MITIGATING PRODUCTION VULNERABILITY OF BANANA THROUGH WEATHER BASED CROP INSURANCE: AN ECONOMIC ANALYSIS

by
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THESIS
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DECLARATION

I, hereby declare that this thesis entitled "**MITIGATING PRODUCTION VULNERABILITY OF BANANA THROUGH WEATHER BASED CROP INSURANCE: AN ECONOMIC ANALYSIS**" 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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Certified that this thesis entitled "**MITIGATING PRODUCTION VULNERABILITY OF BANANA THROUGH WEATHER BASED CROP INSURANCE: AN ECONOMIC ANALYSIS**" is a record of research work done independently by **Mr. Ajmal S. (Admn No. 2017-11-075)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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Ajmal S.

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LIST OF ABBREVIATIONS

BCR	Benefit Cost Ratio
CSO	Central Statistical Organisation
CGWB	Central Ground Water Board
GSVA	Gross State Value Added
GOI	Government of India
GOK	Government of Kerala
HS	High School
HSS	Higher Secondary
IPCC	Intergovernmental Panel on Climate Change
LVI	Livelihood Vulnerability Index
SDMA	State Disaster Management Authority
MFC	Marginal Factor Cost
MPP	Marginal Physical Product
MVP	Marginal Value Product
MFMS	Mobile Fertilizer Management System
MNAIS	Modified National Agricultural Insurance Scheme
VIF	Variable Inflation Factor
WBCIS	Weather Based Crop Insurance Scheme

LIST OF SYMBOLS

°C	Degree Celsius
ha	Hectares
%	Per cent
km^2	Square Kilometre
ha^{-1}	Per hectare
Kg	Kilogram
q	Quintal
t	Tonnes
₹	Rupees

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Introduction

1. INTRODUCTION

Agriculture, with its allied sectors, is undoubtedly the largest contributor to sustenance in India, more than 50% of our population depends directly or indirectly on agricultural activities, even more in vast rural areas. It also assigns a significant level to the Gross Domestic Product (GDP). From the period of independence to the present, India has made rapid progress in the development of agriculture, from an alms bowl to a bread basket. Currently, India is the forerunner in the production and consumption of many agricultural produce and products. Among the agricultural production of India, a considerable part is given by the production of fruits. According to the National Horticultural Board (NHB) estimate in 2017-18, there was a production of 9.73 million tonnes from an area of 65.06 thousand lakh.

Banana is a flowering herbaceous plant, considered to have originated in South East Asia and Papua New Guinea and currently cultivated in 120 countries worldwide. Banana have been part of our diet for about a millennium and its history dates back to around 500 BC. Today they are one of the most popular fruit in the world. Banana crop is grown all over the country and India has a production of about 30,80,000 tonnes of banana from an area of about 8.84 lakh hectares in the year 2017-18 (NHB, 2018). The main feature of this plant is that it can be grown all year round and it is discovered that new technologies and improved cultivation methods increase both yield and profit. In Kerala, banana is consumed by the people daily and many farmers turned to banana cultivation because of profitability. In 2016-17, Kerala produced about 4,89,322 tonnes of banana from an area of 57,140 ha with an average productivity of 8.56 t / ha. The maximum production was in the district of Palakkad (1,39,231 tonnes), followed by Wayanad district (71,357 tonnes) (GOK, 2018). But the banana cultivation is vulnerable to changes in weather parameters, especially rainfall and wind pattern.

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Vulnerability, which can be defined as the extent to which climate change can damage or harm a system, not only depends on the sensitivity of the system but also on the ability to adapt to new climatic conditions (IPCC, 1996 & 2007). In the current scenario, all the components associated with agriculture are highly vulnerable to changes in climate. Frequent extreme weather events and displaced seasons are causing a worry to the farmers and above all, threatens food security. It has been seen that the devastating flood of Kerala in 2018 had affected almost all the districts and caused a great loss in agricultural production. It is clear that both at the macro level (taking a large area, for example in a district) and at the micro level (household level, even individual level), vulnerability to climate change is different. So, it is important to take up vulnerability studies in all the possible levels and to take up corrective policy decisions. In this context, present study analyses the vulnerability of agriculture in general along with vulnerability of banana farmers in particular climate change in the Palakkad and Wayanad districts of Kerala.

Weather Based Crop Insurance Scheme (WBCIS)

WBCIS was introduced in India during Kharif 2007 period to mitigate the hardship of the farmers against adverse weather conditions. The WBCIS uses weather parameters as proxy for crop yields in compensating the farmers for crop losses. Pay-out structures were developed to compensate the extent of losses deemed to have been suffered using the weather triggers. Almost all the crops were covered under this scheme.

Following major weather perils such as, a) Rainfall – Deficit Rainfall, Excess rainfall, Unseasonal Rainfall, Rainy days, Dry-spell, Dry days b) Temperature – High temperature (heat), Low temperature c) Relative Humidity d) Wind Speed e) A combination of the above f) Hailstorm, cloud-burst which are deemed to cause "Adverse Weather Incidence", leading to crop loss covered under this scheme. The perils listed above are only indicative and not exhaustive and any addition / deletion

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may be considered by state government in consultation with insurance companies based on availability of relevant data. Selected Reference Weather Stations (RWS) and additional weather stations designated as Back-up Weather Stations (BWS) is used for getting weather parameters. All the details related with insurance such as area of coverage, sum insured, indemnity level, crops covered will be there in the notification by state government. From 2016 Kharif period, WBCIS had been renamed as Restructured Weather Based Crop Insurance without much changes. In this study, the scope of Weather based crop insurance was analyzed in banana cultivation of Palakkad and Wayanad districts and its needs.

This study was carried out in the Palakkad and Wayanad districts, where banana is grown extensively and implementation of WBCIS is more in Kerala. These places are also most vulnerable to climate change in Kerala. The study is conducted with the following three objectives:

1. To assess the vulnerability of agriculture in general and banana cultivators in particular to climate change in Palakkad and Wayanad districts,
2. To evaluate the economic benefits of weather based crop insurance for banana cultivators.
3. Study the problems and suggest measures for scaling up of Weather Based Crop Insurance.

1.1. SCOPE OF THE STUDY

This study assumes importance as it is attempted to assess the vulnerability of agriculture to climate change of the study area based on the socioeconomic characteristics, physiographic characteristics and meteorological data from the two districts and climate change vulnerability of banana farmers with primary data collected from farmers. Economic benefits for insured farmers in comparison with uninsured farmers was analysed using economic tools. The farmers' level of perception on WBCIS was studied to know the problems associated with it. Analysis was also done to identify the various constraints that farmers face in adopting the WBCIS in banana cultivation.

1.2. LIMITATIONS OF THE STUDY

Since it is a postgraduate programme research work, there is a limitation of time, finance, accessibility and other resources. The study is limited to Palakkad and Wayanad districts and the results cannot be generalised for the entire state of Kerala due to various climatic and physiographic conditions. This is a constrained measure of vulnerability using the available data and not an exact measure due to many limitations. The primary data collected from the farmers were memory-based information. The meteorological data collected from the RARS, Ambalavayal, Wayanad and RARS, Pattambi, Palakkad may not highlight the climatic condition of entire districts. Despite these limitations, the researcher has made sincere efforts to carry out the study as accurately as possible.

1.3. PRESENTATION OF THE THESIS

This thesis contains five chapters. This chapter brings the image of the objectives, scope and limits of the study. The second chapter, review of the literature, contains the previous works related to this research. In the third chapter, materials and methods include the analytical tools used to extract inferences. The fourth chapter, results and discussion, highlights the conclusions drawn from the analysis of the data collected. The fifth chapter represents the summary of the entire study. References and abstracts are provided at the end of the thesis.

1.4. FUTURE PROSPECTS

This study focused only on banana crop. Similar studies can also to be taken in other agricultural crops to bring out the complete picture of vulnerability of climate change. This vulnerability studies can be further used for the better policy formulations. Further study can also be done in WBCIS to make the scheme more farmers friendly and better implementation of the scheme.

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Review of Literature

2. REVIEW OF LITERATURE

A thorough review of previous studies is needed to fully understand the research problem. The objectives of this research problem were to analyze the concept of vulnerability to climate change, the economic benefits of Weather Based Crop Insurance Scheme (WBCIS) as an adaptation and the constraints in adapting it. A detailed review of the literature was carried out to help the present study and to achieve the research objectives. The studies relating to the current research topic are presented in the following subtitles.

2.1. Studies on vulnerability to climate change

2.2. Studies on vulnerability index

2.3. Studies on crop insurance as an adaptation to climate change

2.4. Studies on economic benefits of crop insurance

2.5. Studies on weather based crop insurance

2.6. Studies on constraints in adoption of crop insurance

2.1. STUDIES ON VULNERABILITY TO CLIMATE CHANGE

Agriculture and its allied activities are highly vulnerable to climate change. Vulnerability indicates the extent to which a system is exposed to being damaged. Vulnerability to climate change can be defined for a wide geographical area or even in a farm household level. The following reviews will give a clear idea of the concept of vulnerability to climate change and its various components.

Blaike *et al*. (1994) stated that vulnerability is the characteristics of a person or a group in terms of their ability to anticipate, face, resist and recover from the impact of natural hazards and, furthermore, stated that the vulnerability can be seen in a range of resilience to susceptibility.

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According to IPCC (Intergovernmental panel on climate change) (1996), vulnerability was defined as the extent to which a system can be damaged by the effects of climate change; it does not only depend on the sensitivity of the system but also on its ability to adapt to new climatic conditions.

Adger (1999) recognized vulnerability as the extent to which a social or natural system is likely to be damaged from climate change. It is generally perceived as the function of two components; the effect that an event can have on humans, referred to as capacity or social vulnerability; and the risk of such an event, called an exposure.

Kelly and Adger (2000) defined vulnerability in terms of the ability of individuals and social groups to cope and recover or adapt to any external stress on their livelihood and well-being. This definition of vulnerability places the social and economic well-being of society at the center of the analysis, focusing on the socio-economic and institutional constraints that limit response capacity. From this perspective, the vulnerability or security of any group is determined by the availability of resources and the right of individuals and groups to request these resources.

Luers *et al.* (2003) measured the vulnerability of wheat yields to climate change and to market fluctuations in the Yaqui Valley in Mexico by selecting outcome variables of concern to stressors identified as a function of the state of variables of concern relative with a threshold damage, the sensitivity of the variables to stress factors and the extent and frequency of the stress factors to which the system is exposed. It also provided a framework to assess the extent to which adaptive capacity can reduce vulnerable conditions.

O'Brien *et al.* (2004) stated that vulnerability to climate change is generally considered a function of some of the biophysical and socioeconomic factors. The vulnerability can be characterized on the basis of three components: adaptability, sensitivity and exposure. The adaptability pronounces the ability of a system to adapt to real or expected climatic stresses, or to cope with the consequences.

Sensitivity refers to the degree to which a system responds to climate change, positively or negatively, and exposure is related to the degree of climate stress in a particular unit of analysis; it can be represented as long-term changes in climate conditions or changes in climate variability, including the magnitude and frequency of extreme events.

Luers (2005) recognized that vulnerability can be characterized as the sensitivity to or exposure of a system (from an individual level to a geographical area) to shocks, stresses or disturbances in which the system is relative to a threshold damage, and the system's ability to adapt to changing conditions. The terms shocks, disturbances and stresses particularly refer to the external forces that have a potential to cause an adverse impact and these exogenous forces is beyond the power of the analytical units, such as individual or household.

Adger (2006) stated that vulnerability is the state of susceptibility of a system to harm from the exposure of environmental and social stresses. It results from the absence of adaptation capacity. Vulnerability to climate change can be formulated as a characteristic of social-ecological systems and it is linked to resilience.

The exposure represents the underlying climatic conditions and elements of climate change with respect to which a system operates, and any changes in such conditions. This as a component of vulnerability is not only the extent to which a system is subject to significant climatic variations, but also the degree and duration of these variations (Adger, 2006).

Smit and Wandel (2006) recognized that a system is vulnerable when exposed and is sensitive to the effects of climate change and, at the same time, has only a limited capacity to adapt. On the contrary, a system is less vulnerable if it is less exposed, less sensitive or has a great ability to adapt.

According to the definition of the IPCC (2007), in the context of climate change, vulnerability is the degree to which a system is susceptible and cannot cope with the negative effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, the breadth and speed of climate change and the variations to which a system is exposed, its sensitivity and its ability to adapt. For example, agricultural vulnerability to climate change can be described in terms of exposure to high temperatures, sensitivity of crops to high temperatures and farmers' ability to adapt to the effects of this exposure and sensitivity. This definition specifically provides vulnerability to climate change in terms of three components: exposure, sensitivity and adaptability.

The sensitivity of a system to climate change is the degree to which a system is negatively or beneficially influenced, due to climate variability or change, the effect can be direct or indirect. Sensitivity reflects a system's ability to respond to climate change and the degree to which it could affect its current form. A sensitive system is highly sensitive to the climate and can be significantly influenced by small climate changes. Adaptive capacity is the system's ability or potential to adapt effectively to climate change to limit potential damage, exploit opportunities and cope with consequences (IPCC, 2007).

Nelits *et al.* (2013) stated that, range of approaches available for assessing the vulnerability includes an *impact assessment* focusing on future climate exposure and the sensitivity of the system to this change, a *first-order vulnerability assessment* focusing on exposure and sensitivity to biophysical and socio-economic impacts and evaluation of *second order vulnerability*, which is a first order assessment that includes a consideration of adaptive capacity. These approaches represent top-down methods for assessing local impacts on human communities and ecosystems. Bottom-up or participatory approaches represent different but complementary approaches based on community perspectives and knowledge to understand current and future vulnerabilities.

Shaha *et al.* (2013) characterized vulnerability to climate change based on the exposure and sensitivity of a system to climate extremes and its ability to adapt to its adverse effects, which corresponds to endpoint vulnerability.

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Raju *et al.* (2017) stated that vulnerability is often reflected in the economic system, as well as in the socio-economic characteristics of the population living in a system. Vulnerability assessments can play a fundamental role in the design of adequate adaptation and mitigation policies geared towards climate change and its impacts on ecosystems and for those who depend on sensitive resources for their livelihood and well-being.

2.2. STUDIES ON VULNERABILITY INDEX

Deressa (2008) studied the vulnerability of Ethiopian farmers to climate change, taking that as a function of exposure, sensitivity and adaptability. The Principal Component Analysis was used to calculate the vulnerability index of the regional states of Ethiopia. The results of the study revealed that the Afar and Somali states were more vulnerable to climate change due to their low level of regional development; The more vulnerability of Tigray and Oromia had attributed to a greater incidence of droughts and floods and to a lower access to technology, institutions and infrastructure.

Gbetibouo and Ringler (2009) analyzed the vulnerability of South African farmers to climate change and variability by developing a vulnerability index and comparing vulnerability indicators in the nine provinces of the country. Enough environmental and socioeconomic indicators had identified in the study to reflect the three components of the vulnerability: exposure, sensitivity and adaptive capacity. They found that the region most vulnerable to exposure to extreme events and climate change and variability do not always overlap with the most vulnerable populations and, that vulnerability to climate change and variability are basically linked to social and economic development. Based on the study, large differences in the degree of vulnerability among the provinces indicated that policy makers should develop specific policies in the region to tackle climate change at the local level.

Yusuf and Francisco (2009) built an index of vulnerability to climate change in sub-national administrative areas in seven Southeast Asian countries. They

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assessed the exposure using information from historical documents related to climate-related risks and considered past exposure to climate risks as the best alternative available for future climate risks; and prepared climate risk maps for five climate-related risks: tropical cyclones, floods, landslides, drought and sea level rise. As an indicator of the sensitivity to climate change of human exposure, population density was used with the hypothesis that relatively less populated regions will be less vulnerable than regions with high population density, given the same degree of exposure to climate hazards, and also in the human aspect of vulnerability, the ecological sensitivity of the region was included, using information on biodiversity as a proxy variable. The adaptative capacity index was created based on socio-economic factors, technology and infrastructure. Based on all these indices, authors had constructed an index of general vulnerability to climate change in the region.

Devi *et al.* (2011) studied the vulnerability to water scarcity in all the districts of Kerala over two time periods. The two main factors influencing vulnerability were the combined positive effect of exposure and sensitivity and the negative effect of the level of adaptation. Vulnerability was calculated from the exposure index, the sensitivity and the adaptation indices, which were estimated by selecting some of the variables and based on their hypothesized relation to vulnerability. A vulnerability map was created to classify the fourteen districts into low, medium and high vulnerability categories. The vulnerability index for this mapping was developed based on agronomic, climatic, socio-economic and physical factors.

Heltberg and Osmolovskiy (2011) developed the vulnerability index to climate change and variability in Tajikistan. This index was created based on exposure to climate variability and natural disasters, sensitivity to the impacts of this exposure and the ability to adapt to current and future climate changes. The results revealed that the vulnerability varies according to socioeconomic and institutional development in ways that do not derive directly from exposure or elevation. Also stated, in climate change geography was not the destiny.

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Ravindranath *et al.* (2011) developed an index-based approach to assess the vulnerability profiles of climate change at the district level for the agricultural, water and forestry sectors in the north-eastern region of India. A series of major indicators representing the vulnerability of agriculture, forests and water was selected using the Principal Component Analysis. The impacts of climate change in key sectors represented by changes in indicators were derived from impact assessment models. These relevant indicators were used to calculate the future vulnerability to climate change. The results of the study indicated that most districts in northeastern India were vulnerable to climate-induced vulnerability.

Ashok and Sasikala (2012) studied the vulnerability of farmers and tanks against rainfall variability in the Pudukottai district in Tamil Nadu. The vulnerability was estimated by calculating the livelihood vulnerability index. The exposure was evaluated using the components of natural disasters and climate variability. The social and economic characteristics of the families that influenced their adaptability. The current characteristics of health, food and water resources that determined their sensitivity to climate change. The study showed that farmers in the area of lower than normal rainfall had a greater vulnerability.

Tesso *et al.* (2012) studied the vulnerability of agricultural households in northern Shewa, in Ethiopia. The integrated approach was used to assess vulnerability using socio-economic and biophysical indicators. These indicators were adaptability, exposure, and sensitivity to climate change. The Principal Component Analysis (PCA) was used to calculate the vulnerability index of each agro ecological area. The results showed that farmers living in high-altitude areas were much more vulnerable than farmers living in low-altitude areas.

Haden *et al.* (2012) developed an index of agricultural vulnerability for the state of California, based on 22 biophysical and social variables. Each variable had assigned to any one of the four indices; Climate vulnerability, crop vulnerability, land use vulnerability and socioeconomic vulnerability in order to develop a general agricultural vulnerability. To facilitate statistical analysis, all the variables were standardized to represent percentages, index values, density or weighted averages per area for a 12.5 square kilometer (km^2) raster grid covering the entire territorial area of California (2.628 cells of the total grid). The study revealed that the Sacramento-San Joaquin delta, the Salinas valley, the Merced-Fresno corridor and the imperial valley were had a high agricultural vulnerability.

Karthick (2013) used the integrated assessment approach on the vulnerability of agricultural households to climate variability by developing agricultural vulnerability index. For the construction of indices greater importance was given to the analysis scale of vulnerability assessment, here it was selected as local or household level. The vulnerability index was created by developing indices for three main components; adaptability, sensitivity and exposure, each of which comprises of several sub-components.

Rao *et al.* (2013) developed the vulnerability index for all districts in India to assess the vulnerability of Indian agriculture to climate change. The index was developed based on three vulnerability components; Sensitivity, exposure and adaptive capacity. These were represented through a series of indicators that would reflect these components. The indices of sensitivity, exposure and adaptability had constructed by obtaining a weighted average of the identified indicators. Weights were assigned to each of these indicators based on theoretical and practical knowledge. These three indexes were averaged to obtain the vulnerability index, whose higher value indicates greater vulnerability and lower value indicates a lower vulnerability.

Panda and Govindarajalu (2015) have studied the gaps and variations in the methodologies for assessing the vulnerability of climate change used between the different states of India, which becomes complicated when planning and prioritizing adaptations and measuring their success. They found that it was necessary to develop standard procedures and guidelines for vulnerability assessment in various regions and sectors for efficient adaptation planning.

Bharti (2016) analyzed the vulnerability index and compared it between different districts in the chosen study area of Bihar district. A composite vulnerability index was developed, which emphasizes the three main components, namely exposure, sensitivity and adaptability. The four main vulnerability factors were taken into consideration to assess temporal and spatial vulnerability included demographic factors, climatic factors, agricultural factors and occupational factors. To build and compare vulnerability indices, the period 1976-2015 was divided into 4 parts, from 1976-1985, 1986-1995, 1996-2005 and 2006-2015, which means that the vulnerability was also quantified as spatial and temporal. The study found that, from the period 1986-1995, the Kishanganj district ranks first in the overall vulnerability to climate change among all selected districts in the region that replaced Khagaria district in second place, followed by Purnea district in the third. In the period 1996-2005, the Khagaria district ranked first position with demographic and agricultural indicators that contributed significantly to the general vulnerability to climate change. The values of the vulnerability indices ranged from 0.30 (Madhepura) to 0.59 (Kishanganj) in 1996-2005, which indicated that there was great variability in the factors influencing climate change. In the year 2006-2015, the Supaul district replaced Kishanganj from the first rank with reference to the general vulnerability to climate change.

