RISK ANALYSIS OF AGRICULTURAL ECONOMY OF WAYANAD

By

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(2018-11-050)

DEPARTMENT OF AGRICULTURAL ECONOMICS

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR – 680656

KERALA, INDIA

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DEPARTMENT OF AGRICULTURAL ECONOMICS

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KERALA, INDIA

2020

DECLARATION

I, hereby declare that this thesis entitled **"RISK ANALYSIS OF AGRICULTURAL ECONOMY OF WAYANAD"** 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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Introduction

1. INTRODUCTION

Agriculture is one among the most risk prone business in the world (World Bank, 2015). A farmer has very limited control over the input prices, weather parameters, pest and disease attacks, pre-harvest and post-harvest losses, prices of the products, and all other factors that influence the production and marketing processes. The uncertainties in weather, yields, prices, and government policies can cause wide swings in farm income (USDA, 2020). Though appropriate crop management practices and input use could help in reducing the uncertainties in production, these strategies may not always be effective.

Risk and uncertainty refer to the condition in which a decision maker has limited control over the outcome, but these conditions are also quite different in themselves. Knight (1921) defined risk as the case for which the distribution of outcomes is known, either *a priori* or statistically through experience, and uncertainty as the situation in which the probability of an outcome cannot be quantified. The terminologies related to risks and risk management have been extensively used by various authors with slightly different meanings. In this study, various terminologies related to risk are used with the meaning and definition as given by the Society of Risk Analysis (SRA), an international multidisciplinary society (www.sra.org). Risk is defined as the consequence of a future activity with an associated probability and an activity to be deemed as risky, at least one among the consequence should be negative. A source of risk is an action, component, system, or an event that has the potential to cause specified consequences. Risk analysis is the systematic process to understand and express the nature of risk with the accessible information. The amount and type of risk an organization or an individual is willing to take in pursuit of values or interests is termed as risk appetite. Risk aversion refers to the avoidance of risk, while risk mitigation is the process of actions undertaken to reduce risk. Risk management refers to the ways of handling risks such as prevention, adaptation, mitigation or risk sharing (SRA, 2015).

Risk is an integral part of agriculture and it can be broadly classified into five types *viz.*, production risk, market risk, institutional risk, personal risk, and financial risk (Komarek *et al.*, 2020). Production risks are those risks occurring in different growth phases of a crop, influenced by weather and climate, soil salinity, heavy metal contamination, etc. Market risks are the results of fluctuating prices, costs, and market access which are caused by volatility in production, poor competency in the market, and lack of market information. The unprecedented changes in regulations and policies by formal institutions including the government and informal institutions like rural producer organisations, and trading partners can give rise to institutional risk. Personal risks are caused by individual attributes like health and personal characteristics which include injuries from operating machines and health problems caused by the use of chemicals. The nature and source of credit availed by a farmer can lead to varying degrees of financial risks in the farm. Institutional sources of credit are considered to be less risky, but they have more procedural formalities as compared to non-institutional sources. The changes in interest rate and credit conditions, availability of credit, and timing of credit flow can all influence the financial risks faced by a farmer. One type of risk can often lead to another and it is common to see a combination of risks existing in a farm.

Wayanad district in the state of Kerala faces different types of risks in agriculture on a consistent basis. Taking its name from paddy fields, Wayanad was known for its cool climate and characteristic two rice growing seasons- '*Nancha'* and *'Puncha'*. However, farmers no more find paddy as a remunerative crop, which is evident from its dwindling area in the district. In 1981-82, the area under paddy in the district was 30,021 hectares (GoK, 1988) and it declined to 7,762 hectares in 2018-19 (GoK, 2019a), a decrease of 74.1 per cent. The climate and elevation of Wayanad have favoured the cultivation of plantation crops like coffee, which occupied about 40 per cent of the gross cropped area in the district (GoK, 2019a). Among the other crops, arecanut, rubber, black pepper and coconut accounted for a significant share in the total cropped area of the district.

The economic reforms of 1991 and the subsequent trade liberalisation policies, including the Free Trade Agreements, have brought umpteen challenges to the agricultural economy of Wayanad. As India opened up for the world market, the prices of commodities traded globally, particularly that of black pepper, coffee and tea became more volatile. The effect of price transmission from the global market to domestic market and the resultant fall in prices in the domestic market (Sabu and Kuruvila, 2016) have caused serious unrest among the farmers. The efforts taken by farmers to overcome this situation faced a major setback due to droughts in early years of the new millennium. The agrarian crisis worsened due to the combined effects of crash in prices, indebtedness, and drought (George and Krishnaprasad, 2006), which led to the infamous farmer suicides in Wayanad district (Jeromi, 2007). Meanwhile, some of the farmers ventured into other high value crops like vanilla, which was highly remunerative during early 2000s. However, the inelastic demand for vanilla combined with excess production led to a drastic fall in price. Climate change became a serious concern in the district during the second decade of the new millennium, presenting the farmers with yet another risk to confront. The erratic monsoons and hot summer days have become common in the district. While lack of summer showers affected the coffee farmers, excess monsoon adversely impacted the black pepper farmers. The unprecedented Kerala floods of 2018 and 2019 devastated the agricultural economy of Wayanad. Almost all farmers were affected in one way or the other, exacerbating the agrarian crisis of the district.

Consequently, identifying the risks that the farmers face on a day to day basis, and analysing the effectiveness of the risk management strategies have assumed great importance. The ex-ante and ex-post risk management strategies, which form an important element in the agricultural production process, could help in avoiding the negative impacts of risks and ensure a steady and reasonable income (Holzmann *et al.,* 2003). The ex-ante risk management strategies include the choice of crops and cultivation practices. Even though crop insurance is also an ex-ante risk management strategy, it is less attractive to farmers as there is no provision for compensating losses in production. Ex-post strategies like price stabilisation and Minimum Support Price (MSP) would be effective only if the type of risk under consideration is not affecting the production of crop. Each type of these risks calls for separate management strategies like phasing the sale of produce, collective marketing, waiver of interest or principal, and rescheduling of loans.

Wayanad presents a unique situation in which many types of risks have co-existed over time. The high dependency of the district on agriculture makes it very important to study the types and effects of various risks, and the corresponding coping strategies adopted by the farmers. Studying any one type of risk in isolation pose the problem of overlooking other types of risks which may be equally important, if not more. The type of risk under study could also be the result of any one or more types of risks. So, a collective study of various types of risks is the right way forward.

With the above background information about the types of risks, mitigation strategies, and characteristic nature of agriculture in Wayanad, this study analyses the risks present in the agricultural economy of the district. Efforts have also been made to understand the individual risk appetite of farmers and the risk management strategies adopted by them. A measure of the individual risk appetite shows how good a farmer is in dealing with risks and the extent of support needed from the government. The risk mitigation strategies adopted by the farmer indicate the level of control that the farmer has over the risky venture of agriculture. The overall objective of the study is to identify and analyse the sources and types of risks in the agricultural economy of Wayanad district.

The specific objectives of this study are:

1. To estimate the agricultural risks in Wayanad district.
2. To identify the sources of risks in farm households of Wayanad and to estimate their risk preferences.
3. To assess the types and determinants of coping mechanisms in farm households.

1.1 LIMITATIONS OF THE STUDY

The micro-level analysis in this study is based on the responses of farmers in Wayanad district of Kerala. Even though proportionate sample sizes were allocated for each block in the district and were further randomised before survey, generalisations drawn from the findings of this study should be made with care. The innate errors while undertaking a social survey like missing information, bias in reporting the data, and prejudiced responses of farmers may have found its way into the study. The non-incentivised method of eliciting individual risk appetite, as used in this study, might yield a slightly different result from the actual risk preference of the farmer. The regular limitations of statistical analyses might also have affected the study.

A detailed explanation about the risk game was given to the farmers before playing the game to limit the errors in responses to as minimum as possible. The responses given by farmers in the risk game were further compared with that of the direct risk question to derive the best possible conclusions. All possible measures were taken to ensure that the limitations mentioned above did not affect the authenticity of the results of the study.

1.2 PLAN OF THESIS

The thesis is organised into five different chapters. The first chapter gives an introduction and general idea about the thesis through elucidating the concepts used in the study, its relevance, the theoretical framework, specific objectives, and limitations. The second chapter looks into the context of this study and similar studies in the past, thereby giving the theoretical and empirical background. The third chapter deals with the description of study area and various methodologies used in the study. The fourth chapter presents various results drawn from analysing the data and complements it with a discussion section. The fifth and the final chapter gives the summary and policy implications of the study, which is followed by references, appendices and abstract.

Review of Literature

2. REVIEW OF LITERATURE

A discussion and review of the past studies undertaken in similar areas of research are crucial in understanding the scope of the present study. This is also important in framing the objectives, as well as getting an insight into the methodology to be followed in the present study. This chapter deals with the studies that have been published in similar areas of research and they are presented under five sections. These five sections are so formed based on the objectives as well as methodology of the present study.

2.1 Agricultural economy of Wayanad

2.2 Identification of various sources of risk

2.3 Estimation of various risks

2.4 Elicitation of individual risk preferences

2.5 Types and determinants of risk coping mechanisms

2.1 AGRICULTURAL ECONOMY OF WAYANAD

Wayanad is predominantly an agriculture oriented district with high dependency on plantation crops. The major crops grown in the district are coffee, arecanut, rubber, black pepper, coconut, banana and paddy (GoK, 2019a). The district has a gross cropped area of 1,66,875 hectares and a cropping intensity of 148 per cent during 2017-18 (GoK, 2018). The district has experienced numerous agrarian crises due to fluctuating prices, indebtedness, droughts, climate change, economic reforms and trade liberalisation, and land use changes.

Joy (2004) studied the small coffee growers of Wayanad district with the objective of assessing the costs and returns involved, constraints encountered, extent of price fluctuation, labour absorption capacity, and the impact of climate change on coffee production by using Participatory Rural Appraisal (PRA) method. He found that majority of the farm households were less than two hectares in size, which were mostly owner operated with occasional hiring of casual labourers. Stagnation in price of coffee along with subsequent increase in price of other cash crops like black pepper have led the coffee growers to mixed cropping and thereby reducing the working expenses in coffee. High cost of irrigation facilities coupled with water scarcity prevented the farmers from irrigating their fields, even though evidences showed that it could increase the yield up to 70 per cent. He concluded that distress sale was also a common practice for coffee growers since they were not having the source and means to cushion their financial constraints.

George and Krishnaprasad (2006) studied the agrarian crisis and farmers' suicides in Wayanad and pointed out three main reasons for the agrarian crisis *viz*., crash in prices of commodities, indebtedness, and drought. They reported about a survey conducted by Kerala Karshaka Sangam in 26 farm households in which a farmer suicide has been reported. All those households have availed loans and 20 among them had availed credit from private moneylenders too, as they lacked any collateral to present before the bank. Most of the households were lower middle class and followed mixed cropping with coffee, black pepper, paddy, and arecanut. They concluded that even though the suicides could be immediately linked to mental depression and alcoholism, the underlying truth of agrarian distress cannot be overlooked.

Jeromi (2007) studied the indebtedness and suicides of farmers in Kerala. He reported how a commercial crop producing and export-oriented economy could suffer due to trade liberalisation and the resultant opening up. Based on a survey of 316 families in which a farmer has committed suicide between 2002 and 2006, it was reported that agricultural crisis was the reason for the suicide in 38.9 per cent of the sample households. Though 40 per cent of families could not state the exact reason for the suicide, he suggested that agrarian crisis could be a triggering factor for someone who was already psychologically depressed. Another important finding of the study was that nearly 60 per cent of the farmers who committed suicide had a land holding size of less than one acre and 40 per cent were cultivating on leased in land.

Nair *et al.* (2007) examined the agrarian distress and strategies adopted by households to overcome the distress in the Pulpally region of Wayanad. The region was predominantly occupied by farmers who migrated to Wayanad during the period from 1950 to early 1970s. The fertile forest land along with remunerative prices for crops like black pepper had resulted in the economic boom of the region during 1980s and 1990s. However, the unscientific cultivation practices followed by the farmers had its toll in the form of reduced yields and increased disease infestation. When coupled with the lower market price for black pepper in the mid and late 1990s, it led to economic crisis of farm households in the region. Reduction in consumption as well as family and farm expenditures followed the agrarian crisis. Crop diversification was adopted by farmers with medium and large land holdings. Dairying and animal husbandry proved to be major relief and source of stable income for many farm households which were adversely affected by the agrarian crisis.

Bhavya (2008) studied the causes of indebtedness among farmers and its consequence on farm households in Pulpally Panchayat of Wayanad. Sixty sample respondents were randomly selected and the study showed that the average amount of loan due per farm household was ₹64,518 and the average number of years of indebtedness was 6.9 years. About 48 per cent of the respondents reported to have utilised the credit for non-agricultural purposes. Low price for the produce was ranked to be the major reason for indebtedness among the famers, and changes in lifestyle, along with decreased household consumption were ranked to be the major consequence of indebtedness. Farmers also perceived direct cash compensation as the most useful government intervention to cope with this situation.

Munster (2012) reported the difficulties and constraints in employing ethnographic research in studying the farmer suicides as it goes well over the boundaries of agrarian distress and involves many other socio-political factors. While detailing about the farmer suicides in Wayanad, he reported the issue to have links with problems of debts, personal longings, migration, family issues, alcoholism, and cultivation of cash crops.

Varghese (2012) examined the situation of water scarcity and its socio-economic impacts in Wayanad district through a study of 135 farmers, 15 each from nine Panchayats. A composite vulnerability index was estimated and a logit model was used to identify the factors influencing the vulnerability of farm households. The conversion of paddy land to commercial crops like rubber, arecanut and banana, and a decline in area under black pepper were observed during the last few years. Climate change was reported as one of the major reason for this change, which was justified using the weather data. An inverse relationship between vulnerability and land holding size was established, with diversity index and cropping diversity being the major determinants of vulnerability of a household. Thavinjal Panchayat was identified as the most vulnerable Panchayat in the district, while Muppainad and Vythiri Panchayats being the least vulnerable ones. Irrigation was found to be the major coping strategy adopted by the respondents.

Radhakrishnan and Gupta (2017) developed a Livelihood Vulnerability Index (LVI) based on the recommendations of the Intergovernmental Panel on Climate Change (IPCC) to assess the vulnerability of livelihoods dependent on dairy in Wayanad by randomly selecting 180 sample respondents from three taluks in the district. The estimated vulnerability index showed that farmers in Mananthavady taluk were the most vulnerable while considering the livestock component. The average milk productivity per animal was found to be 10 litres for Sulthan Bathery, while it was just 5 litres for Pulpally and Mananthavady regions. The LVI showed that all taluks were vulnerable to climate variability and change. Pulpally region had 48.33 per cent of its farmers in high level vulnerability group, which was the highest in any of the region studied.

Vijayan (2018) analysed the instability in agricultural income for the state of Kerala as well as all the districts at current and constant prices. The Compound Annual Growth Rate (CAGR) was used to study the growth in agricultural income from 1900-00 to 2015-16. The growth in agricultural income at current prices for the state was 10.6 per cent, but was -0.8 per cent at constant prices. The growth rate in agricultural income for districts were also positive at current prices, but were reported to be negative at constant prices except for Palakkad, Kasaragod and Kottayam. Wayanad, with an instability index of 0.210, was ranked as the second most ‘high risk’ district in the state after Alappuzha (0.225).

2.2 IDENTIFICATION OF VARIOUS SOURCES OF RISK

Zhen *et al.* (2005) assessed the environmental, economic, and socio-institutional aspects of cropping systems in the North China plain. Based on the household survey of 270 farmers combined with soil and ground water analyses, they found that even though all the examined cropping systems were viable, only six per cent of the sample farmers practiced recommended input use. The over exploitation of natural resources made the cropping systems unsustainable in the long run. The indiscriminate use of chemical inputs had caused personal health risks such as headaches and fatigue, leading to further decline in productivity.

Devi and Ponnarasi (2009), while analysing the economics of modern rice production technology, used Garrett ranking technique to study the perceptions of farmers about the adoption of System of Rice Intensification (SRI) in Tamil Nadu. They studied 50 farmers who practiced SRI and 50 farmers who didn't practice SRI. Higher grain and straw yield was ranked first (mean score of 78.91) in their study as the major reason for adoption of SRI, while lack of skilled labour came out as the major reason (mean score of 67.21) for non-adoption of SRI method.

Braendeland *et al*. (2010) explained about the quantitative and qualitative estimation of risks in agriculture. According to them, qualitative estimation of risk dealt with causes and consequences, whereas quantitative estimations were focused on event probability calculations.

Aditto *et al.* (2012) analysed the sources of risk and coping strategies in the farming households of central and northeast regions of Thailand using a five-point Likert scale. An exploratory factor analysis technique was used to categorize the sources of risk and results showed that unexpected variability in prices of input was perceived as the most important source of risk, followed by the variability in prices of products, and disease and pest infestation. Farm mechanisation and maintaining feed/seed reserve were the major production strategies adopted to manage the risks, while marketing strategies followed included obtaining market information and phased sale of products. Multiple regression analysis was used to identify the factors that influenced perception of different risk sources and management strategies. Age, years of education, farming experience, farm size, land ownership size, annual income, and off-farm income were all found to influence the risk perception of the farmers.

Girdziute (2012) stated that risks in agriculture could be categorized as personal, economic, production, political, and credit risks. According to her, any other source of risk could be an extension of any of these. She opined that quantitative estimation of risk in agriculture was very difficult and estimating any one of the above-mentioned types of risk would be sufficient to get a broad picture of risk in agriculture.

Pacin and Oesterheld (2014) studied how diversification and selection of stable enterprises impact the economic stability of farms in the southwest of the Pampa region in Argentina using a simulation procedure for the data collected from 87 farms during the period from 2000 to 2008. The study also provided an understanding on the production and marketing risks of that region. Coefficient of variation of return on capital was used to assess the economic stability of individual farms and the results showed that diversified farms have less economic variability as they had greater mean returns with similar levels of standard deviation as other farms. Livestock was found to give more stable returns as compared to crops, wherein wheat was the most stable crop and corn was the least stable one.

Pelka *et al.* (2015) studied how rainfall could influence the financial risks of farmers who are microfinance beneficiaries in Madagascar. For this, they collected original loan and repayment data from microfinance institutions and tried to relate it with the weather data. They found that excess rainfall directly influenced the repayment of loans, thus putting forth their finding that even a change in climatic factor could make a farmer vulnerable to financial risk.

Reddy (2015) identified 10 types of risks that affect agriculture in India: *viz;* production risk, price/market risk, financial/credit risk, institutional risk, human/personal risk, legal/policy risk, resource risk, health risk, assets risk, and technology risk. Since majority of the population that depend on agriculture were small and marginal land holders or landless labourers, he suggested that facilitating financial services at reasonable cost could help in raising the productivity, income generation and asset formation among the poor. Various directed schemes by the government towards facilitation of financial services included farm credit package, interest subventions, collateral free loans, Kisan Credit Card (KCC) scheme, Agriculture Debt Waiver and Debt Relief Scheme (ADWDRS), and National Agricultural Insurance Scheme (NAIS).

Zalkuwi *et al.* (2015) made a comparative analysis of constraints faced by sorghum farmers in India and Nigeria using Garrett ranking technique. A sample of 240 farmers each from both the countries were asked to rank a series of 12 constraints which were found out in consultation with experts in the field. The per cent position of each rank was converted to scores by using the table given by Garrett and Woodworth (1969). With a mean score of 75.34, low price for sorghum was found to be the first among the constraints faced by farmers in India, whereas in Nigeria, shortage/high cost of inputs, with a mean score of 72.42, was the major constraint.

Campbell *et al.* (2016) evaluated the studies that tried to find the link between climate change and crop production. They found that most of the studies highly depended on climate-crop modelling, which in itself has many shortcomings. Those studies paid little attention to other factors influencing the crop production and food security. Even though climate change does add to crop production risks, a more holistic approach was felt necessary.

Ullah *et al.* (2016) reviewed the various farm risks, its sources, possible impacts and potential management options. They classified agricultural risks under two broad categories *viz.*, business risk and financial risk. Business risk included production, institutional, market and personal risks, whereas financial risk included all risks arising out of financing the farm. They suggested that the farmer's attitude towards risk, farm and household characteristics, and institutional factors collectively influenced the decision of a farmer to adopt various risk mitigation strategies.

United States Department of Agriculture (USDA) identified and described five types of risks in agriculture *viz.*, production risk, price risk, financial risk, institutional risk and personal risk (USDA, 2020).

Chand *et al.* (2018) identified the sources of risks in livestock production and mitigation strategies adopted by livestock farmers in the states of Haryana and Rajasthan through an opinion survey. The three major source of risks in livestock faming as reported by the farmers were breeding, animal health, and marketing. The risk management strategies included selection of better breeds, check-ups, getting veterinary support, and forward selling contracts. Examination of socio-economic characteristics revealed that education, milk production, and size of herd were negatively related to the chance of a farmer being vulnerable to various sources of risks.

Iqbal *et al.* (2018) tried to account all the sources of risks that cotton farmers faced in the Punjab province of Pakistan. A study of 480 farmers revealed that they faced various kinds of risks like natural, environmental, marketing, and economic risks. The major sources of risks, as perceived by famers were the frequent changes in agricultural policies in the country, followed by the high cost of farm equipment. Majority of the farmers found construction of small dams as the major risk mitigating strategy. They suggested increasing awareness among farmers about various sources of risks and developing a community-based risk mitigation campaign to cope up with this situation.

Komarek *et al.* (2020) reviewed 3283 peer-reviewed studies on various sources of risks in agriculture around the world so as to identify the extent of understanding and the extent of research that have taken place on agricultural risks. Surprisingly, 66 per cent of them exclusively dealt with production risk, while only 15 per cent dealt with more than one type of risk. This clearly showed a gap in knowledge regarding the understanding of various sources of risks that farmers face on a daily basis.

2.3 ESTIMATION OF VARIOUS RISKS

Chen *et al.* (2004) conducted a statistical investigation on the variability in yield of principal crops in the U.S due to climate change. They made use of observations on the yield of crops and then tried to extrapolate it, considering the predicted change in climate. The production data over the years were estimated using Just and Pope stochastic production function which embodies variance estimates of yield. This was done by making use of time series as well as panel data of crop yields. The study found that climate change caused changes in crop yields as well as the variability in yield. For corn, increase in rainfall was found to increase the yield and decrease the yield variability, while increase in temperature had resulted in decrease in yield and increase in yield variability. Sorghum showed increased yields as well as yield variability with more rainfall, while temperature had the opposite effect.

