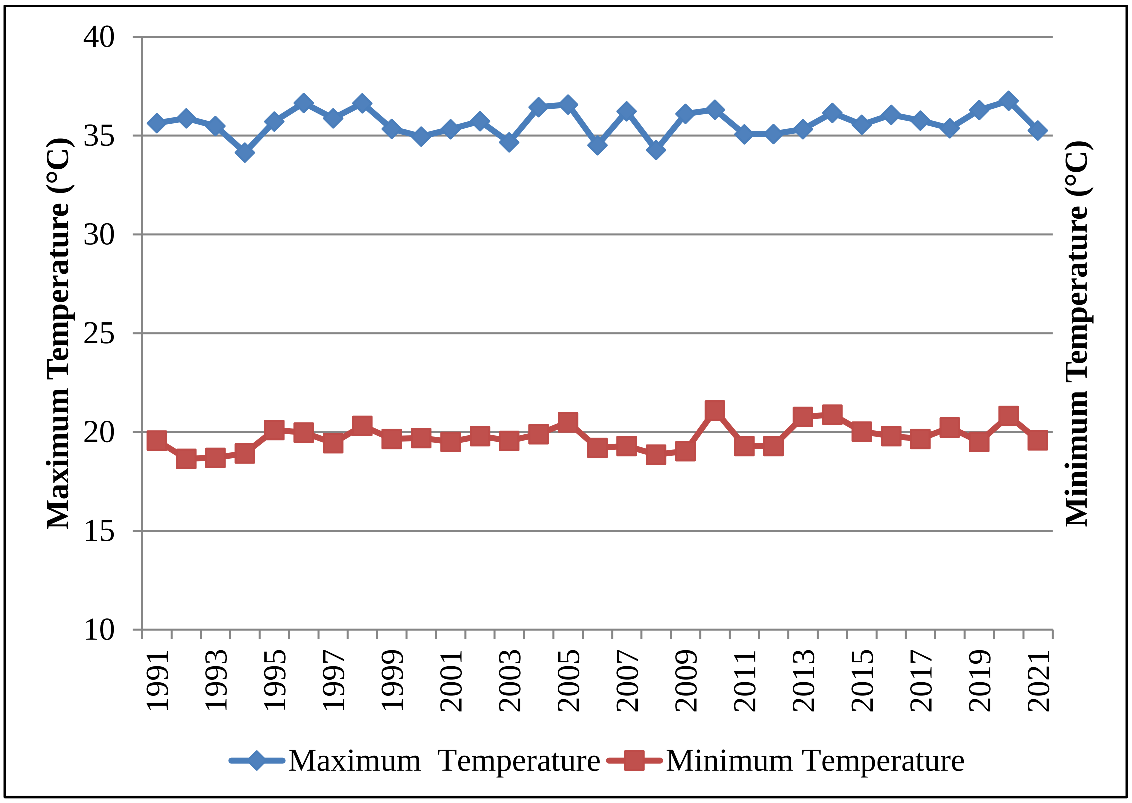

Figure 5. Trend in maximum and minimum temperature in Thiruvananthapuram (1991-2021)

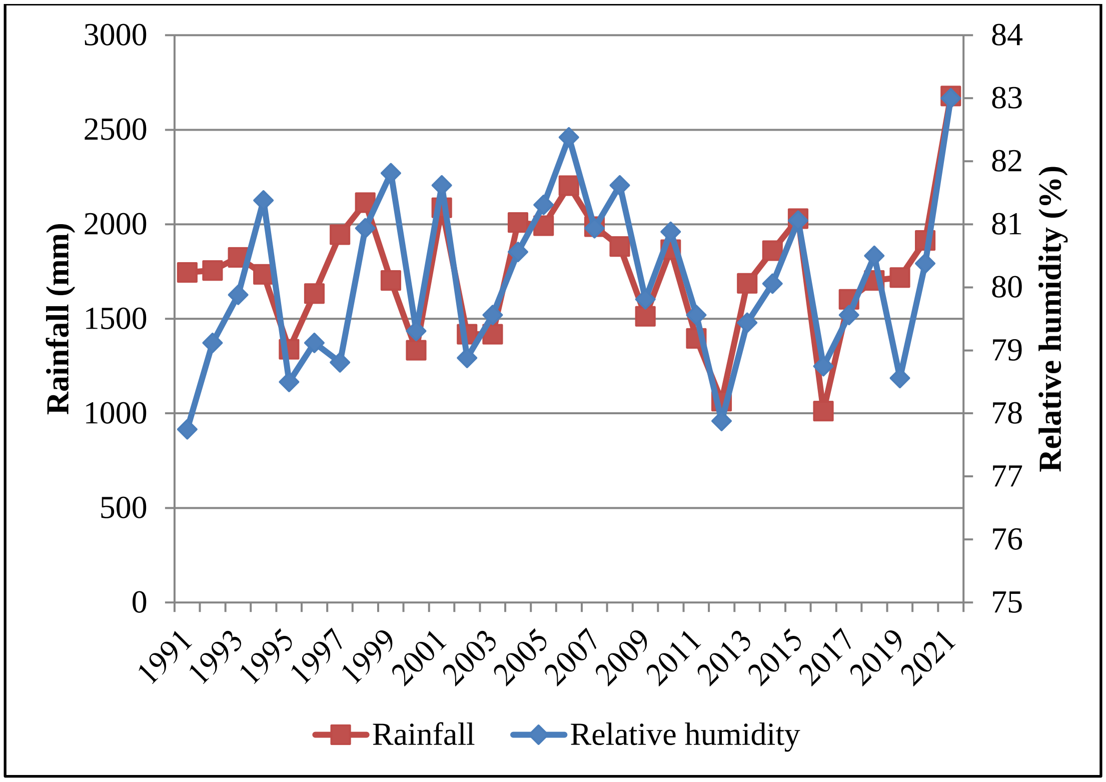

Figure 6. Trend in rainfall and relative humidity in Thiruvananthapuram (1991-2021)

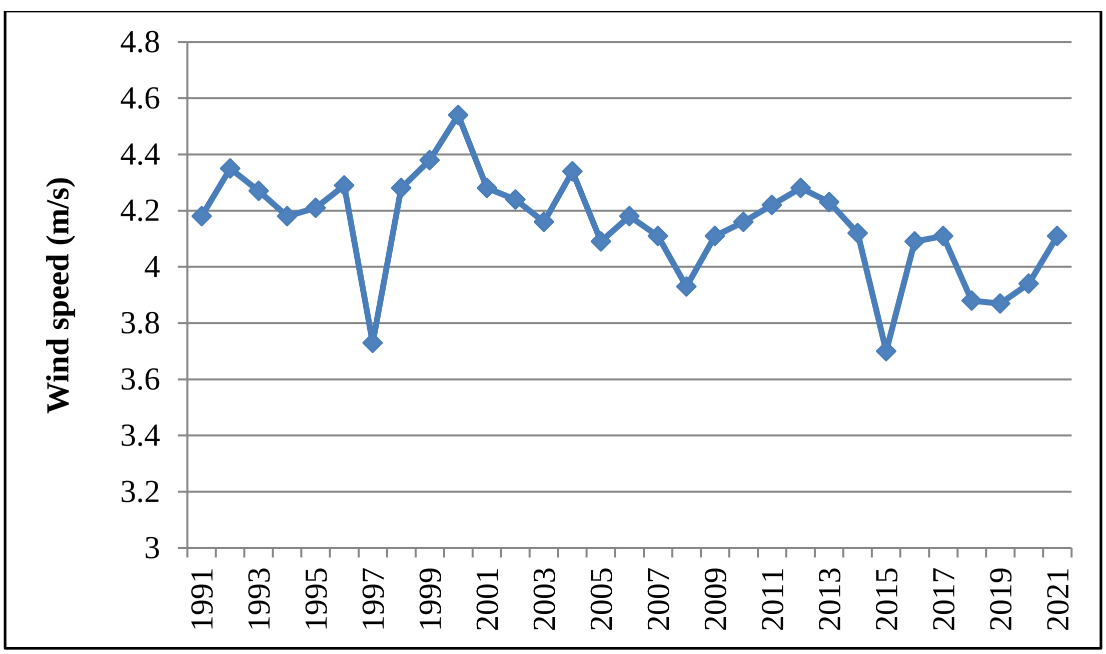

Figure 7. Trend in wind speed in Thiruvananthapuram (1991-2021)

Table 11. Estimates of multiple linear regression model

Sl. No.	Particulars	Coefficient	Standard error	t - value	p- value	VIF
1	Intercept	-161.48	29.103	-5.55	0	-
2	Q_1 Temperature (Jan.- March)	10.143	5.202	1.95	0.066	6.58
3	Q_2 Temperature (April- June)	7.587	5.937	1.28	0.217	7.04
4	Q_4 Temperature (Oct. - Dec.)	13.901***	4.796	2.90	0.009	4.14
5	Q_1 Rainfall (Jan.- March)	0.0514	0.047	1.08	0.293	2.03
6	Q_3 Rainfall (July – Sep.)	0.1353	0.104	1.30	0.21	1.64
7	Q_4 Rainfall (Oct. - Dec.)	0.4291**	0.183	2.34	0.030	2.89
8	Q_1 RH (Jan.- March)	3.0763	1.751	1.76	0.095	5
9	Q_2 RH (Oct. - Dec.)	4.7891	2.903	1.65	0.115	4.18
10	Q_3 RH (July – Sep.)	5.9823	3.137	1.91	0.072	2.25
11	Q_2 WS (Oct. - Dec.)	1.2946	0.649	1.99	0.061	2.15
12	Q_4 WS (Oct. - Dec.)	0.8941	0.631	1.42	0.173	2.31
13	F	5.13				
14	Prob.>F	0.0009				
15	No. of observation	31				
16	R^2	0.7482				
17	Adjusted R^2	0.6023				

****** Significant at 5 per cent level

******* Significant at 1 per cent level

Note: The coefficients were obtained with log values

Among the other variables which were statistically not significant, Q_3 (April- June) relative humidity and Q_2 (July – September) wind speed had a positive effect on the production of banana. The rainfall during Q_1 and Q_3 had negligible coefficients, indicating that they do not influence the yield of banana much. Increase in relative humidity during Q_1 (January - March) and Q_3 (July - Sep.) will result in increase in banana production, as indicated by regression coefficient. It has actually come to light via other studies, that other elements such as solar radiation, soil type, soil fertility, farming techniques, management practices, etc., may have a role in changes in crop yield.