Radhakrishnan and Gupta (2017) analyzed the vulnerability of dairy farmers to climate variability and change in the Wayanad district of the Western Ghats region in Kerala. A Livelihood Vulnerability Index (LVI) was developed based on the definition of the Intergovernmental Panel on Climate Change, with 28 indicators and 7 livelihood vulnerability index components. Normalized data were then combined into three indices, namely, sensitivity, exposure, and adaptability, which is then averaged with weights that were obtained from the principal component analysis in order to obtain the general index. The results indicated that dairy farmers in all Wayanad taluks were vulnerable to climate variability, being Pulpally taluk the most vulnerable, with 48.33% of farmers in the high vulnerability category with a large variation in LVI components between taluks.

2.3. STUDIES ON CROP INSURANCE AS AN ADAPTATION TO CLIMATE CHANGE

According to Raju and Chand (2008), agricultural insurance was one of the methods by which farmers can stabilize farm incomes and investments against the disastrous effects of natural risks and low market prices. Crop insurance also helps farmers start an agricultural production business after a bad agricultural year, helping farmers to overcome the impact of crop losses by providing a minimum amount of protection. It helps farmers distribute crop loss in space and over time and helps farmers invest more in the crop production.

Falco *et al.* (2014) stated that financial insurance for extreme events can play an important role in covering against the implications of climate change. The study conducted on the basis of data extracted from the large Italian farms found that the demand for insurance products is destined to increase in response to weather conditions and the use of insurance reduces the extent of exposure to risk, moreover it has found that farms producing more crops are less likely to adopt the insurance scheme.

Swain (2014) stated that agriculture in India is at high risk due to production uncertainty and price volatility, and even more so in the context of greater climate deviations and globalization. In this situation, crop insurance provides economic support to farmers, stabilizes farm incomes, induces farmers to invest in agriculture, reduces indebtedness and reduces the need for aid measures in the event of crop loss. The insurance sector can help both in mitigation and adaptation to climate change by inducing adequate proactive and reactive responses among insurers. The mitigation responses include measures such as encouraging the use of clean technologies, climate-friendly cultivation patterns, promoting organic farming and energy-efficient agriculture, and proactive adaptation responses include measures such as encouraging the cultivation of varieties resistant to drought, pest management, seed treatment and using an efficient irrigation method.

According to Sarangi and Panigrahi (2016), compensating farmers for a disaster will become the responsibility of a government, however, if the state can take out insurance before a disaster occurs, the cost of catastrophe spending could decrease. If governments were to insure for a catastrophic risk, farmers would be left at a moderately moderate risk, so the premium they have to pay will be reduced and the product of crop insurance will become affordable for them.

Elum *et al.* (2018) studied crop insurance as an adaptation measure to adapt to climate change, in order to reduce risks in production and prices of agricultural products. The study examined the effects of the varying climatic conditions and insurance on the net income of the crops using the method of regression of the instrumental variable in a Ricardian model. Factors that influence insurance studied using a probit model. The results of the study indicated that the possession of insurance, the number of workers employed, the size of irrigated agricultural land and precipitation had significant effects on net income, it was also revealed that the experience, indicated by the years of agriculture and income, influenced the adoption of insurance by farmers.

The Pande (2018) stated that India needs to strengthen crop insurance policies for better adaptation and called on the Indian government to immediately consider crop insurance schemes as climate adaptation schemes and provide coverage of all farmers in these schemes with government guarantee, improved crop loss monitoring systems and timely payments covering the entire loss for farmers.

2.4. STUDIES ON ECONOMIC BENEFITS OF CROP INSUARNCE

Birari *et al.* (2002) conducted a study on the crop insurance scheme as a means of livelihood security in the rainfed agriculture areas of western Maharashtra. They observed that the insured farms had between 11-34% more productivity than uninsured farms. Similarly, the gross yield per hectare of the insured was higher between 26-46% compared to the uninsured farmers. They also realized that the crop insurance scheme as an important measure to improve economic conditions, stabilize incomes and provide additional employment for farmers.

Olubiyo *et al.* (2009) evaluated the impact of crop insurance on agricultural practices and crop production. The results of the study revealed that farmers differ in their use of agricultural resources and the level of output produced. Most insured farmers applied better agricultural practices and were more commercially oriented. Insured farmers have ventured into riskier initiatives and put more of their production up for sale. It was discovered that uninsured farmers were more productive and efficient in using the resources than insured farmers.

Kiran (2010) studied the impact of crop insurance on resource use efficiency in potato cultivation in the Hassan district of Karnataka. The result of the study revealed that insured farmers used resources more efficiently than uninsured farmers. Insured farmers used 6.25 per cent and 20.89 per cent more seeds and FYM respectively than uninsured farmers, which resulted in a higher yield of 9.08 per cent for them.

Rathore *et al.* (2011) assessed the performance of the crop insurance scheme on beneficiary and non-beneficiary farms in the Salumber district of Udaipur district in Rajasthan. The study revealed that agricultural income per household is greater in beneficiary farms than non-beneficiary farms. The use and investment in factors such as human and bullock labour, seeds, manure, fertilizers and pesticides were found to be significantly higher in beneficiary farms than in non-beneficiary farms, mainly due to the guaranteed compensation of the insurance scheme. Moreover, the positive elasticity for the area cultivated with maize and wheat in the beneficiary categories indicated the possibility of a greater use of this input to increase agricultural production and gross income.

Vardan and Kumar (2012) studied the impact of crop insurance on rice cultivation in Tamil Nadu, where the production risk was significantly absorbed and crop specialization was promoted and influenced to the use of high value inputs, which in turn has helped improve returns from farming.

Varalakshmi (2014) studied the impact of WBCIS (Weather Based Crop Insurance Scheme) on chilli farmers of Guntur district of Andhra Pradesh. The results of the study found that cost of the labour, fertilizers and value of farm assets were positive and significant at 5 per cent level in both insured and uninsured chilli cultivators. The farm size, value of assets and holding of insurance policy were found significant in pooled estimates. The sum of elasticities indicated increasing returns to scale in all farms, means that gross value of chilli increases proportionately with an increase in the variable factors. The sign of the coefficient obtained in the analysis was positive, thereby proved that the insured farmers were more efficient in the bundle of resource use than the uninsured farmers. The study found that the net returns obtained by insured farmers (₹ 2,02,978.9 ha^{-1}) were higher than for uninsured farmers (₹ 1,78,951.67 ha^{-1}). The total production per hectare of chilli under insured farmers was 68.42 q while it was 62.97 q for uninsured farmers.

Stephy *et al.* (2018) estimated the cost of cultivation of banana for insured and uninsured farmers separately based on the data collected from a total of 80 farmers from four Panchayats of Neyyatinkara taluk in the Thiruvananthapuram district of Kerala. The results of the study found that insured farmers were investing more in input than uninsured farmers. It was also revealed that farmers who adopted crop insurance incurred a higher cultivation cost, obtained a better yield and a higher BC ratio from Nendran banana cultivation and, they also stated crop insurance as a tool to help farmers to mitigate the risk factor by transferring the risk component. to the insurance authority.

2.4. STUDIES ON WEATHER BASED CROP INSUARNCE

Barnett and Mahul (2007) stated that the weather index insurance for agriculture and rural areas in low-income countries have particular advantages due to the simplification of the process, it was not necessary to estimate the actual loss suffered by the buyer since the indemnities are paid exclusively on the value realized by the underlying index. Furthermore, it was not necessary to classify the

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individual insured according to their risk exposure, unlike traditional insurance products. The weather index insurance offers risk management opportunities for the rural poor and was not based on actual losses suffered by the insured, but on the realization of a weather index.

Biswas *et al*. (2009) stated that the Weather Based Crop Insurance Scheme (WBCIS) was a single insurance product designed to provide protection against crop losses due to adverse weather conditions, and provided benefits against adverse weather incidents in both kharif as well as rabi seasons. WBCIS was introduced in India from the 2003 kharif season and the states such as Andhra Pradesh, Chhattisgarh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan were piloted the scheme. In addition to government agencies, private insurers such as ICICI-LOMBARD and IFFCO-TOKIO were included for the implementation of WBCIS in selected areas. The main limitations of index-based climate insurance were that it covered only a part of the exogenous risks faced by farmers and the main advantage was the low transaction cost compared to traditional crop insurances.

Nair (2010) analyzed the performance of weather-based crop insurance in India through a microanalysis of indemnity payments under the traditional insurance scheme and weather insurance system, and discovered a much wider distribution of benefits under the weather insurance scheme, and it significantly reduced the disadvantages of decades of area yield schemes. The study also points out that there have been critical problems that deserve action to achieve the desired results, rather than their enormous potential to emerge as a sustainable agricultural insurance that meets the risk management needs of rural poor people.

Bokuscheva and Breusted (2012) assessed the predictive power of ex-post risk reduction for different weather based indices, as well as the area yield index and agricultural yield insurance contracts based on data from 40 wheat producers in Kazakhstan. Empirical analysis has shown that the ex post approach can overestimate future reductions in farmers' risk due to crop insurance schemes based on indexes or area yields. Therefore, they argue that the decision to market index-based insurance instruments should be based on a broader approach than the common ex post approach.

Clarke *et al.* (2012) studied the weather index in the insurance market in India, including the evaluation of the indices used for insurance purposes and a description and analysis of common approaches to the design and ratemaking. The results of the study suggested that insurance products should be designed based on agronomic principles and further investments are needed both to quantify the level of risk based on existing products and to develop improved products with lower base risk, the use of hybrid products that combine both area yield and weather indices, a portfolio approach for product prices, legislation for indexed insurance products, product standardization, long-term contracts or separation of product design and delivery roles.

Kumar and James (2012) studied Weather Based Crop Insurance Scheme in the Palakkad district of Kerala. For the study, farmers, both loanee and non-loanee, were interviewed to learn about their response to the scheme and a discussion of the focus group was also held with other interested parties such as insurance agents, bank officials, agricultural officials, leaders of Padashekara Samidi. The results of the study highlighted the need to improve this scheme so that this scheme become transparent and the objective calculation of the weather index and the rapid settlement of claims were essential to make it attractive for farmers. The authors also reported that the weather index insurance was similar to the area insurance yield performance and provides timely compensation based on the climate index.

Mirranda and Farrin (2012) stated that the conventional insurance, which compensates the insured for verifiable production losses deriving from multiple risks, the index-based insurance compensates the insured based on the observed value of a specific "index" or some other closely related, and highly correlated with losses. Index insurance shows lower transaction costs than conventional insurances, which potentially makes it more accessible to the poor in developing countries, but it also offers less effective individual protection against risks.

Ashoka and Reddy (2015) stated that the weather index-based crop insurance scheme aims to provide insurance protection to all farmers against adverse weather conditions affecting crops. They analyzed the performance of WBCIS in India from the 2007 kharif season to the 2014 kharif, using secondary data. The results of the study indicated that there was an immediate need to cover all small and marginal farmers with this crop insurance, most of the farmers who were covered required more awareness, banks, insurers and governments that completely neglected the farmers non loanee farmers, it was also necessary to establish more automated weather stations for accurate management of meteorological data.

Nagaraja and Sriramalu (2015) analyzed the performance of WBCIS in India, with particular attention to the size of the market, the farmers' benefit ratio and the claims settlement ratio. A specific analysis was also carried out on performance of the state of India measured by the farmer's benefited ratio, the percentage of claims settlement, the average insured area and the percentage of claims paid to the gross premium collected under this scheme. The study found that adequate attention was needed to be paid to improving the claims settlement ratio, particularly in states such as Uttar Pradesh and Bihar, where it was found to be very low, also suggested the publication of detailed information on the protection received by the marginal and small farmers, who were resource-poor and prone to loss of income from the climate-influenced loss.

2.4. STUDIES ON CONSTRAINTS IN ADOPTION OF CROP INSURANCE

Manojkumar *et al.* (2003) analyzed the factors that led banana growers to adopt or not adopt an insurance scheme and reported that over 50% of respondents were willing to insure their crops, but the reason for unwillingness were the lack of confidence in the scheme and high premium rates, but most farmers mentioned other reasons and the most important as financial problems. They also reported that

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the respondents found other reasons for not adopting the insurance scheme, such as the difficulty in paying the premium during the crop gestation period, the large procedures and also the lack of knowledge of the scheme.

Kammar and Bhagat (2009) conducted a study to identify the constraints faced by farmers while adopting risk and uncertainty management strategies in the Solapur and Gulberga districts of Maharashtra and Karnataka respectively. Using the tool of regression analysis and factor analysis, it was found that the main constraints faced by farmers were subsequent droughts, increased cultivation costs, inadequate government support, the burden of liability, bad practices of market intermediaries and also poor infrastructure facilities.

Sundar and Ramakrishnan (2015) studied the extent of awareness on crop insurance, the benefits for the purchase and satisfaction among 360 paddy farmers in Kunichampet and Mannadipet villages of Puduchery. The results of the study revealed that factors such as lower benefits and dissatisfaction with the settlement of crop insurance claims were the main limitations in adopting crop insurance.

Mani *et al.* (2012) studied the adaptability of the crop insurance scheme in Tami Nadu, based on data collected from 90 farmers covered by the NAIS (National Agricultural Insurance Scheme) in the districts of Nagapattinam, Vellore and Madurai and 30 farmers under Varsha Bima, a weather-based crop insurance in Nagapattinam. The main limitations encountered in the execution of the insurance were the lack of knowledge of the scheme, delay in the settlement of claims, cumbersome procedure, high rate of premium and great variation between yields of actual and crop cutting experiment farms and lack of confidence in reference weather stations.

Kakumanu *et al.* (2013) studied farmers' preferences regarding weather insurance on rice crop, by analysing the average willingness to pay for weather-based crop insurance using the double bounded dichotomous model of the contingent valuation method. The results indicated that farmers' willingness to pay amounted to around 2.5% of gross income on the condition of timely payment of crop losses, creating awareness of compensation packages and simple documentation.

Rahman *et al.* (2014) studied the problems and prospects of crop insurance based on weather index in developing countries with a special reference to Bangladesh. The study identified that main constraints in implementation were limitations in product design, weather cycle; a problem common to all developing countries and the heterogeneity of farms and local risk variations in which it was specific to Bangladesh.

Sreejamol (2016) studied the policy holders' awareness about Weather Based Crop Insurance Schemes (WBCIS) in Kollengode taluk in the Palakkad district of Kerala. The study analyzed the awareness of the name of the institution that implements the crop insurance, the scope of coverage, the premium to be paid, the crops covered by the scheme and also the knowledge of the various procedures. The results clearly reflected the policy holders' uncertainty about the scheme and their limited experience.

Karthick *et al.* (2017) conducted a study on the adoption of crop insurance in the southern part of Tamil Nadu with a sample of 180 farmers who had adopted crop insurance schemes, to find the factors that influence and constraints in the adoption of crop insurance. The results of the study inferred that the lack of scope for crop diversification and the definitive loss of crops due to adverse weather conditions were the main factors that influenced the adoption of crop insurance schemes and the lack of compensation from the insurance scheme, delays in payment of compensation, shortage the awareness of the regime and the long procedure to avail the crop insurance were the main constraints.

Hazarika and Yasmin (2018) studied the adaptability constraints faced by farmers in the Modified National Agricultural Insurance Scheme (MNAIS) in Assam. The logit model with some of the important selected variables was used to discover the key factors influencing the participation of farmers in the Kamrup (R) and Dhubri district in adopting the crop insurance scheme. The study found that

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slow settlement of claims, crop-cutting experiments, lack of cooperation from officials, insurance units and insurance illiteracy were some of the main constraints faced by farmers in MNAIS.

Sona and Muniraju (2018) studied the state of adaptability, purchase benefits and satisfaction level of crop insurance among 50 farmers from ten villages in Madikeri taluk of Kodagu district in Karnataka. The results of the study indicated that 24 % of respondents opinioned the lack of knowledge about the scheme constituted the main constraint for the adoption of crop insurance such as the crops covered, the sum insured, the premium applied and the method of assessment of the loss. About 16% of farmers who had adopted crop insurance revealed that they were not satisfied with the late payment of indemnity and 12% of farmers expressed that the long procedure as the main constraint. The other constraints faced by farmers in the adoption of crop insurance were lower ability to pay premiums, the availability relief funds from government, administrative reasons and the lack of compensation even if the loss occurred due to crop failure.

Materials and Methods

3. MATERIALS AND METHODS

The choice of the appropriate methodology is extremely important to draw meaningful conclusions from the research. The proper methodology for data analysis was selected based on the literature review. In summary, the description of the study area, the source of the data and the analytical framework are presented in this chapter.

3.1. Description of the study area

3.2. Source of data

3.3. Variables and their measurement

3.4. Analytical framework

3.1. DESCRIPTION OF THE STUDY AREA

3.1.1. Kerala

Kerala is located on the south western tip of the Indian subcontinent, located between the Arabian Sea to the West and the Western Ghats in the East with an area of 38,863 square kilometers. Kerala comprises of 1.18 % geographical area of India and lies between East longitudes 74° 52' and 72° 22' and North latitudes 8° 18' and 12° 48'. Kerala is divided in East-West direction in to three parts- Highland, central plains and coastal areas, highland comprises of the area in and around the Western Ghats or Sahyadri which are mostly wet evergreen forests, the main rivers of Kerala originate from these plateaus. The coastal strip is parallel to the western Ghats and in between the highlands and the coastal plain are the middle lands, it is usually a combination of hills and valleys. There are three types of seasons in Kerala: South West monsoon from June to September (*Edavappathy*), October-December North East monsoon (*Thula Varsham*) and summer season (March-May). Kerala receives an average annual rainfall of 3,107 millimeters, which is higher than the average in India of 1,197 mm.

3.1.2. Palakkad District

Palakkad, also known as rice granary of Kerala, is one of the fourteen districts of Kerala and has no coastal belt. The district opens the state to the rest of the country through the Palakkad gap with a width of 32-40 km and the district is also known as the gateway to Kerala. The total geographical area of the district is approximately 4,480 km^2, equal to 11.5% of the state area, which makes Palakkad the largest district in Kerala. Out of the total district area, approximately 1,360 km^2 of land are covered by forests. Most of the district is in the Midland region, except the area of Nelliampathy-Parambikulam in Chittur taluk in the south and the area of Attappadi-Malampuzha in the north, which are hilly and fall into the highland region.

3.1.2.1. Chittoor Block

Chittur is located about 15 km from the city of Palakkad. Chittur, one of the 13 blocks in the Palakkad district, is bounded by the Kollengode Block to the West, the Malampuzha Block to the North, the Pollachi block of Tamil Nadu to the North, the Palakkad Block to the West. The Sokanashini River flows through Chittur. Agriculture is the main occupation of the people. It has an average altitude of 131 m (430 ft) and the average temperature varies from 25° C to 28° C.

3.1.3. Wayanad District

Wayanad district is located on the southern top of the Deccan highland. The district constitutes total area of 2,132 km^2, at an altitude between 700 m and 2100 m above the mean sea level on the eastern portion of north Kerala, bordering the states of Tamil Nadu and Karnataka. Among total area, about 885.92 sq. km of area is under forest. The district receives an annual rainfall of 2,322 mm. The high rainfall areas are Lakkidi, Vythiri and Meppadi. The district is blessed with rich water resources. One of the major river in the district is Kabani river, a tributary of river Kaveri; it is also one of the only three east flowing rivers in Kerala. Kabani has many tributaries including Thirunelli, Panamaram and Mananthavady rivers.