A long-term study about the trend in growth of agriculture sector and careful examination of the points of structural breaks could throw light into the underlying issues and risks in agriculture over the years. The growth and performance of agriculture sector for the fifteen states of India from 1960-61 to 2006-07 was analysed by Ghosh (2010). The net state domestic product from agriculture was found to be decelerating in the post reform period in all the states except Andhra Pradesh and Gujarat. Also, the point of structural breaks in trend of agricultural growth varied from state to state owing to the differences in the inter-state growth performance.

Anoopkumar (2012) analysed the domestic intra-year and inter-year instability in prices of major plantation crops in India using Cuddy-Della Valle index. He found that the inter-year instability in prices could be explained by the cyclical pattern of production of commodities, whereas intra-year instability could be explained by seasonality in production. For crops like black pepper, rubber and coffee, which were oriented towards international market, the instability in prices were found to increase with opening up of the economy by trade liberalisation, whereas for those crops like cardamom and tea which were oriented towards the domestic market, the price instability was found to decrease after trade liberalisation.

Arumugam *et al.* (2014) conducted a study on how climate variability could impact crop yields of principal crops in Tamil Nadu. They employed Just and Pope stochastic production function as it facilitated the estimation of climatic influence on the mean yield as well as variance in yields. Upon estimating the production function using Feasible Generalised Least Squares (FGLS) method, they concluded that increase in temperature was beneficial for crops like maize, paddy, sugarcane and cotton, whereas the variation in climate was beneficial for banana. Precipitation had a beneficial role in the yield of cotton, but was detrimental for maize. An increase in variance of paddy yield was observed with increased temperature. Further, they predicted that the yields of maize, cotton and sugarcane were likely to decline by the year 2030 in different zones up to the tune of 2.7 per cent, 13 per cent and 4.7 per cent respectively.

The decreasing trend in the cultivation of food crops and movement towards commercial crops which show price volatility in the market have been perceived as a risk to the food security of Kerala. Kanampath and Singh (2015) studied the cropping pattern of the state from 2001 to 2012. They used CAGR to measure the extent of increase or decrease in area under each crop within the state and employed Cuddy-Della Valle index to measure the instability. They recorded an increase in growth of fallow land in the state. An increase in growth was seen for banana and rubber in terms of area up to the tune of 1.53 and 1.07 per cent respectively. Food crops recorded negative growth rates during this period with rice and tapioca showing 4.01 per cent and 3.83 per cent decline in area respectively.

Sabu and Kuruvila (2016) studied the price instability of black pepper before and after trade liberalisation using Cuddy-Della Valle index. Instability of prices was also estimated by calculating the long run exponential trend levels of prices and observing the absolute percentage deviation from this trend. Upon evaluating the annual instability indices for both nominal and real prices in international and domestic markets, they concluded that the instability in prices of black pepper has increased in India during the post-trade liberalisation era. However, the price instability has decreased in the international market following trade liberalisation. They attributed this change to the transmission of price volatility from the international market to the Indian market as a result of trade liberalisation.

Vijayan (2018) used chain index to study the instability in agricultural income for the state of Kerala and its districts over the years. The income disparities among different districts were estimated using the standard deviation in income from agriculture. This was worked out for the period from 1999-00 to 2015-16. The results showed that by the year 2015-16, the agricultural income increased by 357 per cent with respect to the base year. The link relatives showed that there was a gradual and systematic increase in agricultural income over the years, with a slight fluctuation around 2010.

Dube *et al.* (2019) studied the effectiveness of Agricultural Development Led Industrialisation (ADLI) strategy of the Ethiopian government in tackling poverty and strengthening agricultural development by employing structural break analysis. They found a structural break in the economic growth of the country in 2004, with a higher rate of growth afterwards. This finding was also reiterated by their descriptive studies which showed agriculture to be the largest contributor towards GDP of the country.

George (2019) analysed the crop diversification and change in area under different crops for Kerala during the period from 1987-88 to 2001-02 and from 2002-03 to 2016-17. During the first period, a positive growth rate in area was observed for banana (6.38 per cent), arecanut (2.77 per cent), rubber (2.08 per cent), pepper (1.84 per cent), coffee (1.53 per cent) and coconut (0.92 per cent), while paddy (-4.66 per cent), tapioca (-3.21 per cent) and cashew (-2.57 per cent) showed negative growth. In the second period, a positive growth rate in area was observed for rubber (1.19 per cent), banana (0.38 per cent) and coffee (0.11 per cent), whereas negative growth was recorded for black pepper (-8.62 per cent), cashew (-5.38 per cent), paddy (-1.63 per cent), coconut (-1.09 per cent) and arecanut (-0.34 per cent).

2.4 ELICITATION OF INDIVIDUAL RISK PREFERENCES

Anderson *et al.* (1977) in their book 'Agricultural decision analysis' explained about two major techniques in designing interviews to determine the risk appetite of farmers. These two risk elicitation methods were the Equally Likely Certainty Equivalent (ELCE) method and Equally Likely but Risky Outcome (ELRO) method. They also discussed about the situations in which these methods could be adopted, the various utility functions that could be fitted with the elicited data, and the constraints while using this method.

Gneezy and Potters (1997) studied the decision making behaviour of 84 students from Tilburg University, Netherlands, under two different treatments (Treatment L and Treatment H). The aim of this experiment was to study the validity of Myopic Loss Aversion (MLA) put forth by Benartzi and Thaler (1995) for explaining the equity premium puzzle. According to MLA, subjects evaluating returns over a longer period of time (Treatment L) are likely to make more risky choices than subjects evaluating returns more frequently (Treatment H). The results showed that in all cases, students of treatment L showed statistically significant (Mann-Whitney test) and superior bid than students of treatment H.

Risk taking nature of men and women was a subject of study since long time. Eckel and Grossman (2002) studied the actual and forecasted risk attitudes of men and women among 200 students from Saint Cloud State University (SCSU) and Virginia Polytechnic Institute and State University using an incentivised lottery method. They found that the number of women choosing risk free gamble was four times as that of men. Also, both genders predicted that women would be more risk averse than men. Similar studies conducted earlier also showed women to be more risk averse than men (Boverie *et al*., 1995), particularly in financial aspects (Jianakoplos and Bernasek, 1998; Barsky *et al*., 1997; Levin, *et al*., 1998).

Holt and Laury (2002) conducted an experiment to study the risk behaviour of people under real low incentive, hypothetical high incentive, and real high incentive scenarios. They gave paired lottery choices to the respondents from a few dollars to several hundred dollars. The results showed that even under low incentive scenario, two-third of the individuals were risk averse. For hypothetical high incentive scenario, the risk aversion nature was found to be unaffected. However, with real high incentives, the nature of risk aversion was found to increase considerably.

Lejuez *et al.* (2002) employed the Balloon Analogue Risk Task (BART) in evaluating the behavioural measure of risk taking among 86 individuals selected through advertisements. The method involved computer simulated pumping of air into 90 balloons of three different colours. An incentive of five cent was credited to a temporary bank for each pumping of air into the balloon without exploding it. The participant could transfer the amount to a permanent bank anytime by stopping pumping and moving to the next balloon. In all the balloon colours used for simulation, the number of pumps made by the participants were found to be less than the average number of pumps that maximised earning.

Risk taking attitude can be directly elicited by asking respondents to rank them on a particular scale. A study by Weber *et al.* (2002) employing factor analysis strongly suggested that risk taking is domain specific and not all people take risk equally in all domains. Six domains were formulated by him *viz.*, financial investment, gambling, health/safety, ethical, recreational and social. The estimated Pearson rank correlation among the risk taking attitudes of a respondent in different domains showed no significant relation.

There are many criticisms against elicitation of risk using questionnaires and general risk questions, since they are not incentivised as in lottery experiments. However, lottery experiments generally deal with lesser sample size, thereby raising questions on the statistical significance of the method. Risk elicitation by general risk question can have large sample size but lesser appeal as they are not incentivised. Dohmen *et al.,* (2011) studied the risk attitudes of 22,000 individuals using the German Socio-Economic Panel (SOEP) data and validating it with lottery experiment on 450 representative German adults. The samples were selected identical to the SOEP survey and showed similar characteristics in all aspects. The findings of the experiment were in line with the results of SOEP data indicating that general risk question can also elicit individual risk attitude as in lottery experiments. The experiment also showed that risk attitudes among different domains are not perfectly correlated, but have a significant pairwise correlation value of around 0.5. An underlying general attitude towards risk was affirmed by the principal component analysis of general risk questions and domain specific questions, which showed that 60 per cent of the variation in individual risk attitude was explained by one principal component.

Korir (2011) employed ELCE method to elicit the risk attitude of the farmers in Uasin Gishu County of Kenya. He interviewed 96 farmers, wherein they were asked to cite a Certainty Equivalent (CE) amount that will make them indifferent between a gamble of KSh. 2,00,000 and KSh. 0. Based on their response, further questions were asked till the farmer's CE or assured income becomes KSh. 1000. This procedure was followed again to get the CE values between his first chosen assured income (for the gamble of KSh 2,00,000 and KSh 0) and KSh 2,00,000.. Further, the utility function of the farmers were plotted using negative exponential function and their risk attitudes were elicited using Arrow-Pratt absolute risk aversion coefficient. The study showed that all farmers interviewed were risk averse with the risk aversion coefficient ranging from 0.0000006182 to 0.0001279930.

Analysing various experimental methods of elicitation of risk appetites, Charness *et al.* (2013) suggested that any approach used to elicit risk appetite should be custom made in line with the competence of the respondents as well as the nature of questions asked. They said that when complex methods were used to elicit the risk appetite, there was a chance that large number of respondents in the population may fail to comprehend it. This significantly reduced the reliability of the result and could result in biased estimates. Conducting personal interview to elicit the risk appetite of a farmer was one of the most widely used risk elicitation method.

Saqib *et al.* (2016) studied the risk attitudes of farmers in the flood prone areas of Pakistan. For the 168 sample farmers, they used the ELCE method to find out the utility curve of each one of them. A cubic utility function was fitted for the elicited CE values of the farmers and an absolute risk aversion coefficient was calculated to identify their risk taking nature. The study found more than half of the farmers to be risk averse, with the binary variable for risk aversion taking a value of 0.56. Logistic regression was used to find out the effect of socio-economic factors in the risk perception of farmers. They found that farmers who were educated, had more experience in farming, had larger family size, without any non-farm income, and had lower size of land holding were more risk averse than their corresponding counterparts.

Attansai *et al.* (2017) studied the possible relation between general self-assessment risk questions and incentivised methods of risk elicitation by studying 62 undergraduate students at Bocconi University in Milan. In general, they found the correlation between the two methods to be low and statistically insignificant. However, for subjects with constant relative risk aversion, a significant correlation among the two methods could be found.

Sanou *et al.* (2018) compared the reliability of different risk elicitation methods like Likert survey question, incentivised methods, and non-incentivised methods in rural Niger. They found that non-incentivised and Likert scale methods were not reliable in eliciting the risk appetites of rural people as compared to incentivised methods. Even after accounting for differences in design of questions, they found that incentivised and hypothetical methods were not significantly correlated, implying higher reliability of incentivised methods.

Ganguly *et al.* (2019) studied the risk taking behaviour of women SHG members in Muzaffarpur district in Bihar. The respondents were initially asked to rank them as fully willing, more willing, indifferent, less willing, and not willing to take risk. Out of the 317 respondents, majority of them (34 per cent) reported indifference to taking risk. Then they were asked to choose a game option from five paired combinations, where the option one was the least risky with equal probability of winning ₹80, while the option five was the riskiest with equal probability of winning either ₹200 or going empty handed. The results showed that majority of the respondents (28 per cent) chose option three followed by option four (25 per cent). Of the 6.3 per cent of women who reported fully willing to take risk, only 38 per cent actually chose option five and even 29 per cent among them chose option one. Out of the 9.1 per cent of women who were unwilling to take risk, 45 per cent played it safe by choosing option one.

2.5 TYPES AND DETERMINANTS OF RISK COPING MECHANISMS

Manojkumar *et al.* (2003) conducted a case study on the effectiveness of crop insurance scheme as a risk mitigation measure for the banana farmers in Wayanad. Information on cost of cultivation, production, prices, constraints in farming, and willingness to pay for insurance were collected from a sample of 120 farmers from three blocks of the district. They found that only 20 per cent of the farmers who cultivated banana as a major crop were enrolled in the insurance scheme. Majority of the farmers considered banana cultivation as a risky venture and the returns from it to be unpredictable. The premium rate for insurance was calculated after estimating the cost of cultivation and was found to be ₹4.32 per plant in Wayanad.

Flaten *et al.* (2005) studied the risk perception and coping strategies adopted by conventional, as well as organic dairy farmers in Norway. Analysing the data collected from 363 conventional and 162 organic farmers, they concluded that organic farmers were less risk averse as compared to conventional farmers. However, their management practices were quite similar. The management strategy that the dairy farmers adopted included financial measures like liquidity management, prevention of diseases, and availing insurance schemes.

The report of the working group on risk management in agriculture for the eleventh five year plan for India examined the various sources of risks in agriculture and recommended a varied set of formal and informal risk management strategies. The on-farm informal risk management strategies included avoiding risk exposure, crop and plot diversification, mixed farming, income diversification, keeping buffer stocks of crops or liquid assets, and adopting advanced cropping techniques. Informal risk sharing strategies recommended were crop sharing, agricultural equipment and irrigation source sharing, and informal risk pool. Reducing consumption, deferring family functions, sale of assets, migration, reallocation of labour, and mutual aid were included in the informal strategies to cope with shocks (ex-post strategies). The on-farm formal strategies included providing agricultural extension, supply of quality seed and inputs, pest management, and improved infrastructure facilities. The formal risk sharing strategies suggested were contract farming, futures contracts, and insurance. Provision of credit, social assistance, rescheduling of loans, agricultural insurance, relaxed procurement procedures, fodder supply, and cash transfer were included in the formal strategies adopted to cope with shocks (GOI, 2007).

Rao and Bockel (2008) conducted a case study for the Food and Agriculture Organisation (FAO) to suggest the policy measures on how risk management policies can overcome food security issues in India. In their study, they suggested major types of risk management measures that could be adopted in the Indian scenario. On the financial front, they suggested measures like agriculture credit, input subsidies, and calamity funds. For production and asset protection, area yield-based crop insurance, weather-based crop insurance, livestock insurance, and micro-insurance were recommended by them. Minimum Support Price (MSP), electronic spot exchanges, price stabilization fund, commodity markets, and contract farming were suggested as the risk management measures for marketing and price fluctuations.

Drollette (2009) examined the various coping strategies to overcome production risks in agriculture sector of the U.S. She identified the major risk coping strategies in production as diversification to different crops and allied activities, maintaining excess production capacity, getting into lease agreements, enrolling in crop insurance, and remaining updated about the market news and information.

OECD (2009) suggested that extensive focus on a particular type of risk and studying it exclusively could be less effective in policy formulation and suggesting ways to overcome it effectively. A linear approach in studying risk could have a less meaningful conclusions and a more holistic and inter related study was found to be necessary.

Sulewski and Gajewska (2014) studied the risk perception, factors influencing the risk aversion nature, and the risk coping strategies adopted by the farmers participating in the Polish Farm Accountancy Data Network in Poland. The study used regression analysis to determine the factors that influence the risk aversion nature of 600 sample respondents. The results showed that the major determinant of risk aversion nature among farmers was debt ratio, with a regression coefficient of 1.689. This was followed by losses in production in the last 6 years and soil quality, with regression coefficients 0.619 and 0.517 respectively. The economic size of the farm showed a negative and significant relation with risk aversion nature. Majority of the farmers reported crop insurance as the major risk coping strategy.

Chhatre *et al.* (2016) studied the potential risks in extensive and exclusive cultivation of wheat and paddy in the state of Punjab. They found that the cultivation of these two crops in the fields have caused stagnation in yields and soil degradation, thereby challenging the long-term sustainability. They suggested crop diversification as a tool to overcome this risky scenario. With the aid of data from four representative districts, they found that diversification to horticultural crops like cauliflower, tomato, onion, and capsicum, could increase the net returns in all land size classes. A significant reduction in water usage up to 30 per cent could also be achieved through the suggested diversification measures.

Khanam *et al.* (2018) studied the potential for crop diversification as a tool to overcome the price risks in agriculture and to combat issues of food security, thereby achieving the aim of doubling the farmers' income. They found that it was unlikely that all crops would suffer simultaneous low market prices and thereby crop diversification could be used as an effective tool to overcome price risk in agriculture. Crop diversification also enables farmers to obtain surplus production for the market and overcome the issue of food security.

Farid *et al.* (2019) studied the determinants of risk coping strategies that farmers of northern region of Bangladesh adopt to cope with drought. Through focus group discussions, they found that the farmers adopted various ex-ante and ex-post strategies to cope with drought. These include borrowing of money, shifting to less water intensive crops, and reducing consumption. A multinominal logit model was used to identify the major determinants of adopting the coping strategies among the 218 sample farmers. The frequency of drought was found to be the major environmental determinant influencing the adoption of risk coping strategy, while crop loss due to drought and land holding system were the major socio-economic determinants.

Mutaqin (2019) studied the types and determinants of risk coping strategies adopted by farmers in rural west Java of Indonesia. The study found that out of the 180 sample farmers, 74.4 per cent adopted ex-ante strategies like on-farm (water management, randomising plot, and crop diversification) and off-farm (income diversification and savings) measures. The binomial logit model was employed to identify the determinants of adopting coping measures. It was found that risk behaviour and disaster experience positively influenced the adoption of ex-ante measures, while discount rate and percentage of damage had negative influence. The factors like per capita expenditure, size of holding, disaster experience, and access to financial institutions influenced the number of ex-ante strategies adopted by the farmers. The ex-post strategies included getting help from relatives, reducing consumption, utilising savings, etc. The percentage of damage, sharecropping, and location of farm in the downstream area were found to be the positive determinants of adopting ex-post strategies, while disaster experience and value of assets were found to be negatively related.

Methodology

3. METHODOLOGY

This chapter is intended to explain the methodologies adopted for this study, locale of the study, sampling procedure adopted, method of data collection, and various tools used for empirical analysis. The types and sources of secondary data collected are also included in this chapter.

3.1 TYPES OF DATA

This study used both primary and secondary data to analyse the risks in the agricultural economy of Wayanad district. The data on area, production, productivity, and prices of major crops in the district were collected from various secondary sources and were used to estimate the dynamics and instability of these variables over the years. The area under different crops were used to determine the extent of crop diversification in the district. The data on the income from primary sector in Wayanad district was also collected and analysed to study its fluctuations and growth over the years. The weather data was used to identify the impact of climate on crop production and yield. To identify the sources of risks, coping strategies adopted, and individual risk appetite and its determinants, primary data was collected from selected farm households in the district.

3.2 SOURCES OF DATA AND PERIOD OF STUDY

The specifics of secondary data, its sources, and the period for which it was collected are presented in Appendix I. The area, production, productivity, and prices of crops in Wayanad district formed the major part of the collected secondary data. The data on area, production, and productivity were obtained from Statistics for Planning and Agricultural Statistics published by the Directorate of Economics and Statistics, Government of Kerala which were used to determine the trend in growth or decline of major crops, the risks posed by their growth or decline, and the extend of crop diversification. The price data was collected from publications of Spices Board, Rubber Board, and Directorate of Arecanut and Spices. The data on income from primary sector in Wayanad district was collected from various issues of Economic Review published by the Kerala State Planning Board. This data was used to identify the trend in agricultural income of the district as it directly gives an idea about the temporal change in welfare of the farm households. The data on precipitation and temperature for

Wayanad district were collected from Regional Agricultural Research Station, Ambalavayal and daily gridded temperature data set published by Srivastava *et al*. (2009) of National Climate Centre, Indian Meteorological Department, Pune respectively. These were used to study the impact of climate change on production of major crops in the district. The personal interview method using a pre-tested interview schedule was used for primary data collection and the survey was conducted in Wayanad district during the months from March to May, 2020.

3.3 LOCALE OF THE STUDY

The study was conducted in Wayanad district of the state of Kerala. Wayanad is predominantly an agriculture-oriented district ever since its conception and is one among the most backward districts in the state. The district also has the largest number of tribal population and majority of its population depend on agriculture as their livelihood source (GoI, 2011).

3.3.1 Wayanad District

Wayanad is a high range district in Kerala formed on 1st November 1980 as the 12th district of the state. Wayanad is named after two Malayalam words- ‘*vayal*’ and ‘*nadu*’ meaning ‘land of paddy fields’. The district has about 37 per cent of the total geographical area under forest cover and a population density of 384 persons per square kilometre (GoK, 2020). It is also the third smallest district of Kerala after Alappuzha and Kasargod. According to the 2011 census, Wayanad district accounted for 2.4 per cent of the population of the state. The agro-climatic condition of the district favoured the cultivation of plantation crops and hence the district has witnessed immense prosperity in agriculture during 1980s and early 1990s. The droughts during the initial years of the new millennium and fall in the prices of black pepper, coffee, and rubber caused severe agrarian crises in the district. Agriculture still continues to be the principal livelihood activity of the district and dairy plays a vital role in the subsistence of farm households.

3.3.1.1 Location

Wayanad district lies between 11°27′00″ and 11°58′35″ of North latitude and 75°47′50″ and 76°26′35″ of East longitude. The district has a total geographical area of 2,129 square kilometres, which forms 5.47 per cent of the total geographical area of the state. Wayanad is the only district in Kerala that shares its boundary with two other states. The district is bordered by Karnataka in the north and north-east, Tamil Nadu in the south-east, Malappuram district in the south, Kozhikode district in the south-west and Kannur district in the north-west.