The results obtained from this analysis are in harmony with the results obtained by Salvacion (2020) who conducted studies on the effect of climate on provincial-level banana yield in the Philippines for the period from 1991 to 2016. Multiple regression analysis showed that only 10 per cent of the banana producing areas in the country was significantly affected by climate. It was also reported in his study that, rise in temperature and rainfall will affect the banana production.

For the collected data, to check the multicollinearity VIF test was done and values are presented in table 11. VIF value ranged from 1.64 to 7.04. Hence, multicollinearity was not a serious problem among the independent variables included in the analysis. Test for autocorrelation was done using Durbin – Watson test. D-W value was 1.91 and hence it can be concluded that there is no autocorrelation in the function. R^2 value was 0.74 for the multiple linear regression analysis, indicating that 74 per cent of variation in the dependent variable was explained by the independent variables included in the model. Since F calculated value (5.13) is greater than F (11, 19) table value at one per cent level of significance, the overall multiple linear regression model was a good fit to the data.

Salau *et al.* (2016) analyzed data collected for the period 1998 and 2012 from Ondo State, Nigeria, to examine the effects of changes in significant climate variables such as temperature, rainfall, and relative humidity on the production of banana. The results indicated that a satisfactory annual banana production over 61,000 t in Ondo State will result from a mean temperature of 26 °C, average rainfall of about 1,891 mm, and relative humidity of about 77 per cent.

4.3.3. Impacts Perceived due to Climate Change

In the case of primary data analysis, respondents were categorized as adopters and non adopters of adaptation measures to reduce the ill effects of climate change. During the survey, different types of impacts perceived by adopters and non adopters due to change in climate were collected and results are presented in table 12 (Plate 1).

Table 12. Distribution of respondents based on impacts perceived due to climate change.

Sl. No.	Impacts	No. of adopters	No. of non adopters	Total
1	Decreased yield	50 (100)	50 (100)	100 (100)
2	Occurrence of pest	31 (62)	39 (78)	70 (70)
3	Occurrence of disease	40 (80)	48 (96)	88 (88)
4	Decreased availability of ground water	0 (0)	9 (18)	9 (9)
5	Increased soil erosion due to run off	32 (64)	12 (24)	44 (44)

Note: Figures in parentheses indicate percentage to respective total.

As a result of climate change, the major impact perceived was decrease in yield which was reported by 100 per cent of both adopters and non adopters. Occurrence of diseases was the second major impact faced by both adopters and non adopters to the extent of 80 per cent and 96 per cent, respectively. Decreased availability of ground water was the least impact perceived by non adopters to the extent of 18 per cent, while none of the adopters perceived this as the impact of climate change.

In a research study conducted by Ravi and Mustaffa (2013) on impact, adaptation and mitigation strategies for climate resilient banana production results revealed that in Jalgaon, a traditional banana growing region of Maharashtra state, India, the leaf spot disease was not observed earlier, but this devastating disease and cucumber mosaic virus disease were observed. Climate change may be to blame for the development of these new diseases. The negative effects of climate change will be mitigated through adaptation measures such as improvements to farming practices, changes in cropping pattern, and the adoption of new technology.

4.4. ADAPTATION STRATEGIES FOLLOWED BY THE BANANA FARMERS

The analysis of results revealed that growing mixed short duration crops (vegetables) was the major adaptation practice followed by going for crop insurance which was practised by 71 per cent and 65 per cent of the total respondents, respectively. Mixed cropping is an adaptation against crop failure due to abnormal weather conditions and leads to an improvement in the fertility of the soil. Banana plantations were mixed cropped with cucumber, cowpea, yard long bean, amaranthus, okra and bitter gourd which were practised by 100 per cent of adopters and 42 per cent of non adopters. In Thiruvananthapuram district, the banana farmers have insured their crop either with Kerala state crop insurance or with VFPCK. Majority of insured farmers adopted Kerala state crop insurance because it is linked with Krishi Bhavan at village level (Plate 3) and farmers can easily access the information from the agricultural officers and field officers. Problem specific training was provided by scientist or experts to the farmers at the Krishi Bhavan at Parassala panchayath (Plate 4).

Propping and mulching were practised by 65 per cent and 62 per cent of the total respondents, respectively. Props suitably support the plants bearing heavy bunches at the time of bunch emergence. Mulch used was cowpea’s residues, after the harvest of cowpea. Plant residues were used as green manure as well as mulch and banana leaves were also used as mulch. Only few farmers opted for tissue culture planting materials due to more inputs such manures and fertilizers to be used. Results are represented in table 13.

Plate 2: Field survey in the study area

Plate3: Visit to Krishi Bhavan, Chenkal

Plate 4: Training for the banana farmers at Parassala panchayath

Table 13. Distribution of respondents based on adaptation practices followed by the banana farmers.

Sl. No.	Adaptation practices	No. of Adopter	No. of Non-adopter	Total
1	Crop insurance	39 (78)	26 (52)	65 (65)
2	Mulching	50 (100)	12 (24)	62 (62)
3	Mixed cropping (Short term crops)	50 (100)	21 (42)	71 (71)
4	Tissue culture plants	3 (6)	6 (12)	9 (9)
5	Propping	39 (78)	26 (52)	65 (65)

Note: Figures in parentheses indicate percentage to respective total.

Dupdal *et al.* (2022) conducted a study in Vijayapura and Bagalkot districts of Karnataka to assess the adoption of improved technologies by dryland farmers to mitigate the effects of climate change. The farmers in the region sustained crop yields by adopting climate resilient indigenous and modern scientific technologies such as shifting sowing dates, mixed farming, crop diversification, alternate cropping systems and drought tolerant varieties.

4.4.1. Binary logistic regression model – Socioeconomic variables influencing adoption behaviour

A binary logistic regression model was fitted to understand the socioeconomic variables that are influencing adoption of adaptation practices to suit climate change. The estimated coefficients and results are presented in table 14. Dependent variable had values 1 and 0 for adopters and non adopters, respectively. Independent variables were area, income, age of respondents, education status of respondents and occupation. It was found that, area and income were found to be positively significant at 1 per cent level of significance. Odds ratio for area and income were 1.04 and 1.99. This means that farmers who had more area under banana farming and more income were likely to follow the adaptation practices one time more than the farmers who had less area and income. From the socio economic status of respondents, at the aggregate level about 38 per cent of respondents had 0.2 to 0.4 ha of area under banana. In the total 100 respondents, 38 per cent had 0.4 to 1 ha of area under banana which consist of 28 per cent of adopter and 48 per cent of non adopters cultivated banana. This indicated that more area under banana farming was followed the adaptation practices by the respondents. Calculated partial elasticity values showed that one per cent increase in area under banana farming increases the adaptation practices probability by 0.99 per cent. Other variables except education had positive coefficient, but, all were found to be statistically not significant.

Table 14. Binary logit regression model – socio-economic variables influencing adoption behaviour.

Sl. No.	Adaptation	Coefficient	Odds ratio	Partial elasticity	Standard error	z-value	P>|z|
1	Age	0.0046	1.004	0.49	0.031	0.15	0.883
2	Education	-0.0199	0.98	0.45	0.273	-0.07	0.943
3	Occupation	0.4289	1.535	0.72	0.439	1.5	0.134
4	Area	0.0459***	1.047	0.99	0.013	3.7	0
5	Income	1.55e-06***	1.999	0.02	5.70E-07	-2.72	0.007
6	Constant	-1.5834	0.029	-	0.062	-1.65	0.098

Note: *** Significant at 1 per cent level of significance

The results are in line with the study conducted by Abid *et al.,* (2015) on farmers' perception of adaptation strategies in Punjab province of Pakistan, who reported that the land area has positive and significant impacts on changing crop varieties and crop types. A per cent increase in the land area increases these probabilities of changing crop type and changing crop varieties by 0.01 and 0.06 per cent, respectively.

4.5. ECONOMICS OF BANANA CULTIVATION

4.5.1 Annual cost of banana cultivation

Economics of cultivation is important in making proper decision in farming. Annual cost of banana cultivation for adopters and non adopters was calculated using CACP cost concepts and presented in table 15 and 16, respectively.