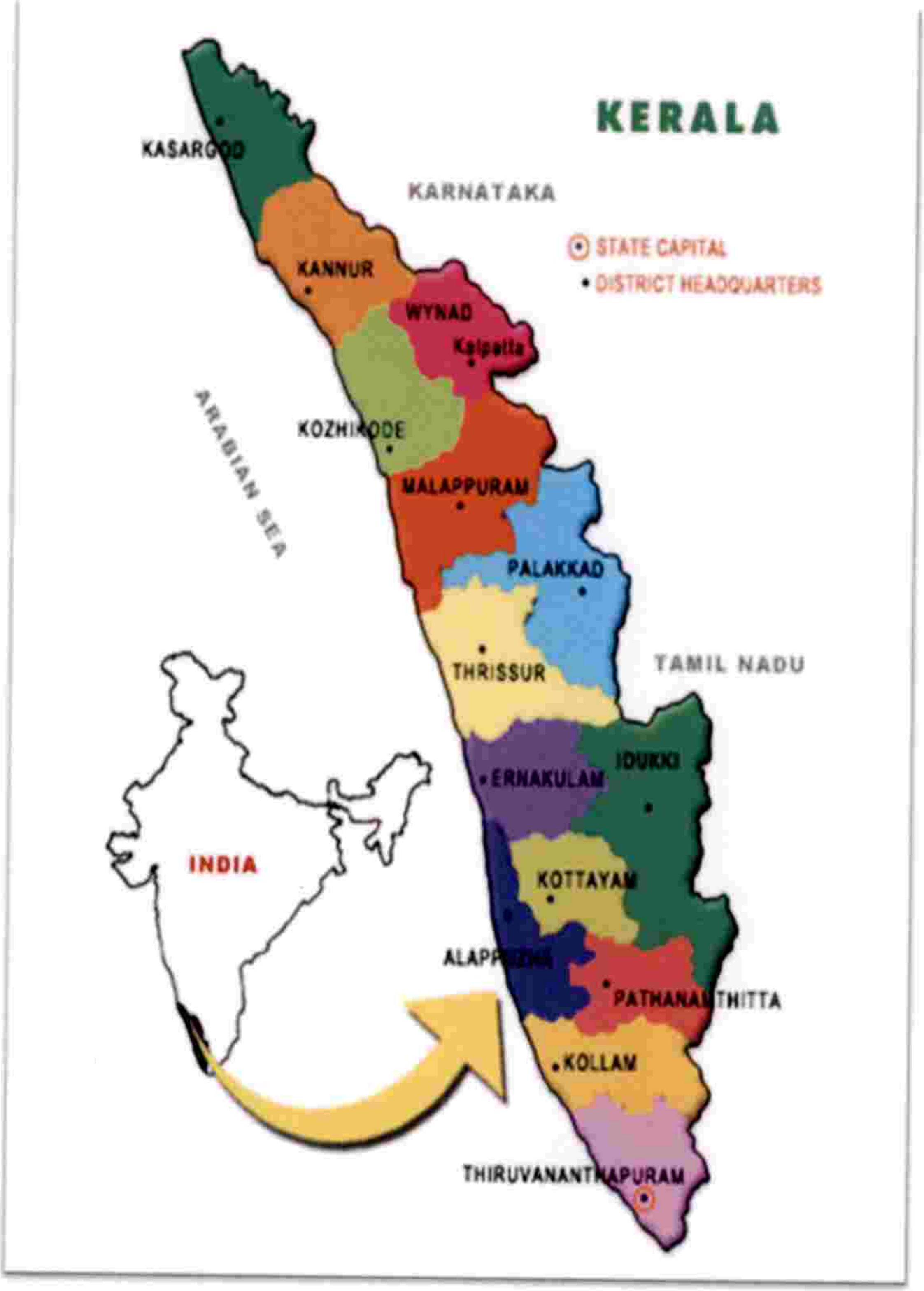

Figure 1. Political map of Kerala state.

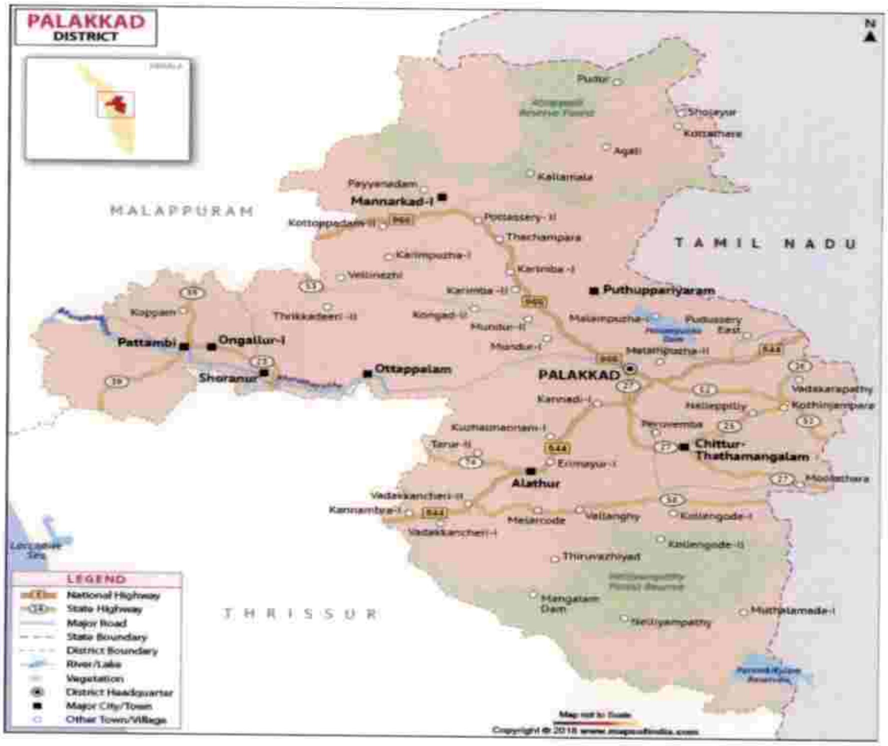

Figure 2. Political map of Palakkad district

Figure 3. Political map of Wayanad district.

3.1.2.1. Mananthavady Block

Mananthavady is located 28 km North-East of the Kalpetta, the district headquarters, 38 km from Sulthan Bathery, 80 km East of Thalassery and 92 km North-East of Kozhikode. Thalassery-Bavali Road is the main road that runs through Mananthavady, which is well connected to Mysore and Kodagu. It is located at an altitude between 700 and 2100 meters above sea level. Agriculture is the main occupation and has a healthy climate. The minimum and maximum average temperatures are 18° C and 29° C respectively.

3.2. SOURCE OF DATA

This study is based on both primary and secondary data.

3.2.1. Primary Data

Primary data was collected from both the Palakkad and Wayanad districts of Kerala, since it is considered that these districts are highly vulnerable to climate change, widely adopted Weather Based Crop Insurance Scheme (WBCIS) and also the forerunners in the banana production of the state. The selection of blocks and panchayath for the study was based on data obtained from Agricultural Insurance Company Limited located in Trivandrum. It is the nodal agency responsible for implementing this scheme in Kerala. Based on the criteria of maximum geographical area, the Chittoor block from Palakkad and Mananthavady from Wayanad districts were selected for the study. From each block, two panchayaths/municipality were selected based on the abundent availability of respondents for the study. Therefore, Nallepilly Panchayath and Eruthempathy panchayath of the Chittoor block and Mananthavady municipality and Thavinjal Panchayath of the Mananthavady block were selected. From each panchayath a sample of 15 insured purposively and 15 uninsured farmers randomly were selected making a sample of 60 farmers from a district and thus making a total sample of 120 farmers from both districts.

3.2.2. Secondary Data

The secondary data was obtained from both Palakkad and Wayanad districts. Meteorological data on rainfall, temperature of the last few years were collected from RARS Ambalavayal for Wayanad and RARS Pattambi for Palakkad district. Data on different vulnerability indicators were collected from various sources, such as government publications and authorized websites.

3.3. VARAIBLES AND THEIR MEASUREMENT

Data was collected from farmers through personal interviews using a pre-tested and well-structured interview schedule. The survey was conducted between March 2019 and April 2019.

3.3.1 Socioeconomic Status of the Selected Farmers

Socio-economic characteristics such as age, level of education, gender, family size, land ownership, annual income, annual expenses, experience in banana cultivation of respondents were collected through personal interview using a pre-tested and structured interview schedule.

3.3.2 Quantity of Inputs

Quantity of inputs such as sucker, farm manure, poultry manure, fertilizers, insecticides, pesticides, fungicides, liming material were collected and the cost of cultivation and the annual returns were calculated.

3.3.3 Cost of Inputs

3.3.3.1. Cost of Manures, Fertilizers and Plant Protection Chemicals

The manure produced on the farm was evaluated based on the prevailing market rates in the study area and the fertilizers, liming material and non-farm manures were valued at the purchase price. The purchase price of pesticides, insecticides and fungicides were used to calculate the cost those inputs.

3.3.3.2. Cost of Labour

1. **Family Labour**

The cost of family labour was imputed based on the prevailing wage rates paid for the hired worker in the area on number of labour days.

2. **Hired Labour**

The wages paid to workers engaged in the production of crops were considered as the cost of human labour wage. The prevailing wage rate in the area was considered for the analysis.

3. **Machine Labour**

The labour cost of the hired machine was calculated on the basis of the prevailing rent for the machine per hour.

3.3.3.3. Land Revenue

This was taken as the actual rate paid to the Revenue Department which was calculated as ₹ 500 ha^{-1} $Year^{-1}$.

3.3.3.4. Interest on Working Capital

It is common practice for farmers to take advantage of short-term loans to pay for supplies, labour and to purchase inputs. To take this into account, interest on working capital was included as an element in the cost of cultivation. Interest on working capital was calculated for the crop period at a rate of 7 per cent $year^{-1}$, since it is the rate at which farmers obtain loans from financial institutions.

3.3.3.5. Interest on Fixed Capital

The present value of assets and equipment constitutes fixed capital. The interest on this can be calculated as in the case of interest on working capital. Interest on fixed investments, excluding land was estimated at an annual rate of 11 per cent, which is the rate of commercial bank loans for long-term loans.

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3.3.3.6. Rental Value of Leased in Land

It was assessed based on the rent paid. Since the selected crop is maintained throughout the year, the rental value of the leased in land has been counted as the rent paid once a year.

3.3.3.7. Rental Value of Owned Land

The rental value of the owned land was calculated by taking the rent for the leased in lands that prevailed in the study area.

3.4.3.8. Depreciation

This was resolved taking into account the wear and tear of the tools and machinery used in banana cultivation. The annual depreciation rate was calculated on each item using the straight-line method and subsequently added to obtain the overall annual depreciation allowance.

3.4.3.9. Insurance Premium

This was the amount paid as premium to the insurance authority to insure the crop.

3.4.3.10. Miscellaneous Expenses

The costs related to the replacement of damaged suckers infested with pests and diseases and the cost of transportation were included as the miscellaneous charges.

3.4.4. Indemnity Obtained

This is the amount obtained as compensation for the yield loss or production loss due to notified climate extremes in the WBCIS for the insured farmers.

3.4.5 Quantity of Output

The quantity of banana purchased is indicated in kg / ha.

3.4. ANALYTICAL FRAMEWORK

Appropriate statistical tools were used to analyse the collected data and draw meaningful conclusions. Tools used for analysis:

3.4.1 Percentages and Averages

The socio-economic characteristics of farmers, such as age, level of education, gender, family size, land tenure, annual income, have been analyzed through the use of percentages and averages.

3.4.2 Binary Logit Regression

Binary logit regression was fitted to know the role socioeconomic variables that influences the adoption of the WBCIS.

$$p = p_{(Y=1\,|X=x)} = \frac{e^{\beta_0+\beta_1 X}}{(1+e^{\beta_0+\beta_1 X})}$$

For a number of independent variables,

$$p = p_{(Y=1\,|X1=x1,\; X2=x2 ......Xn=xn)} = \frac{e^{\beta_0+\beta_1 X1+\beta_2 X2 ......\beta_n Xn.}}{(1+e^{\beta_0+\beta_1 X1+\beta_2 X2 ....\beta_n Xn})}$$

$$q = \frac{1}{(1+e^{\beta_0+\beta_1 X1+\beta_2 X2 ....\beta_n Xn})}$$

Therefore, $\frac{p}{1-p} = e^{\beta_0+\beta_1 X1+\beta_2 X2 ......\beta_n Xn.}$

The ratio $\frac{p}{1-p}$ is called the odds ratio.

$$\text{Y} = \log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X1 + \beta_2 X2 \dots\dots \beta_n Xn.$$

The logarithm of Odds ratio is called logit which ranges from -∞ to +∞, the value of p ranges from 0 to 1.

For this study, Y = $\beta_0 + \beta_1 X1 + \beta_2 X2 + \beta_3 X3 + \beta_4 X4 + e$

Where,

X_1 = Number of years of experience in Banana cultivation (years).

X_2 = Gross income (coding was done).

X_3 = Age of the respondents (years).

X_4 = Education status of the respondents (coding was done).

3.4.3. Assessment of Vulnerability of Agriculture of the study area to climate change

The concept of vulnerability as provided by the IPCC (2007) was adopted in this study. Based on this, vulnerability is a function of three major components; the extent and degree of exposure of a system, sensitivity of the system and the ability to adapt and cope with climate change. A vulnerability index was made measure vulnerability towards climate change as a composite index of major component indices using secondary data collected. In the present study, the methodology adopted by Rao *et al.* (2013) was followed with a modification according to suitability of the study area and also based on the availability of data in order to construct index for the vulnerability of agriculture to climate change. The three major components of vulnerability: sensitivity, exposure and adaptive capacity were represented by 27 sub components that will reflect these components (tables 1, 2 and 3). These sub components were selected from a broader list of indicators based on the review of the literature, thoughts with experts and the nature of the relationship with the three components of the vulnerability according to the field circumstances. Direct / Inverse relationship was also considered, it refers to the effect of sub component on the major component.

The model adopted in the study was;

Vulnerability Index = Sensitivity Index + Exposure Index +Adaptive capacity Index

(Rao *et al.* 2013)

3.4.3.1 Sensitivity

Sensitivity to climate change can be described as human and environmental circumstances that can worsen or ameliorate a risk or generate an impact. It is the degree to which a system is exposed or responsive to climate change (Smit *et al.* 2001). It is considered to be a positive factor for vulnerability to climate

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change. In this study, about eight sub component were selected to study sensitivity (table 1.).

Table 1. Sub components of sensitivity

S. No.	Sub components	Measurement (unit)	Relationship
1	Net sown area	Percentage of net sown area in total geographical area (%)	Direct
2	Barren and uncultivable land	Percentage of barren and uncultivable land to total geographical area (%)	Direct
3	Land slide hazard zonation	Percentage of geographical area prone to land slide (%)	Direct
4	Flood proneness	Percentage of geographical area prone to flood incidence (%)	Direct
5	Drought proneness	Percentage of geographical area prone to severe drought (%)	Direct
6	Cultivable waste land	Percentage cultivable waste land in to geographical area (%)	Direct
7	Rural population density	Ratio of rural population density to total population density	Direct
8	Small and marginal farmers	Percentage of area owned by small and marginal farmers in relation to total sown area (%)	Direct

3.4.3.2 Exposure

In climate change studies exposure is usually considered as the direct effect and extent of weather variables such as precipitation and temperature. It is also considered as a positive factor to climate change vulnerability. In this study, about nine sub components were selected under the exposure to study it (table 2.).

Table 2. Sub components of exposure

S No.	Sub components	Measurement (unit)	Relationship
1	Change in annual rainfall	Percentage change in annual rainfall during 2010-15 relative to 1991-95 (%)	Direct
2	Change in June rainfall	Percentage change in June rainfall during 2010-15 relative to 1991-95 (%)	Direct
3	Change in July rainfall	Percentage change in July rainfall during 2010-15 relative to 1991-95 (%)	Direct
4	Change in maximum temperature	Percentage change in March-May maximum temperature during 2010-15 relative to 1991-95 (%)	Direct
5	Change in minimum temperature	Percentage change in Dec-Feb minimum temperature during 2010-15 relative to 1991-95 (%)	Direct
6	Change in March-May rainfall	Percentage change in March-May rainfall during 2010-15 relative to 1991-95 (%)	Direct
7	Change in Oct-Nov rainfall	Percentage change in Oct-Nov rainfall during 2010-15 relative to 1991-95 (%)	Direct
8	Change in 99 percentile rainfall	Percentage change during 2010-15 relative to 1991-95 (%)	Direct
9	Change in mean annual temperature	Percentage change in mean annual temperature during 2010-15 relative to 1991-95 (%)	Direct

3.4.3.3 Adaptive Capacity

As the name indicates, it is the adaptability of a system to the climate change impacts. It represents the potential to device adaptation measures that help to reduce impacts. It is a negative factor to climate change vulnerability. In this study, about ten sub components were selected to study the adaptive capacity (table 3.).

Table 3. Sub components of adaptive capacity

S No.	Sub components	Measurement (unit)	Relationship
1	Total Literacy	Percentage of people who are literate (%)	Direct
2	SC/ST Population	Percentage of population belonging to SC/ST (%)	Inverse
3	Agricultural Workers	Percentage of number of workers engaged in agriculture to total workers (%)	Inverse
4	Gender gap	Difference between total and female literacy (%)	Inverse
5	Rural electrification	Percentage of rural households with electricity supply in relation to total number (%)	Direct
6	Net irrigated area	Percentage of net irrigated area in relation to total net sown area (%)	Direct
7	Livestock population	Percentage of cattle population in relation to total cattle population of the state (%)	Direct
8	Fertilizer consumption	Percentage consumption of fertilizers (N+P+K) in relation to maximum possible consumption (400 Kg/ha; Rao *et al.* 2013) (%).	Direct

S No.	Sub components	Measurement (unit)	Relationship
9	Groundwater availability	Percentage of availability of ground water (%)	Direct
10	Share of primary sector in Gross State Value Added (GSVA)	Percentage share of primary sector in contribution of district in Gross State Value Added (GSVA) (%)	Inverse

3.4.3.4 Vulnerability Index

The vulnerability index was made as a composite index of the component indices. Process of constructing the component indices involves the normalization of all the sub component values and then taking mean of the normalized value. For each sub components, the assumed relationship (Direct or Inverse) of sub component with corresponding major component was considered for the normalization.

The following formulae have been used to normalize the sub components based on the relationship between the indicator and the dimension or sub component and major component

When the sub component was directly related with the corresponding major component,

$$z_i = \frac{x_i - x_{min}}{x_{max} - x_{min}}$$

When the sub component was inversely related with the corresponding major component,

$$z_i = \frac{x_{max} - x_i}{x_{max} - x_{min}}$$

(Rao *et al.* 2013, Sridevi *et al.* 2014)

Where,

z_i is normalized value of i[th] sub component in the area., x_i is the value of the i[th] sub component in the study area., x_{min} is the possible minimum value of the sub component and x_{max} is the possible maximum value of the sub component.

Three indices of sensitivity, exposure and adaptive capacity have been constructed by taking mean of normalized values of the identified sub components. Higher the value of sensitivity index and exposure index, more will be the sensitivity and exposure to climate change and *vice versa*. Higher value of adaptive capacity index shows less adaptability to climate change and *vice versa*. The weighted mean of the three component indices will give rise to the vulnerability index, whose higher values indicate greater vulnerability and lower values a lower vulnerability. It should be noted that this index is not an absolute measure of damage or risk due to climate change and is only a constrained measure of risk.

The use of same value range for index was needed for assessment of level of vulnerability as well as components. Vulnerability index and component indices had a value range of 0 – 1(Hahn *et al.* 2009). Classification was done by dividing the proportional value of the degree of vulnerability and its components (0-1) into five classes (Rao *et al,* 2013, Sugiarto *et al*, 2017). The criteria for index are presented in table 16.

Table 4. Criteria for index

Index range	**Level of index**
0.0 - 0.2	Very Low
0.2 - 0.4	Low
0.4 - 0.6	Medium
0.6 - 0.8	High
0.8 - 1	Very High

(Rao *et al,* 2013, Sugiarto *et al*, 2017)

3.4.4. Vulnerability assessment of banana farmers to climate change

In this study, the same methodology aforesaid was used to estimate the vulnerability of the banana farmers in Palakkad and Wayanad districts to climate change. This assessment approach focuses mainly on the economic and bio physical status of farmers. Individuals in a community often vary in terms of wealth, health status, access to credit, access to information technology (Karthick, 2013). These variations are responsible for varying vulnerability levels. According to the IPCC (2010), the factors that contribute to the vulnerability of farmers to climate variability have been classified as adaptive capacity, exposure and sensitivity to climate variability. About 14 sub components included to estimate the index of each component and are discussed below (table 5,6 and 7).

The model specification is given as:

Vulnerability Index = Adaptive capacity Index+ Sensitivity Index + Exposure Index

(Rao *et al.* 2013)

Table 5. Sub components of sensitivity of banana farmers to climate change

S. No.	Sub Components	Measurement (Unit)	Relationship
1	Average crop diversification index*	Number of crops cultivated by the sample respondents (%)	Inverse
2	Lack of risk mitigation practices	Percentages of households that do not have any risk mitigation practices (%)	Direct
3	Usage of common irrigation sources	Percentage of respondents that reported a river, lake, pond and tank as their irrigation source (%)	Direct
4	Share of leased in land	Percentage share of leased in land to the total area cultivated by respondents (%)	Direct

Table 6. Sub components of exposure of banana farmers to climate change

S. No.	Sub Components	Measurement (Unit)	Relationship
1	Temperature	Total number of years with large variation in temperature that were reported by respondents in the past 5 years (Count).	Direct
2	Rainfall	Total number of years with variation in rainfall that were reported by respondents in the past 5 years (Count).	Direct
3	Variation in wind pattern	Percentage of respondents reported high variability in wind pattern in the past 5 years (%)	direct

Table 7. Sub components of adaptive capacity of banana farmers to climate change

S. No.	Sub Components	Measurement (Unit)	Relationship
1	Adoption of integrated farming	Percentage of respondents having integrated farming (%)	Direct
2	Farm income	Percentage share of average gross income earned from crop cultivation to the total average income (%)	Direct
3	Savings in financial institutions	Percentage of respondents which have institutional savings (%)	Inverse
4	Usage of own irrigation structure	Percentage of respondents which uses well irrigation for cultivation purpose (%)	Inverse

S. No.	Sub Components	Measurement (Unit)	Relationship
5	Dependence solely on agriculture as a source of income	Percentage of respondents which reported only agriculture as a source of income (%)	Direct
6	Cultivation in owned land	Percentage of respondents which cultivating crops only in owned land (%)	Inverse
7	Deviation in cultivation practice	Percentage of respondents reported variation in cultivation practice against climate variability (%)	Inverse

Note: * Simpson's Diversification Index (SDI) was used to measure the degree of crop diversification, which is given by the formula: $SDI = 1 - (a_j / A)^2$
where, a_j is the area under the j^{th} crop and A- is the gross cropped area.