3.3.1.2 Land utilization pattern

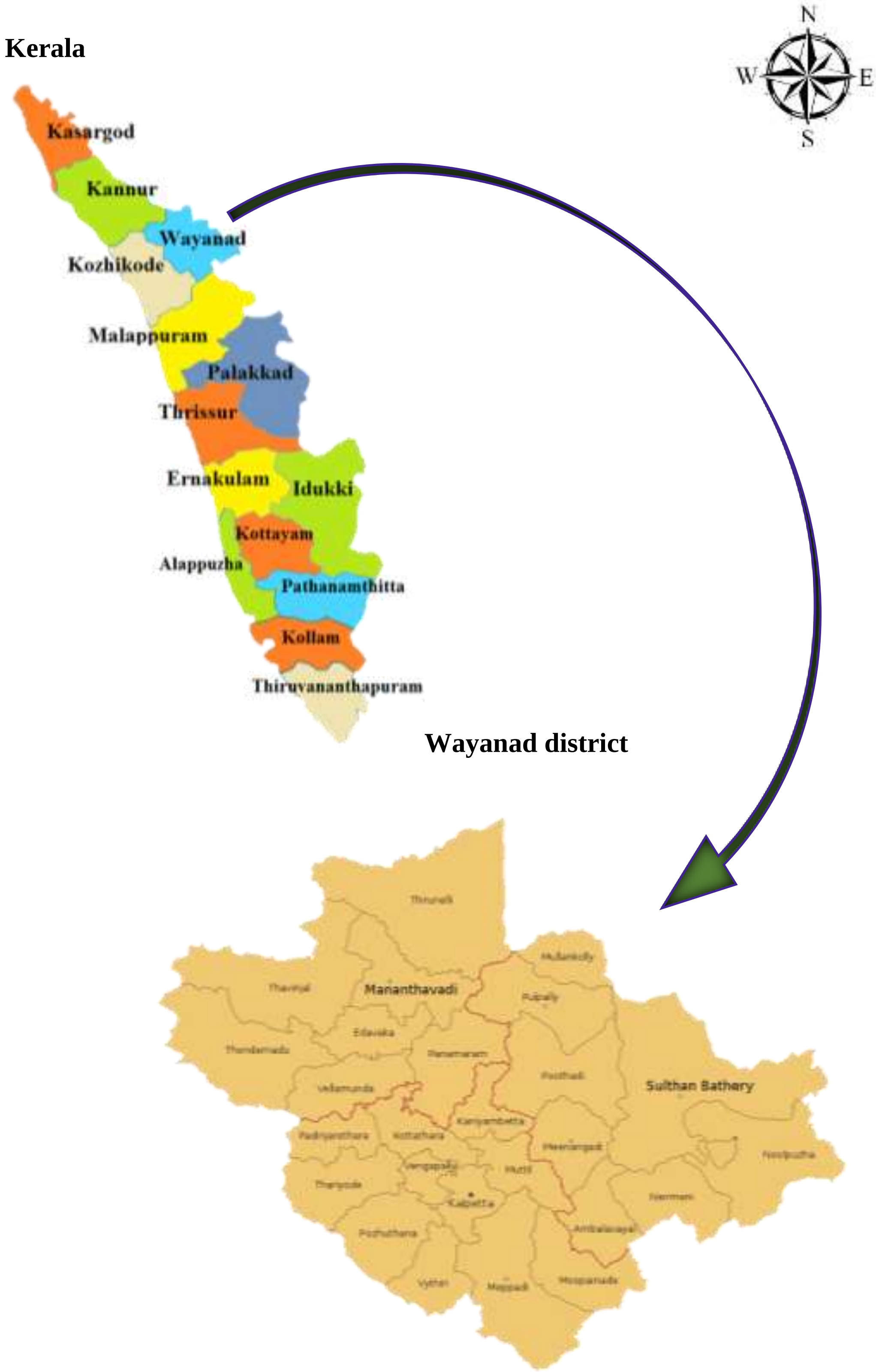
The land utilization pattern of Wayanad district for the year 2017-18 is presented in Table 3.1. The total cropped area of Wayanad district was 79.2 per cent of the geographical area, with a cropping intensity of 148 per cent. The net sown area of the district was 53 per cent of the gross cropped area. Forest accounted for 37 per cent area of the district and 5.54 per cent of the total geographical area was put to non-agricultural uses.

Table 3.1 Land utilization pattern of Wayanad district in 2017-18

Particulars	**Area in Hectares**	**Share in total geographical area (in per cent)**
Total geographical area	212966	100
Forest land	78787	37
Land put to non- agricultural uses	11722	5.50
Barren and uncultivable land	97	0.05
Permanent pastures and grazing land	0	0
Land under miscellaneous tree crops	43	0.02
Cultivable wasteland	1095	0.51
Fallow other than current fallow	1246	0.59
Current fallow	2437	1.14
Marshy land	0	0
Still water	4047	1.90
Water logged area	19	0.01
Social forestry	66	0.03
Net area sown	113407	53.25
Area sown more than once	55257	25.95
Total cropped area	168664	79.20

Source: Agricultural Statistics 2017-18, Directorate of Economics and Statistics, Kerala.

Figure 1 Map of the study area



3.3.1.3 Topography and climate

Wayanad district is located 700 to 2100 metres above mean sea level and has a climate suitable for growing plantation crops and spices. Kabani, with its tributaries, form the major river network of the district, which in turn feeds the Cauvery. The district receives the South-West Monsoon during the months from June to September, along with occasional summer showers. The average annual rainfall of the district is about 2322 mm, with regions like Vythiri receiving about 3000 mm to 4000 mm of annual rainfall. The Northern hills of the district experiences high velocity winds during the South-West Monsoon and dry winds during March and April. The months from December to February are the coldest in the district, while March to May are the hottest. The temperature usually varies between 18ºC and 29 ºC, with notable increase towards the north.

3.3.1.4 Demographic features

Wayanad had a population size of 8,17,420 as per the 2011 census. The district has a sex ratio of 1035 females for every 1000 males and a population density of 384 person per square kilometre. The literacy rate of the district was 89 per cent in 2011, which was 85 per cent in 2001. The district has a total working population of 3,40,077, of which 2,63,445 were main workers and 76,632 were marginal workers. The district also has 69,133 main agricultural labourers and 32,497 marginal agricultural labourers.

3.3.1.5 Cropping pattern

The cropping pattern of Wayanad district is given in Table 3.2. As observed from the table, the major crops of the district are coffee, arecanut, rubber, black pepper, and coconut. Even though the district got its name from paddy fields, the area under paddy was only 4.75 per cent of the gross cropped area in 2017-18. It could be observed that about 70 per cent of the gross cropped area in the district was under plantation crops, which makes it more vulnerable to price changes and import competition from major producer countries of these commodities in the world (GoK, 2019a).

Table 3.2 Cropping pattern of Wayanad district in 2017-18

Sl. No.	Crop	Area in Hectares	Percentage of gross cropped area
1	Coffee	67426	39.98
2	Arecanut	12147	7.20
3	Rubber	10800	6.40
4	Black pepper	10782	6.39
5	Coconut	10368	6.15
6	Paddy	8026	4.75
6	Cardamom	4120	2.44
7	Ginger	2109	1.25
8	Tapioca	1927	1.14
9	Cocoa	614	0.36
10	Turmeric	147	0.09
11	Nutmeg	105	0.06
12	Clove	23	0.01
13	Fruits	23809	14.12
14	Vegetables	1848	1.10
15	Others	14413	8.55
Gross Cropped Area		**168664**	**100**

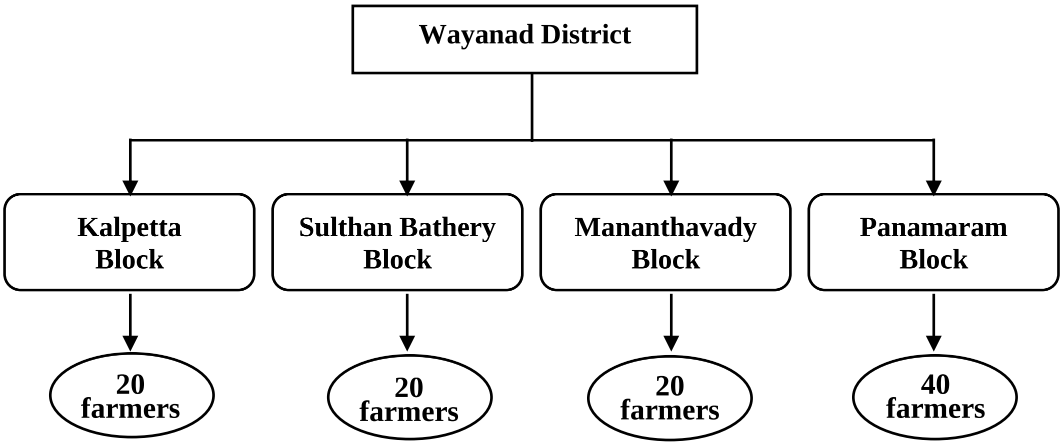
Source: Agricultural Statistics 2017-18, Directorate of Economics and Statistics, Kerala.

3.4 SAMPLING DESIGN

The primary survey was conducted in Wayanad district, which was purposively chosen because of its increased dependency on agriculture and the agrarian crisis that followed a history of prosperous crop cultivation. The area under principal crops in the district was showing a stagnancy or decline in the recent years. The per-capita income for Wayanad has also shown a declining trend in the last decade. The climate change in Wayanad, as evident from the droughts during the initial years of the new millennium and floods of 2018 and 2019, is also causing increased risk to the farmers.

The Wayanad district has four development blocks *viz*., Panamaram, Sulthan Bathery, Kalpetta, and Mananthavady. There are 25 Grama Panchayats in Wayanad, out of which six are in Mananthavady, nine in Kalpetta, and five each in Panamaram and Sulthan Bathery. For selecting a representative sample from the district, the gross cropped area of each block was represented as a percentage of the total cropped area of the district. Then the sample size for each block was decided based on its share in the total cropped area of the district. However, due to the practical difficulties caused by the lockdown amidst the COVID-19 pandemic, a reallocation of the sample was made so that 40 farmers were selected from Panamaram block and 20 farmers each were selected from Kalpetta, Sulthan Bathery and Mananthavady blocks, making a total sample size of 100. The list of farmers in each block was collected from office of the Assistant Director of Agriculture of the respective block and from that list the predetermined number of farmers were randomly selected for each block.

Figure 2 Distribution of sample farmers



3.4.1 Collection of Data

The farm level data from the randomly selected farmers were collected through the personal interview method using a pretested and well-structured interview schedule. Telephonic interview method was used for data collection during the lockdown period. Information regarding the socio-economic profile, landholding size, risks faced in agriculture, crop loss, risk coping strategies, on-farm, non-farm, and off-farm income diversification measures, and transactions in the recent past were collected from the selected farmers. The data pertaining to the number of crops grown, cost of cultivation, revenue, and credit availed were also collected. The individual risk appetite was elicited using direct risk questions and risk games. The interview schedule used to collect the primary level data is given in Appendix II.

3.5 ANALYSES OF DATA

The various tools that were used in the analysis of primary and secondary data are elaborated in this section. Some tools, like those used to measure crop diversification, were used for analysing both secondary and primary data, while others were used for either one of them. They are arranged under different heads as follows:

3.5.1 Performance of Agricultural Economy

3.5.1.1 Compound Annual Growth Rate (CAGR)

3.5.1.2 Decomposition approach

3.5.1.3 Growth accounting approach

3.5.2 Macro-level Risks and Instabilities

3.5.2.1 Trend breaks

3.5.2.2 Just and Pope method

3.5.2.3 Cuddy-Della Valle Index

3.5.2.4 Chain index and link relatives

3.5.3 Micro-level Risks and Instabilities

3.5.3.1 Just and Pope method

3.5.3.2 Garret ranking technique

3.5.4 Individual Risk Appetite

3.5.4.1 Risk question

3.5.4.2 Risk game

3.5.5 Crop Diversification

3.5.5.1 Herfindahl Index

3.5.5.2 Ogive Index

3.5.5.3 Entropy Index

3.5.5.4 Modified Entropy Index

3.5.5.5 Composite Entropy Index

3.5.6 Determinants of Risk Coping Strategies

3.5.6.1 Linear regression

3.5.6.2 Logistic regression

3.5.1 Performance of Agricultural Economy

3.5.1.1 Compound Annual Growth Rate (CAGR)

The growth rate is an important tool for studying the trend of any variable under study. The CAGR was used to determine the trend in area, production, and productivity of major crops from 1981-82 to 2018-19 for Wayanad district. An exponential function of the following form was used for this analysis (Patil and Yeledhalli, 2016).

$$Y = ab^t e^{U_t}$$

Where,

Y is the area/ production/ productivity

a is the intercept term

b is the regression coefficient

U_t is the disturbance term for the year 't'

When transformed to logarithmic form, it becomes:

$$log\, Y = \log a + tlog\; b + U_t$$

Log linear form of the equation was estimated using Ordinary Least Squares (OLS) technique. From the estimate, CAGR (r) can be computed as:

r = (Antilog b – 1) x 100

The significance of the CAGR was tested using 't' statistic as:

$$t = \frac{r}{SE(r)}$$

Where,

SE(r) is the Standard Error of the CAGR

3.5.1.2 Decomposition approach

The change in production of a crop over a given period of time can be decomposed into several contributing factors using the decomposition approach (Sharma, 1977). In this analysis, the variations in production of major crops in the district were decomposed into area effect, productivity effect, and the interaction effect of productivity and area. Following Sharma and Subramanyam (1984), the decomposition equation can be written as:

$$P_0 = Y_0 * A_0 \quad \cdots\cdots\cdots\cdots \quad (3.5.1)$$

$$P_n = Y_n * A_n \quad \cdots\cdots\cdots\cdots \quad (3.5.2)$$

Where,

P_0 and P_n are the production of the crop in the base period and nth year

Y_0 and Y_n are the productivity of the crop in the base period and nth year

A_0 and A_n are the area under the crop in the base period and nth year

Upon subtracting equation (3.5.1) from (3.5.2) and simplifying the result, we get:

$$\Delta P = \Delta A * Y_0 + \Delta Y * A_0 + \Delta Y * \Delta A \quad \cdots\cdots\cdots\cdots \quad (3.5.3)$$

Where,

$\Delta P = P_n - P_0$

$\Delta Y = Y_n - Y_0$

$\Delta A = A_n - A_0$

On the Right Hand Side (R.H.S.) of the equation (3.5.3), the first part gives the area effect, second part provides the productivity effect, and the last part denotes the interaction effect. These three effects are then divided by the absolute change in production and expressed as the respective percentages.

3.5.1.3 Growth accounting approach

The growth accounting approach is a method used to discriminate between various factors that are contributing towards growth of any variable. Minot *et al.* (2004) used this approach to measure the income diversification in northern upland of Vietnam. In this study, the factors contributing to change in agricultural revenue are considered as the area, productivity, and price of crops (Reddy, 2011). Consequently, the equation for gross revenue is expressed as:

$$R = \sum AYP \quad \cdots\cdots\cdots\cdots \quad (3.5.4)$$

Where,

R is the gross revenue

A is the area under crop

Y is the productivity of crop

P is the price of crop

By taking the total derivative of equation (3.5.4), the total change in gross value of output contributed by area, productivity, and prices can be estimated as:

$$dR \approx AYdP + APdY + PYdA \quad \cdots\cdots\cdots\cdots \quad (3.5.5)$$

In the above equation, the change in gross revenue is expressed as the sum of different components. The change in gross revenue due to change in real price of commodities, change in crop yields or technology, and change in total cropped area are given by the first, second, and third part of the equation respectively. By dividing equation (3.5.5) by the change in gross revenue, the proportionate share of each factor in the overall change in agricultural revenue can be estimated.

3.5.2 Macro-level Risks and Instability

3.5.2.1 Trend breaks

The analysis of trend breaks helps in identifying the significant structural breaks in a time series data. Luitel and Mahar (2015) used Chow test to provide formal evidence for structural break in US GDP data. Lee (2008) explained the practical applications of Chow test in analysing the regression discontinuities. For a time series data showing a trend break at period ‘t’, the significance of the break can be analysed using the following steps:

(a) Identify a point of break ‘t’ in the data exogenously.

(b) Estimate regression for the whole period and get the Residual Sum of Squares (RSS_W).

(c) Estimate regressions from the beginning to time ‘t’ and from time ‘t’ to the end. From these regressions, get the respective Residual Sum of Squares (RSS_1 and RSS_2 respectively).

(d) Add the Residual Sum of Squares from both the periods in step (b) to get the unrestricted Residual Sum of Squares (RSS_{UR})

(e) Estimate the *F* value using the following equation and check for its significance at 'k' and 'n-2k' degrees of freedom for the numerator and denominator respectively. Here, 'k' is the number of parameters estimated and 'n' is the total number of observations.

$$F = \frac{(RSS_W - RSS_{UR})/k}{(RSS_{UR})/(n-2k)} \sim F_{[k,(n-2k)]}$$

The *F* test is employed to check whether the sum of RSS in both the periods is significantly different from the RSS value estimated for the entire period. If the estimated *F* value is greater than the critical value at 5 per cent level for (k, n-2k) degrees of freedom, then the break in trend at time 't' is considered to be significant.

3.5.2.2. Just and Pope method

3.5.2.2.1 Measurement of climate risk

Just and Pope (1978) proposed a stochastic production function which establishes the relationship between independent climatic variables and probability distribution of crop production. A major advantage of this method is that no dependency is imposed on an independent item's effect on average production and production variability (Chen *et al.,* 2004). In this study, the Just and Pope production function, as used by Arumugam *et al.* (2014) was used to statistically determine how production and its variance are influenced by climate. The production function used is:

$$Y_{it} = f(X_{it}, \beta) + h(X_{it}, \alpha)\varepsilon_{it}$$

Where,

Y_{it} is the crop production at time 't'

X_{it} represents the set of independent variables (acreage and climate at time 't')

f(·) is the average production function

h(.) is the variance/ risk function

The functional form $h(\cdot)$ for the error term is an explicit form for heteroskedastic errors, allowing estimation of variance effects. By estimating the parameters β and α, the average effect of climatic variables on production and the effect of each climatic variable on variance of the crop production are obtained respectively. After the estimation of parameters of $h(\cdot)$, the interpretation could be made by looking at the sign of those parameters. A positive sign in the parameter implies that an increase in that variable will result in an increase in variance of the crop production, while a negative sign implies the opposite.

The average production function in the Just and Pope production function was estimated using Weighted Least Squares (WLS) method with the predicted standard deviations as weights. The variance function was estimated using OLS method assuming a semi-log linear form (Arumugam *et al.*, 2014). The linear average production function is given as:

$$f\ (X;\ \beta,\ d) = \beta 0 + \beta 1\ Acreage + \beta 2\ Temperature + \beta 3\ SD\text{-}Temperature + \beta 4\ Precipitation + \beta 5\ SD\text{-}\ Precipitation$$

The semi-log linear form of the variance function is represented as:

$$ln\ h^2\ (X;\ \beta,\eta) = \delta 0 + \delta 1\ Acreage + \delta 2\ Temperature + \delta 3\ SD\text{-}Temperature + \delta 4\ Precipitation + \delta 5\ SD\text{-}\ Precipitation$$

Where,

$ln\ h^2\ (x;\ \delta,\ \eta)]$ is the logarithm of squared residuals from the first stage OLS

The steps involved in the estimation process can be summarized as:

(a) Estimation of the average production function using OLS method with annual production as the dependent variable and acreage, mean temperature, standard deviation of temperature, annual precipitation, and standard deviation of precipitation as the independent variables to obtain the residuals.

(b) The log of squared residuals from the first stage OLS is regressed against the same independent variables. This is the variance function.

(c) The predicted standard deviations are calculated by taking the square roots of the antilogarithms of predicted dependent variable in step (b).

(d) Then the original model is estimated by WLS method with the predicted standard deviations as weights.

The stationarity of variables were checked using ACF and PACF plots prior to the estimation of Just and Pope yield function, since stationarity of variables is an underlying assumption in the model.

3.5.2.3 Cuddy-Della Valle Index

Cuddy and Valle (1978) proposed a method to measure the instability in time series data, which could be used to measure the price instability of a commodity over years. This is given by the following equation:

$$Cuddy - Della\,Valle\ Instability\ Index = \frac{\sigma}{\bar{x}} * 100 * \sqrt{1 - \bar{R}^2}$$

Where,

σ is the standard deviation in price

$\bar{x}$ is the mean value of price

$\bar{R}^2$ is the coefficient of determination

The index is used to measure the instability in the prices of major crops grown in the district. The whole period was divided into four sub-periods to facilitate meaningful comparison.

3.5.2.4 Chain index and link relatives

The chain index and link relatives were used to measure the instability in income from the primary sector of the district from 1982-83 to 2018-19. The chain index compares the income of any given year to that of the initial year in the analysis, while the link relative compares the income of an year to its preceding year.

The value of the variable for every year was expressed as the per cent of the previous year to get the link relatives. The chain index for an year was computed by multiplying the link relative of that year with the chain index of previous year and then dividing it by 100. Following Landefeld and Parker (1997), the link relative and chain index for the current year was computed as:

Link relative of the current year

$$= \frac{\text{Income from primary sector for the current year}}{\text{Income from primary sector for the previous year}} \text{ X } 100$$

Chain index of the current year

$$= \frac{\text{Link relative of current year X Chain index of previous year}}{100}$$

The chain index of an year was used to compare the growth in income of that year to that of the initial year, while the link relatives facilitated the comparison between adjacent time periods.

3.5.3 Micro-level Risks and Instability

3.5.3.1 Just and Pope method

3.5.3.1.1 Measurement of production risk

By making appropriate modifications in the specification of the independent variables, Just and Pope production function can be used to estimate the production risk due to input factors. This helps to identify how the inputs influence production and levels of risk (Asche and Tveteras, 1999). The Just and Pope production function is given as:

$$Y = f(X, \beta) + h(X, \alpha)\varepsilon$$

Where,

Y is the crop production

X represent the set of independent explanatory variables (input factors)

f(·) is the average production function

h(.) is the variance/ risk function

The average and variance production functions were estimated using the Cobb-Douglas production function as given by:

$$Y = a_0 X_1{}^{a_1} X_2{}^{a_2} X_3{}^{a_3} X_4{}^{a_4} X_5{}^{a_5} X_6{}^{a_6}$$

Where,

Y is the crop production (kilogram)

X_1 is the cost of human labour (man days)

X_2 is the cost of machine labour (Rupees)

X_3 is the cost of fertilizers (Rupees)

X_4 is the cost of plant protection chemicals (Rupees)

X_5 is the farming experience (years)

X_6 is the size of land holding (ha)

$a_0 \ldots a_6$ are the **p**roduction elasticity and efficiency parameter of corresponding variables

The variance function can be estimated using the same independent variables as:

$$V(Y) = a_0 X_1{}^{a_1} X_2{}^{a_2} X_3{}^{a_3} X_4{}^{a_4} X_5{}^{a_5} X_6{}^{a_6}$$

The coefficients of the production function were estimated using OLS technique.