Cost A_1 for adopter farmers was ₹ 2,32,645 ha^{-1}. In this, hired labour accounted for the maximum of 39.72 per cent, followed by cost of manures, fertilizers and soil ameliorants (15.78 %) and adaptation practices (14.63 %). Cost incurred for suckers was 10.93 per cent of Cost A_1. Cost incurred on land revenue and plant protection chemicals were less and were 0.27 and 1.42 per cent, respectively. Depreciation cost of machines and equipments accounted for 4.50 per cent. Share of interest on working capital and miscellaneous cost were 5.52 per cent and 7.22 per cent, respectively. Cost A_2, Cost B and Cost C were ₹ 2,69,045 ha^{-1}, ₹ 3,38,731 ha^{-1}, and ₹ 3,74,844 ha^{-1}, respectively.

On similar lines, Cost A_1 for non adopter farmers was ₹ 1,89,115.82 ha^{-1}. In this, hired labour accounted for the maximum of 47.45 per cent, followed by cost of manures, fertilizers and soil ameliorants (17.15 %) and cost of suckers (13.15 %). Cost incurred for adaptation practices was 8.44 per cent of Cost A_1. Cost incurred on land revenue and plant protection chemicals were less and were 0.44 and 1.05 per cent, respectively. Depreciation cost of machines and equipments accounted for 3.30 per cent. Share of interest on working capital and miscellaneous cost were 6.19 and 2.84 per cent, respectively. Cost A_2, Cost B and Cost C were ₹ 2,29,837.11 ha^{-1}, ₹ 3,01,312.26 ha^{-1} and ₹ 3,33,862.31 ha^{-1}, respectively.

From the analysis it is understood that, at Cost C adopters incurred 12.27 per cent more cost than that of the non adopters. Hired labour cost, cost of fertilizers, manures and soil ameliorants and cost of suckers, were the major costs incurred by both categories of farmers.

Kathirvel (2007) studied the costs and returns of banana production and calculated the returns to scale in Karur district of Tamil Nadu. Large farmers (₹ 66,404.37 $acre^{-1}$) have higher cost of cultivation compared to small (₹ 60,132.75 $acre^{-1}$) and medium (₹ 62,521.443 $acre^{-1}$) farmers. Among the cost, the cost of labour and fertilizer was more. The output of banana much depended upon maintenance of plants, timely application of fertilizers, manures, pesticides and water availability.

Table 15. Annual cost of banana cultivation for adopters.

Sl. No.	Item	Cost (₹ ha^{-1})	Percentage to cost A_1
1	Cost of suckers	25,424.00	10.93
2	Cost of hired labour	92,411.00	39.72
3	Cost of plant protection chemicals	3,297.00	1.42
4	Cost of manures, fertilizers and soil ameliorants	36,721.00	15.78
5	Land revenue	632.00	0.27
6	Depreciation	10,478.00	4.50
7	Cost of adaptation practices	34,040.00	14.63
8	Miscellaneous	16,796.00	7.22
9	Interest on working capital	12,846.00	5.52
10	**Cost A_1**	**2,32,645.00**	
11	Rental value of leased in land	36,400.00	
12	**Cost A_2**	**2,69,045.00**	
13	Rental value of owned land	55,660.00	
14	Interest on owned fixed capital excluding land	14,026.00	
15	**Cost B**	**3,38,731.00**	
16	Imputed value of family labour	36,112.00	
17	**Cost C**	**3,74,844.00**	

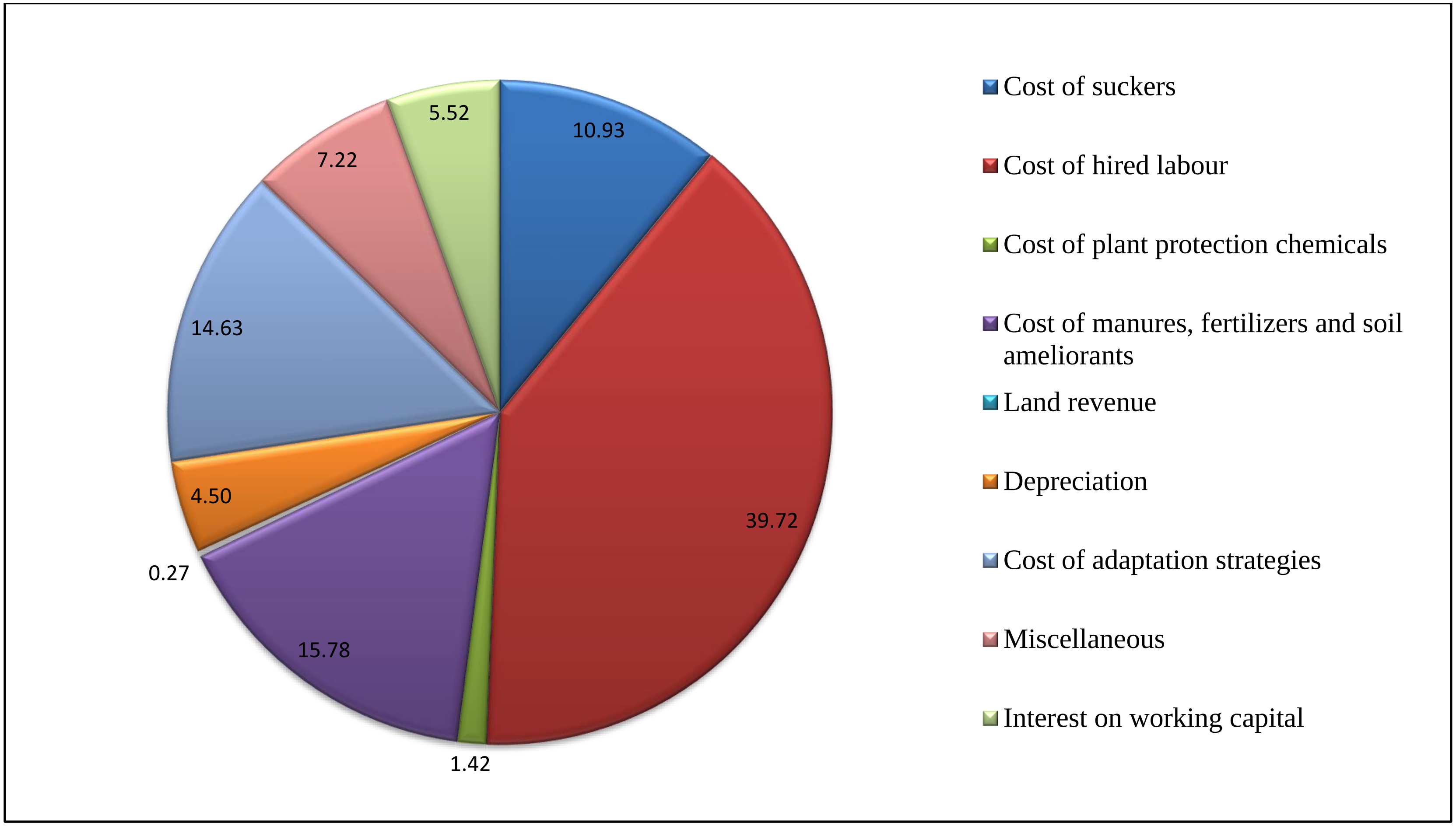

Figure 8. Cost A_1 of banana cultivation for adopters and per cent share of different items (%)

Table 16. Annual cost of banana cultivation for non adopters.

Sl. No.	Item	Cost (₹ ha^{-1})	Percentage to cost A_1
1	Cost of suckers	24,875.76	13.15
2	Cost of hired labour	89,741.59	47.45
3	Cost of plant protection chemicals	1,977.58	1.05
4	Cost of manures, fertilizers and soil ameliorants	32,430.91	17.15
5	Land revenue	828.34	0.44
6	Depreciation	6,244.38	3.30
7	Cost of adaptation practices	15,953.96	8.44
8	Miscellaneous	5,362.77	2.84
9	Interest on working capital	11,700.52	6.19
10	**Cost A_1**	**1,89,115.82**	
11	Rental value of leased in land	40,721.28	
12	**Cost A_2**	**2,29,837.11**	
13	Rental value of owned land	57,756.78	
14	Interest on owned fixed capital excluding land	13,718.37	
15	**Cost B**	**3,01,312.26**	
16	Imputed value of family labour	32,550.05	
17	**Cost C**	**3,33,862.31**	

4.5.2. Cost of adaptation practices

Cost of various adaptation practices followed by adopters and non adopters was calculated and presented in table 17.

Table 17. Cost of adaptation practices.

Sl. No.	Adaptation practices	Adopters (₹ ha^{-1})	Non-adopters (₹ ha^{-1})	Per cent difference
1	Crop insurance	5,335 (15.67)	2,965 (18.58)	79.93
2	Mulching	1,953 (5.73)	933 (5.84)	109.32
3	Mixed cropping (Short duration crops)	5,008 (14.71)	1,867 (11.70)	168.23
4	Tissue culture suckers	4,023 (11.81)	1,238 (7.75)	224.95
5	Cost of propping	17,722 (52.06)	8,951 (56.10)	97.98
	Total (₹)	34,041 (100)	15,954 (100)	113.36

Note: Figures in parentheses indicate percentage to respective total.