3.4.5 Cost of Cultivation

The cost of cultivating banana was calculated as the total sum of the cost incurred in various inputs that were used in production. In this study, the cost concept was used to calculate the cost of cultivation and returns.

Cost Concept

The **Cost A_1** includes

a) Cost of sucker plant
b) Cost of hired labour
c) Cost of manures, fertilizers and soil ameliorants
d) Cost of plant protection chemicals
e) Cost of propping material and irrigation
f) Land revenue
g) Depreciation
h) Interest on working capital
i) Miscellaneous cost & insurance premium

Cost A_2

Cost A_1 + rent paid for leased-in land.

Cost B

Cost A_2 + rental value of owned land & interest on owned fixed capital excluding land.

Cost C

Cost B + imputed value of family labour.

(CSO, 2008)

3.4.3. Returns

3.4.3.1. Gross returns

The gross returns were calculated as the total value of the products at the current market price.

Gross returns = Quantity of product * unit price

3.4.3.2. Net returns

Net returns were obtained by deducting the total cost from gross returns.

Net returns = Gross returns- cost of cultivation

3.4.4 Benefit-Cost Ratio (BC Ratio)

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

BC ratio = Gross returns / cost of cultivation

3.4.5. Resource Use Efficiency

The analysis of resource use efficiency is important to calculate in a production process how efficiently the farmers are using or allocating their scarce farm resources in a judicious manner. To describe the relationship between the output and various inputs used in production, Cobb-Douglas production function was used.

Several production functions can be used as a basis for examining and comparing the economic characteristics between the group of farms. There is no strict rule according to which a given functional form is more appropriate than another. However, for this type of study, the Cobb-Douglas production function has had a wide application and is the functional form used in this comparative analysis (Olubiyo et al., 2009).

Cobb- Douglas production function in algebraic form can be written as,

$$Y = a \prod_{i=1}^{4} (X_i^{bi}) e$$

The functional form of production function fitted for this study is

$$Y = a.\ X_1^{b1}\ X_2^{b2}\ X_3^{b3} X_4^{b4}\ e$$

In log-log form the above function can be written as

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + \log e$$

Where,

Y = Quantity of output (kg / ha)

X_1 = Quantity of manures, fertilizer and soil ameliorants (kg/ha)

X_2 = Hired labour / ha

X_3 = Family labour / ha

X_4 = Quantity of plant protection materials/ha

a = Intercept

$b_1, b_2 \dots b_4$ = Regression coefficients of dependent variables.

The Cobb-Douglas production function is estimated using the ordinary least squares method assuming that the error term (e) is distributed in a normal and independent way. The multiple determination coefficient (R^2) was tested to determine its significance by applying the F test. The regression coefficients (b_i) were tested to determine their significance by the t-test at the chosen significance level.

3.4.6. Marginal Productivity Analysis

The ratio between Marginal Value Product (MVP) and Marginal Factor Cost (MFC) calculated for each input to understand the efficiency of input use.

$$MPPi = bi \frac{\overline{Y}}{\overline{X}}$$

Where,

MPP = Marginal Physical Product

$\overline{Y}$ = Geometric mean of production.

$\overline{X}$ = Geometric mean of the i^{th} independent variable.

b_i = Regression coefficient of the i^{th} independent variable.

The MVP of each resource was calculated by multiplying MPP with the unit price of the product. The formula used for the MVP calculation was:

MVP of $X_i = b_i \times P_y \times \overline{Y} / \overline{X}_i$

Where,

P_y = Unit price of the product.

Allocative efficiency (K) is calculated using the following formula:

$K_i = MVP_i/MFC_i$

Where,

K_i = Allocative efficiency of i^{th} resource.

MVP_i = Marginal Value Product of i^{th} resource.

MFC_i = Marginal Factor Cost of i^{th} resource.

K> 1, indicates under use or sub optimal use of resources

K= 1, optimum use of resources (allocative efficiency)

K< 1, indicates excess use of resources.

3.4.8. Constraint Analysis

Garett's ranking technique was used to analyse the constraints faced by farmers. Several constraints have been listed in different groups based on the literature, experts' suggestions and conditions prevailing in the area. During the survey, respondents were asked to rank these constraints. These ranks were then converted to the percentage position using the formula.

$$\text{Percentage position} = 100 \text{ X } (R_{ij} - 0.5) / N_j$$

Where,

R_{ij} = Rank given for i^{th} factor by j^{th} individual

N_j = No. of factors ranked by the j^{th} individual

(Garrett, 1969)

With the help of Garrett's table, the estimated percentage position becomes a score. Therefore, for each constraint, the scores of different respondents were added and the average value was calculated. The mean scores obtained for each of the restrictions were sorted in descending order. The attribute with the highest average value was considered the most important constraint.

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Results and Discussions

4. RESULTS AND DISCUSSION

In the last chapters we discussed the review of the previous works, description of the study area and the methodology adopted for the study. The data collected from the survey were tabulated and analysed using different statistical tools to reach meaningful conclusions. The results obtained from the analysis are described and discussed in this chapter in detail under the following sections:

4.1. Socio economic status of the respondents
4.2. Assessment of vulnerability of agriculture in the study area to climate change
4.3. Vulnerability assessment of banana farmers to climate change
4.4. Economics of banana cultivation by insured and uninsured farmers
4.5. Perception of insured and uninsured respondents about WBCIS
4.6. Constraints in the adoption of WBCIS

4.1. SOCIO ECONOMIC STATUS OF THE RESPONDENTS

Using the collected primary data, the socio-economic status of the farmers was analysed in order to understand the sociological and economic nature of the respondents. In this study, the components of socioeconomic status included age of the respondents, educational status, family size, gender, occupational status, size of land holding, experience in banana farming and average annual income. The results of the analysis are discussed in detail in the following sub headings.

4.1.1. Age of respondents

According to the age group, respondents were classified in to five different categories. < 30 years, 30 - 40 years, 40 - 50 years, 50 - 60 years and > 60 years. The results are given in table 8. Out of 120 total respondents, 51 belong to 40-50 years group, which was 42.50 per cent to total. Majority of the respondents (96.16 %) falls in the age range of 30-60, only 2.5 percent of respondents were below 30 years of age and 3.33 per cent above 60 years of age. Average age of insured farmers was found to be higher (45.12 Years) than that of uninsured farmers (43.18 Years). Total average age of the respondent was 44.15 years.

Table 8. Distribution of respondents based on age

Particular	Age (Years)					Total	Average (Years)
	< 30	30 - 40	40 - 50	50 - 60	> 60		
Crop Insured	2 (3.33)	15 (25.00)	24 (40.00)	16 (26.66)	3 (5.00)	60 (100.00)	45.12
Crop Uninsured	1 (1.66)	19 (31.66)	27 (45.00)	12 (20.00)	1 (1.66)	60 (100.00)	43.18
Total	3 (2.50)	34 (28.33)	51 (42.50)	28 (23.33)	4 (3.33)	120 (100.00)	44.15

(Figures in parentheses denote percentage to total)

4.1.2. Educational status

The respondents were classified into five groups based on their educational status: Illiterate, Primary, High school, Higher secondary/pre degree and Graduation. The results are given in table 9. Out of the total 120 respondents 94.17 per cent was literates. Among total respondents, majority had primary education (47.50 %), categorically 46.66 per cent of insured and 43.33 per cent of uninsured farmers had primary education. Among uninsured farmers 8.33 per cent were illiterate but it was only 3.33 per cent among insured farmers. About 26.66 per cent insured and 28.33 per cent uninsured farmers had high school level of education. Among insured farmers 15 per cent had HSS/pre degree level of education and 8.33 per cent had graduation level, but in the case of uninsured farmers it was only 8.33 and 6.66 per cent respectively.

Table 9. Distribution of respondents based on educational status

Particular	Education level					Total
	Illiterate	Primary	HS	HSS/pre degree	Graduation	
Crop Insured	2 (3.33)	28 (46.66)	16 (26.66)	9 (15.00)	5 (8.33)	60 (100.00)
Crop Uninsured	5 (8.33)	29 (48.33)	17 (28.33)	5 (8.33)	4 (6.66)	60 (100.00)
Total	7 (5.83)	57 (47.50)	33 (27.5)	14 (11.66)	9 (7.50)	120 (100.00)

(Figures in parentheses denote percentage to total)

4.1.3. Family size

Distribution of respondents based on the family size are given in table 10. Among total respondents, majority had (56.66 per cent) family size of four or less than or equal to four members. Among insured farmers 53.33 per cent had family size ≤ 4 and 46.66 per cent had 5-8 as family size. In the case of uninsured famers 60.00 per cent had family size ≤ 4 (Nuclear) and 40.00 per cent had 5-8 as family size. Average family size of insured farmers (4.5) was found to be higher than uninsured farmers (4.38). Total average family size was 4.44.

Table 10. Distribution of respondents based on family size

Particular	Family size		Total	Average size
	≤ 4	5-8		
Crop Insured	32 (53.33)	28 (46.66)	60 (100.00)	4.5
Crop Uninsured	36 (60.00)	24 (40.00)	60 (100.00)	4.38
Total	68 (56.66)	52 (43.33)	120 (100.00)	4.44

(Figures in parentheses denote percentage to total)

4.1.4. Gender

Gender wise distribution of the respondents are presented in Table 11. Among the total respondents 97.50 per cent of the respondents were male and only 2.50 per cent of the sample were female. About 96.67 per cent of insured and 98.33 per cent of uninsured farmers were males. Number of females were more in insured category (3.33 %) than in the uninsured category (1.67 %).

Table 11. Distribution of respondents based on gender

Particular	Gender		Total
	Male	Female	
Crop Insured	58 (96.67)	2 (3.33)	60 (100.00)
Crop Uninsured	59 (98.33)	1 (1.67)	60 (100.00)
Total	117 (97.5)	3 (2.5)	120 (100.00)

(Figures in parentheses denote percentage to total)

4.1.5. Occupational status

The respondents were classified into two major groups based on their occupational status: Agriculture as main and subsidiary occupation. Agriculture as subsidiary was again classified in to as service and own business. Distribution of respondents based on the occupational status are given in table 12. Among total respondents 77.50 per cent had considered agriculture as their main occupation and in the remining were part time farmers (15.83 % in service sector and 6.66 % having own business). In the insured farmers category 80.00 per cent respondents had agriculture as main and 20.00 per cent considered agriculture as subsidiary occupation. Among uninsured farmers 77.50 per cent considered agriculture as main and 22.50 per cent as subsidiary.

Table 12. Distribution of respondents based on family size

Particulars	Agriculture as main	Agriculture as subsidiary		Total
		Service	Own business	
Crop Insured	48 (80.00)	9 (15.00)	3 (5.00)	60 (100.00)
Crop Uninsured	45 (75.00)	10 (16.66)	5 (8.33)	60 (100.00)
Total	93 (77.50)	19 (15.83)	8 (6.66)	120 (100.00)

(Figures in parentheses denote percentage to total)

4.1.6. Size of land holding

The respondents were grouped into three categories: size of holding with <0.4, 0.4-0.8 and >0.8 hectares. Among the total respondents, maximum respondents (38.33 per cent) falls in the category of land holding with 0.4-0.8 hectares. Majority (40 %) of insured farmers had a land holding of range 0.4-0.8 hectare. But in the case of uninsured farmers, maximum respondents (41.66 %) belongs to <0.4-hectare category. The average land holding size of insured and uninsured farmers were 0.58 and 0.57 hectares respectively, large for insured farmers compared to uninsured farmers. Total average land holding size was 0.575

hectares. Distribution of respondents based on the size of holding are given in table 13.

Table 13. Distribution of respondents based on size of holding.

Particulars	Size of holding (ha)			Total	Average size of holding (ha)
	<0.4	0.4 – 0.8	> 0.8		
Crop Insured	19 (31.66)	24 (40.00)	17 (28.33)	60 (100.00)	0.57
Crop Uninsured	25 (41.66)	22 (36.66)	13 (21.66)	60 (100.00)	0.58
Total	44 (36.66)	46 (38.33)	30 (25.00)	120 (100.00)	0.575

(Figures in parentheses denote percentage to total)

4.1.7. Experience in Banana farming

Distribution of respondents based on the experience in banana farming are given in table 14. Based on the experience in banana farming respondents were classified into three categories: <10, 10-20, > 20 years of experience categories. Among the total respondents, majority (67.50 %) had experience in banana farming in the range 10-20 years. Among the both insured and uninsured farmers, majority were belonging to 10-20 years of experience, 75.00 and 63.33 per cent of respondents respectively. About 6.66 per cent of insured and 15.00 per cent of uninsured farmers were having experience less than 10 years.

Table 14. Distribution of respondents based on experience in banana farming.

Particulars	Experience in Banana farming (Years)			Total	Average experience
	< 10	10 - 20	>20		
Crop Insured	4 (6.66)	45 (75.00)	11 (18.33)	60 (100.00)	15.68
Crop Uninsured	9 (15.00)	38 (63.33)	13 (21.67)	60 (100.00)	14.33
Total	12 (10.00)	81 (67.50)	27 (22.50)	120 (100.00)	15.00

(Figures in parentheses denote percentage to total)

In the category of >20 years of experience, belongs 18.33 per cent of insured and 21.67 per cent of uninsured farmers. Average years of experience of insured farmers (15.68 years) was found to be higher than uninsured farmers (14.33 years). Total average years of experience of respondents were 15.00 years.

4.1.8. Annual income

Distribution of respondents based on their annual income are given in table 15. According to the annual income, respondents were classified into four categories: below ₹1,50,000, ₹1,50,000-₹2,50,000, ₹2,50,000-₹3,50,000 and above ₹3,50,000. Among total, insured and uninsured respondents, majority of respondents fall in the annual income range of ₹1,50,000-₹2,50,000. From both insured and uninsured farmers only 5 per cent lies below 1.5 lakhs margin. Annual income of 28.33 per cent of insured and 21.66 per cent uninsured farmers lies in the range of ₹2,50,000-₹3,50,000. About 23.33 per cent of insured farmers had annual income above 3.5 lakhs, but it was only 6.66 per cent in the case of uninsured farmers. Average annual income of insured farmers (₹ 2,78,883.33) was found to be higher than uninsured farmers (₹ 2,54,541). Average annual income of total respondents was ₹ 2,66,712.

Table 15. Distribution of respondents based on annual income.

Particular	**Annual income (₹)**				**Total**	**Average annual income (₹)**
	< ₹1,50,000	**₹1,50,000-₹2,50,000**	**₹2,50,000-₹3,50,000**	**> ₹3,50,000**		
Crop Insured	3 (5.00)	26 (43.33)	17 (28.33)	14 (23.33)	60 (100.00)	2,78,883
Crop Uninsured	3 (5.00)	40 (66.66)	13 (21.66)	4 (6.66)	60 (100.00)	2,54,541
Total	6 (5.00)	66 (55.00)	30 (25.00)	18 (15.00)	120 (100.00)	2,66,712

(Figures in parentheses denote percentage to total)

4.1.9. Binary Logit Regression Model – Socioeconomic Variables Influencing Insurance Adoption

A binary logit regression model was fitted to understand the influence of socioeconomic variables in the adoption of insurance scheme. Dependent variables were given the value as 1 for insured farmers and 0 for uninsured farmers. The independent variables selected were annual income, number of years of experience in banana farming, age of the respondents, educational status and size of land holding. Coding was also done for independent variables, annual income and educational status.

The results of binary logistic regression are presented in table 16. It was found that number of years of experience in banana farming was significant at 5 per cent level of significance. Odds ratio for significant variable was 1.1. It means that likelihood of adoption of insurance by farmers having more experience is 1.1 times greater than that of farmers having less experience. All other variables except age of respondents and size of land holding had positive coefficient, but were found statistically insignificant.

Table 16. Binary logit regression model.

Sl. No.	Particular	Coefficient	Odds ratio	Standard error	P value
1	Intercept	-0.259	0.77	1.588	0.870
2	Number of years of experience in banana farming	0.104**	1.10	0.480	0.030
3	Annual income	0.090	1.09	0.211	0.688
4	Age of respondents	-0.047	0.95	0.368	0.194
5	Educational status	0.278	1.32	0.248	0.263
6	Size of land holding	-0.291	0.74	0.531	0.584

**Significance at 5 per cent level of significance

This result was consistent with the results by Amogh (2017) on farmers' adaptation for climate change in pepper cultivation in Wayanad district of Kerala, where it was found that experience in farming has positive relation with the adaptation practices.

4.2. ASSESSMENT OF VULNERABILITY OF AGRICULTURE IN THE STUDY AREA TO CLIMATE CHANGE

According to IPCC (2007), the contributing factors of vulnerability towards climate change have been classified into three major components: adaptive capacity, sensitivity and exposure. These components consider mainly socioeconomic and bio physical status of a system to assess its vulnerability (Karthick, 2013). The methodology of the study was explained in detail in chapter 3. The vulnerability assessment was done by quantifying and standardisation of selecting the potential set of sub components under major components and then analytically combined to obtain a single value for vulnerability (Hahn *et al.* 2009).

Considering the ever-increasing change in vulnerability to climate change, it is foremost important to develop tools like index on a frequent basis for mitigating, adapting and for policy making and timely interventions (Pandve and Chawla, 2011). Development of vulnerability index at district level, be the key administrative unit and it is more important for policy interventions (Ravindranath *et al.* 2011). For each of the components of vulnerability to climate change, respective indices can be estimated and combined by aggregating across scales and sectors like development of Human Development Index (Downing *et al.* 2001). Separate indices for sensitivity, exposure and adaptive capacity were constructed using the normalised sub components between 0 and 1 (Hahn *et al.* 2009). Weighted averages of the component indices will give rise to vulnerability index (Sathyan *et al.* 2018).

The normalisation was done on the basis of functional relationship (Direct or Inverse) of the sub component with corresponding component indices and whether it contribute to increase or decrease in the overall vulnerability. For indicators which decrease vulnerability, the values were transferred to derive a positive value from the actual value which contributes increase in vulnerability (Sathyan *et al.* 2018). In this study all the sub components assumed to have equal importance, and so equal weights were given. Similar attempts were given by Cutter *et al.* 2008 also.

In this study, it analyses the vulnerability of agriculture in Palakkad and Wayanad district. Vulnerability index was constructed using the selected sub components under each contributing component. A total of 27 sub components were selected under the three components for the estimation of vulnerability index. There were eight sub components under sensitivity, nine under exposure and ten sub components to explain the adaptive capacity. The values of each sub components are presented in tables 17, 18 and 19. Normalised values of the sub components of each major component are given in the tables 20, 21 and 22.

The component indices were obtained by calculating the mean of the normalised values of the corresponding sub components. From these three component indices, vulnerability index for each district was obtained as the weighted mean of the component indices (table 23).

Higher the value of sensitivity index and exposure index, more will be the sensitivity and exposure to climate change and *vice versa*. Higher value of adaptive capacity index shows less adaptability to climate change and *vice versa*.

Higher the value of vulnerability index, higher will be vulnerability of agriculture to climate change and *vice versa*. The present study also analysed how the vulnerability varies between these two districts and to make a simple framework for assessment of vulnerability of agriculture to climate change.

4.2.1. Sensitivity Index

It is evident from table 17. That for Wayanad district, the sub component of net sown area had some more contribution to sensitivity index than Palakkad district, because of more value of the sub component for Wayanad district. Whereas the effect of barren and uncultivable land had caused little more contribution for Palakkad in sensitivity index, like that the sub components such as land slide hazard zonation, flood proneness and cultivable waste land had similar pattern. All these sub component values were more for Palakkad district. But the sub component contribution of drought proneness and rural population density was more for Wayanad district than Palakkad district. Contribution of sub component small and marginal farmers was similar for both districts.

The value of sensitivity index obtained were 0.312 and 0.345 for Palakkad and Wayanad districts respectively, indicating low level of sensitivity index for both districts. In other words, Wayanad district was 10.58 per cent more sensitive to climate change than Palakkad district. The sub components that were contributed more to the increase in sensitivity index of Wayanad district over Palakkad were net sown area, drought proneness and rural population density. Geographical variations along with structural changes between these districts were the major reasons caused sensitivity variations.

4.2.2. Exposure Index

The sensitivity index obtained were 0.136 and 0.166 for Palakkad and Wayanad districts respectively. Both the districts had very low level in the exposure index. But exposure to climate change of Wayanad district was 22.05 per cent more than that of Palakkad district.

It is evident from table 18. the sub components related to rainfall was negative whereas for temperature it was positive for both districts. However, change in June rainfall and 99 percentile rainfall was higher for Palakkad than Wayanad district. Effect of all the sub components related to temperature was higher for Wayanad district. Moreover the sub components change in July rainfall and Oct-Nov rainfall contributed more to the exposure.

It should be understood that the all the sub components under exposure are climatic parameters and it is not possible to control.