3.5.3.2 Garret ranking technique

The garret ranking technique was used to rank the major sources of risks that the farmers face in agriculture, which were initially identified through a pilot survey and literature review.

For this analysis, the farmers were asked to rank the identified constraints in the order in which they find them as important. They were also asked to mention the coping strategies that they adopted to deal with those risks. Then the ranks assigned were converted to per cent position using the following formula:

$$\text{Per cent position} = \frac{100(R_{ij} - 0.5)}{N_j}$$

Where,

R_{ij} is the rank of i^{th} factor given by j^{th} individual

N_j represents the number of factors ranked by j^{th} individual

After computing the per cent positions, they were then converted into scores on a scale of 100 by referring to the table given by Garret and Woodworth (1969). The mean score for each risk was then derived from the above obtained score and they were ranked accordingly.

3.5.4 Individual Risk Appetite

3.5.4.1 Risk question

The elicitation of risk appetite through risk question is a simple and straight forward approach. In this method, the respondents are asked to rank themselves on a scale of one to five based on their risk appetite. The scale used for this purpose is given in Table 3..

Table 3.3 Scale used for risk question

Scale	Risk appetite
1	Extremely risk averse
2	Risk averse
3	Moderately risk taking
4	Risk taking
5	Extremely risk taking

The results will tell us how the respondents think about their own risk taking capacity. Of course, this result cannot be considered as a clear representation of the individual's risk taking capacity due to possible personal bias in the responses. However, a comparison of these self-ratings with the ones derived through the risk game will help in understanding the difference in self-perceived and actual risk taking capabilities.

3.5.4.2 Risk game

The risk elicitation method followed by Holt and Laury (2002) is widely accepted as one of the simple, yet efficient method of risk elicitation. Since incentivising the lottery was beyond the scope of this study, a non-incentivised hypothetical lottery method was followed to elicit the individual's risk appetite.

The elicitation process involved playing a lottery game with the same respondents after asking them the risk question. Before playing the lottery, the farmer was well informed about the lottery and its possible outcomes so that his response stays as close as possible to his real risk appetite. The farmer was then asked to choose one option from the five possible choices as given in Table 3.3. Now a coin was flipped before him and the outcome was recorded.

Table 3.4 Lottery options in risk game

Options	Lottery		Chosen option (Tick the respective row)	Outcome
	Tail	Head		
1	Rs. 100	Rs. 100		
2	Rs. 75	Rs. 125		
3	Rs. 50	Rs. 150		
4	Rs. 25	Rs. 175		
5	Rs. 0	Rs. 200		

A farmer choosing option one was considered as extremely risk averse and a farmer choosing option five was considered as extremely risk taking. The extent of agreement or disagreement between the self-assessments and choices made in actual risk game by the respondent farmers were later analysed using chi-square test.

3.5.5 Crop Diversification

3.5.5.1 Herfindahl Index (H.I.)

Herfindahl-Hirschman index, commonly known as Herfindahl Index, is a standard index used to determine the extent of diversification or specialisation in a given situation. This was first used by Hirschman in the 1940s (Hirschman, 1980) and a modified form of this, as used currently, was used by Herfindahl during 1950s (Herfindahl, 1959). H.I. of a particular farm household or a district in an year was computed using the following formula:

$$H.I. = \sum_{i=1}^{N} P_i^2$$

Where,

N is the total number of crops

P_i is the acreage share of i^{th} crop in total cropped area

An H.I. value of zero denotes perfect diversification, whereas one denotes monocropping. Practically, an H.I. value of zero is unattainable because whatever be the number of crops that a farmer grows, P_i will invariably be greater than zero.

3.5.5.2 Ogive Index (O.I.)

Ogive index measures the extent of departure from a standard set by uniform proportion for all crops (Shiyani and Pandya, 1998). O.I. was at first used to measure industrial diversity (Tress, 1938). Agricultural diversity can be computed using O.I. as:

$$O.I. = \frac{\sum_{i=1}^{N}\{P_i-(1/N)\}^2}{(1/N)}$$

Where,

N is the total number of crops

P_i is the acreage share of ith crop in total cropped area

Ogive index tends to approach zero as N approaches 1. Therefore, O.I. approaches zero in situations of monocropping and perfect diversification.

3.5.5.3 Entropy Index (E.I.)

Garrison and Paulson (1973) used the entropy index to measure the geographic concentration of economic activity in a region. E.I. was later extensively used by other authors to know about the extent of economic diversification in a region and its role in stabilising the economy from outside fluctuations (Hackbart and Anderson, 1975; Singh *et al.*, 1985). Agricultural diversity can be measured by E.I. using the following formula:

$$E.I. = -\sum_{i=1}^{N} P_i log P_i$$

Where,

N is the total number of crops

P_i is the acreage share of ith crop in total cropped area

The value of E.I. increases as diversification increases and it becomes zero in situations of monocropping. The drawback of this index is that its upper range depends upon the base of logarithm and the number of crops present. When the number of crops is higher than the value of the base of logarithm, then the entropy index can exceed one, and in the other case, it can be less than one.

3.5.5.4 Modified Entropy Index (M.E.I.)

Modified entropy index can be used to overcome the above mentioned limitation of E.I., as suggested by Shiyani and Pandya (1998). Here, the base of the logarithm is changed to the number of crops so that the value of the index varies between zero and one. Modified entropy index can be calculated as:

$$M.E.I. = -\sum_{i=1}^{N} P_i log_N P_i$$

Or

$$M.E.I. = \frac{E.I}{logN}$$

Where,

N is the total number of crops

P_i is the acreage share of i^{th} crop in total cropped area

The limitation of this index is that it merely measures the deviation from equal distribution among the given crops and it does not account for the total number of crops.

3.5.5.5 Composite Entropy Index (C.E.I.)

Shiyani and Pandya (1998) suggested the use of composite entropy index to overcome the limitations possessed by M.E.I. by giving due weightage for the number of crops used in the analysis. C.E.I. can be computed as:

$$C.E.I. = -\left(\sum_{i=1}^{N} P_i log_N P_i\right)\left\{1 - \frac{1}{N}\right\}$$

Or

$$C.E.I. = M.E.I.* \left(1 - \frac{1}{N}\right)$$

Where,

N is the total number of crops

P_i is the acreage share of i^{th} crop in total cropped area

The first and second part of the equation represents the distribution and the number of crops respectively, and both of these range from zero to one. The value of C.E.I. increases as diversity increases and decreases with crop specialisation.

Since $-\log_N P$ is used as the weight, it gives higher weightage to lower quantity and lower weightage to higher quantity.

3.5.6 Determinants of Risk Coping Strategies

3.5.6.1 Linear regression

To identify the determinants of risk appetite among individuals, a linear regression model was used. The risk appetites of individuals, as elicited by the risk game, were regressed against various personal and socio-economic attributes to find out the influence of these factors on the risk taking behaviour of the respondents. significance. The model specified for this analysis is given below:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \cdots + b_nX_n$$

Where,

Y is the risk preference elicited through risk game

b_0 is the intercept

$b_1, b_2, b_3 \ldots b_n$ are the regression coefficients

$X_1, X_2, X_3, \ldots X_n$ are the independent variables

The coefficient of multiple determination was examined to see the extent to which this model could explain the variability in individual risk appetite with the given independent variables. The independent variables that could influence the risk appetites of farmers were then identified using the individual regression coefficients.

3.5.6.2 Logistic regression

To identify the factors that determine whether a farmer is risk taking or not, a logistic regression function was used. The elicited risk appetites of the respondents were used to classify them as risk taking and risk averse. This binary classification of the respondents was taken as the dependent variable and various socio-economic and personal attributes were taken as the independent variables. The model specification for this analysis, following Madhura (2010) can be explained as follows:

Suppose Y_i and X_i be the dependent and independent variables used in this model. If P_i denotes the probability that a farmer is risk taking, then ($1-P_i$) denotes the probability that he is risk averse. The logit model can now be expressed as:

$$P_i = \frac{1}{1+e^{-z}} \qquad \text{......................} \quad (3.5.6)$$

Where,

$Z = a + \sum b_i X_i$

From (3.5.6), we get $1 - P_i = 1 - \frac{1}{1+e^{-z}}$, which can also be stated as

$$1 - P_i = \frac{1}{1+e^{-z}} \qquad \text{..} \ (3.5.7)$$

Therefore, from (3.5.6) and (3.5.7) we get:

$$\frac{P_i}{1-P_i} = e^z$$

The ratio P_i/ ($1-P_i$) shows the ratio of number of chances of the farmer being risk taking to that of him being risk averse. This is known as the odds ratio, and taking logarithm of this ratio to the base *e* we get:

$$log_e\left(\frac{P_i}{1-P_i}\right) = Z_i = a + \sum b_i X_i$$

Or

$$L^* = Z_i = a + b_i X_i$$

Where,

L^* (logit) = $Ln(P_i/1-P_i)$

The mean value of all the variables were estimated and then multiplied with their corresponding coefficients to get Z_i. This Z value was then used in equation (3.5.6) to obtain the probabilities of a farmer being risk taking.

Results and Discussion

4. RESULTS AND DISCUSSION

The primary and secondary data collected for the study were analysed using the methodological framework described in the previous chapter. The main focus of the study was to identify the risks in agricultural economy of Wayanad and the risk coping strategies adopted by the farmers. The analytical tools described in the chapter on methodology were used to find meaningful results and to draw useful inferences. The findings from the analysis of primary and secondary data, along with their interpretations, are described in this chapter under the following sections.

4.1 Performance of agricultural economy

4.2 Risks and instabilities in the agricultural economy

4.3 Crop diversification

4.4 Micro-level risks and risk coping strategies

4.5 Individual risk appetite and its determinants

4.1 PERFORMANCE OF AGRICULTURAL ECONOMY

The performance of agricultural sector in Wayanad district was analysed using Compound Annual Growth Rates (CAGRs), decomposition approach, and growth accounting approach. These were estimated to understand the dynamics in area, production, and productivity of major crops in the district during the period from 1981-82 to 2018-19. This section presents and explains the growth rates, decomposed sources of variation in production, and factors influencing gross revenue and output in key areas of agricultural sector in the district, thereby providing insights into the agricultural economy of Wayanad.

4.1.1 Dynamics in area, production, and productivity of major crops

The patterns of growth in area, production, and productivity of major crops in the district were analysed using CAGRs. The whole period from 1981-82 to 2018-19 was divided into four sub-periods and CAGR for each sub-period was estimated so as to facilitate comparison between them. Each sub-period represents a decade, starting from 1981-82 to 1989-90, 1990-91 to 1999-'00, 2000-01 to 2009-10, and 2010-11 to 2018-19.

4.1.1.1 Compound Annual Growth Rates of area under crops

Table 4.1 shows the decadal CAGR of area under 15 major crops in Wayanad district. Arecanut was the only crop with a positive CAGR in area during all the four decades. The area under rubber and tea were found to have positive CAGRs in the last three sub-periods. Paddy was found to be the only crop for which the area was on a continuous decline during all the four decades. The area under ginger was found to decline in the last three decades. The crops like coffee and coconut were having positive CAGRs in three of the four sub-periods, while that of turmeric, tapioca, plantain, and cashew reported negative CAGRs during three of the four sub-periods.

The decade-wise analysis showed that area under 10 major crops in the district showed a decline in CAGRs during the third sub-period (2000-01 to 2009-10). This sub-period also coincided with the years of peak agrarian distress in the district. While the area under coffee, coconut and cardamom showed an increasing trend in the last decade, area under paddy reported the highest decline during this sub-period. Even though the district is named after paddy fields, a continuous decline in area under paddy could be observed. This also shows that the current schemes and policies were not able to prevent the paddy fields from being left fallow or getting converted to the cultivation of other crops like banana, arecanut and coconut.

Table 4.1 Compound Annual Growth Rates of area under major crops in Wayanad district (per cent per annum)

Crops	1981-82 to 1989-90	1990-91 to 1999-'00	2000-01 to 2009-10	2010-11 to 2018-19
Coffee	0.0245	0.0139	-0.0003	0.0001
Arecanut	0.0060	0.1438	0.0675	0.0159
Rubber	-0.1994	0.0348	0.0470	0.0088
Coconut	0.0170	0.1024	-0.0083	0.0010
Black pepper	0.1541	0.0599	-0.1049	-0.0592
Banana	0.0898	0.1952	-0.0079	-0.0206
Tea	-0.0006	0.0025	0.0055	0.0299
Paddy	-0.0435	-0.0178	-0.0158	-0.0432
Mango	-0.0094	0.0832	-0.0380	0.0314
Cardamom	0.0162	-0.0063	-0.0001	0.0002
Ginger	0.2130	-0.0162	-0.0812	-0.0731
Turmeric	-0.0207	-0.0273	0.0347	-0.0113
Tapioca	-0.0602	-0.0118	0.0052	-0.0741
Plantain	-0.0115	0.0223	-0.0536	-0.0040
Cashew	-0.0289	0.0852	-0.0827	-0.0349

4.1.1.2 Compound Annual Growth Rates in production of crops

The CAGRs in production of 15 major crops in Wayanad district during the period from 1981-82 to 2018-19 are presented in Table 4.2. Coconut was found to be the only crop having an increase in production throughout all the four decades. An increase in CAGRs were reported in the last three sub-periods for mango, while a decline in CAGRs for the same period was reported for ginger. Arecanut, black pepper, banana, and tea showed positive CAGRs in three of the four decades, while coffee, paddy, cardamom, and cashew showed negative CAGRs. It is important to note that 11 out of the 15 major crops in the district showed a decline in production during the last quarter. Also, the crops like coffee, arecanut, rubber, and cardamom have exhibited a decline in production, even after having positive CAGRs in area in the last sub-period, which in turn raises serious concerns about the productivity of these crops during the sub-period.

Table 4.2 Compound Annual Growth Rates in the production of major crops in Wayanad district (per cent per annum)

Crops	1981-82 to 1989-90	1990-91 to 1999-'00	2000-01 to 2009-10	2010-11 to 2018-19
Coffee	-0.0606	0.1298	-0.0174	-0.0045
Arecanut	0.0844	0.0805	0.0798	-0.0783
Rubber	-0.1958	0.0469	0.0873	-0.0193
Coconut	0.0283	0.1819	0.0075	0.0118
Black pepper	0.1464	0.0963	-0.1424	0.0318
Banana	0.0877	0.1548	0.0065	-0.0205
Tea	0.0283	0.0132	-0.0328	0.0215
Paddy	-0.0307	0.0072	-0.0021	-0.0274
Mango	-0.1359	0.1295	0.0344	0.0554
Cardamom	-0.0078	-0.0009	0.0461	-0.0711
Ginger	0.3093	-0.0052	-0.0143	-0.0994
Turmeric	0.0039	-0.0275	0.1103	-0.0410
Tapioca	-0.0196	0.0143	0.0436	-0.1258
Plantain	0.0658	0.1450	-0.0987	-0.0025
Cashew	-0.1733	0.1793	-0.0478	-0.1380

4.1.1.3 Compound Annual Growth Rates in productivity of crops

The CAGRs in productivity of 15 major crops in Wayanad district during the four decades from 1981-82 to 2018-19 are presented in Table 4.3. The productivity of coconut and paddy showed an increasing trend in all four decades, while that of mango increased in last three decades. The CAGRs in productivity of coffee showed negative values and that of rubber, ginger, tapioca and plantain showed positive values in three of the four sub-periods. The declining productivity in coffee is a matter of serious concern, given that the crop occupied the largest area in Wayanad district during the entire period. After coffee, arecanut and rubber occupied the largest area in the district

(GoK, 2019a), and they also exhibited a decline in productivity in the last sub-period. It could be observed that seven out of the nine crops that reported a decline in productivity in the last sub-period were having a positive CAGR in the third decade. This suggested the existence of instabilities and risks in the agricultural economy of Wayanad, which needs to be studied in detail. However, a positive CAGR in productivity of paddy during all the decades suggested that any fruitful measures taken to increase the acreage under the crop could yield good results.

Table 4.3 Compound Annual Growth Rates in the productivity of major crops in Wayanad district (per cent per annum)

Crops	1981-82 to 1989-90	1990-91 to 1999-'00	2000-01 to 2009-10	2010-11 to 2018-19
Coffee	-0.0830	0.1144	-0.0171	-0.0046
Arecanut	0.0779	-0.0553	0.0115	-0.0927
Rubber	0.0044	0.0117	0.0385	-0.0279
Coconut	0.0111	0.0721	0.0160	0.0108
Black pepper	-0.0067	0.0344	-0.0419	0.0967
Banana	-0.0020	-0.0339	0.0146	0.0002
Tea	0.0290	0.0107	-0.0382	-0.0082
Paddy	0.0134	0.0254	0.0139	0.0165
Mango	-0.1277	0.0427	0.0753	0.0233
Cardamom	-0.0237	0.0055	0.0461	-0.0713
Ginger	0.0794	0.0112	0.0729	-0.0284
Turmeric	0.0251	-0.0002	0.0731	-0.0301
Tapioca	0.0432	0.0264	0.0381	-0.0558
Plantain	0.0782	0.1201	-0.0477	0.0015
Cashew	-0.1487	0.0867	0.0380	-0.1069

The CAGRs in area, production, and productivity of major crops shows a decline in production of many crops despite an increase in acreage under these crops. The crops like coffee, arecanut, rubber and cardamom were showing negative CAGRs values for their productivity during the last decade, while the CAGRs in area for these crops were positive. Apart from the above crops, ginger, tapioca, cashew, turmeric and tea were also showing negative CAGRs in productivity during the last sub-period. Considering the constraints in expanding area under cultivation, as suggested by the declining CAGR in area, the decline in productivity amplifies the impediments to the agricultural economy of the district.

4.1.2 Decomposition of sources of variations in production of crops in Wayanad district

The sources of changes in the production of major crops in the district were decomposed into area effect, productivity effect, and the interaction effect of area and productivity. Paddy, being a major crop during the initial years after the formation of the district, was also included in the analysis along with coffee, arecanut, rubber, coconut, and black pepper. The entire period was divided into four sub-periods, with each sub-period representing a decade, starting from 1981-82 to 1989-90, 1990-91 to 1999-’00, 2000-01 to 2009-10, and 2010-11 to 2018-19. Finally, a separate decomposition analysis was also carried out for the overall period from 1981-82 to 2018-19. The decomposed components of the sources of variation in production of individual crops are presented from Table 4.4 to Table 4.9 as the percentage effect in the change in production for all the specified periods.

4.1.2.1 Sources of variation in production of coffee

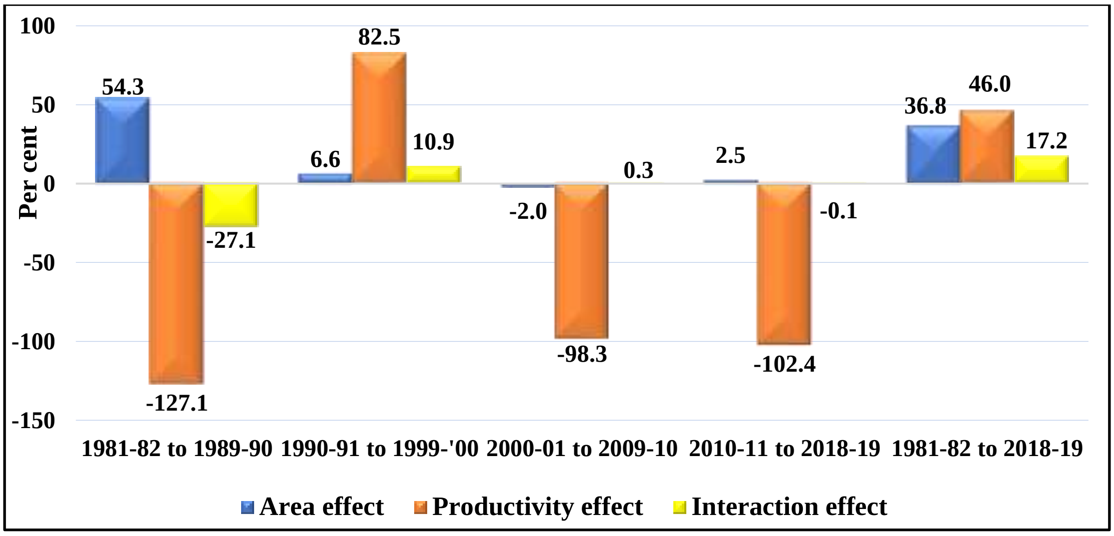
The decomposed sources of changes in the production of coffee are presented in Table 4.4. The area effect was found to be positive for the first, second and last quarter, while it was negative in the third quarter. In all the decades under consideration, with the exception of 1990s, the productivity effect was found to be negative. The interaction effect was estimated as negative during the first and last decades. The analysis from 1981-82 to 2018-19 showed that the increase in production of coffee as compared to the base year was mainly due to the productivity effect, which contributed 46 per cent of the increase in production. The contribution of area to the change in production was estimated as 36.8 per cent and the combined effect of area and productivity was 17.2 per cent during the whole period.

Table 4.4 Decomposition of sources of variation in production of coffee in Wayanad district (in per cent)

Sub-periods	Change in production*	Area effect	Productivity effect	Interaction effect
1981-82 to 1989-90	-1045	54.26	-127.13	-27.13
1990-91 to 1999-'00	32120	6.59	82.53	10.88
2000-01 to 2009-10	-8550	-1.96	-98.32	0.28
2010-11 to 2018-19	-1939	2.54	-102.45	-0.09
1981-82 to 2018-19	**26886**	**36.76**	**46.04**	**17.20**

Note: *In tonnes. Negative values indicate decrease in production

Figure 3 Decomposition of sources of variation in production of coffee in Wayanad district



From Figure 3, it could be inferred that there has been a decline in production of coffee in 1980s, 2000s, and 2010s as compared to their respective base years because the negative productivity effect in all these decades was either reinforced by the negative area or interaction effects or more than offset the positive area or interaction effects. The decline in productivity was the major reason for the decline in production of coffee in Wayanad. However, in the overall period while comparing with the production in 2018-19 to the base year, an increase in production was found in which all the effects have contributed positively to growth in production, with productivity effect accounting for the major share.