From the analysis, for adopters, cost of propping was the major cost (52.06 %) which was ₹ 17,722 ha^{-1}, followed by premium for crop insurance ₹ 5,335 ha^{-1} , intercropping with short duration crops ₹ 5,008 ha^{-1}, tissue culture suckers or superior varieties ₹ 4,023 ha^{-1} and mulching ₹ 1,953 ha^{-1}. Total cost of adaptation practices was ₹ 34,041 ha^{-1}.

For non adopters, cost of propping was the major cost (56.10 %) which was ₹ 8,951 ha^{-1}, followed by premium for crop insurance ₹ 2,965 ha^{-1}, intercropping with short duration crops ₹ 1,867 ha^{-1} tissue culture suckers or superior varieties ₹ 1,238 ha^{-1} and mulching ₹ 933 ha^{-1}. Total cost of adaptation practices was ₹ 15,954 ha^{-1}. Non adopters who did not follow the adaptation practices continuously for the past three years and have casual approach towards adaptation.

Most of the farmers cultivated tuber crops such as arrowroot, vegetables such as amaranthus, okra, bitter gourd and snake gourd etc. as intercrops. Three months after

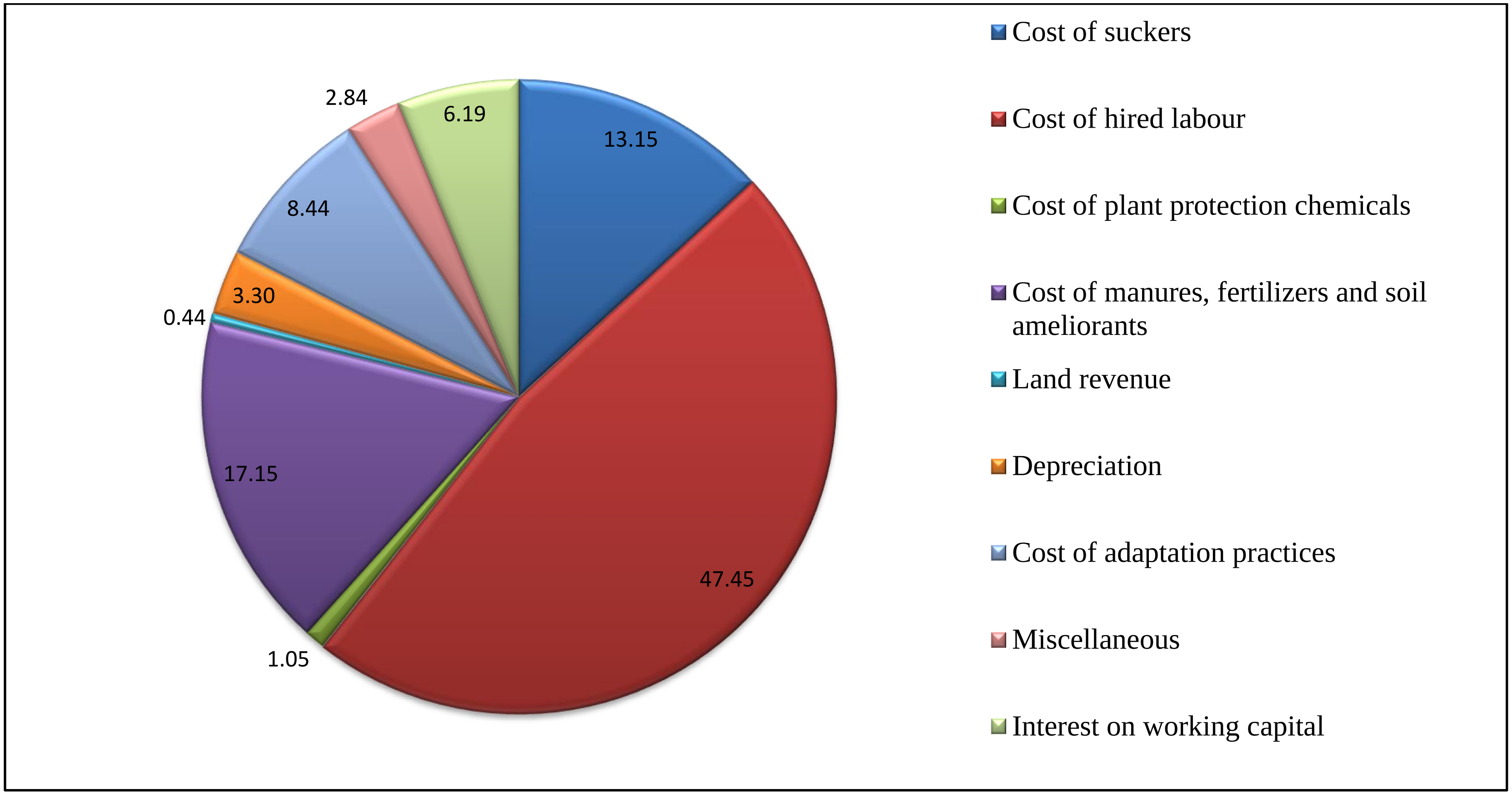

Figure 9. Cost A_1 of banana cultivation for non adopters and per cent share of different items (%)

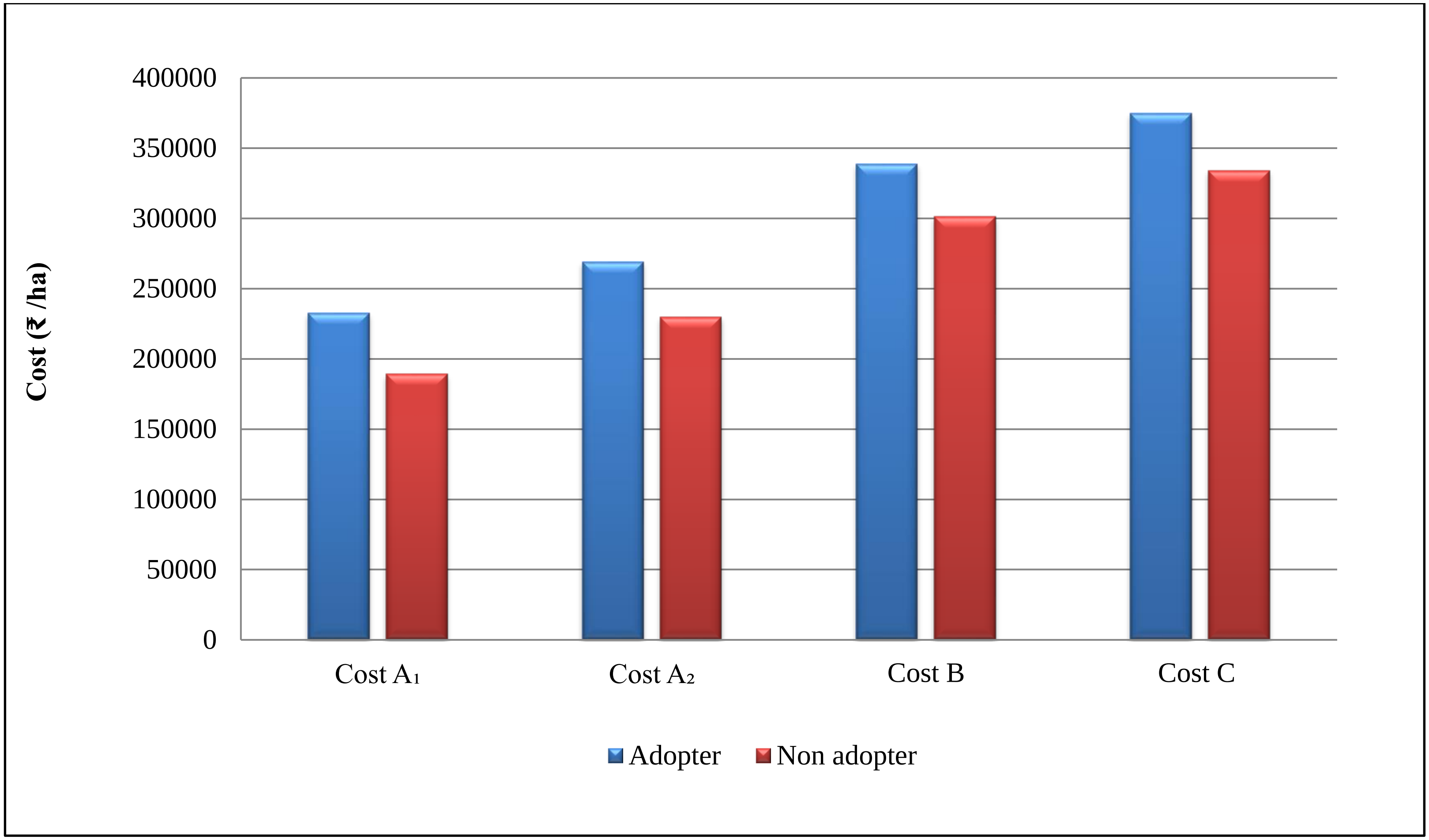

Figure 10 . Comparison of CACP costs of banana cultivation for adopters and non adopters

planting they were used as green manures. Adopters incurred double the cost of adaptation practices compared to non adopters.