Table 17. Sub component values of sensitivity

S No.	Major component & Sub components	Unit	Value		Data source
			Palakkad	Wayanad	
1	Net sown area	Per cent	46.21	53.25	Agri statistics 2017-18, GOK
2	Barren and uncultivable land	Per cent	0.34	0.05	Agri statistics 2017-18, GOK
3	Land slide hazard zonation	Per cent	7.24	4.82	sdma.kerala.gov.in, 2019
4	Flood proneness	Per cent	12.66	10.11	sdma.kerala.gov.in, 2019
5	Drought proneness	Per cent	4.30	12.10	sdma.kerala.gov.in, 2019
6	Cultivable waste land	Per cent	4.13	0.51	Agri statistics 2017-18, GOK
7	Rural population density	Ratio	0.76	0.96	Census 2011
8	Small and marginal farmers	Per cent	99	99	Agri census 2015, GOI

Table 18. Sub component values of exposure

S No.	Major component & Sub components	Unit	Value		Data source
			Palakkad	Wayanad	
1	Change in annual rainfall	Per cent	-16.05	-21.27	RARS- Ambalavayal & Pattambi
2	Change in June rainfall	Per cent	-21.23	-6.78	RARS- Ambalavayal & Pattambi
3	Change in July rainfall	Per cent	-37.57	-41.48	RARS- Ambalavayal & Pattambi
4	Change in maximum temperature	Per cent	1.61	1.95	RARS- Ambalavayal & Pattambi
5	Change in minimum temperature	Per cent	6.31	12.36	RARS- Ambalavayal & Pattambi
6	Change in March - May rainfall	Per cent	-5.94	-17.69	RARS- Ambalavayal & Pattambi
7	Change in Oct – Nov rainfall	Per cent	-10.01	-34.79	RARS- Ambalavayal & Pattambi
8	Change in 99 percentile rainfall	Per cent	-22.68	-9.20	RARS- Ambalavayal & Pattambi
9	Change in mean annual temperature	Percent	1.34	3.73	RARS- Ambalavayal & Pattambi

Table 19. Sub component values of adaptive capacity

S No.	Major component & Sub components	Unit	Value		Data source
			Palakkad	Wayanad	
1	Total Literacy	Per cent	89.31	89.03	Census, 2011
2	SC/ST Population	Per cent	16.11	45.33	Census, 2011
3	Agricultural Workers	Per cent	30.48	45.30	Census, 2011
4	Gender gap	Per cent	7.31	6.81	Census, 2011
5	Rural electrification	Per cent	92.41	80.53	Census, 2011
6	Net irrigated area	Per cent	16.60	5.97	Agri statistics 2017-18, GOK
7	Livestock population	Per cent	12.49	5.47	Livestock census, 2012
8	Fertilizer consumption	Per cent	28.06	38.00	mfms.nic.in, 2019
9	Groundwater availability	Per cent	17.74	12.97	cgwb.gov.in, 2019
10	Share of primary sector in GSVA	Per cent	84	78	Economic review 2017, GOK

Table 20. Normalised sub component values of sensitivity

S No.	Major component & Sub components	Value		Relation	X_{min}	X_{max}	Normalised value	
		Palakkad	Wayanad				Palakkad	Wayanad
1	Net sown area	46.21	53.25	Direct	0	100	0.462	0.533
2	Barren and uncultivable land	0.34	0.05	Direct	0	100	0.003	0.000
3	Land slide hazard zonation	7.24	4.82	Direct	0	100	0.072	0.048
4	Flood proneness	12.66	10.11	Direct	0	100	0.127	0.101
5	Drought proneness	4.30	12.10	Direct	0	100	0.043	0.121
6	Cultivable waste land	4.13	0.51	Direct	0	100	0.041	0.005
7	Rural population density	0.76	0.96	Direct	0	100	0.759	0.961
8	Small and marginal farmers	99.00	99.00	Direct	0	100	0.990	0.990
	Sensitivity Index						**0.312**	**0.345**

Table 21. Normalised sub component values of exposure

S No.	Major component & Sub components	Value		Relation	X_{min}	X_{max}	Normalised value	
		Palakkad	Wayanad				Palakkad	Wayanad
1	Change in annual rainfall	-16.05	-21.27	Direct	0	100	0.160	0.213
2	Change in June rainfall	-21.23	-6.78	Direct	0	100	0.212	0.068
3	Change in July rainfall	-37.57	-41.48	Direct	0	100	0.376	0.415
4	Change in maximum temperature	1.61	1.95	Direct	0	100	0.016	0.020
5	Change in minimum temperature	6.31	12.36	Direct	0	100	0.063	0.124
6	Change in March - May rainfall	-5.94	-17.69	Direct	0	100	0.059	0.177
7	Change in Oct – Nov rainfall	-10.01	-34.79	Direct	0	100	0.100	0.348
8	Change in 99 percentile rainfall	-22.68	-9.20	Direct	0	100	0.227	0.092
9	Change in mean annual temperature	1.34	3.73	Direct	0	100	0.013	0.037
	Exposure Index						**0.136**	**0.166**

Table 22. Normalised sub component values of adaptive capacity

S No.	Major component & Sub components	Value		Relation	X_{min}	X_{max}	Normalised value	
		Palakkad	**Wayanad**				**Palakkad**	**Wayanad**
1	Total Literacy	89.31	89.03	Direct	0	100	0.107	0.110
2	SC/ST Population	16.11	45.33	Inverse	0	100	0.161	0.453
3	Agricultural Workers	30.48	45.30	Inverse	0	100	0.305	0.453
4	Gender gap	7.31	6.81	Inverse	0	100	0.073	0.068
5	Rural electrification	92.41	80.53	Direct	0	100	0.076	0.195
6	Net irrigated area	16.60	5.97	Direct	0	100	0.834	0.940
7	Livestock population	12.49	5.47	Direct	0	100	0.875	0.945
8	Fertilizer consumption	28.06	38.00	Direct	0	100	0.719	0.620
9	Groundwater availability	17.74	12.97	Direct	0	100	0.823	0.870
10	Share of primary sector in GSVA	84.00	78.00	Inverse	0	100	0.840	0.780
	Adaptive Capacity Index						**0.481**	**0.543**

4.2.3. Adaptive Capacity Index

The adaptive capacity index obtained were 0.481 and 0.543 for Palakkad and Wayanad districts respectively. It means that Palakkad was more adaptive to climate change compared to Wayanad district. But both districts had low level for the adaptive capacity index. It has been found that, all the sub components except gender gap, fertilizer consumption and share of primary sector in Gross State Value Added (GSVA) were having index value high for Wayanad district than Palakkad. The variation on the adaptive capacity had mainly caused by the sub components such as SC/ST population, agricultural workers, rural electrification, livestock population. All these sub components had more variation in index value for Wayanad than Palakkad districts. It was understood that, according to our study, the adaptive capacity index can be reduced by policy changes in the sub components, thereby increasing adaptability to climate change.

4.2.4. Vulnerability Index

Table 23. Index of the major components and vulnerability index.

District	Sensitivity Index	Exposure Index	Adaptive capacity Index	Vulnerability Index
Palakkad	0.312	0.136	0.481	**0.322**
Wayanad	0.345	0.166	0.543	**0.365**

From the study, it was found that vulnerability index of Palakkad district was 0.322 and for Wayanad district it was 0.365. The level of vulnerability index for both the districts were found as low, but the vulnerability index of Wayanad district was found higher than Palakkad. Wayanad district was found 13.35 per cent more vulnerable to climate change than Palakkad district. A study by Sridevi *et al.* (2014) had obtained vulnerability index for Palakkad district as 0.214 and for Wayanad district 0.399, low level of vulnerability index. Das (2013) had obtained

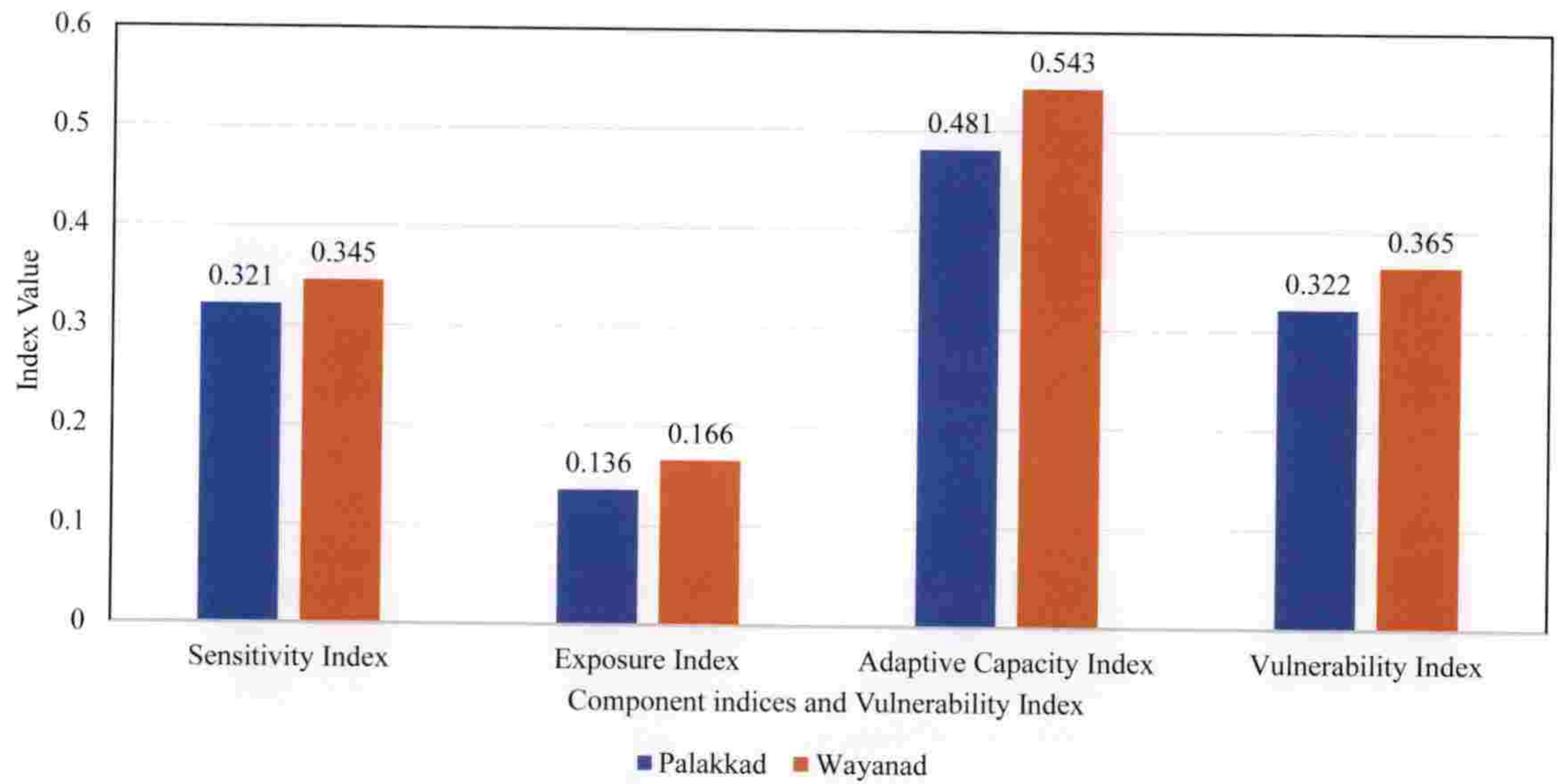

Figure 4. Comparison of vulnerability index and component indices regarding vulnerability of agriculture to climate change in the study area

0.377 as agricultural vulnerability index for Kerala as a combination of socioeconomic vulnerability index and biophysical vulnerability index. It was understood that, Palakkad and Wayanad districts considerably change in their level of vulnerability of Agriculture to climate change due of a wide range of reasons. Due to limited control over exposure variables in a climate change scenario the policy focus should be on sensitivity and adaptive capacity components that lead to vulnerability (Devi *et al.* 2011).

4.3. VULNERABILITY ASSESSMENT OF BANANA FARMERS TO CLIMATE CHANGE

The same methodology which was used in the vulnerability assessment of agriculture in general in the previous section was used to analyse the vulnerability assessment of banana farmers to climate change with appropriate modifications using primary data collected. In this study, vulnerability of banana farmers to climate change in the Palakkad and Wayanad district were analysed by constructing a vulnerability index using the selected sub components under three contributing components (Adaptive capacity, Sensitivity and exposure).

Total of 14 sub components were selected under the three components for the estimation of vulnerability index. There were four sub components under sensitivity, three under exposure and seven to explain the adaptive capacity. The values of each sub components, which was obtained during the primary data collection are presented in table 24. Separate indices for sensitivity, exposure and adaptive capacity were constructed using the normalised values of the corresponding sub components and are presented in tables 25, 26 and 27. From the weighted mean of three component indices, vulnerability index for each district were obtained (Table 28.). Higher the value of vulnerability index, higher will be vulnerability of farmers to climate change and *vice versa.*

4.3.1. Sensitivity Index

Sensitivity can be described as the degree to which a system is affected, it can be either negatively or positively (IPCC, 2010). In this study sensitivity was described using four selected sub components: average crop diversification index, percentage share of leased in land in the total cultivated area by the farmers, percentage of farmers who do not have any risk mitigation measures and farmers using common irrigation structures.

The sensitivity index obtained for Palakkad district were 0.425 and for Wayanad district it was 0.458. Both districts had medium level of sensitivity index. The banana farmers in Wayanad district was 7.76 per cent more sensitive to climate change compared to in Palakkad district. The sub component of crop diversification index was calculated using the Simpson's diversification index, the value of index was higher for Palakkad district (0.78) than Wayanad district (0.74). Banana farmers of Wayanad district was found to be adopting less crop diversification than Palakkad district.

In Palakkad, share of farmers who do not adopted any risk mitigation measures was 28.33 per cent, but it was 35 per cent in Wayanad. About 71.67 per cent of farmers were using common irrigation structures in Palakkad, but it was 78.33 in Wayanad. Average share of leased in land in total cultivated area for the banana farmers in Palakkad district were 48.07 per cent but it was only 43.70 per cent in Wayanad district. The substantial difference of these sub components between these two districts caused increase in the sensitivity index of the Wayanad district than Palakkad district.

4.3.2. Exposure Index

Exposure was represented based on the perception of farmers about variation in the temperature, rainfall and wind pattern in the last five years. Average number of years for the variation in temperature and rainfall, and percentage of respondents reported high variability in wind pattern were taken to construct the index of exposure. All the sub component had direct relationship with exposure, so higher values will increase the exposure index. Average count obtained for variation in the temperature and rainfall for Palakkad district were 2.33 and 2.07 and for Wayanad it was 2.45 and 2.43 respectively. About 81.67 per cent farmers from Palakkad district and 85.00 per cent from Wayanad had reported variation in the pattern of windfall.

The exposure index obtained were 0.566 and 0.609 for Palakkad and Wayanad districts respectively. Palakkad district had medium level in exposure index whereas Wayanad district had high level in exposure index. This clearly shows that the exposure of banana farmers to climate change was 7.6 per cent more for Wayanad than Palakkad district. It should be noted that weather parameters in the two districts differ significantly. Due to the dependence of exposure index on weather related sub components, obviously there will be substantial change.

4.3.3. Adaptive Capacity Index

The sub components of adaptive capacity were represented by wealth or financial capital (farm income and savings in financial institutions), technological change (deviation in cultivation), livelihood strategy (dependence solely on agriculture as a source of income, cultivation in owned land and adoption of integrated farming) and also potential for own irrigation structure. Farmers with higher income, better livelihood strategy, financial support, good technical knowledge will be better prepared to climate change impacts. This represents good adaptive capacity of the farmers.

Adaptive capacity index for Palakkad district were 0.618 and for Wayanad it was 0.622. Both districts had high level of index for adaptive capacity. But the adaptability to climate change of Wayanad district was found lower than that of Palakkad district. Adoption of integrated farming by the banana farmers were more in Palakkad district (46.67 per cent) than Wayanad (43.33 per cent), which have a direct relationship with the adaptive capacity. For higher values less will be the index. More the percentage of share of farm income in total income, less will be the adaptive capacity of the farmers, this sub component had an inverse relationship with the vulnerability. It was found that farm income share was more in Palakkad district (69.31 per cent) than Wayanad district (68.41 per cent). Lower value of this sub component caused an increase in adaptive capacity index of Wayanad district.

About 35 per cent of farmers from Palakkad had savings in any financial institutions, but from Wayanad it was only 31.67 per cent. The direct relation of this subcomponent causes decrease in index for higher values. Due to the direct relationship with the adaptive capacity, contribution of the of the sub component use of own irrigation structure to their respective adaptive capacity index were more for Wayanad district than Palakkad, because 28.33 per cent of farmers in Palakkad uses own irrigation compared to 25.00 per cent in Wayanad. In Palakkad district, percentage of farmers who solely depends upon agriculture as sole source of income were 51.67 per cent but it was 50.00 per cent in Wayanad district. This caused a negligible decrease in adaptive index of Wayanad index than Palakkad district due to inverse relationship of the respective sub component.

Change in adaptive capacity index due to sub component of cultivation in owned land were slightly more for Wayanad district as compared to Palakkad. Inverse relationship and the higher value of sub component in Wayanad district (40 per cent) than Palakkad (23.33 per cent) had caused that change. Similarly, the deviation in cultivation practice sub component had same effect due to direct relationship, but the Palakkad had more percentage of farmers (55.00 per cent) adopting deviation in cultivation practice than Wayanad (43.33 per cent).

Table 24. Sub component values of vulnerability of banana farmers to climate change

Major components	Sub components	Unit	Palakkad	Wayanad
Sensitivity	Simpson's crop diversification index	-	0.78	0.74
	Lack of any risk mitigation practices	Per cent	28.33	35.00
	Use of common irrigation sources	Per cent	71.67	78.33
	Share of leased in land	Per cent	48.07	43.7
Exposure	Temperature	Count	2.33	2.45
	Rainfall	Count	2.07	2.43
	Variation in wind pattern	Per cent	81.67	85.00
Adaptive capacity	Adoption of integrated farming	Per cent	46.67	43.33
	Proportion of farm income	Per cent	69.31	68.41
	Savings in financial institutions	Per cent	35.00	31.67
	Use of own irrigation structure	Per cent	28.33	25.00
	Dependence solely on agriculture as a source of income	Per cent	51.67	50.00
	Cultivation in owned land	Per cent	23.33	40.00
	Deviation in cultivation practice	Per cent	55.00	43.33

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Table 25. Normalised sub component values of sensitivity of banana farmers

S No.	Major component & Sub components	Value		Relation	X_{min}	X_{max}	Normalised value	
		Palakkad	Wayanad				Palakkad	Wayanad
1	Simpson's crop diversification index	0.78	0.74	Inverse	0	1	0.220	0.260
2	Share of leased in land	28.33	35.00	Direct	0	100	0.2833	0.35
3	Usage of common irrigation sources	71.67	78.33	Direct	0	100	0.7167	0.7833
4	Lack of risk mitigation practices	48.07	43.7	Direct	0	100	0.4807	0.437
	Sensitivity Index						**0.425**	**0.458**

Table 26. Normalised sub component values of exposure of banana farmers

S No.	Major component & Sub components	Value		Relation	X_{min}	X_{max}	Normalised value	
		Palakkad	Wayanad				Palakkad	Wayanad
1	Temperature	2.33	2.45	Direct	0	5	0.466	0.49
2	Rainfall	2.07	2.43	Direct	0	5	0.414	0.486
3	Variation in wind pattern	81.67	85.00	Direct	0	100	0.8167	0.85
	Exposure Index						**0.566**	**0.609**

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Table 27. Normalised sub component values of adaptive capacity of banana farmers

S No.	Major component & Sub components	Value		Relation	X_{min}	X_{max}	Normalised value	
		Palakkad	Wayanad				Palakkad	Wayanad
1	Adoption of integrated farming	46.67	43.33	Direct	0	100	0.533	0.567
2	Proportion of farm income	69.31	68.41	Inverse	0	100	0.693	0.684
3	Savings in financial institutions	35.00	31.67	Direct	0	100	0.650	0.683
4	Use of own irrigation structure	28.33	25.00	Direct	0	100	0.717	0.750
5	Dependence solely on agriculture income	51.67	50.00	Inverse	0	100	0.517	0.500
6	Cultivation in owned land	23.33	40.00	Direct	0	100	0.767	0.600
7	Deviation in cultivation practice	55.00	43.33	Direct	0	100	0.450	0.567
	Adaptive Capacity Index						**0.618**	**0.622**

4.3.4. Vulnerability Index

From the study, it was found that vulnerability index of the banana farmers to climate change in Palakkad district as 0.552 and for the Wayanad as 0.572, which means that banana farmers in Palakkad district were more vulnerable to climate change than Wayanad and both districts were having medium level of vulnerability index. Banana farmers in Wayanad district was 3.6 per cent more vulnerable to climate change than in Palakkad district. All the component indices values of the Wayanad district were found more than that of Palakkad district. Among the sub components of adaptive capacity except proportion of farm income and cultivation in owned land, all other sub components had higher index value for Wayanad district than Palakkad. In the case of sensitivity, except lack of risk mitigation practices, all other sub components had index value higher for Wayanad district than Palakkad. In the case of exposure, all the sub component indices were higher for Wayanad district.

In the adaptive capacity sub components, dependence of solely on agriculture as main source of income, higher percentage share of farm income in the total income and lack of any deviation from cultivation to adopt climate change were the major sub components that caused more increase in vulnerability index of the banana farmers in the Wayanad district compared to Palakkad district. Among sensitivity, more use of common irrigation sources, increased share of leased in land and less crop diversification were contributed high to vulnerability. Similar pattern in results were obtained for Aman (2016) during the study on vulnerability banana-based farming communities in Apayo, Philippines.