4.1.2.2 Sources of variation in production of arecanut

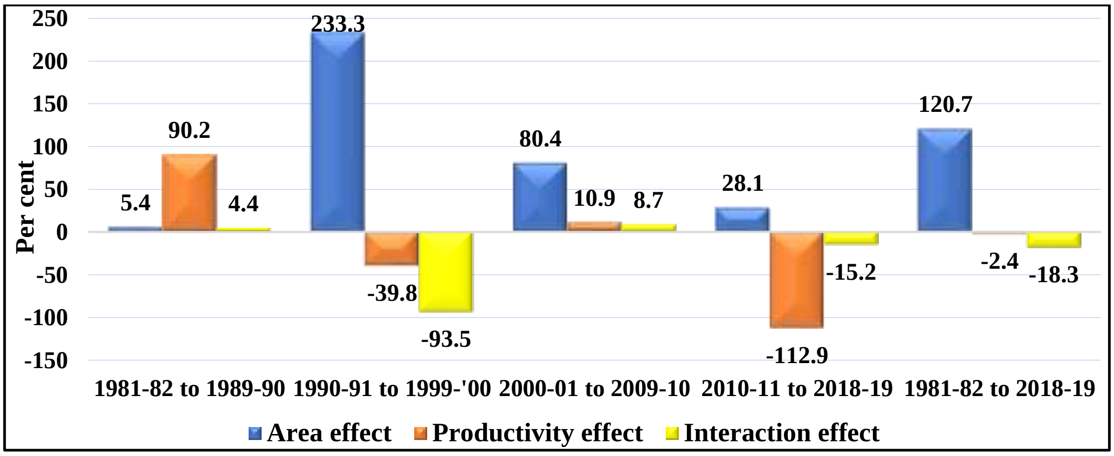
The decomposed sources of change in the production of arecanut in Wayanad district are presented in Table 4.5 and depicted in Figure 4. It could be observed from the table that there was an increase in the production of arecanut as compared to the base years in the first three decades. The area effect was the major factor contributing to the increase in production, and even a negative productivity and interaction effects in the second sub-period could not offset the positive area effect. In the last decade, a decline in the production of arecanut was observed, and the negative productivity effect was strong enough to offset the positive area effect. During the overall period, even though the productivity and interaction effects were negative, there was increase in production due to the higher growth in area which was reflected in the strong area effect of 120.68 per cent.

Table 4.5 Decomposition of sources of variation in production of arecanut in Wayanad district (in per cent)

Sub-periods	Change in production*	Area effect	Productivity effect	Interaction effect
1981-82 to 1989-90	454	5.40	90.16	4.44
1990-91 to 1999-'00	871	233.34	-39.81	-93.53
2000-01 to 2009-10	2686	80.43	10.87	8.70
2010-11 to 2018-19	-3383	28.12	-112.91	-15.21
1981-82 to 2018-19	**3181**	**120.68**	**-2.37**	**-18.31**

Note: *In million nuts. Negative value indicate decrease in production

Figure 4 Decomposition of sources of variation in production of arecanut in Wayanad district



4.1.2.3 Sources of variation in production of rubber

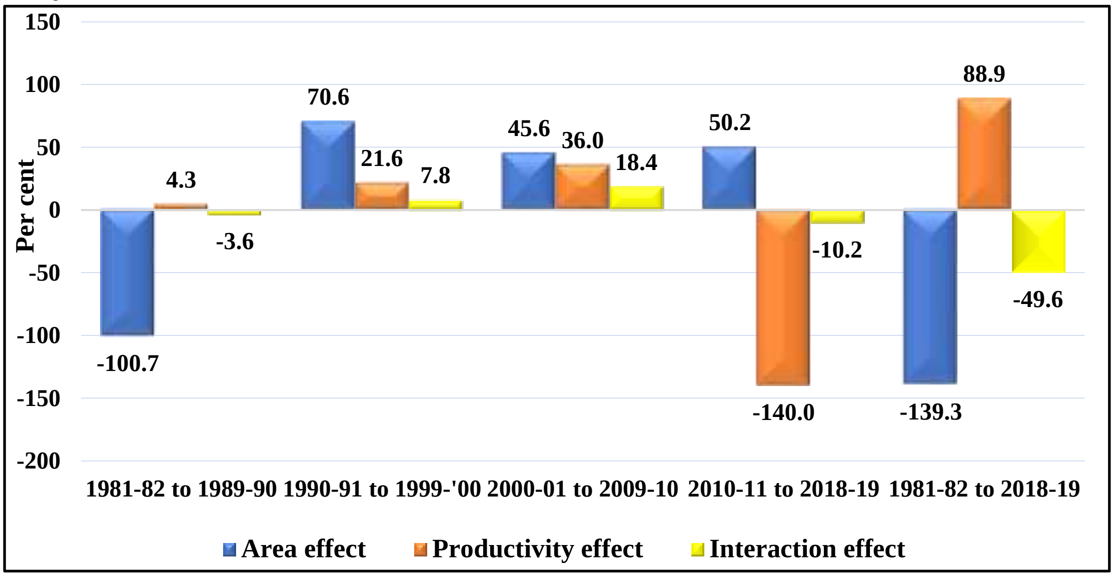
The decomposed sources of change in the production of rubber in Wayanad district are presented in Table 4.6 and Figure 5. With the exception of the latest decade, the area effect was found to be the major source of variation in production in all the other decades. The area effect was negative in the first sub-period and positive in the remaining decades. The productivity effect was found to be positive in the first three decades, while it was negative in the last decade. The interaction effect was estimated as negative in the first and last decades. While the negative area effect caused the decline in production in the 1980s, it was the negative productivity effect that caused the decline in production in the last decade. The 1990s and 2000s recorded positive effects of area, productivity, and the interaction between area and productivity. The analysis for the overall period indicated a decline in production of rubber in 2018-19 as compared to 1981-82 which was primarily due to the decline in area, as represented by the negative area effect. The interaction effect also contributed to this decline by 49.6 per cent.

Table 4.6 Decomposition of sources of variation in production of rubber in Wayanad district (in per cent)

Sub-periods	Change in production*	Area effect	Productivity effect	Interaction effect
1981-82 to 1989-90	-10596	-100.73	4.34	-3.61
1990-91 to 1999-'00	1321	70.59	21.62	7.80
2000-01 to 2009-10	4445	45.57	36.00	18.44
2010-11 to 2018-19	-1300	50.19	-140.04	-10.15
1981-82 to 2018-19	**-5142**	**-139.31**	**88.90**	**-49.59**

Note: *In tonnes. Negative values indicate decrease in production

Figure 5 Decomposition of sources of variation in production of rubber in Wayanad district



4.1.2.4 Sources of variation in production of coconut

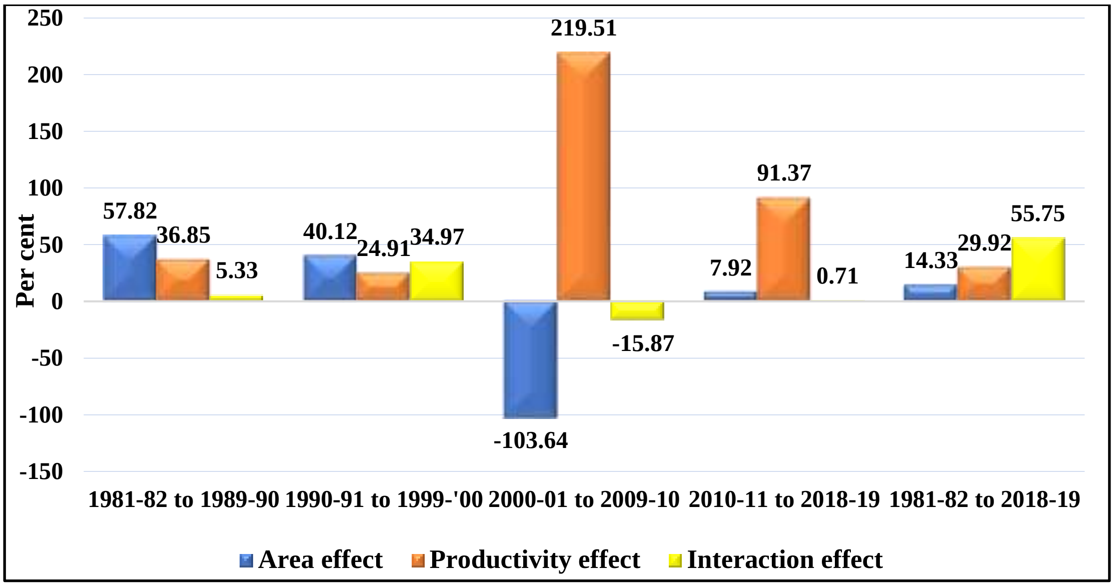
As could be observed from Table 4.7 and Figure 6, the production of coconut has increased in all the four decades and it was the only crop in the district that showed a positive trend in production throughout the whole period. The productivity effect was found to be positive in all the four decades and the effect was strong enough in the third decade (2000s) to offset the negative area and interaction effects. The decomposition analysis for the overall periods revealed that the increase in production of coconut in Wayanad was mostly contributed by the interaction effect of area and productivity (55.7 per cent), with each of these effects individually contributing 14.3 per cent and 29.9 per cent respectively.

Table 4.7 Decomposition of sources of variation in production of coconut in Wayanad district (in per cent)

Sub-periods	Change in production*	Area effect	Productivity effect	Interaction effect
1981-82 to 1989-90	1	57.82	36.85	5.33
1990-91 to 1999-'00	21	40.12	24.91	34.97
2000-01 to 2009-10	3	-103.64	219.51	-15.87
2010-11 to 2018-19	5	7.92	91.37	0.71
1981-82 to 2018-19	**52**	**14.33**	**29.92**	**55.75**

Note: *In million nuts

Figure 6 Decomposition of sources of variation in production of coconut in Wayanad district



4.1.2.5 Sources of variation in production of black pepper

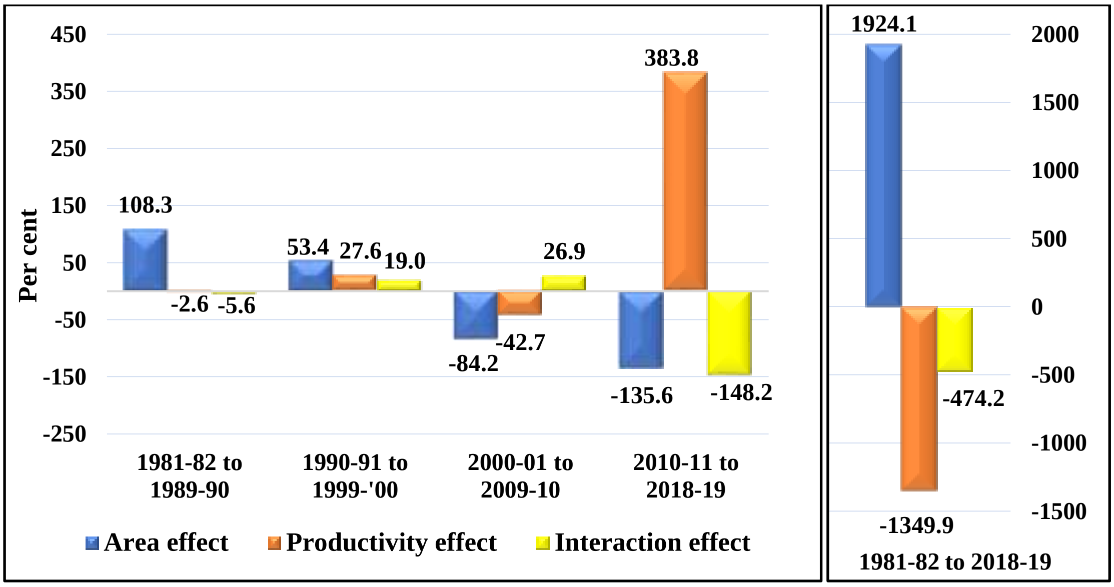
The results of the decomposition of sources of change in production of black pepper is presented in Table 4.8 and Figure 7. It could be observed that negative area effects were observed in third and fourth decades, while the productivity effects were negative in 1980s and 2010s. The interaction effect was also found to be negative in first and last decades. The area effect was the major contributing factor to the increase in production during first and second decades, while positive productivity effect in the last decade more than offset the negative area and interaction effects in 2010s, which caused the increase in production. The analysis of the change in production between 1981-82 and 2018-19 revealed an increase in production contributed by higher positive area effects which offset the high negative productivity and interaction effects. The very high values of area, production, and interaction effects could be attributed to the small change in production of black pepper (56 tonnes) in 2018-19 as compared to 1981-82. It is worthwhile to note that even though the change in production of black pepper from 1981-82 to 2018-19 was negligible, there was very high rise and fall in production of black pepper during the years in between.

Table 4.8 Decomposition of sources of variation in production of black pepper in Wayanad district (in per cent)

Sub-periods	Change in production*	Area effect	Productivity effect	Interaction effect
1981-82 to 1989-90	6081	108.25	-2.62	-5.63
1990-91 to 1999-'00	9755	53.41	27.60	18.98
2000-01 to 2009-10	-13418	-84.25	-42.69	26.94
2010-11 to 2018-19	692	-135.62	383.79	-148.17
1981-82 to 2018-19	**56**	**1924.14**	**-1349.89**	**-474.25**

Note: *In tonnes. Negative values indicate decrease in production

Figure 7 Decomposition of sources of variation in production of black pepper in Wayanad district



4.1.2.6 Sources of variation in production of paddy

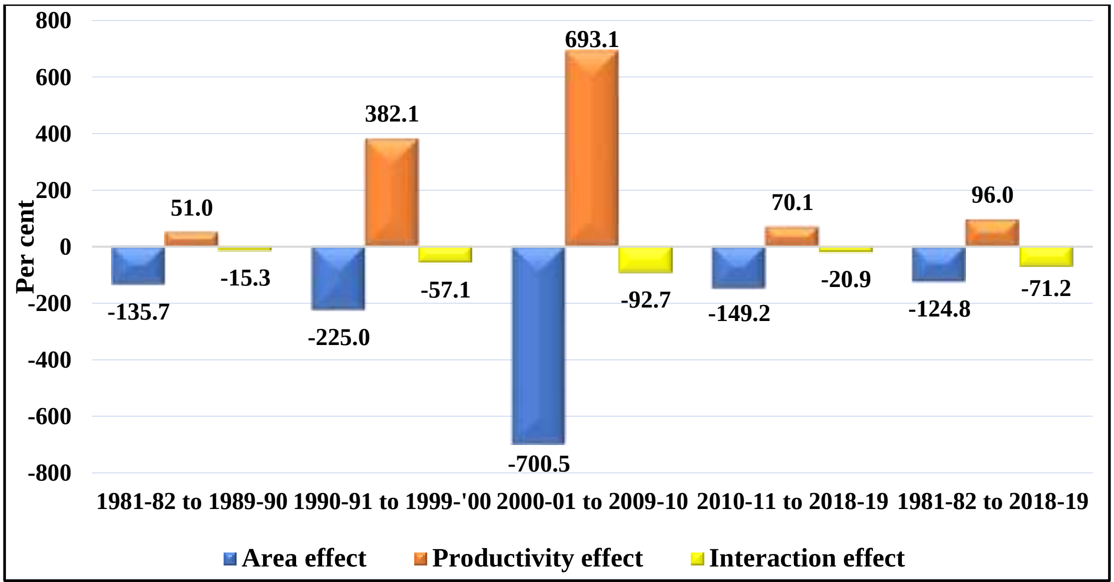
The results of the decomposition analysis on sources of changes in production of paddy are depicted in Table 4.9 and Figure 8. A positive productivity effect and negative area and interaction effects could be observed for paddy in all the four decades. The negative effects of area and interaction caused the decline in production of paddy in all sub-periods, except the second one. In 1990s, the positive productivity effect more than offset the combined negative area and interaction effects, which caused the production to increase. The overall analysis of the change in production of paddy between 1981-82 and 2018-19 revealed that even though there existed a strong productivity effect in favour of paddy, the decline in area was large enough to bring down the production. It could be concluded that any successful attempt made towards increasing the acreage under paddy can have positive results on production in the district, as the productivity was increasing throughout the years.

Table 4.9 Decomposition of sources of variation in production of paddy in Wayanad district (in per cent)

Sub-periods	Change in production*	Area effect	Productivity effect	Interaction effect
1981-82 to 1989-90	-12137	-135.746	51.024	-15.278
1990-91 to 1999-'00	2787	-224.988	382.064	-57.076
2000-01 to 2009-10	-645	-700.496	693.147	-92.651
2010-11 to 2018-19	-5571	-149.205	70.073	-20.869
1981-82 to 2018-19	**-32684**	**-124.824**	**96.011**	**-71.187**

Note: *In tonnes. Negative values indicate decrease in production

Figure 8 Decomposition of sources of variation in production of paddy in Wayanad district



4.1.3 Estimation of sources of variation in gross revenue of principal crops

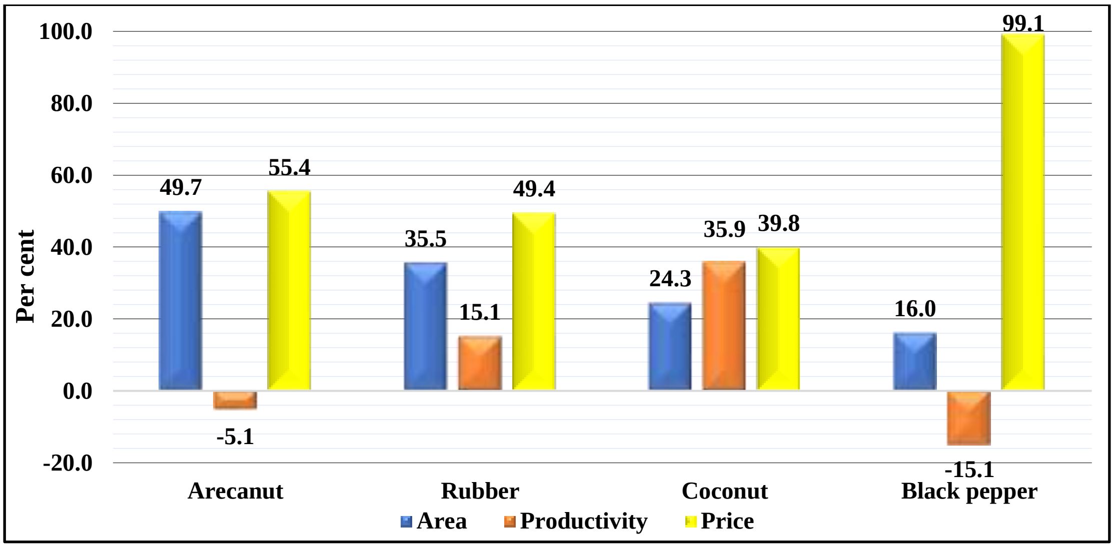
The growth accounting approach was used to estimate the contributions of area, productivity and price to the change in revenue from principal crops in the district during the period from 1981-82 to 2018-19 and the results are presented in Table 4.10. The revenue from a crop was calculated by multiplying the area, productivity and average price of the crop in a particular year. The changes in revenue were estimated by subtracting the revenue in 1981-82 from that in 2018-19, and were expressed as per cent contributions of area, productivity and price. The area and price were found to influence positively the change in revenue of arecanut almost equally (55.4 and 49.7 per cent respectively), whereas productivity had a negative impact (-5.1 per cent). In the case of rubber, the price was found to have the highest positive influence of 49.4 per cent, followed by area and productivity with 35.5 and 15.1 per cent respectively. The area, productivity and price were found to be having higher positive influence in the growth in revenue from coconut. Also, coconut was the only crop with all the three factors exerting a positive influence on the growth in revenue. Price was found to be the major factor influencing the change in revenue from black pepper, accounting for 99.1 per cent. The findings that area and productivity exerted equally but limited and opposite influence (16.0 and -15.1 per cent respectively) on the change in revenue from black pepper further highlighted the significant role of the price.

For all the crops studied, price was found to be the greatest influencing factor on the changes in revenue from the crops. The influence of the area, productivity and price on the variations in revenue from arecanut, rubber, coconut and black pepper are depicted in Figure 9.

Table 4.10 Results of growth accounting analysis on variations in revenue from major crops of Wayanad district (in per cent)

Crops	Contributing factors		
	Area	Productivity	Price
Arecanut	49.73	-5.14	55.41
Rubber	35.50	15.10	49.40
Coconut	24.30	35.92	39.78
Black pepper	16.01	-15.06	99.05

Figure 9 Contribution of area, productivity and price on the variation in revenue of major crops in Wayanad district



4.2 RISKS AND INSTABILITIES IN THE AGRICULTURAL ECONOMY

This section identifies and estimates the risks and instabilities existing in the agricultural economy of Wayanad district using secondary data. The trend break analysis was carried out to check for significant regression discontinuities in area and production of important crops. The climate risk faced by the farmers due to changes in temperature and precipitation were estimated using Just and Pope production function. The instabilities in prices of commodities pose a major risk to farmers as low prices during the harvesting seasons force the farmers to make distress sales. The Cuddy-Della Valle instability index was used to estimate the instability in prices of major crops cultivated in the district. Any form of risks or instabilities will ultimately affect the stability of farmers' income, thereby adversely affecting their family welfare. The instabilities in income from the primary sector of Wayanad district at constant prices was estimated using the chain index and link relatives.

4.2.1 Estimation of trend breaks

4.2.1.1 Estimation of trend breaks in area under major crops

The results of the Chow test for identifying the trend breaks in area under major crops of Wayanad district are given in Table 4.11. The year of break denotes the period from which there is a discontinuance in regression for area under the crop. The area under major crops from 1981 to 2018, along with the trend lines fitted separately for the data during the two periods (prior to and after the break) are shown from Figure 10 to Figure 15.

Table 4.11 Results of Chow test for identifying trend breaks in area under major crops in Wayanad district

Crops	Year of break	Estimated $F_{(2,34)}$ values*	Inference
Coffee	1992	110.290	Significant
Arecanut	2006	4.234	Significant
Rubber	2004	13.896	Significant
Coconut	2007	52.100	Significant
Black pepper	1999	140.73	Significant
Paddy	1994	8.536	Significant

*Note: 1. Critical value for rubber with (2,33) degrees of freedom (df) at five per cent level of significance is 3.293.
2. For all other crops the df is (2,34) and the critical value at five per cent level of significance is 3.284.