Crop insurance scheme is being implemented by the Department of Agriculture and the Krishi Bhavans at the panchayat level. Insurance coverage is available for 25 major cultivable crops in Kerala. The crops covered in this scheme are paddy, coconut, arecanut, banana, rubber, cashew, vegetables, nutmeg, clove, betel vine, etc. The premium amount should be paid in the District Cooperative Bank of the concerned area. Premium rate was ₹ 3 per banana plant and in case of calamity, the compensation for bunched banana was ₹ 300 per plant and for unbunched it was ₹ 150 per plant.

VFPCK has set up a crop insurance package for protecting the farmers from uncertainties during crop production period, with a tie up with Agriculture Insurance Company of India Ltd. (AIC). Under this scheme banana, vegetables and tuber crops were included and insurance claim can be obtained on the basis of total loss or damage to banana plants due to natural calamities, damage by wild animals, Kokkan disease and Pseudostem weevil attack. The premium rate was ₹ 5.50 per banana plant, and the share of insured farmer was ₹ 3. The compensation for banana was ₹ 60 per plant for unbunched and ₹ 85 per plant for bunched.

4.5.3. Returns from banana cultivation

Returns from banana cultivation by adopter and non adopter farmers are presented in table 18.

Table 18. Returns from banana cultivation by adopter and non- adopter farmers.

Sl. No.	Parameters	Adopters	Non-adopters	Per cent difference
1	Yield (kg ha^{-1})	16,056	11,287	42.25
2	Price (₹ kg^{-1})	50	47	6.38
3	Gross returns (₹ ha^{-1})	8,02,775	5,30,497	51.32
4	Net returns at Cost A_1 (₹ ha^{-1})	5,70,130	3,41,381	67.00
5	Net returns at Cost A_2 (₹ ha^{-1})	5,33,730	3,00,660	77.51
6	Net returns at Cost B (₹ ha^{-1})	4,64,044	2,29,184	102.47
7	Net returns at Cost C (₹ ha^{-1})	4,27,932	1,96,634	117.62

Adopter farmers obtained 42.25 per cent higher yield (16,056 kg ha^{-1}) than that of non adopters (11,287 kg ha^{-1}). Market price per kg was ₹ 50 kg^{-1} for adopters and ₹ 47 kg^{-1} for non adopters due to better marketing, selling through VFPCK and traders.

Gross returns in case of adopters was ₹ 8,02,775 ha^{-1}, which was 51.32 per cent higher than that of non adopters (₹5,30,497 ha^{-1}).

Net returns of adopters at Cost A_1, Cost A_2, Cost B, and Cost C were ₹ 5,70,130 ha^{-1}, ₹ 5,33,730 ha^{-1}, ₹ 4,64,044 ha^{-1} and ₹ 4,27,932 ha^{-1}, respectively. Net returns of non adopters at Cost A_1, Cost A_2, Cost B and Cost C were ₹ 3,41,381 ha^{-1}, ₹ 3,00,660 ha^{-1}, ₹ 2,29,184 ha^{-1} and ₹ 1,96,634 ha^{-1} respectively. From the analysis it is known that net returns of non adopters had less than 50 per cent net returns ha^{-1} at Cost C compared to adopters.

The study conducted by Noor *et al.* (2015) revealed that the average production cost of banana was ₹ 1,58,581 $acre^{-1}$ which included fixed costs, labour cost, capital inputs and marketing costs which were ₹ 88,300, ₹ 20,100, ₹ 28,847 and ₹ 21,334, respectively. Gross returns per acre was estimated ₹ 2,50,250 with net income ₹ 91,669.

4.5.4. Benefit Cost Ratio

Benefit Cost Ratio or Profitability Index Rate explains the value of output per rupee of input. This ratio indicates whether cost incurred in the production activity is recovered from the returns obtained. It indicates the returns generated per rupee invested. B: C ratio of adopters and non adopters is presented in table 19 .

Table 19. Benefit cost ratio of adopter and non adopter banana farmers.

Sl. No.	B-C ratio	Adopters	Non adopters
1	Cost A_1	3.45	2.81
2	Cost A_2	2.98	2.31
3	Cost B	2.37	1.76
4	Cost C	2.14	1.59

From the results, at Cost A_1 ,Cost A_2 ,Cost B and Cost C, the B-C ratio of adopters was greater than that of non adopters.

Bondar *et al.* (2015) conducted a study on economics of banana production in Kolhapur district of Maharashtra. Farmers were classified into three groups viz., small, marginal and large. The gross return from banana was ₹ 5,64,283.57 ha^{-1} with B:C ratio of 2.07 at cost C. B:C ratio of small, medium and large farmers was 2.01, 2.08 and 2.12, respectively.

Summary

CHAPTER V

SUMMARY

Climate change, the outcome of the "Global Warming" has now started showing its impacts worldwide. Global Climate change has considerable implications in Indian agriculture and hence food security and farmers livelihood. Agriculture sector is the most sensitive sector to the climate changes because climate of a country determines the nature and characteristics of vegetation and crops. Increase in temperature, can reduce crop duration, increase crop respiration, a effect the survival and distribution of pest populations, decrease fertilizer use efficiency and hasten nutrient mineralisation in soils. As a result there will be a threatened in food security. In this context, a study on "Impact of climate change and adaptation strategies in banana production in Thiruvananthapuram district" was undertaken. The objective of the study was to quantify the impact of climate change on yield of banana, identification and analysis of the adaptation practices practised by farmers.

The study was based on both primary and secondary data. The major varieties such as robusta, red banana, poovan, rasthali, nendran, virupakshi, monthan, karpuravalli, sakkai, peyan, matti, and dwarf cavendish of banana growing district of Kerala, *viz*. Thiruvananthapuram was selected for the study. The primary data analysis was confined to Thiruvananthapuram district for the agricultural year 2021-2022. The sample size was 100, which consisted of 50 adopters who had used adaptation tactics during the previous three years and 50 non adopters who had used adaptation strategies during the previous, not continuously three years and not serious approach towards adaptation to climate change. Secondary data regarding climatic variables were collected for district from NASA power website for the period 1991-2021. Secondary data on area, production, productivity were collected for district from the Directorate of Economics and Statistics, Government of Kerala, Thiruvananthapuram for the period 1991 to 2021.

Multiple linear regression model was done to identify the climatic variables that are influencing the production, binary logistic regression was fitted to understand the socioeconomic variables influencing adoption of adaptation practices, CACP cost concepts were used to calculate the annual cost of banana farmers and compound annual growth rate was calculated for the area, production, productivity and climatic parameters given to know the growth trend.

The socio economic characteristics of the respondent farmers such as age, education, gender, family size, land holding, area under banana crop, occupation and cropping pattern and cost of cultivation were analyzed using percentages and averages. Out of 100 respondents, 62 were in the age group of 45-60 years, which was 62 per cent of the sample respondents. This shows the involvement of middle adult hood age group in farming. It was found that 100 per cent of total sample farmers were literates, among which 44 per cent have attained education up to pre degree level. Majority 78 per cent of the farmers belonged to medium size family. From, the results it is understood that 91 per cent of the sample farmers were male and only nine per cent of the sample farmers were female who have taken up banana farming. Agriculture was the primary and main occupation for 84 per cent of sample. Fifty per cent adopter farmers and 38 per cent non adopter farmers had 0.4 to1 ha of land holdings. First highest position was occupied by cucumber as mixed crop grown with banana (main) for adopter (80 %) and non adopter (28 %) farmers. In the total 100 respondents, 38 per cent had 0.4 to 1 ha of area under banana which consist of 28 per cent of adopter and 48 per cent of non adopters cultivated banana.

The analysis clearly depicted positive growth of area (5.35 % per annum) and production (2.86 % per annum) spite of having negative trend in productivity (-2.36 % per annum). The productivity was found declining over years. Average maximum temperature, average minimum temperature, average rainfall, average relative humidity and average wind speed were 35.65 °C, 19.73 °C, 1748.07 mm, 80.09 per cent and 4.15 m/s, respectively. Coefficient of Variation was faced to be the highest for rainfall among all weather parameters i.e., 19.52 per cent. All weather parameters have positive growth rate except wind speed (-0.24 % per annum at 1 % level of significance). Positive trend of minimum temperature was 0.13 per cent per annum and was significant at 5 per cent level of significance.

On doing multiple linear regression analysis, Q_4 (October to December) the coefficient for temperature was positively significant at 1 per cent level of significance. This means that increased temperature during this period resulted in increased production of banana in the district. Also Q_4 (October to December) rainfall was positively significant at 5 per cent level of significance. This means that increase in rainfall during this period resulted in increased production of banana in the district. This means that one per cent increase in temperature during Q_4 will increase the production by 13.9 per cent and one per cent increase in rainfall during Q_4 will increase the production of banana by 0.42 per cent due to optimum temperature and rainfall. Q_4 is the important growth stage in banana for those who planted in Q_2 (April- June), Q_4 coincided with flowering, pollination and fruit formation.

Among the other variables which were statistically not significant, Q_3 (April- June) relative humidity and Q_2 (July – September) wind speed had a positive effect on the production of banana. The rainfall during Q_1 and Q_3 had negligible coefficients, indicating that they do not influence the yield of banana much. Increase in relative humidity during Q_1 (January - March) and Q_3 (July - Sep.) will result in increase in banana production, as indicated by its regression coefficient. It has other elements such as solar radiation, soil type, soil fertility, farming techniques, management practices, etc., may have a role in changes in crop yield.