Table 28. Index of the major components and vulnerability index.

S No.	Indicator	Palakkad	Wayanad
1	Sensitivity Index	0.425	0.458
2	Exposure Index	0.566	0.609
3	Adaptive Capacity Index	0.618	0.622
	Vulnerability Index	**0.552**	**0.572**

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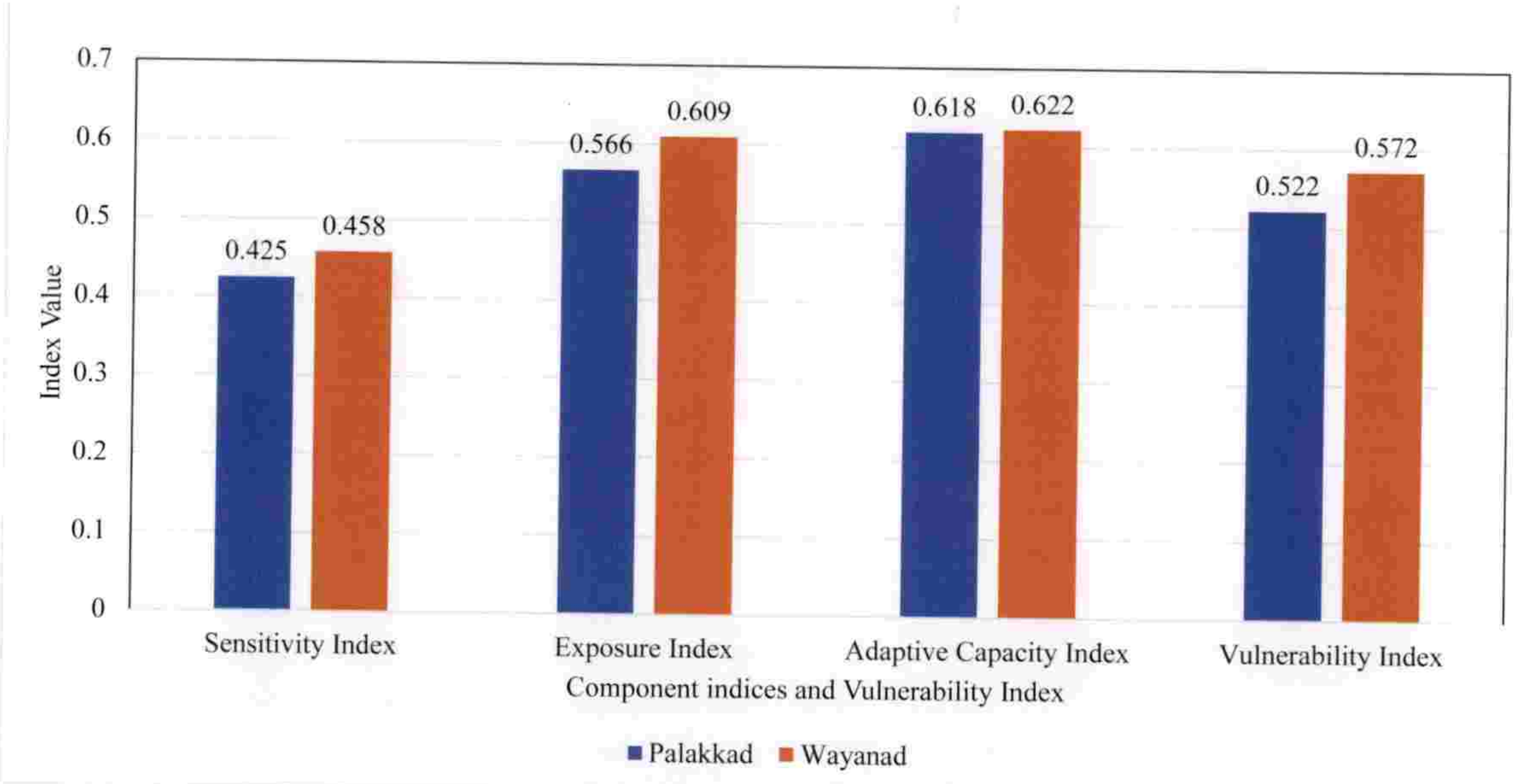

Figure 5. Comparison of vulnerability index and component indices regarding vulnerability of banana farmers to climate change in the study area

4.4 ECONOMICS OF BANANA CULTIVATION BY INSURED AND UNINSURED FARMERS

4.4.1 Cost of Cultivation

Cost of cultivation of banana for insured farmers and uninsured farmers were calculated using cost concept and presented in tables 29 and 30 respectively.

The Cost A_1 for insured farmers was 2,84,939.11 ha^{-1}. Among Cost A_1, cost of manures, fertilizers and soil ameliorants component accounted maximum of 30.39 per cent, followed by cost of propping and irrigation which accounted for 22.37 per cent and then cost of hired labour with 21.73 per cent. Cost incurred on planting material was about 12.97 per cent. The cost on plant protection and interest on working capital each contributed with 3.23 and 4.69 per cent respectively. Cost incurred on depreciation, land revenue, insurance premium and machine labour were very less which was 1.52, 0.61, 1.19 and 1.28 per cent respectively. Cost incurred on miscellaneous were 0.24 per cent. Cost A_2, Cost B and Cost C were 3,18,410.27, 3,45,545.67, and ₹3,86,021.13 ha^{-1} respectively.

The Cost A_1 for uninsured farmers was 2,52,041.41 ha^{-1}. Among Cost A_1, cost of manures, fertilizers and soil ameliorants component accounted maximum of 30.58 per cent, followed by, cost of hired labour which accounted for 22.68 per cent and then cost of propping and irrigation with 21.46 per cent. Cost incurred on planting material was 14.51 per cent. The cost on plant protection and interest on working capital each contributed with 2.82 and 4.75 per cent respectively. Cost incurred on depreciation, land revenue and machine labour were contributed with 1.24, 0.08 and 1.54 per cent respectively. Cost incurred on miscellaneous were 0.29 per cent. Cost A_2, Cost B and Cost C were 2,81,023.5, 3,12,904.06 and ₹3,50,910.06 ha^{-1} respectively.

From this analysis, it was understood that insured farmers incurred more cost than that of the uninsured farmers at Cost C. Cost of fertilizers, manures and soil ameliorants, hired labour cost and cost of propping and irrigation, were the major cost incurred by both insured and uninsured farmers.

Table 29. Cost of cultivation of insured farmers

Sl. No	Item	Cost (₹/ha)	Percentage to Cost A1
1	Sucker	36,969.33	12.97
2	Cost of manures, fertilizers and soil ameliorants	86,604.70	30.39
3	Cost of hired labour	61,927.91	21.73
4	Cost for plant protection	9,220.37	3.23
5	Cost for machine labour	3,636.50	1.28
6	Cost for propping and irrigation	63,731.60	22.37
7	Depreciation	4,319.80	1.52
8	Land revenue	174.85	0.61
9	Miscellaneous cost	680.98	0.24
10	Interest on working capital	13,385.35	4.69
11	Insurance premium	3,387.73	1.19
12	**Cost A1**	2,84,939.11	-
13	Rent of leased in land	34,371.17	-
14	**Cost A2**	3,18,410.27	-
15	Rental value of own land and interest on fixed capital	27,135.40	-
16	**Cost B**	3,45,545.67	-
17	Imputed value of family labour	4,0475.46	-
18	**Cost C**	3,86,021.13	-

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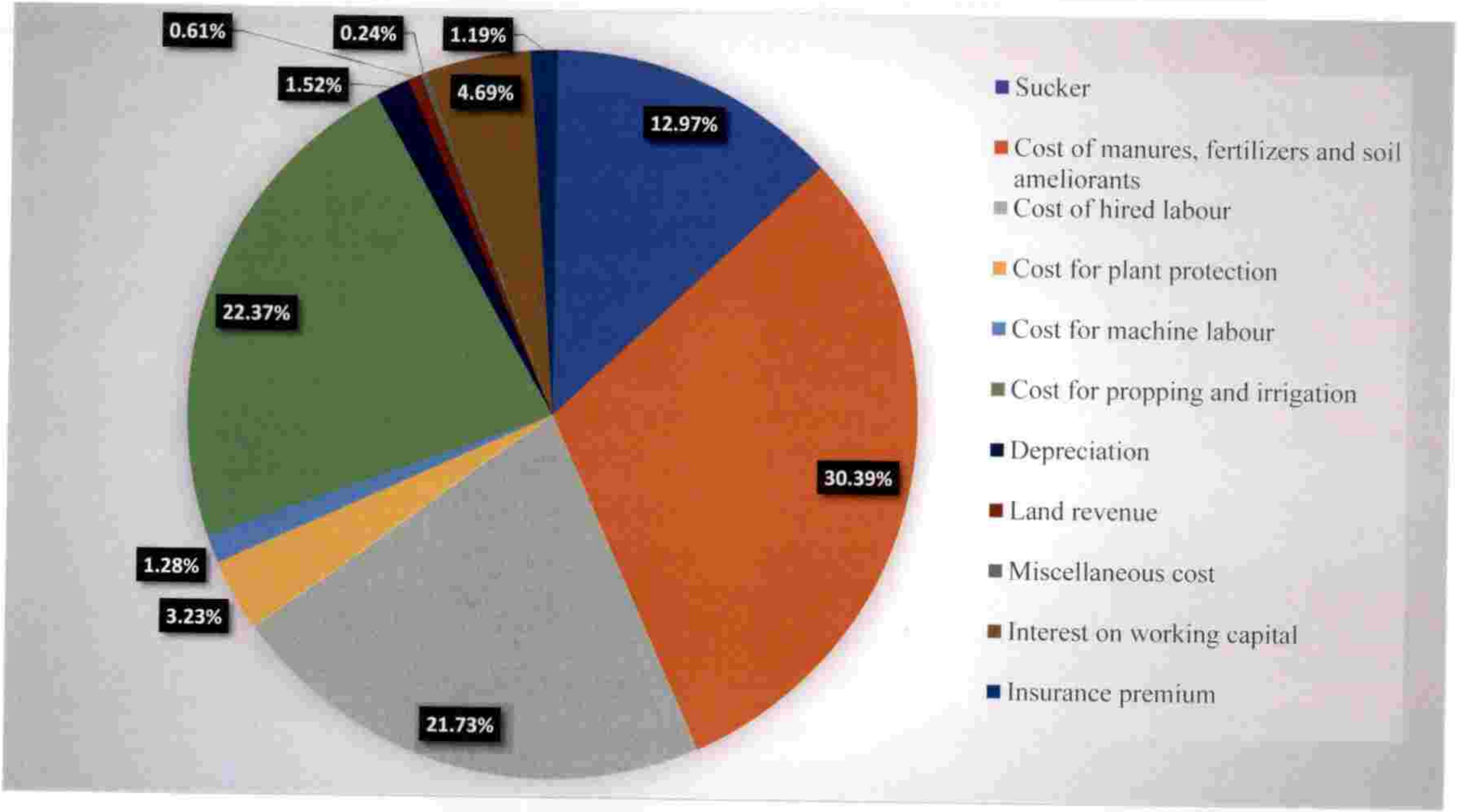

Figure 6. Cost A_1 of the insured banana farmers

Table 30. Cost of cultivation of uninsured farmers

Sl. No	Item	Cost (₹/ha)	Percentage to Cost A_1
1	Sucker	36,582.34	14.51
2	Cost of manures, fertilizers and soil ameliorants	77,093.00	30.58
3	Cost of hired labour	57,184.13	22.68
4	Cost for plant protection	7,115.03	2.82
5	Cost for machine labour	3,892.22	1.54
6	Cost for propping and irrigation	54,105.57	21.46
7	Depreciation	3,134.67	1.24
8	Land revenue	204.19	0.08
9	Miscellaneous cost	742.51	0.29
10	Interest on working capital	11,987.75	4.75
11	Insurance premium	0.00	-
12	**Cost A1**	2,52,041.41	-
13	Rent of leased in land	28,982.04	-
14	**Cost A2**	2,81,023.5	-
15	Rental value of own land and interest on fixed capital	31,880.56	-
16	**Cost B**	3,12,904.06	-
17	Imputed value of family labour	38,006.00	-
18	**Cost C**	3,50,910.06	-

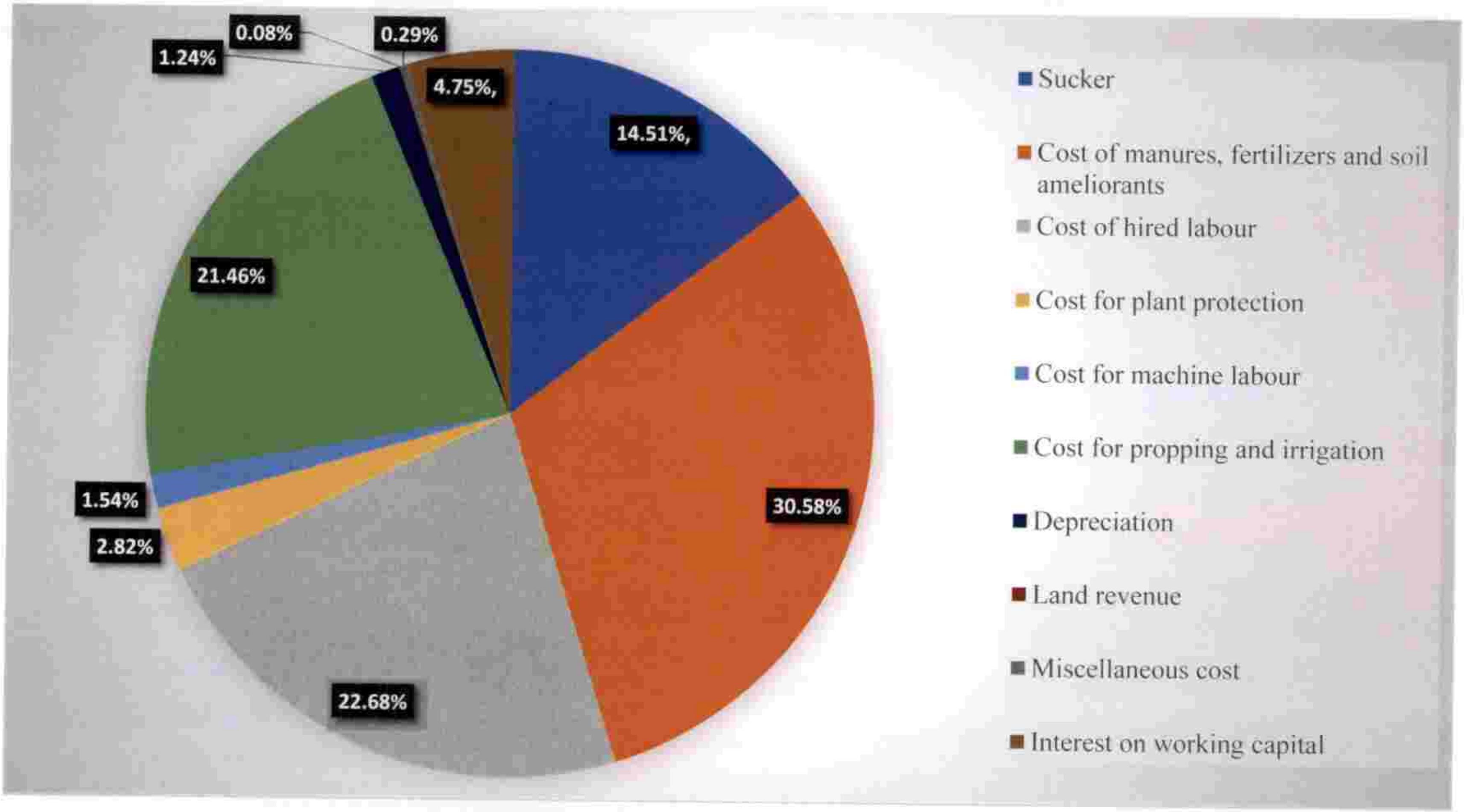

Figure 7. Cost A_1 of the uninsured banana farmers

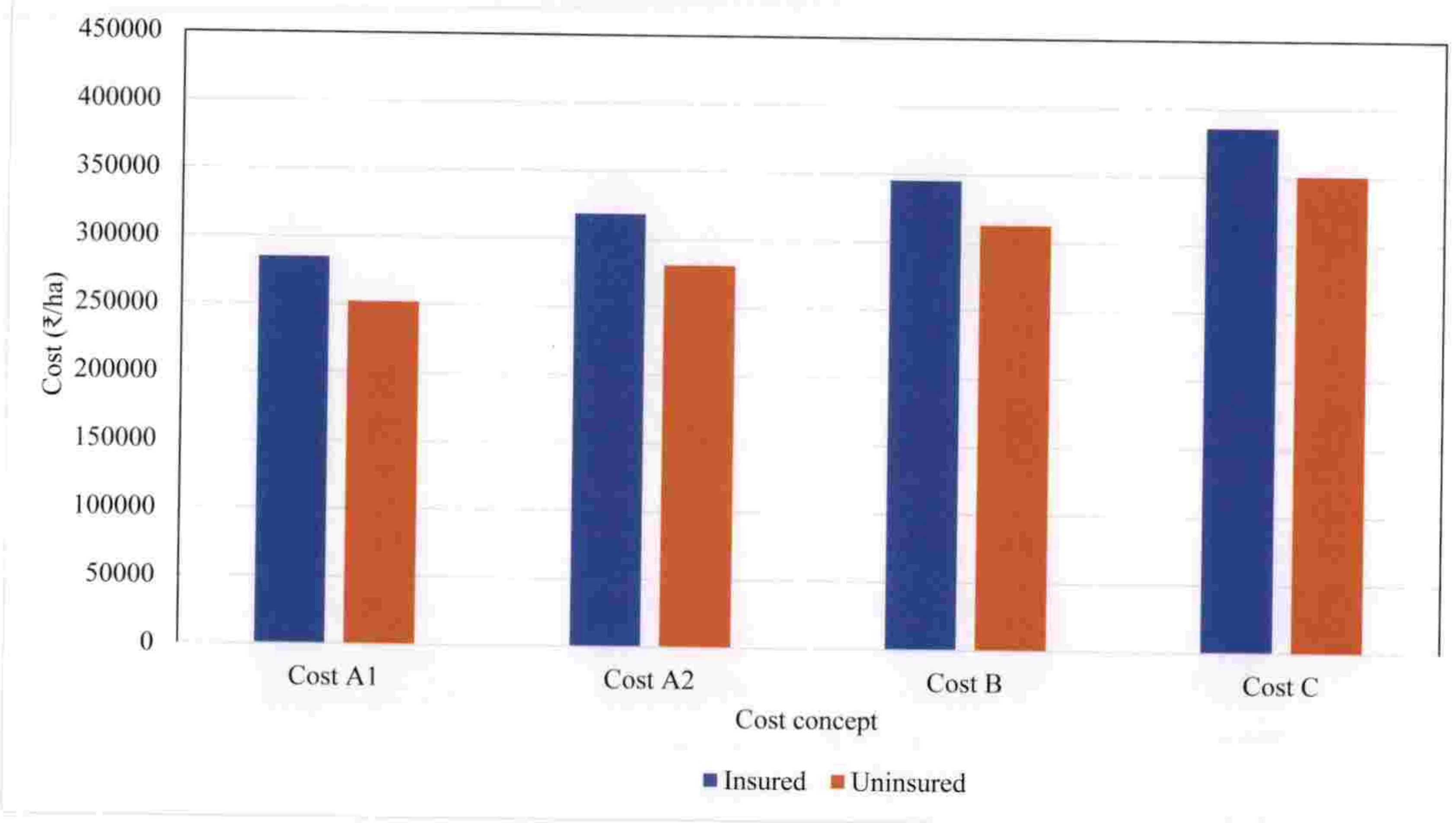

Figure 8. Comparison of ABC cost of banana cultivation of insured and uninsured farmers.

4.4.2 Net Returns

Net returns are a concept of farm business analysis which is used to find out profit and efficiency of farm business. Average yield of banana for insured and uninsured farmers were ₹259.7 and ₹220.9 q ha^{-1} respectively. Increased input use, credit liability, leased in cultivation and more importance to propping by insured farmers along with that the lack of moral hazard among insured farmers are the probable reasons for the increased yield. Moreover they were progressive in outlook. Average price (₹/kg) obtained for insured farmers was ₹25.74 and for uninsured farmers it was ₹25.28. Using the average yield and unit price, gross returns from banana were worked out.

Gross return from banana was more for insured farmers (₹ 7,42,282.75 ha^{-1}) than that of uninsured farmers (₹ 6,75,108 ha^{-1}). Net returns at cost A_1 was ₹ 4,57,343.64 ha^{-1} for insured farmers and ₹4,23,066.59 ha^{-1} for uninsured farmers. The net returns of insured farmers at Cost A_2, Cost B and Cost C were 4,23,871.73, 3,96,737.08 and ₹ 3,56,261.62 respectively. For uninsured farmers the net returns at Cost A_2, Cost B and Cost C were 3,94,084.50, 3,62,203.94 and ₹ 3,24,197.94 respectively. At all the costs, net returns of insured famers were more than that of uninsured farmers. It shows that insured were making more economic benefits than uninsured farmers from banana cultivation.