It could be inferred from Table 4.11 that the periods before and after the year of break showed significant regression discontinuance in all the crops. This means that there is a statistically significant difference in the trend shown during the two periods. Coffee was the first crop to show a trend break in 1992, followed by paddy, black pepper, rubber, arecanut and coconut during 1994, 1999, 2004, 2006 and 2007 respectively. It could be observed from Figure 10 to Figure 15 that coconut and arecanut were showing an upward trend during both the pre and post-break periods, but the rate of growth was lower during the second period. The trend break in area under coconut occurred during the year 2007, and the fall in price of coconut following this period could be attributed as the reason for this break. The price of coconut for 1000 nuts was ₹4,800 in the year 2000, while it decreased to ₹3,800 in the year 2007. The price then increased gradually over the years with occasional ups and downs. The break in trend for area under coffee happened in the year 1992. Coffee was showing a rising trend in area during the pre-break period, but it almost got stagnated during the post-break period. It was around the period of the trend break that the trade liberalisation and opening of Indian economy happened. The marketing problems arising from the repeal of the International Coffee Agreement, along with the export problems and stagnating trend in domestic consumption pushed the coffee production and marketing scenario into real peril (GoK, 1992). The monopsonic marketing system of the Coffee Board collapsed and gave way to a process of decontrol in coffee marketing (GoK, 1993). This crisis in the marketing front caused serious unrest among the producers in the country and in the state. A sigh of relief came in 1993 as the international price of coffee quadrupled due to the widespread frost and drought in Brazil causing a crop loss of 40 per cent. The coffee farmers of Wayanad took advantage of their increased productivity and the new trade policy, ultimately compelling the Indian government to cap the exports by imposing a maximum limit of 1.1 lakh tonnes so as to ease the availability of the commodity for internal consumption and bring domestic price under control (GoK, 1994). Even though small coffee farmers owning up to 10 hectares were given permission for 100 per cent free sale of their produce, some institutional arrangement for guidance in marketing was needed for them to compete in the free market economy (GoK, 1995; GoK, 1996). Coffee being a perennial crop, the sudden hike in prices did not lead to an increase in area, but a stagnation in area was observed with increasing productivity every year (GoK, 1997). Enactment of free sale quota for the coffee farmers and the impact of trade liberalisation, along with sudden hike in international prices could be considered as the reasons for this break in trend.

Figure 10 Trend break in area under coffee in Wayanad district

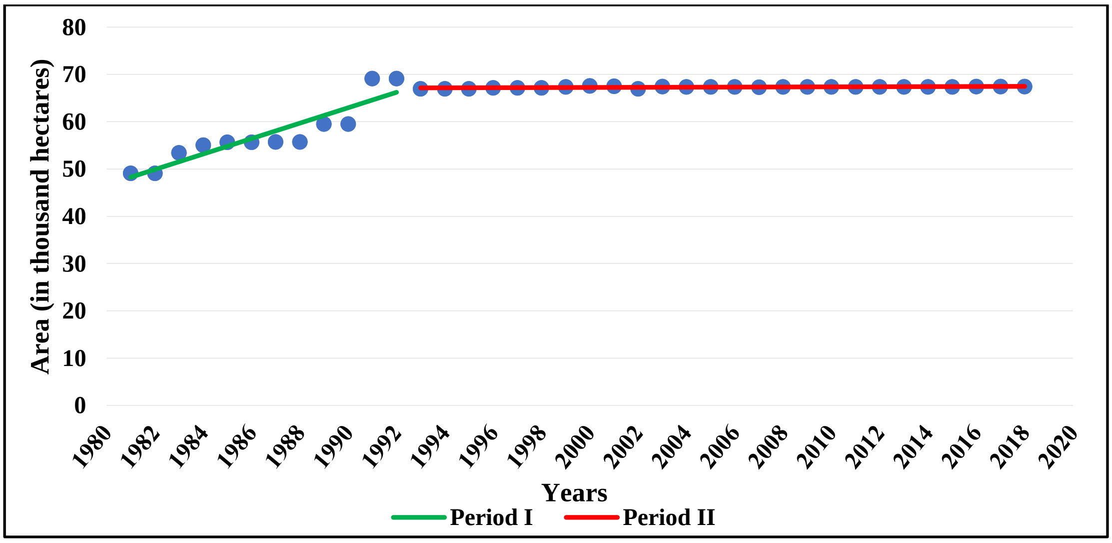


Figure 11 Trend break in area under arecanut in Wayanad district

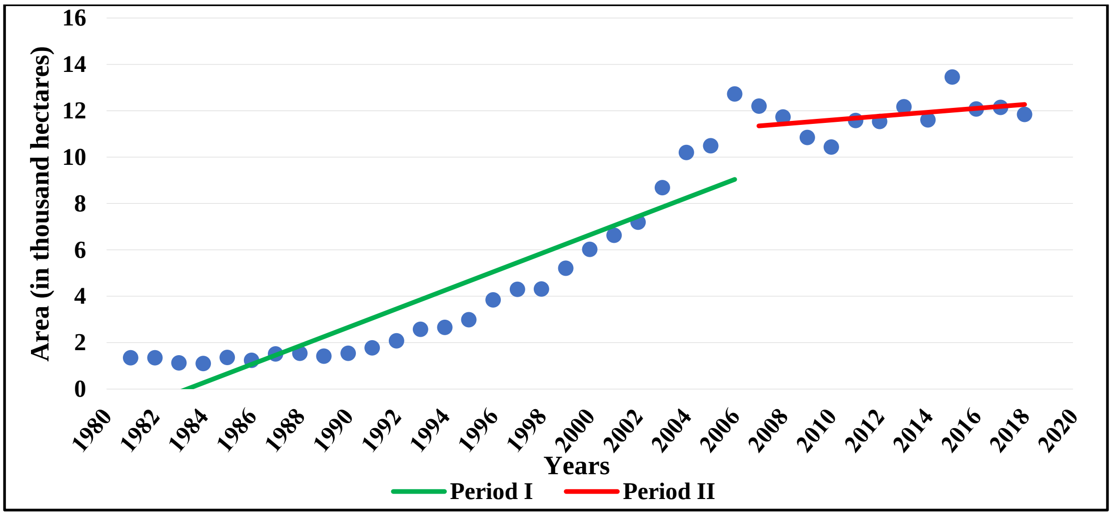


Figure 12 Trend break in area under rubber in Wayanad district

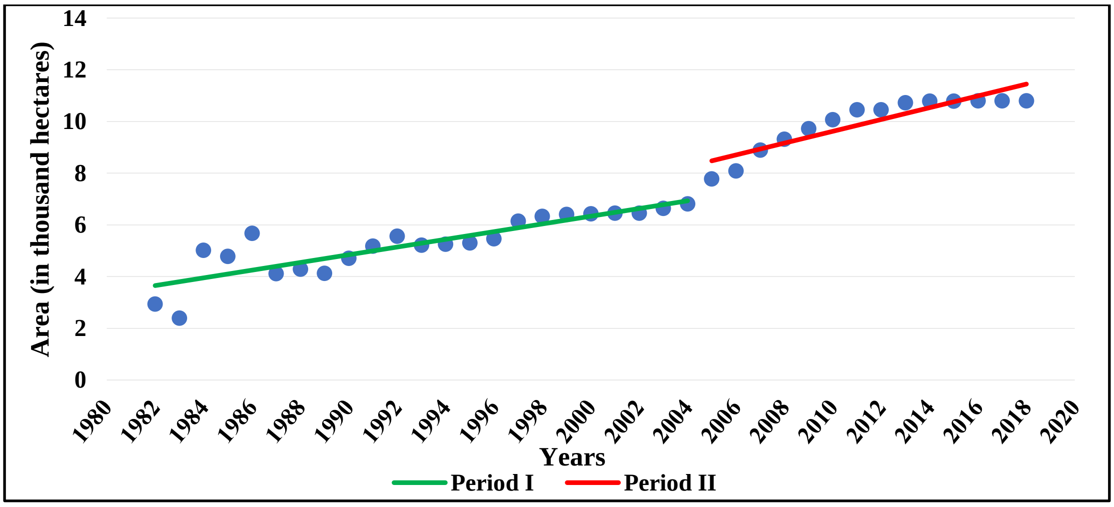
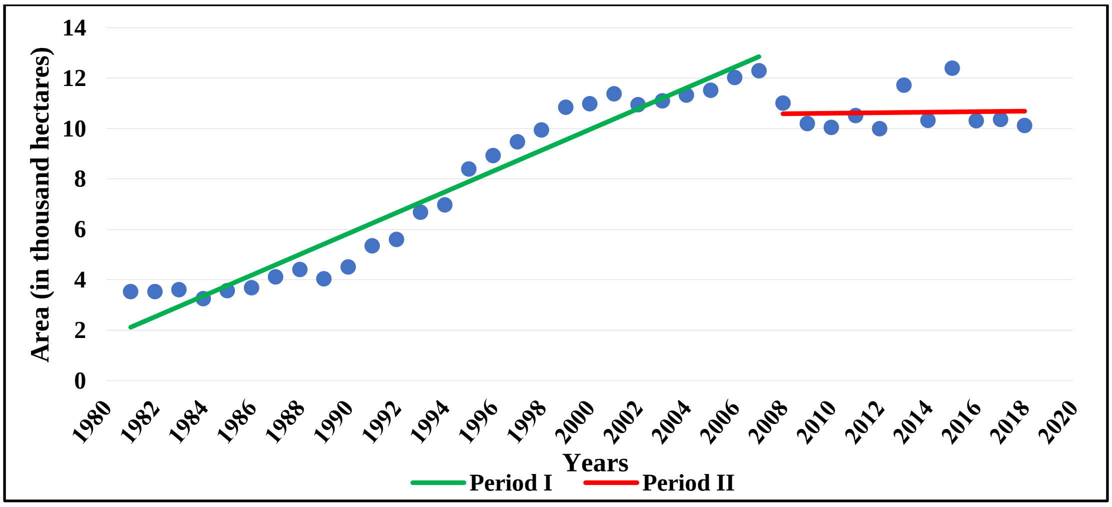


Figure 13 Trend break in area under coconut in Wayanad district



The trend break in area under rubber in Wayanad happened in the year 2004. Rubber showed a slightly higher upward trend in the second period as compared to the first period. The price of rubber was around ₹4,000 per quintal in 2003, which then subsequently increased to ₹5500 in 2004 and about ₹20,000 per quintal by the year 2010. This rise in price could be attributed as the major reason for the break in trend for area under rubber. Black pepper showed the most significant break in trend, with a highly increasing trend until 1999, breaking into a highly decreasing trend thereafter. There were wide instances of quick wilt disease and crop loss in black pepper plantations during this period. Also, the drought in the subsequent years aggravated the problems for black pepper, leading to the sudden and huge decline in acreage under the crop. Even though paddy continued to show a downtrend in the second period as in the first period, following a trend break in 1994, the rate in decline was found to be comparatively lower after the break.

Figure 14 Trend break in area under black pepper in Wayanad district

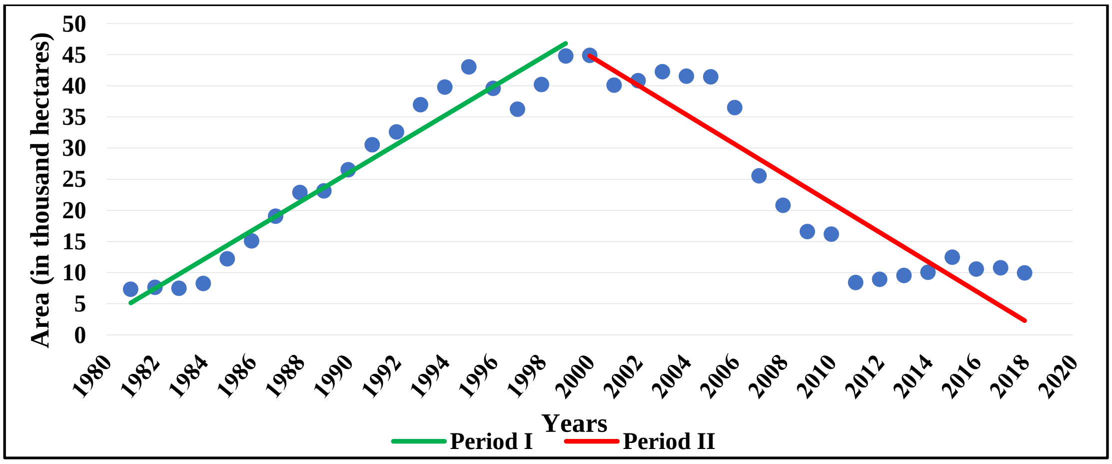
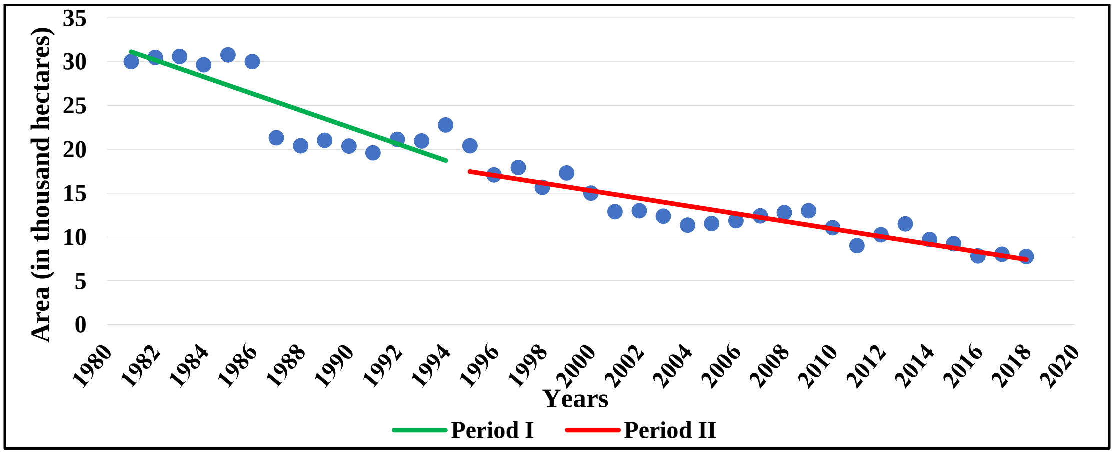


Figure 15 Trend break in area under paddy in Wayanad district



The interpretations about trend breaks in area under major crops should be made by keeping in mind that crop acreage cannot grow forever. The trend after the break in crops like arecanut, coconut, rubber, and coffee were still positive and therefore could be viewed as normal and inevitable. But the trend break in black pepper and the extreme trend reversal following the break should be considered seriously, given that it was the prime crop for a large number of farmers in the district. Also, the trend break in paddy occurred long back in 1994, and the acreage under the crop has been continuously declining at the same rate, which is a serious threat to the production of rice and consequently, food security of the state.

4.2.1.2 Estimation of trend breaks in production of major crops

The break of trend in production of a commodity shows the increase or decrease in the rate of growth in output. Table 4.12 gives the results of Chow test for the trend break in production of major crops in Wayanad district. Figure 16 to Figure 21 show the production of major crops in Wayanad district from 1981 to 2018, along with the fitted trendlines for the pre-break and post-break periods.

Table 4.12 Results of Chow test for identifying breaks in production of major crops in Wayanad district

Crops	Year of break	Estimated $F_{(2,34)}$ values*	Inference
Coffee	2000	6.581	Significant
Arecanut	2005	4.250	Significant
Rubber	2005	29.667	Significant
Coconut	2002	0.004	Insignificant
Black pepper	1998	39.860	Significant
Paddy	1995	1.253	Insignificant

*Note: 1. Critical value for rubber with (2,33) degrees of freedom (df) at five per cent level of significance is 3.293.
2. For all other crops the df is (2,34) and the critical value at five per cent level of significance is 3.284.

It could be observed from the figures that coffee was the only crop showing a positive trend in production after a significant trend break. However, the positive trend in production of coffee was higher during the first period as compared to the second, indicating that there has been a significant decline in the rate of growth in production of coffee. Since the production and trend break in production of coffee shows a similar pattern to that of its area, the same reasons attributed for the break in area could also hold true in the case of production. Crops like black pepper, rubber, and arecanut, which showed an increasing trend during the pre-break period exhibited a shift to decreasing trend following the break. The shift in trend was the most pronounced for black pepper, followed by rubber and arecanut. The trend break in production of black pepper was exactly around the period where it showed a trend break in acreage. In case of rubber, there was increase in production until 2010, the year which corresponded to the highest price. However, in the years that followed, there was a drastic fall in the price of rubber, which forced many farmers to stop tapping the trees. As a result of this, there was significant decline in the production of rubber which caused the trend break in production, even though the acreage under the crop was comparatively steady. The trend breaks in production of coconut and paddy were found to be insignificant at five per cent level, which indicated the existence of comparable trends during both the periods. Coconut showed a fairly discernible upward trend till 2002, which even continued in similar fashion after the break. Paddy, on the other hand, showed similar downward trends in both the periods.