In order to combat the change in climate, the analysis revealed that growing mixed short duration cropping (vegetables) was the major adaptation practice followed by crop insurance which was practised by 71 per cent and 65 per cent of the total respondents, respectively. The major impact perceived was decrease in yield which was reported by 100 per cent of both adopters and non adopters. Occurrence of diseases was the second major impact faced by both adopters and non adopters to the extent of 80 per cent and 96 per cent, respectively. Also, cost of propping was the adaptation practice which costed them ₹ 17,722 ha^{-1} compared to other adaptation practices followed by adopters. In the case of non adopters cost of propping was the major cost which was ₹8,951 ha^{-1} as compared to other adaptation practices followed. Adopters incurred double the cost of adaptation practices compared to non adopters.

Results of binary logistic regression model fitted to understand the socioeconomic variables influencing adoption of adaptation practices to suit climate change showed that, area and income were found to be positively significant at 1 per cent level of significance. Odds ratio for area and income were 1.04 and 1.99. From the socio economic status of respondents, at the aggregate level about 38 per cent of respondents had 0.2 to 0.4 ha of area under banana. This means that farmers who had more area under banana farming and more income were likely to follow the adaptation practices one time more than the farmers who had less area and income. Calculated partial elasticity values showed that one per cent increase in area under banana farming increases the adaptation practices probability by 0.99 per cent. Other variables except education had positive coefficient, but, all were found to be statistically non significant.

Cost A_1 for non adopter farmers was ₹ 1,89,115.82 ha^{-1}. In this, hired labour accounted for the maximum of 47.45 per cent, followed by cost of manures, fertilizers and soil ameliorants (17.15 %) and cost of suckers (13.15 %). Cost incurred for adaptation practices was 8.44 per cent of Cost A_1. Cost A_2, Cost B and Cost C were ₹ 2,29,837.11 ha^{-1}, ₹ 3,01,312.26 ha^{-1} and ₹ 3,33,862.31 ha^{-1}, respectively. On similar lines, Cost A_1 for adopter farmers was ₹ 2,32,645 ha^{-1}. With again lion share of hired labour of 39.72 per cent, followed by cost of manures, fertilizers and soil ameliorants (15.78 %) and adaptation practices (14.63 %). Cost incurred for suckers was 10.93 per cent of Cost A_1. Cost A_2, Cost B and Cost C for adopters were ₹ 2,69,045 ha^{-1}, ₹ 3,38,731 ha^{-1}, and ₹ 3,74,844 ha^{-1}, respectively. Gross returns of adopters and non adopters was ₹ 8,02,775 ha^{-1} and ₹ 5,30,497 ha^{-1}, respectively.

The magnitude of Cost C incurred by adopters (₹ 3,74,844 ha^{-1}) was 12.27 per cent higher than that of non adopters (₹ 3,33,862.31 ha^{-1}). Net returns at Cost C for adopters was ₹ 4,27,932 ha^{-1} and for non adopters was ₹ 1,96,634 ha^{-1}. Benefit cost ratio at Cost C for adopters was 2.14 which was more than non adopters who had 1.59. The yield recorded by adopters (16,056 kg ha^{-1}) was 42.25 per cent higher than that of non adopters (11,287 kg ha^{-1}). Gross returns in case of adopters was ₹ 8,02,775 ha^{-1}, which was 51.32 per cent higher than the non adopters (₹ 5,30,497 ha^{-1}).

5.1. POLICY SUGGESTIONS

- Problem specific practical training may be provided to farmers regarding the time of adopting the adaptation practices and input usage by Ministry of Agriculture Development and Farmer's Welfare, Kerala.

- Efforts need to be taken to simplify the procedure of crop insurance, such that all transactions are made through Krishi Bhavan and creation of awareness and conviction about the benefits of crop insurance to the farmers.
- More number of automatic weather stations may be installed to provide location specific solutions to climate change.
- As the occurrence of pest and disease was one of the major impact of climate change as perceived by the farmers, pest and disease control measures may be properly adopted as per the recommendations of Kerala Agricultural University.

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CHAPTER VI

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Appendix

APPENDIX

Kerala Agricultural University

College of Agriculture, Vellayani

Department of Agricultural Economics

Impact of climate change and adaptation strategies in banana production in Thiruvananthapuram district

Questionnaire

1. Name of the Krishibhavan:

2. Name of the respondent:

3. Address:

4. Household Information

Sl. No.	Relation with head	Sex	Age	Education	Primary Occupation

Relation with head: 1. Head, 2. Wife, 3. Son, 4. Daughter, 5. Son in law, 6. Daughter in law, 7. Sister, 8. Brother, 9. Grandson, 10. Granddaughter, 11. Others (Specify).

Sex: 1. Male, 2. Female

Education: 1. No schooling, 2. Primary school, 3. Upper primary school, 4. High school (up to tenth), 5. Higher secondary, 6. Graduate, 7. Post graduate, 8. Others (Specify)

Occupation: 1. Agriculture only, 2. Govt. employee, 3. Private employee, 4. Own Business, 5. Agricultural labourer, 6. Non agricultural labourer, 7. Not working, 8. House wife, 9. Student

5. Land particulars

Sl. No.	Particulars (Cents)	Wet land (Cents)	Garden land (Cents)	Rainfed (Cents)	Irrigated (Cents)	Total (Cents)
1.	Area owned					
2.	Area leased in					
3.	Area leased out					
4.	Net cropped area					
5.	Area under banana					
6.	Land revenue (₹)					

6. Implements

Sl. No.	Particulars	Number	Year of purchase	Value (₹)	Expected life (Years)	Depreciation (₹)
1.	Manvetties					
2.	Pickaxe					
3.	Spades					
4.	Sprayers					
5.	Vaakathi/Knife					
6.	Ladder					
7.	Others 1. 2. 3.					

7. Buildings and machineries owned by respondent farmer

Sl. No.	Particulars	Number	Year of purchase/ Construction	Purchased Value (₹)	Expected life (Years)	Depreciation (₹)	Maintainance cost (₹)
1.	House						
2.	Store house						
3.	Tractor/ tiller						
4.	Weed cutter						
5.	Pump set						
6.	Others a. b. c.						

8. Livestock owned by the farmer

Sl. No.	Animal	Number	Breed	Year of purchase	Value (₹)
1.	Cow				
2.	Goat				
3.	Pig				
4.	Hen				
5.	Others				

9. Banana

Sl. No.	Area under banana (Cents)	Year of planting	Type of planting material used	Variety grown	Highest yield per plant	Average bunch weight per plant	Production (kg) and price (₹ kg^{-1})	
							2020	2021

10. Types of mixed crops grown

Sl. No.	Crops	Area (Cents)/ No.	Irrigation	Cost of planting	Cost of maintenance	Other cost (harvest and post harvest)	Yield (kg.)	Inco me (₹)
1.	Banana							
2.								
3.								
4.								

11. Input Costs

Sl. No.	**Input used**	**Quantity applied**		**₹/unit**	**Total expenses (₹)**
		Unit	Quantity		
1.	Sucker used				
2.	Manures a. Cow dung b. Green manure c. Sheep manure d. Poultry manure				
2.	Fertilizer application a. Urea b. DAP c. MOP d. Complex e. Others				
3.	Soil ameliorants a. Lime b. Others				
4.	Weedicides a. b.				
5.	Pesticides a. b.				
6.	Fungicides a. b.				
7.	Total				

12. Labour Cost

Wage rate: Men (₹/ day): Women (₹/ day):

Machinery rent (₹/ hour): Total cost (₹):

Sl. No.	Particulars		Family labour (man days)		Hired labour (man days)		Machine labour (hours)
			Men	Women	Men	Women	
1.	Clearing of land						
2.	Digging pits						
3.	Organic manure						
4.	Fertilizers						
5.	Liming materials						
6.	Plant protection operations	Bio control					
		Chemical					
7.	Irrigation						
8.	Weeding						
9.	Other intercultural operations a. Desuckering b. Propping c. Basin						
10.	Harvesting						
11.	Post harvest operations						
12.	Transport						
13.	Miscellaneous						

Other information:

Awareness and Adaptation strategies:-

1. Have heard of the term "climate change" – yes/ no

2. Do you think that the climate change is there in your ecosystem? – Yes/ no

3. What have you perceived as the impacts of climate change?

Sl. No.	Impacts	Yes/No	Increase or positively	Decrease or Negatively
1.	Yield			
2.	Pest occurrence			
3.	Disease occurrence			
4.	Availability of ground water			
5.	Soil erosion			
6.	Others a. b. c.			

4. Are you practising the adaptation strategies for climate change? Yes/ No

Sl. No.	Adaptation strategies	Cost of practice (₹)	No. of years practices followed
1.	Crop insurance		
2.	Mulching		
3.	Supplementary irrigation		
4.	Purchase of superior varieties/ tissue culture banana		

Questions asked to Directorate of Economics and Statistics, Thiruvananthapuram:

Data on area, production and productivity of banana for the past 31 years.

Thiruvananthapuram			
Year	Area (ha)	Production (t)	Productivity (kg ha^{-1})

Data on Maximum Temperature, Minimum Temperature, Rainfall, Relative Humidity and Wind speed for the past 31 years.