Table 31. Gross returns and net returns of insured and uninsured banana farmers

Sl. No	Particular	Returns	
		Insured farmers	Uninsured farmers
1	Yield (q/ha)	259.7	220. 9
2	Price (₹ /kg)	25.74	25.28
3	Gross return (₹/ha)	7,42,282.75	6,75,108.00
4	Net returns at cost A_1 (₹ /ha)	4,57,343.64	4,23,066.59
5	Net returns at cost A_2 (₹ /ha)	4,23,871.73	3,94,084.50
6	Net returns at cost B (₹ /ha)	3,96,737.08	3,62,203.94
7	Net returns at cost C (₹ /ha)	3,56,261.62	3,24,197.94

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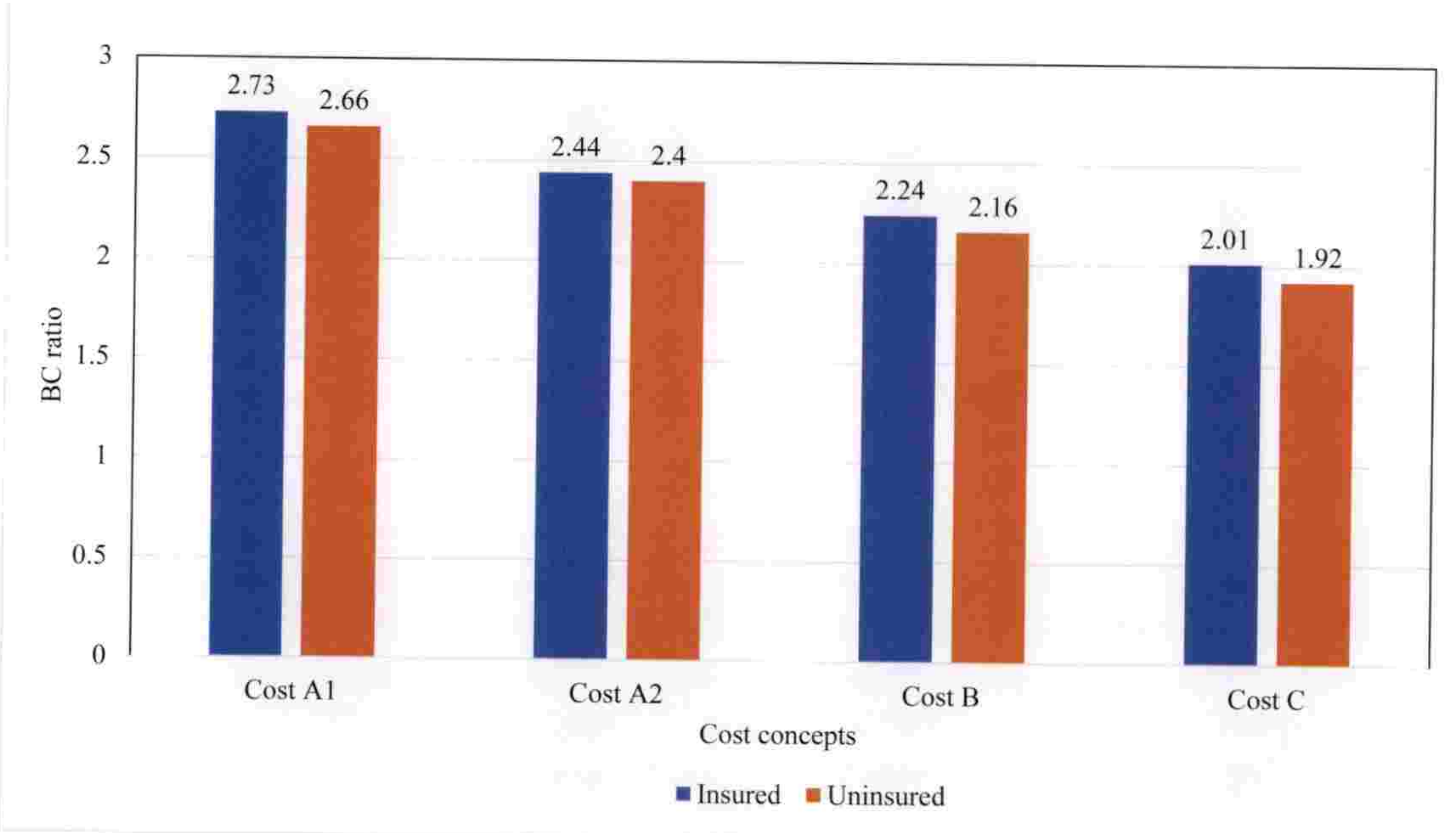

Figure 9. BC ratio at different costs for insured and uninsured banana farmers.

4.4.3 B C ratio

Benefit cost ratio indicates rate of the value of output per unit price of input or returns generated per rupee invested. This concept indicates the profitability of a business, higher value indicates more profit and *vice versa*. B-C ratio of insured and uninsured farmers from banana cultivation is presented in table 32.

Table 32. Benefit Cost ratio of cost of cultivation by insured and uninsured banana farmers

Cost	**Insured farmers**	**Uninsured farmers**
Cost A_1	2.73: 1	2.66: 1
Cost A_2	2.44: 1	2.40: 1
Cost B	2.24: 1	2.16: 1
Cost C	2.01: 1	1.92: 1

From the results, B-C ratio of insured farmers at Cost A_1 is 2.73: 1 and for uninsured farmers it was 2.66: 1. For insured farmers B-C ratio at Cost A_2, Cost B and Cost C were 2.44: 1, 2.24: 1 and 2.01: 1 respectively. Whereas in the case of uninsured farmers B-C ratio at Cost A_2, Cost B and Cost C were 2.40: 1, 2.16: 1 and 1.92: 1 respectively. The results indicate that insured farmers were getting more profit than uninsured farmers. This can be attributed to higher yield based on the income guarantee due to crop loss. The results obtained were similar to study conducted by Stephy (2018) on insured and uninsured banana farmers in Thiruvananthapuram district of Kerala.

4.4.4 Resource Use Efficiency

Cobb Douglas production function was fitted for the insured and uninsured farmers separately to study the resource use efficiency in banana production. Yield was taken as dependent variable. Quantity of manures, fertilizers and soil ameliorants, number of hired labour days, number of owned labour days and quantity of plant protection materials were selected as the independent variable for the study. Both dependent and independent variables were taken in physical quantities. Multicollinearity among the selected independent variables was checked by calculating VIF.

Results of resource use efficiency for insured farmers are shown in table 33. R^2 value of the fitted model was 0.86. This means, 86 per cent of the variation in dependent variable was explained by the independent variables included in the model. The quantity of manures, fertilizers and soil ameliorants, number of hired labour days, number of owned labour days were found significant at 1 per cent level of significance with positive coefficients. Quantity of plant protection materials had positive coefficient and statistically insignificant. All the independent variables found to be positively influencing dependent variable. Σb_i, returns to scale value was 1.165, which means, simultaneous increase of all the independent variables by 1 per cent would increase the returns by 1.165 per cent, which is increasing returns to scale. VIF value found to be ranges from 1.16 to 2.82, which indicates that there was negligible multicollinearity among the selected independent variables.

Table 33. Cobb-Douglas production function for insured farmers.

Particulars	**Coefficients**	**Standard Error**	**P value**	**VIF**
Intercept	3.245	0.481	0.000	-
Quantity of manures and fertilizers and soil ameliorants	0.370***	0.669	0.000	2.24
Hired labour	0.448***	0.701	0.000	2.82
Family labour	0.346***	0.073	0.000	1.16
Quantity of plant protection materials	0.001	0.018	0.950	1.66
R^2	0.87			
$\bar{R}^2$	0.86			
F	92.24			
Σb_i	1.165			
No. of observations	60			

*** significant at 1 per cent level of significance

Note: coefficients were obtained with log values

Results of resource use efficiency for uninsured farmers are shown in table 34. R^2 value of the fitted model was 0.79. This means, 79 per cent of the variation in dependent variable was explained by the independent variables included in the model. The quantity of manures, fertilizers and soil ameliorants, number of hired labour days were found significant at 1 per cent level of significance with positive coefficients. Number of family labour was found to be significant at 5 per cent level of significance with positive coefficient. But quantity of plant protection materials had positive coefficient and statistically insignificant. All the independent variables found to be positively influencing dependent variable. Σb_i, returns to scale value was 1.09, which means, simultaneous increase of all the independent variables by 1 per cent would increase the returns by 1.09 per cent, which is increasing returns to scale. VIF value found to be ranges from 1.45 to 3.04, which indicates that there is no serious problem of multicollinearity among the selected independent variables.

Table 34. Estimated production function for uninsured farmers.

Particulars	**Coefficients**	**Standard error**	**P value**	**VIF**
Intercept	3.08	0.662	0.000	-
Quantity of manures and fertilizers and soil ameliorants	0.455***	0.108	0.000	3.04
Hired labour	0.416***	0.106	0.000	2.95
Family labour	0.218**	0.102	0.038	1.45
Quantity of plant protection materials	0.001	0.018	0.000	1.52
R^2	0.79			
$\bar{R}^2$	0.77			
F	51.78			
Σ b_i	1.09			
No. of observations	60			

** significant at 5 per cent level of significance

*** significant at 1 per cent level of significance

Note: coefficients were obtained with log values

4.4.5 Marginal Productivity Analysis

Marginal Value Product (MVP) and Marginal Factor Cost (MFC) are the two important components used to find out the resource use efficiency. MVP is obtained for each input was calculated using unit price of output and geometric mean of all the component and also regression coefficients. Ratio of the MVP and MFC is known as allocative efficiency.

The allocative efficiency of insured farmers is presented in table 35. The K value of quantity of manures, fertilizer and soil ameliorants (3.27), hired labour (5.45) and family labour (6.15) was more than one which indicated the underutilization of resources and it can be increased to enhance the allocative efficiency in production. K value for quantity of plant protection materials (0.11) was less than one, which indicated that the input is overutilized.

Table 35. MVP and MFC of inputs for insured farmers.

Particular	Geometric mean	MVP	MFC	K=MVP/MFC
Yield of Banana (Y)	14632.57	-	-	-
Quantity of manures, fertilizers and soil ameliorants (x_1)	10736.33	12.84	3.92	3.27
Hired labour (x_2)	46.28	3632.25	662.14	5.45
Family labour (x_3)	30.67	4228.43	684.03	6.15
Quantity of plant protection materials (x_4)	3.27	117.20	1070.38	0.11

The allocative efficiency of uninsured farmers is presented in Table 36. Likewise, for the insured farmers K value of quantity of manures and fertilizer (4.05), hired labour (4.80) and family labour (3.65) was more than one which indicated the underutilization of resources and it can be increased to enhance the allocative efficiency in production. K value for quantity of plant protection materials (0.17) was less than one, which indicated that the input is overutilized.

Table 36. MVP and MFC of inputs for uninsured farmers.

Particular	Geometric mean	MVP	MFC	K=MVP/MFC
Yield of Banana (Y)	13180.9	-	-	-
Quantity of manures, fertilizers and soil ameliorants (x_1)	9661.14	15.69	3.87	4.05
Hired labour (x_2)	44.07	3145.31	655	4.80
Family labour (x_3)	29.56	2457.63	67342	3.65
Quantity of plant protection materials (x_4)	2.33	143.27	858.22	0.17

4.5. PERCEPTION OF INSURED AND UNINSURED RESPONDENTS ABOUT WEATHER BASED CROP INSURANCE SCHEME (WBCIS)

4.5.1 Insured farmers' awareness about the WBCIS

To study the insured farmers' awareness about the WBCIS, six particulars were selected about awareness such as procedural formalities, premium and subsidy rate, time period of scheme, risks covered, method of indemnity calculation and current changes in the scheme. It was found large number of farmers (49.80 per cent) was aware about premium rates and subsidies available, followed by procedural formalities (43.16 per cent) and then about starting and closing dates and time period of the scheme (39.84 per cent). About 38.18 per cent of farmers was aware about method of indemnity calculation. Only 29.88 per cent of farmers was aware about risk covered, coverage level and sum insured and current changes in the scheme. From the study, it was found that farmers less awareness level about the scheme they availed. The analysis about awareness of crop insurance are presented in table 37.

Table 37. Insured farmers' awareness about the WBCIS

S. No.	Particular	Number	Percentage to total
1	Procedural formalities of the scheme	26	43.16
2	Premium rate and subsidies available	30	49.80
3	Starting and closing dates and periods of the scheme	24	39.84
4	Risks covered, coverage level and sum insured	18	29.88
5	Method of indemnity calculation	23	38.18
6	Current changes in the scheme	18	29.88

4.5.2 Insured farmers' participation in the WBCIS

Insured farmers' participation in the scheme are presented in table 38. It was found that among total insured farmers, 51.84 per cent had involuntary participation in the scheme. Only 48.14 per cent farmers participated in the scheme voluntarily. Involuntary participation of the farmers was due to compulsory participation in the scheme for loanee farmers.

Table 38. Insured farmer's participation in the WBCIS

S. No.	Particular	Number	Percentage to total
1	Voluntary	29	48.14
2	Involuntary	31	51.86
	Total	60	100.00

4.5.3 Insured farmers' perception on premium rate

To study about insured farmers' perception about premium rate, it was categorised into four levels such as reasonable, low, high and unable to say. About 51.67 per cent of farmers stated that the premium rate was high followed by 26.67

per cent stating as reasonable amount. Remaining 13.33 per cent of farmers stated it as unable to say and only 8.33 per cent had an opinion that premium rate was low. Insured farmer's perception on premium rate are presented in table 39.

Table 39. Insured farmers' perception on premium rate

S. No.	Particular	Number	Percentage to total
1	Reasonable	16	26.67
2	Low	5	8.33
3	High	31	51.67
4	Unable to say	8	13.33
	Total	60	100.00

4.5.4 Insured farmers' willingness to pay the premium

Insured farmers' willingness to pay for premium rate was analysed by converting the rate into four different slabs: 1-2, 2-3, 3-4 and 4-5 per cent of sum insured and setting 5 per cent as maximum rate. About 80.08 per cent farmers was ready to pay 1-2 per cent as premium rate for the scheme. Only 19.92 per cent of farmers was ready to pay in the range 2-3 percent. It was found that among farmers no one was ready to pay a premium amount of above 3 per cent. Insured farmer's willingness to pay for premium rate are presented in table 40.

Table 40. Insured farmers' willingness to pay the premium.

S. No.	Particulars	Number	Percentage to total
1	1-2 %	38	80.08
2	2-3%	12	19.92
3	3-4%	0	0
4	4-5%	0	0
	Total	60	100.00

4.5.5 Insured farmers' satisfaction with the WBCIS

For the study, satisfaction levels were categorised in to three: dissatisfied, satisfied and very satisfied. Majority (56.67 per cent) of insured farmers were dissatisfied with the scheme, 36.66 per cent of farmers were satisfied with the scheme. But there were only 6.67 per cent of farmers very satisfied with the scheme. Insured farmer's satisfaction with the scheme are presented in table 41.

Table 41. Insured farmers' satisfaction with the WBCIS.

S. No.	Particulars	Number	Percentage to total
1	Dissatisfied	34	56.67
2	Satisfied	22	36.66
3	Very satisfied	4	6.67
	Total	60	100.00

4.5.6 Factors influencing adoption of the WBCIS among insured farmers

The factors influencing adoption of insurance scheme among insured farmers has been studied and results are presented in table 42. There were seven factors of influence selected for the study, which included, bank/financial institution's compulsion, financial security, production changes in the recent years, lack of farm diversification, suggested by experienced farmers, due to good awareness about benefits of the scheme and due to influence of affordable premium rate.

Based on the responses given by the farmers, factors were ranked from one to seven. The most influential factor was adoption due to the compulsion of bank or any financial institution, 73.33 per cent of farmers responded for this factor, followed by the financial security responded by 60.00 per cent of farmers. About 48.33 per cent of farmers responded to adoption due to production changes in recent years and came third position in factors influencing. In ranking this was followed by lack of farm diversification (16.67 per cent), suggested by experienced farmers (11.67 per cent), due to good awareness of the scheme (6.67 per cent) and at last affordable premium rate (5.00 per cent).

Table 42. Factors influencing adoption of the WBCIS among insured farmers.

S. No.	Particulars	Percentage	Rank
1	Bank/financial institution's compulsion	73.33	1
2	Financial security	60.00	2
3	Production changes in the recent years	48.33	3
4	Lack of farm diversification	16.67	4
5	Suggested by experienced farmers	11.67	5
6	Good awareness about benefits of the scheme	6.67	6
7	Affordable premium rate	5.00	7

4.5.7 Insured farmers' source of information about the WBCIS

An analysis was conducted to study insured farmers' the source information about the scheme and are presented in table 43. Among insured farmers, the source of information for 53.34 per cent was financial institutions, 18.33 per cent had source of information from fellow farmers, for 15 per cent farmers from Krishi Bhavans and other sources such as insurance agents for about 13.33 per cent of farmers.

Table 43. Insured farmer's source of information about the WBCIS.

S. No.	Particulars	Number	Percentage
1	Financial institutions	32	53.34
2	Other farmers	11	18.33
3	Krishi Bhavans	9	15
4	Others	8	13.33
	Total	60	100.00

4.5.8 Insured farmer's suggestions to improve the WBCIS

Table 44. Insured farmer's suggestions to improve the WBCIS.

S. No.	Particular	Number	Percentage
1	Unit area should be changed in to smaller levels	36	60.00
2	Quick settlement of claims and increase in indemnity level	60	100.00
3	Non-compulsory nature	36	60.00
4	All possible risks should notify	46	76.67
5	Should include post-harvest loss	43	71.67
6	More awareness on the scheme	37	61.67
7	Make more efficient number of weather stations	20	33.33
8	Include more incentives for the adoption of the scheme	43	71.67

Insured farmers' suggestions to improve the scheme were taken and analysis are presented in table 44. There were eight suggestions were listed out based on review of literature and the response of insured farmers were collected on that. All the farmers need to have quick settlement of claims in order to compensate their loss and increase in indemnity level. The scheme should cover all the weather risks associated with banana production, suggested by 76.67 per cent of insured farmers. About 71.67 per cent farmers had suggestion that to include more incentives from the part of government for better adoption and also the scheme should include the post-harvest losses of farmers. More awareness about the scheme for the implementation was suggested by 61.67 per cent of farmers. About 60.00 per cent of farmers suggested change in reference area into smaller levels and to make the scheme non-compulsory for loanee farmers. Only 33.33 per cent of farmers suggested to make more efficient number of reference weather stations for the recording of weather parameters.

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4.5.9 Uninsured farmers' past participation in the WBCIS

Uninsured farmers' past participation was studied and results are presented in table 45. It was found that about 85.00 per cent of the uninsured farmers had never availed the Weather Based Crop Insurance Scheme in the past. But 15.00 per cent of the farmers had availed scheme in the past period.

Table 45. Uninsured farmers' past participation in the WBCIS.

S. No.	Particular	Number	Percentage
1	Yes	9	15.00
2	No	51	85.00
	Total	60	100.00

4.5.10 Uninsured farmers' reasons for not availing the WBCIS

Uninsured farmers' reason for not availing the scheme were studied and are presented in table 46. About 75 percent of responded one of the reasons as less indemnity level. Lack of awareness about the scheme was given as another reason for about 68.33 per cent of farmers. Among total uninsured farmers 36.67 per cent had less faith in the scheme, which was also a barrier for the adoption. Delay in settlement of claims came as one of the reasons for about 26.67 per cent of farmers. Lack of need for 23.33 per cent respondents and previous bad experience for 11.67 per cent of farmers was given as part of their reasons for not adopting the scheme.

Table 46. Uninsured farmer's reason for not adopting the WBCIS.

S. No.	Particular	Number	Percentage
1	Lack of awareness about the scheme	41	68.33
2	Less faith in the scheme	22	36.67
3	Lack of need	14	23.33
4	less indemnity level	45	75
5	Delay in settlement of claims	16	26.67
6	Previous bad experience	7	11.67

4.6 CONSTRAINTS IN THE ADOPTION OF WEATHER BASED CROP INSURANCE SCHEME (WBCIS)

A proper understanding of the constraints faced by the farmers is very important for correct policy formulation. There are many constraints faced by the banana farmers in the adoption of Weather Based Crop Insurance Scheme. In this study, about nine constraints were selected based on review of previous studies and situations prevailing in the area. The major constraints selected were delay in getting the indemnity, due to lack of confidence in the scheme, less satisfaction due to inadequate indemnity, lack of awareness about the scheme, lack of motivation from officials, low premium paying capacity of the farmers, problem of non-coverage even if the farmers face the loss, due to non-coverage of post-harvest loss and also due to lengthy procedure. The constraint analysis was done using the Garret's ranking method. Both the insured and uninsured farmers were asked to rank the constraints based on their perception about the scheme. Later these ranks were converted to Garrett score using Garrett table. The results are presented in table 47.