Figure 16 Trend break in production of coffee in Wayanad district

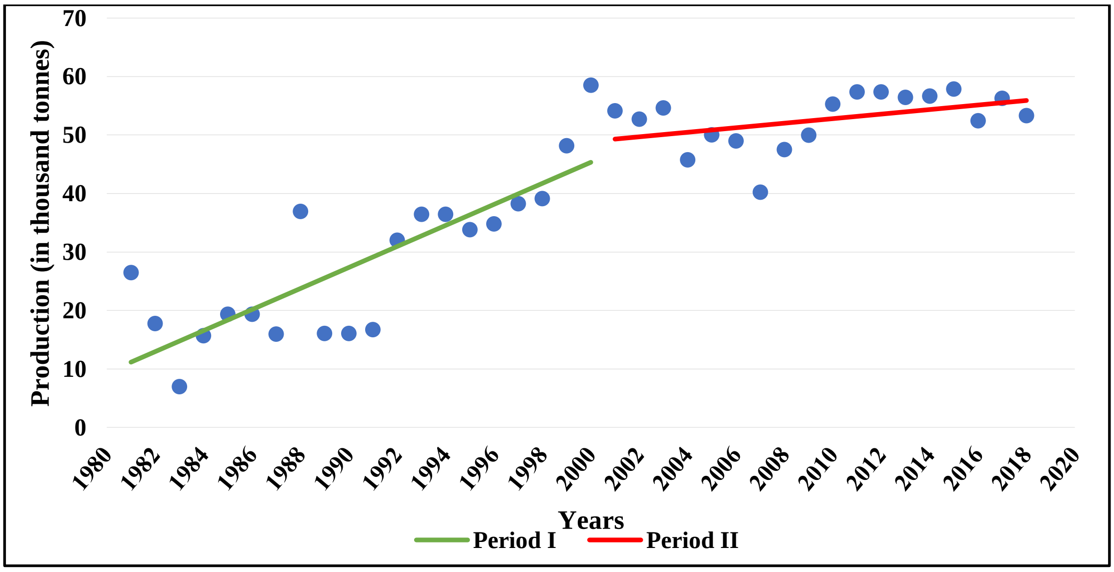


Figure 17 Trend break in production of arecanut in Wayanad district

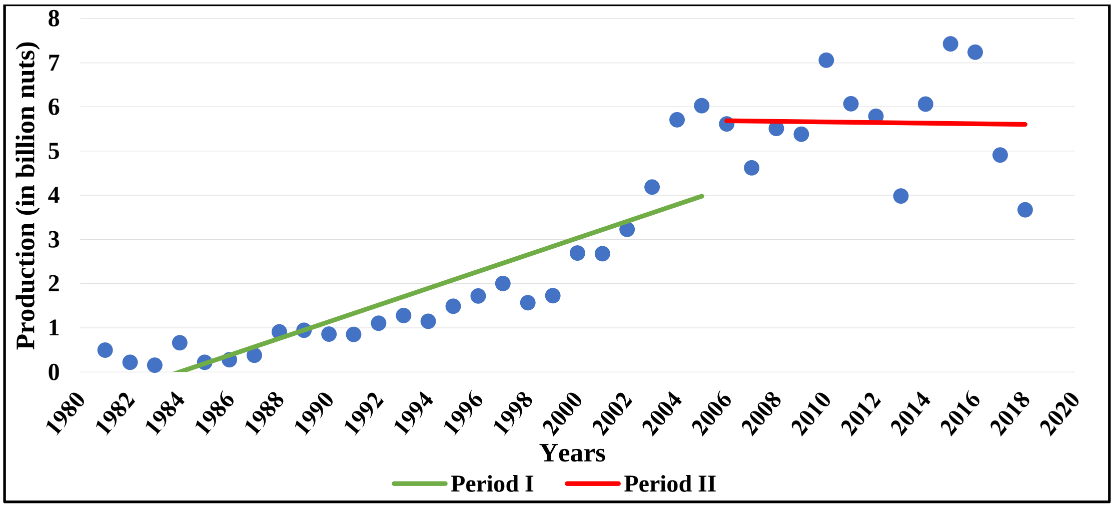


Figure 18 Trend break in production of rubber in Wayanad district

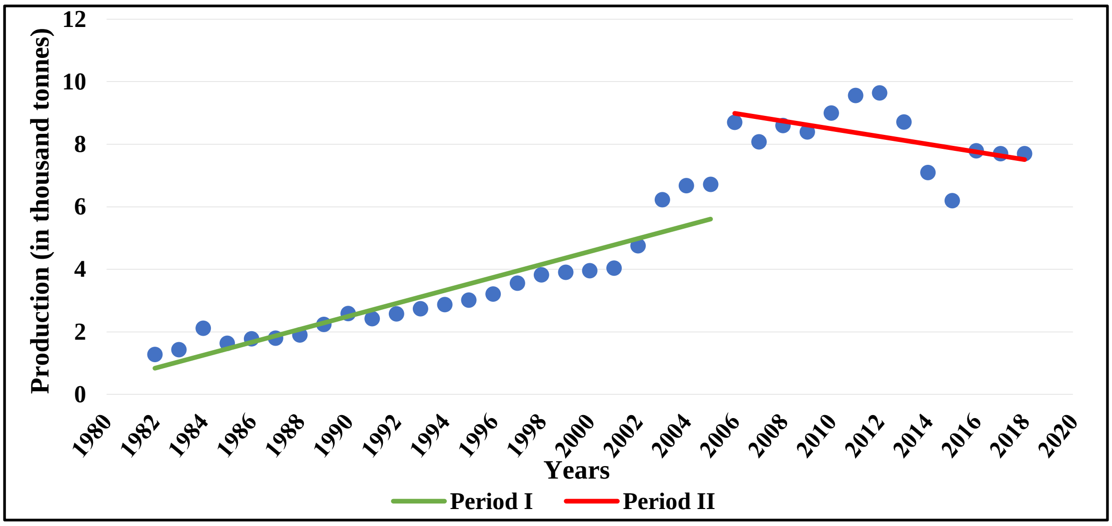


Figure 19 Trend break in production of coconut in Wayanad district

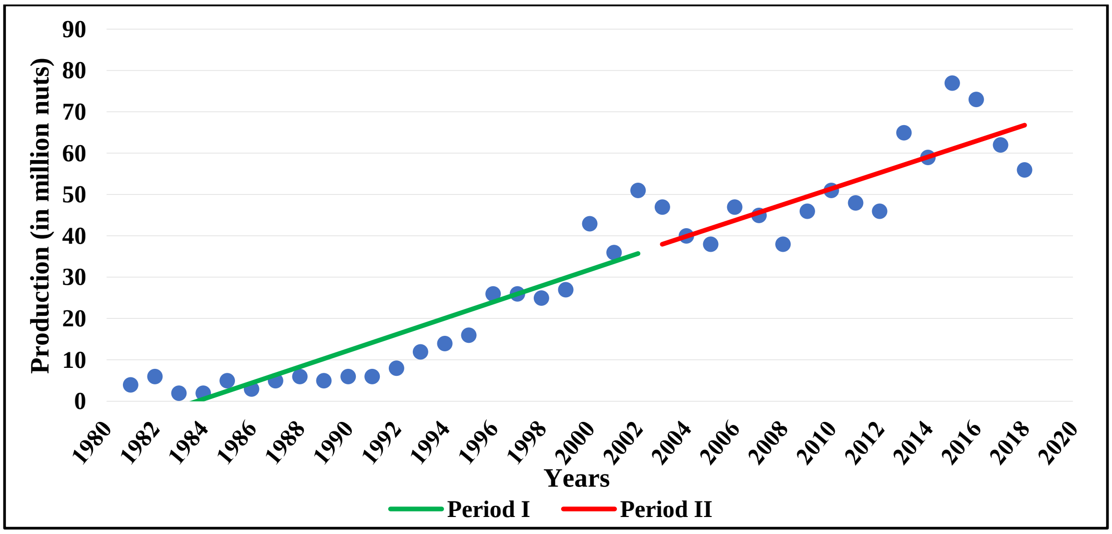


Figure 20 Trend break in production of black pepper in Wayanad district

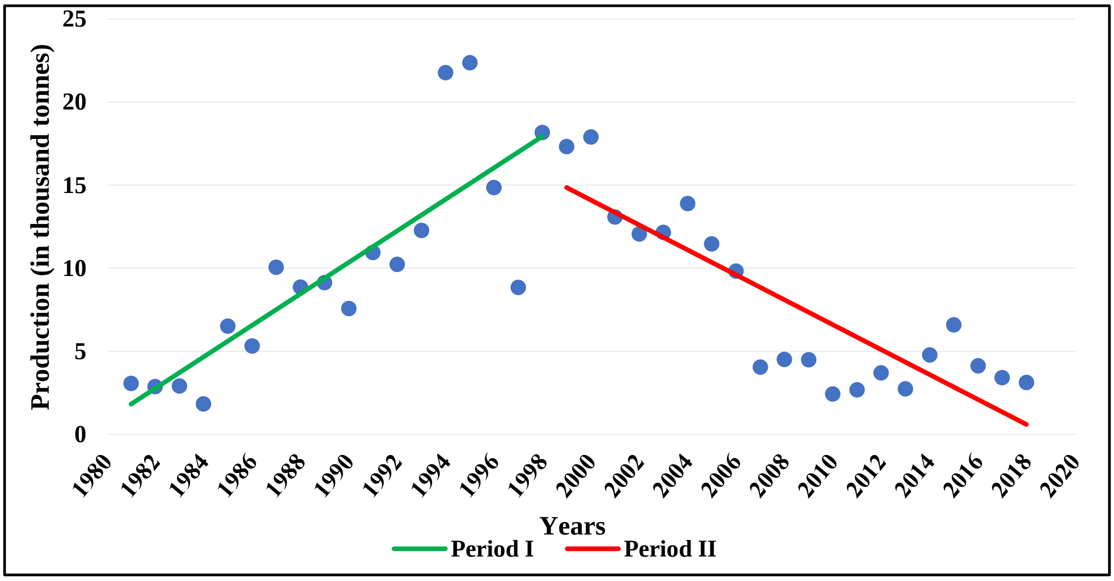
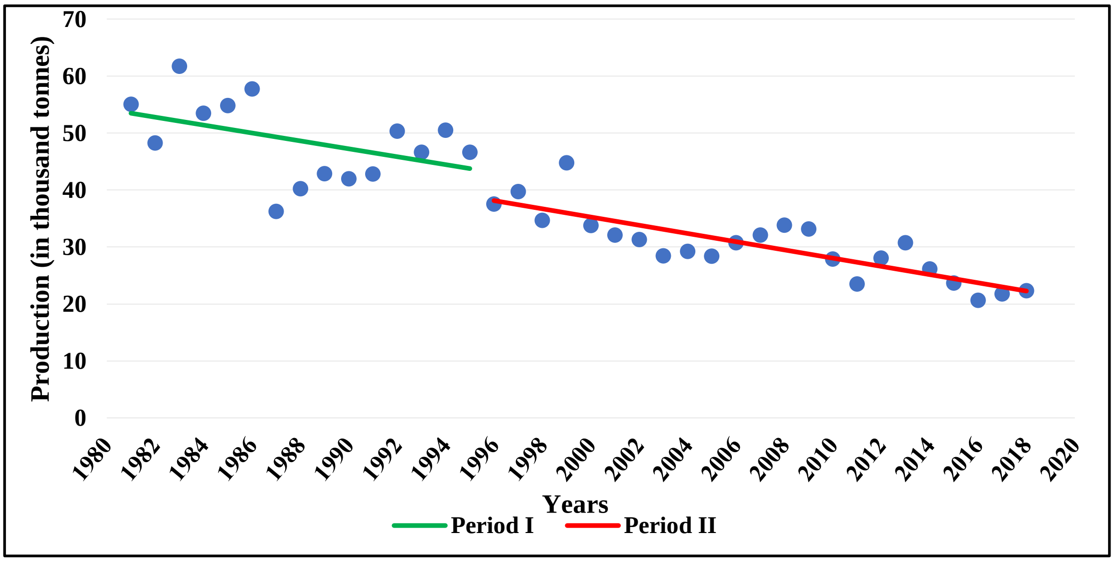


Figure 21 Trend break in production of paddy in Wayanad district



The only two encouraging findings from the trend break analysis of production of crops in Wayanad district were the sustained upward trend in production of coffee even after the break and the insignificant break in upward trend in production of coconut. All other crops showed downward trend after the break, indicating the existence of growing risks in agricultural production of the district.

4.2.2 Estimation of climate risk

The data on climatic factors such as temperature, precipitation, standard deviation in temperature, and standard deviation in precipitation, along with the data on area and production of principal crops of Wayanad district from 1983 to 2019 were used to estimate the influence of climatic parameters on production of crops in the district. The Just and Pope yield function, as used by Arumugam *et al.* (2014) was used for the estimation of climate risk.

The effect of climate on the production of five major crops in the district *viz.*, coffee, arecanut, rubber, coconut, and black pepper were estimated. The estimates of the average production function for these crops estimated using WLS method are given in Table 4.13. It could be observed from the table that for all the crops, area was found to be positively related to production at one per cent level of significance. This indicates a straightforward relationship between increase in production and the increase in area under the crop. The standard deviation of temperature was found to negatively affect coffee production in the district. This was also found to be highly significant at one per cent level, implying that higher deviations from the mean temperature during an year could result in decrease in production of coffee in the district. The standard deviation of precipitation was found to negatively affect the production of black pepper in the district at 10 per cent level of significance. This means that higher rainfall over lesser number of days during an year could cause decline in the production of black pepper. In the case of arecanut, no significant relationship was found between any of the climatic variables and production of nuts. This suggests that the changes in temperature and precipitation in the district over the years was not sufficient enough to influence the annual average production of arecanut. The mean annual temperature was found to be positively influencing the production of coconut, while it was affecting negatively the production in the case of rubber, both at one per cent level of significance. It could be concluded from these results that an increase in average annual temperature increased the production of coconut in the district, while it decreased the production of rubber.

Table 4.13 Estimates of average production function about the influence of climatic parameters on production of major crops of Wayanad district

Independent variables	Coffee		Black pepper		Arecanut		Coconut		Rubber	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Area (Hectares)	0.966***	0.263	0.352***	0.045	0.481***	0.039	0.006***	0.001	1.21***	0.102
Mean Temperature (ºC)	11304.8	8568.197	-3343.58	2258.55	626.867	553.267	21.438***	6.478	-3230.9***	915.868
SD temperature (ºC)	-50328.9***	14312.79	-1563.84	4021.819	114.512	1055.186	1.839	12.907	1650.169	1454.077
Precipitation (mm)	-15.692	12.903	-0.311	2.866	0.727	0.816	0.01	0.01	-0.881	0.983
SD Precipitation (mm)	137.112	113.644	-4.609*	28.503	-10.579	7.189	-0.008	0.084	4.729	8.746
Constant	-206679.0	204958.3	84402.86	54119.98	-15075.87	13294.37	-556.49***	155.17	72828.88***	20994.27

Note:1. *** denotes significance at one per cent level
2. * denotes significance at 10 per cent level

Table 4.14 Estimates of variance regression about the influence of climatic parameters on variability in production of major crops of Wayanad district

Independent variables	Coffee		Black pepper		Arecanut		Coconut		Rubber	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Area (Hectares)	0.0	0.0	0.001**	0.001	0.0*	0.0	0.0	0.0	0.0	0.0
Mean Temperature (ºC)	-1.417	1.242	0.775	1.658	-0.319	1.092	0.145	1.328	1.196	2.892
SD temperature (ºC)	-0.129	2.217	-0.590	3.029	-3.592	1.981	-2.108	2.573	0.929	4.621
Precipitation (mm)	-0.001	0.002	-0.001	0.003	-0.001	0.002	0.0	0.0	0.0	0.0
SD Precipitation (mm)	0.003	0.016	0.001	0.002	0.015	0.014	0.014	0.018	0.014	0.029
Constant	55.718*	29.686	-4.079	40.976	25.140	26.128	2.405	31.660	-21.583	66.038

Note:1. *** denotes significance at one per cent level
2. * denotes significance at 10 per cent level

The results of the log production variance regression are given in Table 4.14. It could be observed from the table that no significant relationship was established between any of the climatic parameters and variance in the production of crops. Even though climatic parameters were found to influence the production of crops, they had no significant influence on their yield variability. The annual average temperature and rainfall data for Wayanad district from 1983 to 2019 are given in Appendix III. This data does not show significant variations in the climatic parameters during the period of the analysis. Therefore the insignificant influence of these parameters on the variability in production was expected.

It is important to know about the limitations of this study before drawing any conclusions from it. The average annual weather data used in this study does not give much idea about the intra-annual variations in the weather parameters. For crops like coffee, the timing of receipt of pre-blossom showers is very crucial and it influences the production of the crop. The variations induced by climate change in the intra-annual weather parameters go beyond the scope of the present analysis. The assumption that the climate data obtained from Regional Agricultural Research Station (RARS) Ambalavayal is representative for the whole district is also quite restricting. These limitations must be accounted before making any conclusions from these results.

4.2.3 Estimation of instabilities in prices of major commodities

The instabilities in prices of major crops were estimated using Cuddy-Della Valle instability index for the period from 1981-82 to 2018-19. The index was worked out for four sub-periods, with each sub-period representing a decade and the results of the analyses are presented in Table 4.15. It could be observed from the table that arecanut exhibited the highest instability in price (21.3) during 1980s, while during 1990s it exhibited the least instability (10.6). The value of the index for the last two decades were 15.2 and 14.12 respectively. For rubber, the highest instability was observed during 1990s (28.7), while the least instability was estimated for 1980s (5.7). Price instability was highest for coconut during the first decade (23.3), then decreased and showed similar index value of 13.4 in the second and third decades and further increased to 20.1 in the last decade. Black pepper was showing high instability in price from 1980s onwards, which was found to increase over time and the highest instability index of 31.4 was observed during 2000s (31.4).

Table 4.15 Cuddy-Della Valle instability index for prices of major crops of Wayanad district

Crops	1981-82 to 1989-90	1990-91 to 1999-'00	2000-01 to 2009-10	2010-11 to 2018-19
Arecanut	21.28	10.59	15.22	14.13
Rubber	5.67	28.71	7.48	10.23
Coconut	23.27	13.41	13.48	20.11
Black pepper	24.54	28.30	31.39	30.36

Figure 22 Cuddy-Della Valle instability index for prices of major crops of Wayanad district

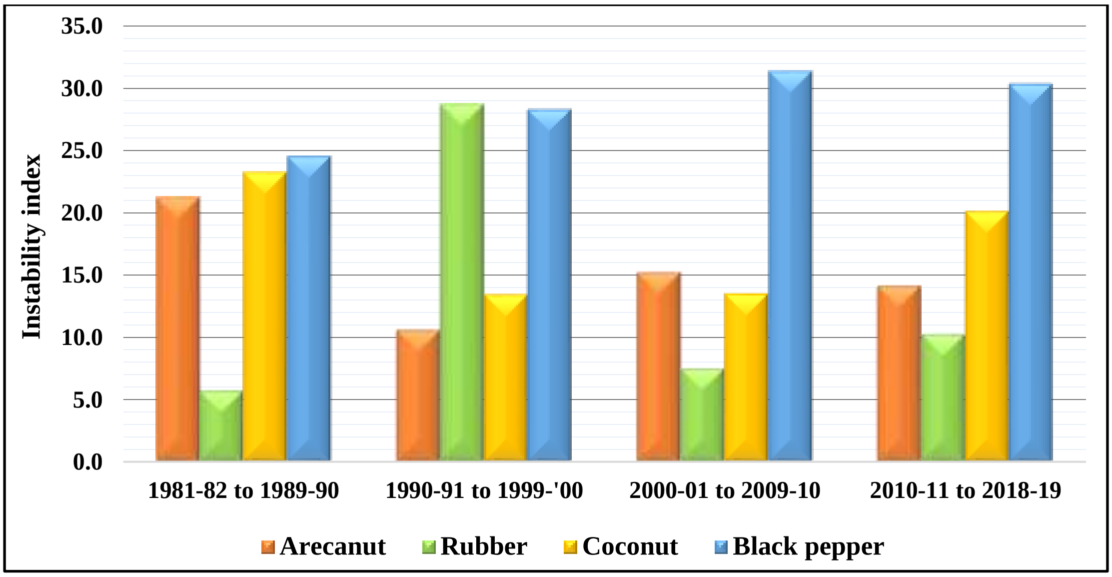


Figure 22 depicts the instability indices for prices of major crops during the four decades from 1981-82 to 2018-19. It could be observed that black pepper showed the highest instability in price among the four crops. The price of black pepper started to fluctuate during 1990s due to the economic reforms and the trade liberalisation that followed (Sabu and Kuruvila, 2016). As mentioned earlier, the incidence of quick wilt disease and the sudden decline in production of black pepper during the early 2000s also contributed to the instability in price. With the exception of 1990s, rubber was showing the least instability in prices among the crops. The effects of price transmission from the global market to domestic markets following the opening of economy could be the reason for high instability in price of rubber during 1990s. Even though coconut and arecanut exhibited similar trends in price instability, the latter was on the lower side in all the other decades with the exception of the second decade. The import of palm oil and other edible oils led to the decline in price of coconut and coconut oil in the state. Even though the central government imposed certain restrictions on import of palm oil through the ports of Kerala in 2007, those measures were insufficient to curb the instability in price of coconut.

4.2.4 Estimation of instabilities in income from primary sector

Any form of risk or difficulty faced by the farmers will be reflected in the year to year variation in income received by them. The instabilities in income from the primary sector of Wayanad district for which agriculture contributes a major share were estimated using chain index and link relatives. Agriculture accounted for 98.5 per cent of the income from primary sector for Wayanad district during 2018-19 (GoK, 2019b). Therefore, the findings from the analysis of instability in primary sector income will hold good for income from agriculture also. The data on income from the primary sector of the district from 1982-83 to 2018-19 at constant prices (base year 1980-81) was used for the estimation. The data on constant prices was used for the estimation so as to account for inflationary changes in money and hence it makes an acceptable comparison between different years.

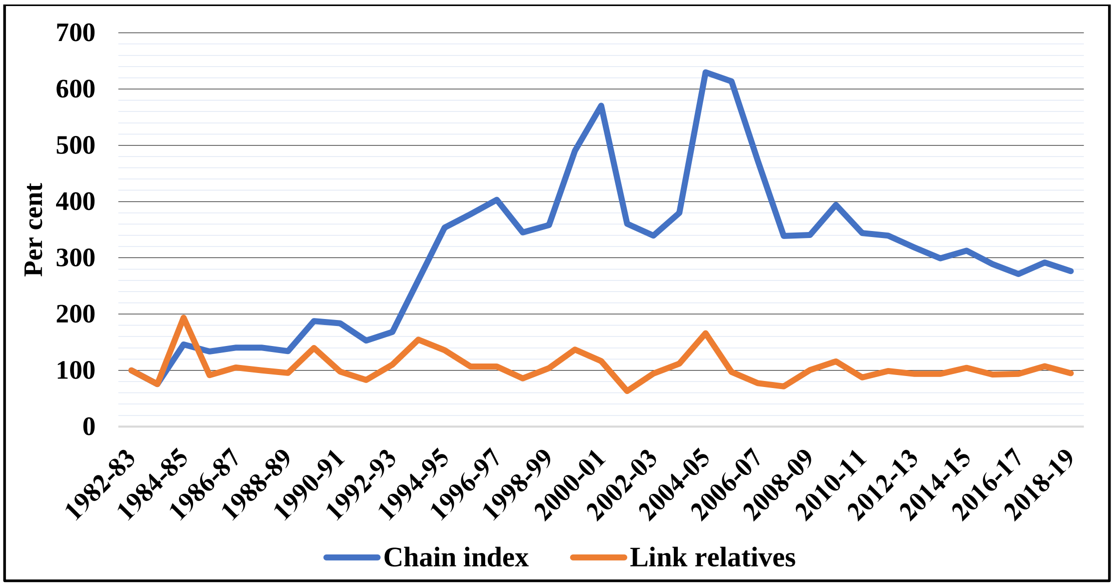
In this method, the link relative for each year was estimated as a percentage of its preceding value, with the first link relative taken as 100. The chain index value for a particular year was computed by multiplying the link relative value of that year with the chain index value of the preceding year and dividing it by 100. The first chain index value was also taken as 100. The chain indices can be used to identify the overall growth in income over the entire period and the link relative facilitates the comparison of year to year changes in income.

Table 4.16 shows the chain indices and link relatives of income from primary sector in Wayanad district. The chain index for the year 2018-19 was found out to be 276.22, which means that the income from primary sector in Wayanad increased by 276.22 per cent for the year 2018-19 as compared to 1982-83. The link relatives were found to be fluctuating around the 100 per cent level. Since the link relative value for an year was estimated as the per cent value of income during that year to that of the previous year, the results showed frequent year to year increase and decrease in income as understood from the rise and fall of link relatives from the 100 per cent level.

Table 4.16 Chain indices and link relatives of income from primary sector in Wayanad district (in per cent)

Year	Chain indices	Link relatives	Year	Chain indices	Link relatives
1982-83	100	100	2001-02	360.34	63.17
1983-84	75.49	75.49	2002-03	339.33	94.17
1984-85	146.13	193.58	2003-04	380.13	112.02
1985-86	133.54	91.39	2004-05	629.83	165.69
1986-87	140.44	105.16	2005-06	613.48	97.40
1987-88	140.61	100.12	2006-07	472.49	77.02
1988-89	134.37	95.56	2007-08	339.04	71.76
1989-90	187.56	139.59	2008-09	340.67	100.48
1990-91	183.69	97.94	2009-10	394.20	115.72
1991-92	152.77	83.17	2010-11	343.80	87.21
1992-93	168.21	110.11	2011-12	339.32	98.70
1993-94	260.15	154.66	2012-13	318.40	93.83
1994-95	353.60	135.92	2013-14	298.99	93.90
1995-96	377.54	106.77	2014-15	312.51	104.52
1996-97	403.28	106.82	2015-16	288.91	92.45
1997-98	345.11	85.58	2016-17	271.39	93.94
1998-99	358.40	103.85	2017-18	291.87	107.55
1999-00	490.04	136.73	2018-19	276.22	94.64
2000-01	570.46	116.41			

Figure 23 Chain indices and link relatives of income from primary sector in Wayanad district



A better idea about the fluctuations in chain indices and link relatives could be drawn from Figure 23. An initial upward trend was observed for chain indices up to 2004-05, when it touched the maximum of 629.83 per cent. Subsequently, it declined over the years to 276.22 per cent in 2018-19. After reaching the maximum of 193.58 per cent in 1984-85, the link relatives kept on fluctuating around the 100 per cent level till it went down to touch the minimum at 63.17 per cent in 2001-02. This marked the largest year to year fall of 36.83 per cent. A couple of years later, in 2004-05, the second highest year to year rise in income after 1984-85 occurred. The link relative of 2004-05 was 165.69 per cent, meaning a 65.69 per cent increase in income from the previous year.

The general conclusion that could be drawn from the analysis is that the income from the primary sector in Wayanad district, in which agriculture has the foremost share, is highly volatile. It is not just the absolute values alone, even the year to year fluctuations were also high and hence the income from agriculture in the district could be considered as highly unstable.