Thiruvananthapuram					
Year	Maximum Temperature (°C)	Minimum Temperature (°C)	Rainfall (mm)	Relative Humidity (%)	Wind Speed (m//s)

IMPACT OF CLIMATE CHANGE AND ADAPTATION STRATEGIES IN BANANA PRODUCTION IN THIRUVANANTHAPURAM DISTRICT

by

TAKALE ASMITA BHAUSAHEB

(Admn. No. 2020-11-131)

Abstract of the Thesis

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL ECONOMICS
COLLEGE OF AGRICULTURE
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2023

Abstract

ABSTRACT

The research entitled "Impact of climate change and adaptation strategies in banana production in Thiruvananthapuram district" was conducted. The objective of the study was to quantify the impact of climate change on yield of banana, identification and analysis of the adaptation practices practised by farmers. Secondary data regarding area production, productivity and climatic variables were collected for Thiruvananthapuram district for the period 1991-2021 from Directorate of Economics and Statistics, Vikas Bhavan, Thiruvananthapuram and NASA power website and primary data were confined to Thiruvananthapuram district for the agricultural year 2021-2022.

Multiple linear regression model was done to identify the climatic variables that are influencing the production, binary logistic regression was fitted to understand the socio-economic variables influencing adoption of adaptation practices, CACP cost concepts were used to calculate the annual cost of banana farmers and compound annual growth rate was calculated for the area, production, productivity and climatic parameters given to know the growth trend.

A positive growth of area (5.35 % per annum) and production (2.86 % per annum) were observed spite of having negative trend in productivity (-2.36 % per annum). Coefficient of variation was high in area as compared to production and productivity of banana in Thiruvananthapuram and coefficient of variation for area, production and productivity were 42.68, 32.62 and 32.71 per cent, respectively. Coefficient of variation was highest for rainfall among all weather parameters i.e., 19.52 per cent. All weather parameters have positive growth rate except wind speed (-0.24 % per annum at 1 % level of significance). Positive trend of minimum temperature was 0.13 per cent per annum and was significant at 5 per cent level of significance.

On doing multiple linear regression analysis, Q_4 (October to December) the coefficient for temperature was positively significant at 1 per cent level of significance. This means that increased temperature during this period resulted in increased production of banana in the district. Also Q_4 (October to December) rainfall was positively

significant at 5 per cent level of significance. This means that one per cent increase in temperature during Q_4 will increase the production by 13.9 per cent and one per cent increase in rainfall during Q_4 will increase the production of banana by 0.42 per cent due to optimum temperature and rainfall. Q_4 is the important growth stage in banana for those who planted in Q_2 (April- June), Q_4 coincided with flowering, pollination and fruit formation.

The analysis revealed that growing mixed short duration cropping (vegetables) was the major adaptation practice followed by crop insurance which was practised by 71 per cent and 65 per cent of the total respondents, respectively. The major impact perceived was decrease in yield which was reported by 100 per cent of both adopters and non adopters. Also, cost of propping was the adaptation practice which costed them ₹ 17,722 ha^{-1} compared to other adaptation practices followed by adopters. In the case of non adopters cost of propping was the major cost which was ₹8,951 ha^{-1} as compared to other adaptation practices followed.

Binary logistic regression analysis was done to identify the socioeconomic variables influencing adaptation practices followed by adopters. It was found that, area and income were found positively significant at 1 per cent level of significance. Odds ratio for area and income were 1.04 and 1.99. From the socio economic status of respondents, at the aggregate level about 38 per cent of respondents had 0.2 to 0.4 ha of area under banana. This means, the farmers who were having more area under banana farming and more income are likely to adopt the adaptation practices one times more than the farmers who are having less area and income. Calculated partial elasticity showed that for one per cent increase in area under banana farming increases the probability of adopting adaptation practices by 0.99 per cent.

Annual cost of cultivation was calculated using CACP cost concepts. The magnitude of Cost C incurred by adopters (₹ 3,74,844 ha^{-1}) was 12.27 per cent higher than non adopters (₹ 3,33,862.31 ha^{-1}). Net returns at Cost C for adopters was ₹ 4,27,932 ha^{-1} and for non adopters was ₹ 1,96,634 ha^{-1}. Benefit cost ratio at Cost C for adopters was 2.14 which was more than that of non adopters who had 1.59. The yield recorded by adopters (16,056 kg ha^{-1}) was 42.25 per cent higher than that of non adopters (11,287 kg ha^{-1}). Gross returns in case of adopters was ₹ 8,02,775 ha^{-1}, which was 51.32 per cent higher than the non adopters (₹ 5,30,497 ha^{-1}).

Q4 (October to December) temperature and rainfall had positive impact on banana production. Increase in area and income under banana farming increases the probability of adopting adaptation practices. Net returns of adopters were more than that of non adopters. Increase in labour cost, fluctuation in market prices and high cost of adaptation practices were major problems faced by both farmers. Coefficient of variation was highest for rainfall among all weather parameters. All weather parameters have positive growth rate except wind speed. Hence adaptation measures are propping, crop insurance and intercropping with short duration crops helps to reduce the risk of flooding.

സംഗ്രഹം

"തിരുവനന്തപുരം ജില്ലയിലെ വാഴപ്പഴ ഉൽപ്പാദനത്തിൽ കാലാവസ്ഥാ വ്യതിയാനത്തിന്റെ സ്വാധീനവും പൊരുത്തപ്പെടുത്തൽ തന്ത്രങ്ങളും" എന്ന തലക്കെട്ടിൽ ഗവേഷണം നടത്തി. കാലാവസ്ഥാ വ്യതിയാനം വാഴയുടെ വിളവിൽ വരുത്തുന്ന ആഘാതം അളക്കുക, കർഷകർ അനുവർത്തിക്കുന്ന പൊരുത്തപ്പെടുത്തൽ രീതികൾ തിരിച്ചറിയുക, വിശകലനം ചെയ്യുക എന്നിവയായിരുന്നു പഠനത്തിന്റെ ലക്ഷ്യം. 1991-2021 കാലഘട്ടത്തിലെ തിരുവനന്തപുരം ജില്ലയുടെ വിസ്തീർണം ഉൽപ്പാദനം, ഉൽപ്പാദനക്ഷമത, കാലാവസ്ഥാ വ്യതിയാനങ്ങൾ എന്നിവയെക്കുറിച്ചുള്ള ദ്വിതീയ ഡാറ്റ ഡയറക്ടറേറ്റ് ഓഫ് ഇക്കണോമിക്സ് ആൻഡ് സ്റ്റാറ്റിസ്റ്റിക്സ്, വികാസ് ഭവൻ തിരുവനന്തപുരത്തു നിന്നും നാസ പവർ വെബ്സൈറ്റിൽ നിന്നും ശേഖരിച്ചു, 2021-22 കാർഷിക വർഷത്തിലെ തിരുവനതപുരം ജില്ലയുടെ പ്രാഥമിക വിവരങ്ങളും ശേഖരിച്ചു.

ഉൽപ്പാദനത്തെ സ്വാധീനിക്കുന്ന കാലാവസ്ഥാ വ്യതിയാനങ്ങൾ തിരിച്ചറിയാൻ മൾട്ടിപ്പിൾ ലീനിയർ റിഗ്രഷൻ മോഡൽ നടത്തി, അഡാപ്റ്റേഷൻ രീതികൾ സ്വീകരിക്കുന്നതിനെ സ്വാധീനിക്കുന്ന സാമൂഹിക-സാമ്പത്തിക വേരിയബിളുകൾ മനസിലാക്കാൻ ബൈനറി ലോജിസ്റ്റിക് റിഗ്രഷൻ ഘടിപ്പിച്ചു, വാഴ കർഷകരുടെ വാർഷിക ചെലവ് കണക്കാക്കാൻ CACP ചെലവ് ആശയങ്ങൾ ഉപയോഗിച്ചു. വളർച്ചാ പ്രവണത അറിയാൻ നൽകിയിരിക്കുന്ന വിസ്തീർണ്ണം, ഉൽപ്പാദനം, ഉൽപ്പാദനക്ഷമത, കാലാവസ്ഥാ പാരാമീറ്ററുകൾ എന്നിവയ്ക്കായി വാർഷിക വളർച്ചാ നിരക്ക് കണക്കാക്കുന്നു.

ഉൽപ്പാദനക്ഷമതയിൽ (-2.36 % പ്രതിവർഷം) നെഗറ്റീവ് പ്രവണത ഉണ്ടായിരുന്നിട്ടും വിസ്തൃതിയിലും (പ്രതിവർഷം 5.35 %) ഉൽപ്പാദനത്തിലും (പ്രതിവർഷം 2.86 %) നല്ല വളർച്ച രേഖപ്പെടുത്തി. തിരുവനന്തപുരത്തെ വാഴപ്പഴത്തിന്റെ ഉൽപ്പാദനവും ഉൽപ്പാദനക്ഷമതയുമായി താരതമ്യം ചെയ്യുമ്പോൾ വിസ്തൃതിയിൽ വ്യത്യാസത്തിന്റെ ഗുണകം ഉയർന്നതാണ്. എല്ലാ കാലാവസ്ഥാ പരാമീറ്ററുകൾക്കിടയിലും മഴയുടെ ഏറ്റവും ഉയർന്ന വ്യതിയാനത്തിന്റെ ഗുണകം, അതായത് 19.52 ശതമാനം. കാറ്റിന്റെ വേഗത ഒഴികെ എല്ലാ കാലാവസ്ഥാ പാരാമീറ്ററുകൾക്കും പോസിറ്റീവ് വളർച്ചാ നിരക്ക് ഉണ്ട് (പ്രതിവർഷം -0.24 % പ്രാധാന്യമുള്ള 1% തലത്തിൽ). കുറഞ്ഞ താപനിലയുടെ പോസിറ്റീവ് പ്രവണത പ്രതിവർഷം 0.13 ശതമാനവും 5 ശതമാനം ലെവൽ ഓഫ് സിഗ്നിഫിക്കൻസിൽ പ്രാധാന്യമർഹിക്കുന്നതുമാണ്.