Table 47. Constraints in the adoption of WBCIS by banana farmers

S. No.	Constraint	Garret's score	Rank
1	Delay in getting indemnity	47.71	7
2	Lack of confidence in the scheme	52.10	3
3	Less satisfaction with inadequate indemnity	54.68	1
4	Lack of awareness about the scheme	53.26	2
5	Lack of motivation from officials	49.43	5
6	Low premium paying capacity	48.73	6
7	Scheme does not cover even if the loss incurred	51.30	4
8	Lengthy procedure	46.95	8
9	Post-harvest loss is not covered	42.53	9

The results revealed that less satisfaction with the inadequate indemnity received was the major constraint faced by the farmers in adoption of insurance scheme with a Garret score of 54.68. This was followed by the constraint - lack of awareness about the scheme with a Garret score of 53.26. Feel of lack of confidence in the scheme was the third most important constraint faced by the farmers, it had a Garret score of 52.10. The next major constraint faced by the farmers as the feel of scheme does not cover even if the farmer faces loss. It had a Garret score of 51.30. This constraint can be due to past bad experience or through experience of fellow farmers. Lack of motivation from the officials associated with the farmers was the fifth ranked constraint with a Garret score of 49.43. This was followed by the constraint low premium paying capacity of the farmers. It had a Garret score of 48.73. The other constraints faced by the farmers in ranking order were delay in getting indemnity, lengthy procedural formalities and non-coverage of post-harvest loss with Garret score of 47.71, 46.95 and 42.53 respectively.

Summary

5. SUMMARY

Climate change has many adversative effects on agriculture both in the short and long term. All activities related to agriculture are vulnerable to climate change. This vulnerability diverges from individual level to extended area level. Therefore, it is significant to study the climate change vulnerability at all levels in order to have correct policy formulations to adapt their adverse effects. One of the most important institutional adaptive mechanism to overcome the adverse effects of climate change is adoption of crop insurance, among which Weather Based Crop Insurance Scheme (WBCIS) is very important. It acts as a measure to stabilize the farm income against yield loss due to climatic factors. It is also act as an incentive to use more inputs and improved technologies for improving the crop yield, hence the farmers are getting more economic benefits. It helps farmers to have more investment with an income guarantee, even if unfavourable conditions occur.

The main objective of the study was to assess the vulnerability of agriculture in general banana farmers in particular to climate change in Palakkad and Wayanad districts, to evaluate the economic benefits of Weather Based Crop Insurance for banana cultivators and to study the problems and suggest measures for scaling up of Weather Based Crop Insurance.

The study was based on both primary and secondary data. Palakkad and Wayanad districts were selected for the study. The primary data was collected from both the districts with a pre structured interview schedule. The sample size was 120, which consisted of 30 insured and 30 uninsured from both districts. Secondary data regarding climatic variables were collected from Regional Agricultural Research Station, Pattambi, Palakkad and Regional Agricultural Research Station, Ambalavayal, Wayanad for the period 1991 to 2015. The secondary data regarding socio economic status, physiographic factors and others were collected from official websites and different publications.

Analysis was done to know the vulnerability of agriculture to climate change. A framework was made for the vulnerability assessment based on the methodology of Rao et *al.* (2013) with appropriate modifications. A vulnerability index was developed for the analysis with three major component indices; adaptive capacity index, sensitivity index and exposure index. Under these three components about 28 sub components were selected based on the review of literature and their values were recorded. All the sub component indicators were collected from secondary data. Major component indices were obtained by averaging the normalised values of the corresponding sub components. The vulnerability index was obtained as the weighted mean of the major component indices. Higher the value of index higher is the vulnerability and *vice versa.* The vulnerability index for Palakkad district were 0.322 and 0.365 for Wayanad. The sensitivity index, exposure index and adaptive capacity index obtained for Palakkad district were 0.312, 0.136 and 0.481 and for Wayanad district it was 0.345, 0.166 and 0.543 respectively. The study was found that, both Palakkad and Wayanad comes under low vulnerability level but Wayanad district was closer to medium vulnerability level. Wayanad district was found 13.35 per cent more vulnerable to climate change than Palakkad district. It was understood that how the vulnerability of agriculture to climate change varies from one place to another.

The same methodology was used to analyse the vulnerability of banana farmers to climate change in the study area. The sub components of vulnerability index was based on the primary data collected during the survey. About seven subcomponents under adaptive capacity, four under sensitivity and three under exposure were selected for the study. The vulnerability index obtained for Palakkad district were 0.552 and 0.572 for Wayanad district, both were having medium level of vulnerability. The banana farmers in Palakkad district was found more vulnerable to climate change than Wayanad district. The sensitivity index, exposure index and adaptive capacity index obtained for Palakkad district were 0.618, 0.425, 0.566 and 0.618 for Wayanad district were 0.458, 0.609 and 0.622 respectively. Banana farmers in Wayanad district was 3.6 per cent more vulnerable to climate change than in Palakkad district It was found that how the vulnerability of banana farmers to climate change occurs and how it varies, and what can be done to reduce climate change vulnerability. From the study, it is understood that vulnerability assessment should be done at micro levels in order to have better policy adaptations and to know the need of risk mitigation measure.

Binary logit regression was fitted to understand the influence of socioeconomic variables on the adoption of WBCIS. From the analysis it was understood that number of years of experience in banana farming had a positive and significant effect, which indicate that the probability of taking insurance practices increases with increase in the number of years of experience in banana farming. The value of partial elasticity value revealed that, one per cent increase in number of years of experience in banana farming will increase the probability of adopting adaptation practices by 0.99 per cent. Odds ratio revealed that, farmers who have greater number of years of experience in banana farming are likely to adopt adaptation practices 1.1 times higher than the farmers who have smaller number of years of experience.

To evaluate economic benefits of WBCIS, comparison of farm business analysis was done using ABC cost concept. At Cost C, insured farmers had incurred cost of about ₹ 3,86,021.13 ha^{-1} and uninsured farmers had ₹3,50,910.06 ha^{-1}. Insured farmers had incurred 10 % more cost than uninsured farmers. The net returns at Cost C for inured farmers were ₹3,56,261.62 ha^{-1} and for uninsured farmers it was ₹3,24,197.94 ha^{-1}. Insured farmers had 9.89 per cent higher net return at Cost C than uninsured farmers. The BC ratio obtained for insured farmers at Cost C were 1: 2.01 for insured farmers and 1: 1.92 for the uninsured farmers. It was found that, the insured farmers were having more economic benefits than uninsured farmers from banana cultivation.

Cobb Douglas production function was fitted to know the resource use efficiency of insured and uninsured farmers. In the case of both insured and uninsured farmers quantity of manures and fertilizers, hired labour and family labour were found positively significant, quantity of plant protection chemicals had positive coefficient but insignificant. The returns to scale of insured farmers (1.16) was found higher than uninsured farmers (1.09). All the inputs except quantity of plant protection chemicals were found underutilised for both insured and uninsured farmers, which was found overutilized. The resource utilization of insured farmers except in the case of quantity of manures and fertilizers found less than uninsured farmers.

Response of insured and uninsured farmers was studied to analyse different aspects associated with WBCIS. Regarding the awareness of insured farmers, majority of farmers were aware about the premium rate and subsidies available still the overall awareness level was poor. It was found that, 51.86 per cent of insured farmers showed involuntary participation in the scheme. Moreover, majority (51.67 per cent) had perception of premium rate as high. Majority of insured farmers expressed as willingness to pay only up to 3 per cent of sum insured as premium. About 56.67 per cent of insured farmers were found dissatisfied with the scheme. The financial institution's compulsion was ranked first among the factors influencing for adoption of the scheme. Information from financial institutions was ranked the first as source of information about the scheme among the farmers. Insured farmers unanimously suggested the quick settlement of claims and increase in the indemnity level as a solution to improve the scheme.

Constraints in the adoption of WBCIS was studied among all the farmers and found that less satisfaction with the indemnity level found the most important constraint followed by the constraint of lack of awareness about the scheme. The third most constraint was lack of confidence in the scheme for farmers and then comes the constraint scheme does no cover the farmer sometimes even if the farmer had loss. Other constraints in ranking order were lack of motivation from officials, low premium paying capacity, delay in getting indemnity, lengthy procedure and non-coverage of post-harvest loss.

5.1. SUGGESTIONS

- Availability of recent data and inclusion of more relevant sub components, vulnerability to climate change can be studied better
- The present study can be extended to other districts in order to formulate sustainable policies
- The optimum use of all the factors of production can be insisted to increase the banana production and to reduce cost of cultivation
- Policy makers should take initiative for wide spread implementation of WBCIS with collaboration of all officials related to it
- Suggestions from the present study can be incorporated while formulating new policies on the WBCIS

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Appendix I

Appendix I

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF AGRICULTURE, VELLAYANI

DEPARTMENT OF AGRICULTURAL ECONOMICS

SURVEY SCHEDULE FOR THE STUDY- "MITIGATING PRODUCTION VULNERABILITY OF BANANA THROUGH WEATHER BASED CROP INSURANCE: AN ECONOMIC ANALYSIS".

A. **General particulars**

Name of the Krishi bhavan:

Name of the respondent:

Address:

House no.:	Village:	Block:
Taluk:	Pin:	Phone:

Age	:	Years		
Education	:	Illiterate/ Primary/ High school/ Higher secondary/ Graduation		
Farming experience in banana cultivation	:	Years		
Family composition	:	Nuclear/ Joint		
Family size (Nos)	:	Adults:	Male:	Female:
		Children:	Male:	Female:

B. Land particulars:

S. 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 value (Rs.)					

C. Buildings

S. No	Particulars	Nos.	Year of construction	Present value (Rs)	Remarks
1	Farm house				
2	Store house				
3	Cattle shed				
4	Pump shed				
5	Others (specify)				

D. Irrigation Structure

S. No	Particulars	No.	Year of construction	Present value (Rs)	Maintenance cost, if any (Rs/year)	Area irrigated (cents)
1	Open well					
2	Tube well					
3	Pond					
4	Canal					
5	Tank					

E. Machineries/ Implements

Sl. No.	Particulars	Number	Year of purchase	Purchase price (Rs)	Expected life (Years)
1	Pickaxe				
2	Spades				
3	Sprayers				
4	Vaakathi/ Knife				
5	Ladder				
6	Others 1. 2. 3. 4.				

F. Livestock

Livestock ownership: Yes/No

If Yes;

S. No.	Animal	Nos.	Market value (Rs)	Annual production	Annual Income (Rs)
1.	Work Bullock				
2.	Cow: Milch				
	Male				
	Calf				
3.	Buffalo: Milch				
	Male				
	Calf				
4.	Goat				
5.	Sheep				
6.	Poultry				
7.	Others				

G. Sources of income

S. No	Particulars	Unit	Annual income (Rs)	Remarks
1	Crop income			
2				
3				
4				
5				
6				

H. Cropping pattern

Cropping pattern: Sole cropping

Mixed cropping

Relay cropping

Crop rotation

S. No.	Crops	Variety	Area (Cents)	Irrigated /rainfed	Yield (kg)	Income (Rs)
1	Banana					
2						
3						
4						
5						

I. Loans availed & Savings

Does have savings in any financial institutions: Yes/No

S. No.	Purpose	Season / Year	Amount borrowed	Amount paid	Insured/ non-insured
1.					
2.					

Details about Weather Based Crop Insurance Scheme (WBCIS).

Whether insured under WBCIS: Yes/No

- **Insured farmers**

Whether aware about procedural formalities of the scheme: Yes/No

Aware about premium rate and subsidies available: Yes/No

Aware about starting and closing dates and periods of the scheme: Yes/No

Aware about method of indemnity calculation:	Yes/No
Aware about risks, coverage level and sum insured:	Yes/No
Aware about current changes in the scheme:	Yes/No
About participation in the scheme:	Voluntary Involuntary
Insured farmers perception on premium rate:	Reasonable Low High Unable to say
Insured farmers willingness to pay for premium rate:	1-2 % 2-3% 3-4% 4-5 %
Insured farmers satisfaction about the insurance:	Dissatisfied Satisfied Very satisfied

- **Uninsured farmers**

Have ever insured under WBCIS:	Yes/No
Source of information about this scheme:	Don't know Financial institutions Other farmers Krishi Bhavan

Reasons for not availing the WBCIS;

Lack of awareness about the scheme: Yes/No

Less faith in the scheme: Yes/No

Lack of need: Yes/No

Less indemnity level: Yes/No

Delay in settlement of claims: Yes/No

Previous bad experience: Yes/No

J. Experience of crop loss and insurance:

Crops	Cause of loss	Yield component				Total loss (Rs)	Premium paid (Rs)	Claim received (Rs)
		Normal yield (Kg)	Max. yield (Kg)	Expected yield (Kg)	Yield loss (Kg)			
Banana								

K. <u>Constraints in adoption of WBCIS</u>:

S. No.	Constraints	Rank
1.	Lack of awareness about the scheme	
2.	Low premium paying capacity	
3.	Lengthy procedure	
4.	Delay in getting indemnity	
5.	Post-harvest loss is not covered	

6.	Lack of confidence in the scheme	
7.	Not satisfied with the indemnity level	
8.	Scheme does not cover even if the loss incurred	
9.	Lack of motivation from officials	

L. Factors influencing the adoption of WBCIS:

S. No.	Factors	Rank
1.	Financial security	
2.	Production changes in the recent years	
3.	Suggested by experienced farmers	
4.	Good awareness about benefits of scheme	
5.	Affordable premium rate	
6.	Financial institution compulsion	
7.	Lack of farm diversification	
9.	Others	

M. Suggestions of the insured farmers on WBCIS

S. No	Particulars	Yes/No
1.	Unit area should be changed into smaller level	
2.	Quick settlement of claims and increase in indemnity level	
3.	Non-compulsory nature	
4.	All possible risks should be notified	
6.	Should include post-harvest loss	
7.	Make more efficient number of weather stations	
8.	More awareness on the scheme	
9.	Include more incentives for the adoption of the scheme	

N. Experience of any changes in the weather parameters over the years:

Variation in the rainfall in last 5 years: (Count)

Variation in the temperature in last 5 years: (Count)

Variation in wind pattern in recent years: Yes/No

O. Cost of cultivation

Wage rate: Men (Rs/ day),

Women (Rs/ day),

Machinery rent (Rs/ hour),

Cost of cultivation							
Sl.no	Input used	Quantity applied		Price	Labour		Total expenses (Rs)
		Unit	Quantity		M	F	
1	Banana sucker						
2	Clearing land						
3	Digging pits						
4	Props (types)						

5	Fertilizer Application 1. Urea 2. DAP 3. MOP 4. Complex 5. Others					
6	Manures 1. Cow dung 2. Green Manure 3. Sheep Manure 4. Poultry Manure					
7	Soil ameliorants 1. Lime					
	2. Others					
8	Weedicides 1. 2. 3.					
9	Insecticides 1. 2. 3.					

10	Fungicides 1. 2. 3.					
11	Biocontrol agent 1. 2. 3.					
12	Irrigation					
13.	Harvesting					
14	Post-harvest operation					
15	Transport					
16	Miscellaneous					

P. Yield and returns

Yield	Quantity		Unit Price received		Total price received	Marketing agency
	Main product	By product	Main product	By product		

Appendix II

APPENDIX - II

GARRETT RANKING CONVERSION TABLE

The conversion of orders of merits into units of amount of "socres"

Percent	Score	Percent	Score	Percent	Score
0.09	99	22.32	65	83.31	31
0.20	98	23.88	64	84.56	30
0.32	97	25.48	63	85.75	29
0.45	96	27.15	62	86.89	28
0.61	95	28.86	61	87.96	27
0.78	94	30.61	60	88.97	26
0.97	93	32.42	59	89.94	25
1.18	92	34.25	58	90.83	24
1.42	91	36.15	57	91.67	23
1.68	90	38.06	56	92.45	22
1.96	89	40.01	55	93.19	21
2.28	88	41.97	54	93.86	20
2.69	87	43.97	53	94.49	19
3.01	86	45.97	52	95.08	18
3.43	85	47.98	51	95.62	17
3.89	84	50.00	50	96.11	16
4.38	83	52.02	49	96.57	15
4.92	82	54.03	48	96.99	14
5.51	81	56.03	47	97.37	13
6.14	80	58.03	46	97.72	12
6.81	79	59.99	45	98.04	11
7.55	78	61.94	44	98.32	10
8.33	77	63.85	43	98.58	9
9.17	76	65.75	42	98.82	8
10.06	75	67.48	41	99.03	7
11.03	74	69.39	40	99.22	6
12.04	73	71.14	39	99.39	5
13.11	72	72.85	38	99.55	4
14.25	71	74.52	37	99.68	3
15.44	70	76.12	36	99.80	2
16.69	69	77.68	35	99.91	1
18.01	68	79.17	34	100.00	0
19.39	67	80.61	33		
20.93	66	81.99	32		

Abstract

MITIGATING PRODUCTION VULNERABILITY OF BANANA THROUGH WEATHER BASED CROP INSURANCE: AN ECONOMIC ANALYSIS

by

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Abstract of the thesis
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2019

ABSTRACT

The research entitled "Mitigating production vulnerability of banana through weather based crop insurance: an economic analysis" was conducted in the Palakkad and Wayanad districts of Kerala during 2017-19. The objectives of the study were to assess vulnerability of agriculture in general and banana farmers in particular to climate change in Palakkad and Wayanad districts. To evaluate economic benefits of Weather Based Crop Insurance Scheme (WBCIS) for banana farmers and to study the problems and suggest measures for scaling up of WBCIS. Primary data was collected from the farmers of both the districts for the agricultural year 2017-18. Secondary data regarding weather parameters, socio-economic and physiographic factors were collected from various sources.

Climate change vulnerability in both districts was assessed by constructing a composite index. It consists of three major component indices: adaptive capacity, sensitivity and exposure and those components were constituted of 27 sub components based on the secondary data collected. The adaptive capacity index, sensitivity index and exposure index obtained for Palakkad district were 0.481, 0.312 and 0.136 and for Wayanad district they were 0.543, 0.345 and 0.166 respectively. The climate change vulnerability index for Palakkad district was 0.322 and for Wayanad it was 0.365. Higher the value of index higher is the vulnerability to climate change. All the indices were more for Wayanad district compared to Palakkad.

Same methodology was used to analyse the vulnerability of banana farmers to climate change in the study area. The 14 sub components of vulnerability index were selected based on the primary data collected during the survey. The adaptive capacity index, sensitivity index and exposure index obtained for Palakkad district were 0.618, 0.425 and 0.566 for Wayanad district were 0.622, 0.458 and 0.609 respectively. The vulnerability index obtained for Palakkad was 0.552 and Wayanad was 0.572. The banana farmers in Palakkad district exhibited slightly more vulnerability change when compared to Wayanad districts.

To evaluate economic benefits of WBCIS for banana farmers, comparison of was done using cost concepts. At Cost C, insured farmers had incurred more cost (₹ 3,86,021 ha^{-1}) than uninsured farmers (₹3,50,910.06 ha^{-1}). The net returns at Cost C for insured farmers were ₹3,56,261 ha^{-1} and for uninsured farmers it was ₹3,24,197 ha^{-1}. Insured farmers had 9.89 per cent higher net return at Cost C than uninsured farmers. The BC ratio obtained for insured farmers (2.01) at Cost C were more than that of uninsured farmers (1.92). It was found that the insured farmers were having more economic benefits than uninsured farmers from banana cultivation.

The results of Cobb-Douglas production function revealed that R^2 value for insured and uninsured farmers was 0.87 and 0.79 respectively, which indicated a good fit. The analysis of allocative efficiency for insured and uninsured farmers revealed that quantity of hired labour, family labour and quantity of manures, fertilizers and soil ameliorants were underutilized. Furthermore, quantity of plant protection materials was overutilized by both categories of farmers.

Binary logit regression was fitted to understand the influence of socioeconomic variables on the adoption of WBCIS. From the analysis it was understood that number of years of experience in banana farming had a positive and significant effect, which indicates that the probability of taking insurance increases with increase in the number of years of experience in banana farming. Odds ratio was found as 1.1, meaning that the likelihood of adoption of insurance by more experienced farmers was 1.1 times that of farmers having less experience.

Response of insured and uninsured farmers was studied to analyse different aspects associated with WBCIS. Regarding the awareness of insured farmers, majority of farmers were aware about the premium rate and subsidies available, still the overall awareness level was poor. It was found that 51.86 per cent of insured farmers showed involuntary participation in the scheme. Moreover, majority (51.67 per cent) had perception of premium rate as high. Majority of insured farmers expressed willingness to pay only up to 3 per cent of sum insured as premium. About 56.67 per cent of insured farmers were found dissatisfied with the scheme.

The financial institution's compulsion was ranked first among the factors influencing adoption of the scheme. Information from financial institutions was ranked the first as source of information about the scheme among the farmers. Insured farmers unanimously suggested the quick settlement of claims and increase in the indemnity level as a solution to improve the scheme.

The main constraint in the adoption of WBCIS was 'less satisfaction with the indemnity level' and then 'lack of awareness about the scheme'. Among the uninsured farmers about 15 per cent farmers adopted the scheme in the previous years. Less indemnity level was the most common reason (75 per cent) for not availing the scheme among the uninsured farmers followed by lack of awareness about the scheme (68.33 per cent).

Thus, it can be concluded that Banana farmers in Wayanad district were more vulnerable to climate change compared to Palakkad district. Similar pattern was observed in the vulnerability of agriculture in general to climate change for both districts. WBCIS can be used as a good institutional mechanism for the farmers to adapt to vulnerability due to changes in climate.