മൾട്ടിപ്പിൾ ലീനിയർ റിഗ്രഷൻ വിശകലനം നടത്തുമ്പോൾ, Q4 (ഒക്ടോബർ മുതൽ ഡിസംബർ വരെ) താപനിലയുടെ ഗുണകം 1 ശതമാനം ലെവൽ ഓഫ് സിഗ്നിഫിക്കൻസിൽ പ്രാധാന്യമുള്ള തലത്തിൽ പോസിറ്റീവായി. അതായത് ഇക്കാലയളവിൽ ചൂട് കൂടിയത് ജില്ലയിൽ വാഴയുടെ ഉത്പാദനം വർധിക്കാൻ

കാരണമായി. കൂടാതെ Q4 (ഒക്ടോബർ മുതൽ ഡിസംബർ വരെ) 5 ശതമാനം ലെവൽ ഓഫ് സിഗ്നിഫിക്കൻസിൽ മഴയ്ക്ക് നല്ല പ്രാധാന്യമുണ്ട്. അതായത് Q 4 കാലയളവിലെ താപനിലയിലെ ഒരു ശതമാനം വർദ്ധനവ് ഉത്പാദനം 13.9 ശതമാനവും Q 4 കാലത്ത് മഴയുടെ ഒരു ശതമാനം വർദ്ധനവും ഒപ്റ്റിമൽ താപനിലയും വാഴയുടെ ഉത്പാദനം 0.42 ശതമാനം വർദ്ധിപ്പിക്കും. Q 2 വിൽ (ഏപ്രിൽ-ജൂൺ) വാഴ നട്ടവർക്ക് വളർച്ചയുടെ പ്രധാന ഘട്ടമാണ് Q 4, എന്തെന്നാൽ Q4 പൂവിടുന്നതും പരാഗണം നടക്കുന്നതും കായ് രൂപപ്പെടുന്നതുമായി ഒത്തുചേരുന്നു.

മൊത്തത്തിൽ പ്രതികരിച്ചവരിൽ 65 ശതമാനവും 71 ശതമാനവും യഥാക്രമം വിള ഇൻഷുറൻസ് എടുത്തവരും, സമ്മിശ്ര ഹ്രസ്വകാല വിളകൾ (പച്ചക്കറികൾ) കൃഷി ചെയ്യുന്നതും പ്രധാന അഡാപ്റ്റേഷൻ രീതിയാണെന്ന് വിശകലനം വെളിപ്പെടുത്തി. പൊരുത്തപ്പെടൽ തന്ത്രങ്ങൾ പിന്തുടരുന്നവരിലും അല്ലാത്തവരിലും റിപ്പോർട്ട് ചെയ്ത വിളവിൽ 100 ശതമാനം കുറവുണ്ടായതാണ് പ്രധാന ആഘാതം. കൂടാതെ, പൊരുത്തപ്പെടൽ തന്ത്രങ്ങൾ സ്വീകരിക്കുന്നവർ പിന്തുടരുന്ന മറ്റ് അഡാപ്റ്റേഷൻ രീതികളുമായി താരതമ്യപ്പെടുത്തുമ്പോൾ അവർക്ക് 17,722 ഹെക്ടർ$^{-1}$ രൂപ ചെലവ് വരുന്ന അഡാപ്റ്റേഷൻ പരിശീലനമാണ് പ്രോപ്പിംഗ് . പൊരുത്തപ്പെടൽ തന്ത്രങ്ങൾ പിന്തുടരാത്തവരുടെ കാര്യത്തിൽ, പിൻതുടർന്ന മറ്റ് അഡാപ്റ്റേഷൻ രീതികളുമായി താരതമ്യപ്പെടുത്തുമ്പോൾ, പ്രോപ്പിംഗിനുള്ള പ്രധാന ചിലവ് 8,951 ഹെക്ടർ$^{-1}$ ആയിരുന്നു.

പൊരുത്തപ്പെടൽ തന്ത്രങ്ങൾ പിന്തുടരുന്നവരുടെ അഡാപ്റ്റേഷൻ രീതികളെ സ്വാധീനിക്കുന്ന സാമൂഹിക സാമ്പത്തിക വേരിയബിളുകൾ തിരിച്ചറിയാൻ ബൈനറി ലോജിസ്റ്റിക് റിഗ്രഷൻ വിശകലനം നടത്തി. പ്രാധാന്യത്തിന്റെ 1 ശതമാനം തലത്തിൽ വിസ്തീർണവും വരുമാനവും പോസിറ്റീവ് പ്രാധാന്യമുള്ളതായി കണ്ടെത്തി. വിസ്തീർണ്ണത്തിനും വരുമാനത്തിനുമുള്ള അസന്തുലിത അനുപാതം 1.04 ഉം 1.99 ഉം ആയിരുന്നു. പ്രതികരിക്കുന്നവരുടെ സാമൂഹിക സാമ്പത്തിക സ്ഥിതിയിൽ നിന്ന്, മൊത്തം തലത്തിൽ, പ്രതികരിച്ചവരിൽ 38 ശതമാനം പേർക്കും 0.2 മുതൽ 0.4 ഹെക്ടർ വരെ വാഴക്കൃഷി ഉണ്ടായിരുന്നു. ഇതിനർത്ഥം, ഏത്തവാഴ കൃഷിയിൽ കൂടുതൽ സ്ഥലവും കൂടുതൽ വരുമാനവുമുള്ള കർഷകർ, വിസ്തൃതിയും വരുമാനവും കുറവുള്ള കർഷകരെ അപേക്ഷിച്ച് ഒരു മടങ്ങ് കൂടുതൽ അഡാപ്റ്റേഷൻ രീതികൾ സ്വീകരിക്കാൻ സാധ്യതയുണ്ട്. കണക്കാക്കിയ ഭാഗിക ഇലാസ്തികത കാണിക്കുന്നത് വാഴക്കൃഷിയുടെ വിസ്തൃതിയിൽ ഒരു ശതമാനം വർധനവുണ്ടായാൽ, അഡാപ്റ്റേഷൻ രീതികൾ അവലംബിക്കുന്നതിനുള്ള സാധ്യത 0.99 ശതമാനം വർദ്ധിക്കുന്നു.

CACP ചെലവ് ആശയം ഉപയോഗിച്ചാണ് വാർഷിക കൃഷിച്ചെലവ് കണക്കാക്കുന്നത്. പിന്തുടരുന്നവർ (₹ 3,74,844 ഹെക്ടർ$^{-1}$) ചെലവ് സി യുടെ അളവ് പിന്തുടരാത്തവരെകാൾ (₹ 3,33,862.31 ഹെക്ടർ$^{-1}$) 12.27 ശതമാനം കൂടുതലാണ്.

പിന്തുടരുന്നവർക്കുള്ള C-യിൽ അറ്റ വരുമാനം ₹ 4,27,932 ഹെക്ടർ$^{-1}$ ആയിരുന്നു, പിന്തുടരാത്തവർക്ക് ₹ 1,96,634 ഹെക്ടർ$^{-1}$. പിന്തുടരുന്നവർക്കുള്ള കോസ്റ്റ് സിയിലെ ബെനഫിറ്റ് കോസ്റ്റ് റേഷ്യോ 2.14 ആയിരുന്നു, ഇത് പിന്തുടരാത്ത വരേക്കാൾ 1.59 ആയിരുന്നു. പിന്തുടരുന്നവരുടെ (16,056 കി.ഗ്രാം ഹെക്ടർ$^{-1}$) വിളവ് പിന്തുടരാത്തവരേക്കാൾ (11,287 കി.ഗ്രാം ഹെക്ടർ$^{-1}$) 42.25 ശതമാനം കൂടുതലാണ്. പിന്തുടരുന്നവരുടെ കാര്യത്തിൽ മൊത്ത വരുമാനം 8,02,775 ഹെക്ടർ$^{-1}$ ആയിരുന്നു, ഇത് പിന്തുടരാത്തവരേക്കാൾ 51.32 ശതമാനം കൂടുതലാണ് (₹ 5,30,497 ഹെക്ടർ$^{-1}$).

Q4 (ഒക്ടോബർ മുതൽ ഡിസംബർ വരെ) താപനിലയും മഴയും വാഴ ഉൽപാദനത്തിൽ നല്ല സ്വാധീനം ചെലുത്തി. വാഴക്കൃഷിക്ക് കീഴിലുള്ള വിസ്തൃതിയിലും വരുമാനത്തിലും വർധനവ് അനുരൂപീകരണ രീതികൾ സ്വീകരിക്കുന്നതിനുള്ള സാധ്യത വർദ്ധിപ്പിക്കുന്നു. പിന്തുടരുന്നവരുടെ മൊത്തം വരുമാനം പിന്തുടരാത്തവരേക്കാൾ കൂടുതലാണ്.