4.3 CROP DIVERSIFICATION

The crop diversification in Wayanad district since its formation in 1980 was computed using five different indices. The indices used were Herfindahl Index (H.I.), Ogive Index (O.I.), Entropy Index (E.I.), Modified Entropy Index (M.E.I.), and Composite Entropy Index (C.E.I.). Each of the index measures diversification in a slightly different manner, some measuring the overall diversification, whereas the others measuring the deviations from equal allocation of area for all crops. The data on area under 20 crops from 1981-82 to 2018-19 was used for the estimation of various diversification indices. The crops included in the estimations were coffee, black pepper, arecanut, coconut, rubber, paddy, ginger, turmeric, cardamom, jack, mango, banana, plantain, pineapple, papaya, cashew, tapioca, drumstick, cocoa, and tea. Table 4.17 shows the various crop diversification indices for Wayanad district from 1981-82 to 2018-19.

Table 4.17 Crop diversification indices for Wayanad district

Year	H.I.	O.I.[1]	E.I.[2]	M.E.I.	C.E.I.
1981-82	0.201	3.029	0.865	0.665	0.632
1982-83	0.241	3.814	0.828	0.637	0.605
1983-84	0.259	4.170	0.807	0.620	0.589
1984-85	0.248	3.956	0.827	0.635	0.604
1985-86	0.237	3.745	0.835	0.642	0.610
1986-87	0.229	3.585	0.846	0.651	0.618
1987-88	0.226	3.523	0.861	0.662	0.628
1988-89	0.218	3.367	0.868	0.667	0.634
1989-90	0.232	3.647	0.846	0.650	0.618
1900-91	0.220	3.403	0.863	0.663	0.630
1991-92	0.230	3.602	0.849	0.653	0.620
1992-93	0.224	3.485	0.856	0.658	0.625
1993-94	0.213	3.257	0.873	0.671	0.638
1994-95	0.208	3.166	0.875	0.672	0.639
1995-96	0.208	3.156	0.876	0.673	0.640

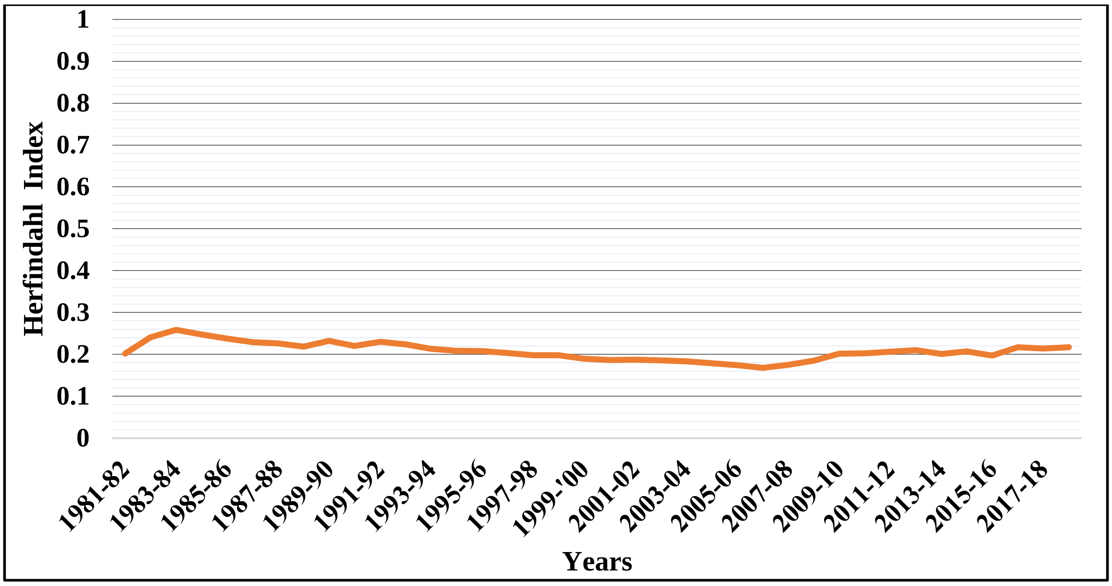
1996-97	0.203	3.068	0.893	0.686	0.652
1997-98	0.198	2.960	0.905	0.696	0.661
1998-99	0.198	2.961	0.904	0.695	0.660
1999-'00	0.190	2.797	0.915	0.704	0.668
2000-01	0.187	2.736	0.923	0.710	0.674
2001-02	0.187	2.737	0.927	0.713	0.677
2002-03	0.186	2.712	0.927	0.713	0.677
2003-04	0.183	2.666	0.930	0.715	0.679
2004-05	0.179	2.579	0.940	0.722	0.686
2005-06	0.174	2.483	0.948	0.729	0.693
2006-07	0.168	2.356	0.963	0.740	0.703
2007-08	0.175	2.503	0.961	0.739	0.702
2008-09	0.185	2.701	0.949	0.730	0.693
2009-10	0.202	3.041	0.923	0.709	0.674
2010-11	0.202	3.048	0.924	0.710	0.675
2011-12	0.206	3.126	0.928	0.713	0.677
2012-13	0.210	3.209	0.919	0.706	0.671
2013-14	0.201	3.024	0.928	0.713	0.678
2014-15	0.207	3.136	0.926	0.712	0.676
2015-16	0.197	2.945	0.938	0.721	0.685
2016-17	0.217	3.345	0.913	0.702	0.667
2017-18	0.214	3.280	0.916	0.704	0.669
2018-19	0.217	3.342	0.907	0.697	0.662

Note: 1. Various indices are measured on a scale from zero to one, unless otherwise specified.
2. [1]Ogive Index starts from 0 and has no upper boundary
3. [2]Entropy index starts from 0 and has an upper boundary of 1.301 in this analysis

4.3.1 Herfindahl Index

Herfindahl Index is the most commonly used index for measuring crop diversification. It measures the diversification on a scale ranging from zero to one, with zero indicating perfect crop diversification and one indicating perfect crop specialisation (monocropping). The crop diversification over the years in Wayanad district measured using H.I. is presented in Figure 24.

Figure 24 Crop diversification in Wayanad district measured using Herfindahl Index

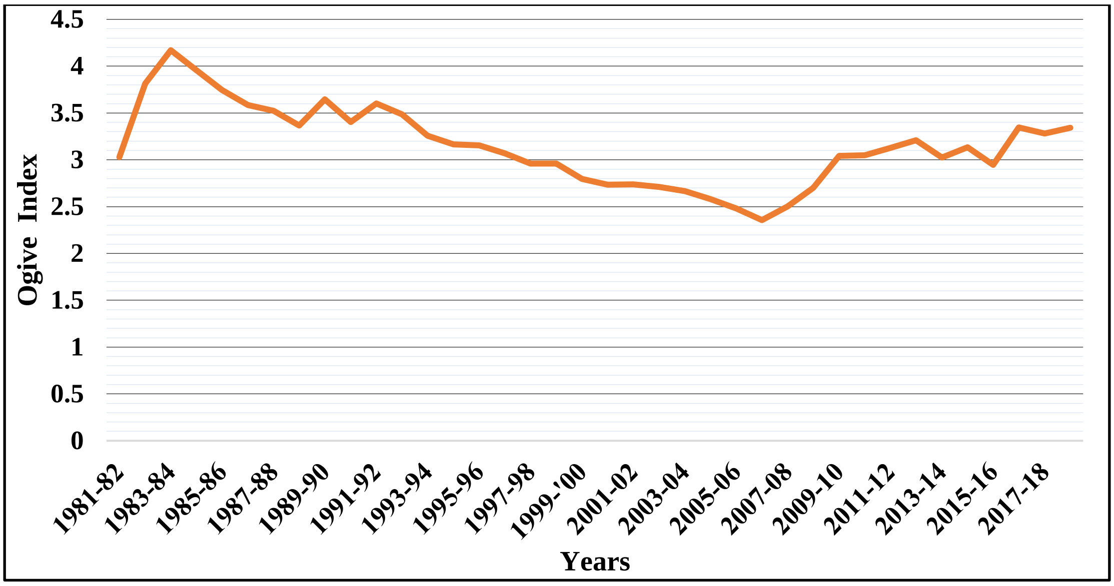


From Figure 24, it is clear that the district was having a high level of crop diversification ever since its formation. The maximum value of H.I. (least diversification) for the district was found to be 0.259 in the year 1983-84. A H.I. value less than 0.33 is generally considered as good level of diversification, and even the maximum reported H.I. for the district was found to be less than this. There was increased crop diversification in the district after 1983-84, which reached the maximum (minimum H.I.) in the year 2006-07, with a value of 0.168. There was a slight decline in crop diversity following this, but the overall value was found to be hovering around 0.2.

4.3.2 Ogive Index

The Ogive Index measures the departure from equal allocation of area for all the crops in the total cropped area. It has a scale starting from zero (either monocropping or perfect diversification) with no upper boundary. Lesser the O.I., greater will be the equality in allocation of area among various crops. The crop diversification of Wayanad district measured using O.I. for the years from 1981-82 to 2018-19 is presented in Figure 25.

Figure 25 Crop diversification in Wayanad district measured using Ogive Index



Since equal number of crops are used in the analysis throughout the given period, an year to year comparison of O.I. shows the variations in the allocation of area among those crops. A trend similar to that observed in H.I. can be seen here, with a few crops occupying maximum area in 1983-84 (O.I.= 4.170) and maximum equitable allocation among crops in the year 2006-07 (O.I.= 2.356). In the year 1983-84, the three major crops (coffee, paddy, and black pepper) occupied nearly 74 per cent of the total cropped area (GoK, 1988), whereas it came down to approximately 57 per cent by 2006-07 (GoK, 2007). The O.I. for the year 2018-19 was found to be 3.342, similar to those during the early 1990s.

4.3.3 Entropy Index

Entropy Index is a measure of crop diversification with zero as its lower boundary and the upper boundary equal to the logarithm of number of crops. In this analysis, the upper boundary is equal to log20, i.e., 1.301. Similar to O.I., the E.I. also measures the deviations from equal allocation of area among all the crops. Higher the E.I value, higher will be the equity in allocation of area among different crops. The crop diversification of Wayanad district measured using E.I. over the years is presented in Figure 26.

Figure 26 Crop diversification in Wayanad district measured using Entropy Index

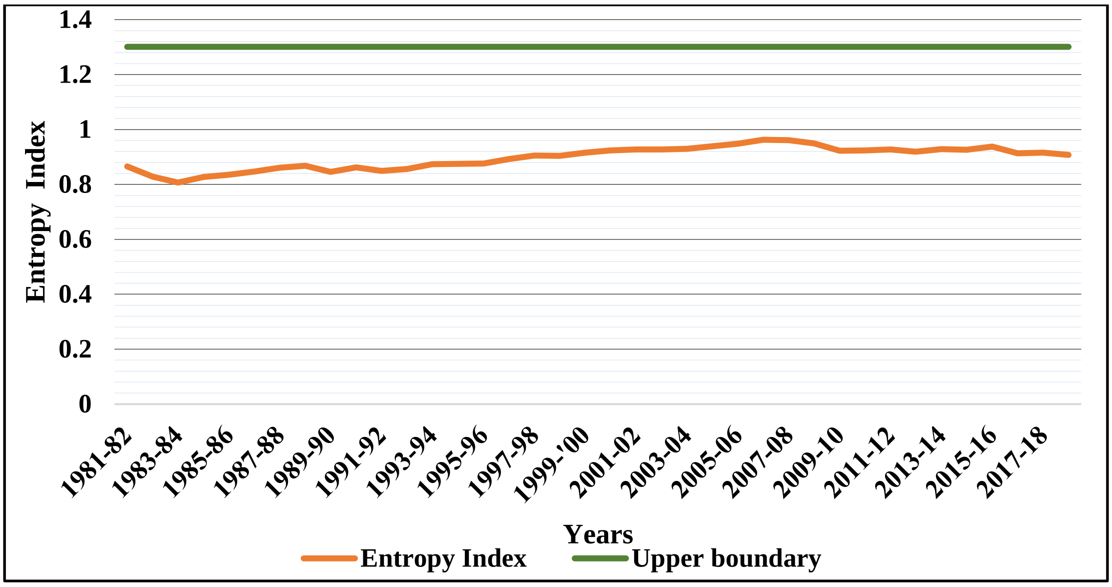


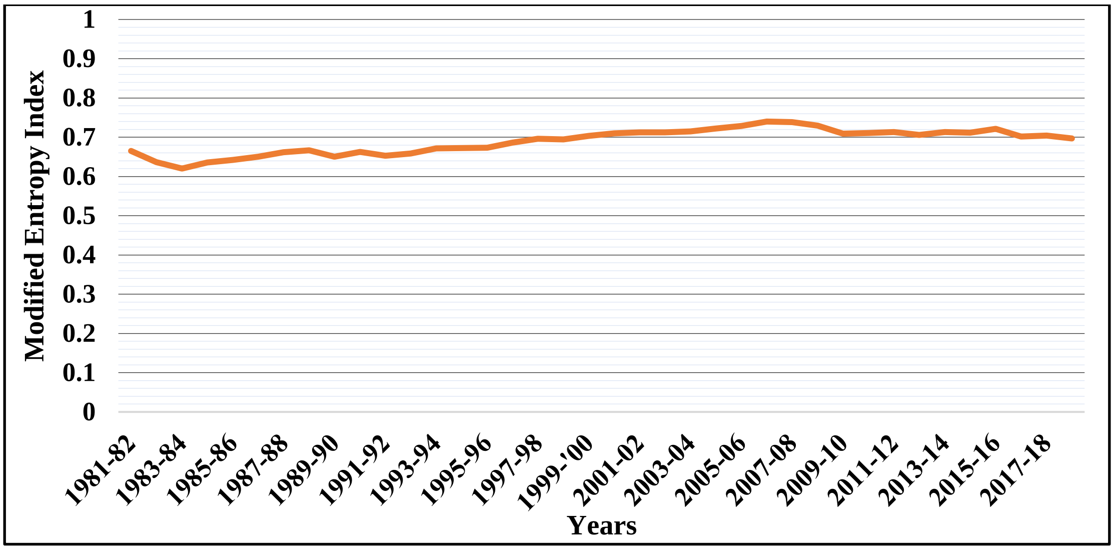
Figure 26 shows an initial decline in E.I., with the lowest point of 0.807 in the year1983-84. This was followed by an upward trend until it reached a maximum of 0.963 in 2006-07. A slight reduction in crop diversification was seen after this and the E.I. value was estimated as 0.907 in 2018-19. During all the years under consideration, it could be observed that the E.I. values were close to the upper boundary, indicating that there was considerable crop diversification in Wayanad district.

4.3.4 Modified Entropy Index

The Modified Entropy Index is an improved form of E.I. with a constant scale ranging from zero to one. A value of zero for the M.E.I. denotes monocropping, while one denotes equal allocation of area among different crops. Like O.I. and E.I., the M.E.I. also does not account for the number of crops used in the analysis, but measures the deviations from the equal allocation of area among different crops. The dynamics in crop diversification of Wayanad district over the years measured using M.E.I. is presented in Figure 27**.**

From Figure 27, it could be understood that with M.E.I. values in all the years above 0.6, the crop diversification in Wayanad district was fairly high. The highest M.E.I. was reported in 2006-07 (0.740), while it was lowest in 1983-84 (0.620). A decline in M.E.I. was seen after 2006-07, and it decreased to 0.697 in 2018-19.

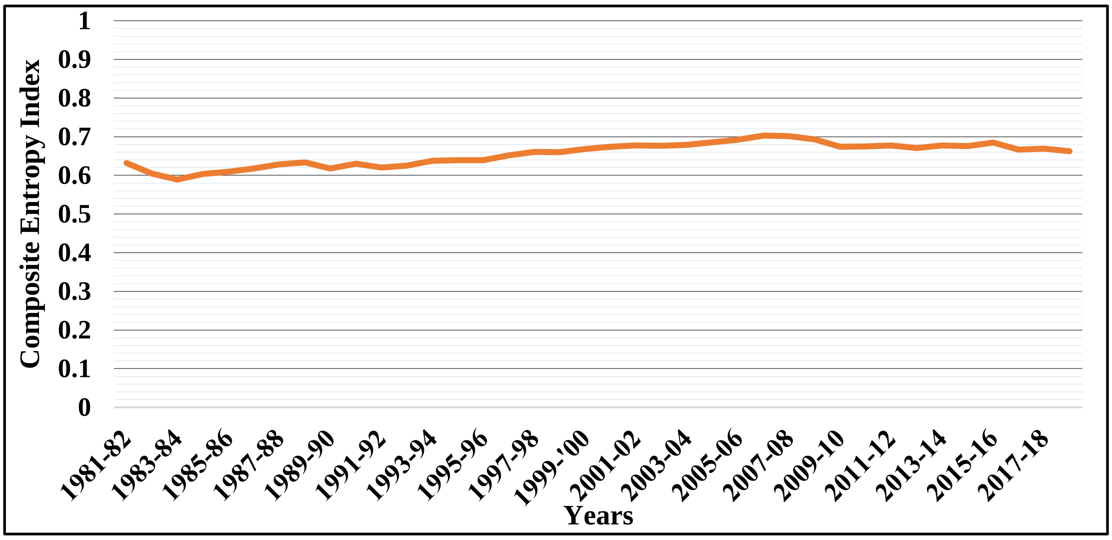
Figure 27 Crop diversification in Wayanad district measured using Modified Entropy Index



4.3.5 Composite Entropy Index

The Composite Entropy Index is an improvement over both E.I. and M.E.I. as it has a uniform scale from zero to one, and it accounts for the number of crops used in the analysis. It is similar to H.I. in measuring crop diversification and the major difference is with respect to the direction of the scale. A value of zero in C.E.I. indicates monocropping and one indicates perfect crop diversification. The crop diversification in Wayanad district measured using C.E.I. is represented in Figure 28**.**

Figure 28 Crop diversification in Wayanad district measured using Composite Entropy Index



The findings of C.E.I. were in perfect agreement with that of the other crop diversification measures, with a minimum value of 0.589 in 1983-84 and a maximum of 0.703 in 2006-07. The C.E.I. for the year 2018-19 was found to be 0.662. Like H.I., the C.E.I. also suggests that after a short reduction in crop diversification, the district showed an improvement until it reached its maximum in 2006-07. The latest level of C.E.I. was sufficient enough to suggest that Wayanad district has increased crop diversification.

From the analysis of crop diversification using the above indices, it was clear that Wayanad has, and always had, a high level of crop diversification. The diversification increased until 2006-07, following which there was a slight reduction. Indices like O.I., E.I., and M.E.I. measure diversification as the deviance from equal allocation of area among all the crops. Their results showed that there was unequal allocation of area among various crops in the beginning, which then gradually decreased over the years and became more equitable. The three major crops (coffee, paddy, and black pepper) occupied 74 per cent of gross cropped area of the district in 1983-84 (GoK, 1988), which decreased to 58 per cent (coffee, arecanut, and rubber) in 2018-19 (GoK, 2019a). The topography and climate of Wayanad district is unique as compared to other districts in the state. Plantation crops like coffee and tea which grow in high altitudes are cultivated in some parts of the district, while crops requiring water logged conditions like paddy is also cultivated in some other parts. This unique condition facilitates the cultivation of larger number of crops in the district, which in turn resulted in increasing crop diversification.

4.4 MICRO-LEVEL RISKS AND COPING STRATEGIES

The risks faced by farmers of Wayanad district during the entire crop production and marketing phases, the losses in production of different crops due to various factors, and the coping strategies that the farmers adopt to manage these risks were identified and analysed using primary data collected from the sample respondents. Crop diversification, subscription to crop insurance schemes, income diversification, selling of assets, and availing credit facilities were considered as the major risk coping measures and are analysed in this section.

4.4.1 Estimation of farm level production risk of major crops

The farm level production risks for major crops in 2019 were estimated using the Just and Pope production function after appropriately modifying the independent variables.

The Cobb-Douglas production functions were used for the estimation of average production function and the risk function. The independent factors considered in the estimation were costs incurred for human labour, machine labour, fertilizers, and plant protection chemicals; along with experience of the farmer and area under the crop. It was assumed that the responses given by the farmers about their input usage in 2019 were similar during last three years. This assumption was crucial because perennial crops take two to three years to respond to the input applications. The average production function was first estimated using these independent factors and the output as the dependent factor. The OLS estimates of the Cobb-Douglas average production function give the effect of inputs on the average output.

The risk function was then estimated using the same independent factors and variance in production as the dependent factor (Asche and Tveteras, 1999). The logarithm of squared residuals from the OLS estimates of the Cobb-Douglas average production function is taken as the variance in production (Arumugam *et al.*, 2014) and was regressed against the input factors to determine the effects of input factors on the variability in production.

The Cobb-Douglas production and risk functions were fitted for coffee, black pepper, and coconut, which occupied nearly 55 per cent of the total cropped area in Wayanad district (GoK, 2019a). The farm level production risks of these crops were estimated using the Just and Pope production and risk functions.

4.4.1.1 Estimation of farm level production risk in coffee

The results of the average production function for coffee estimated using the Cobb-Douglas production function are given in Table 4.18. The coefficient of multiple determination was estimated to be 0.783, which indicated that 78.3 per cent of variations in output of coffee could be explained by the factors included in the model.

Table 4.18 Estimates of Cobb-Douglas average production function for coffee

Model summary			
Multiple R	0.885		
Coefficient of multiple determination (R^2)	0.783		
Adjusted R^2	0.757		
Estimates			
Independent variables	**Coefficient**	**Standard Error**	**t statistic**
Cost of human labour (₹)	0.515***	0.154	3.344
Cost of machine labour (₹)	-0.041	0.030	-1.346
Cost of fertilizers (₹)	0.036	0.039	0.912
Cost of plant protection chemicals (₹)	0.091***	0.027	3.383
Experience in farming (Years)	0.267	0.173	1.546
Area under cultivation (Hectares)	0.415*	0.241	1.723

Note: 1. *** denotes significance at one per cent level
2. * denotes significance at 10 per cent level

Examining the coefficients and its corresponding t statistics show that human labour and plant protection chemicals have highly significant and positive relationship with the output. The increase in cost of labour implies employing more labourers and better crop management practices, while the increase in cost of plant protection chemicals implies lesser yield losses. These two findings go hand in hand because any crop management practice would naturally call for utilisation of more human labour. A positive relationship between area under cultivation and output indicates an increase in production as area under the crop increases.

After estimating the average production function, the risk function was then estimated. The estimates of the risk function for coffee farmers fitted using Cobb-Douglas production function are given in Table 4.19. The coefficient of multiple determination was found out to be 0.611, indicating that 61.1 per cent of the variation in the dependent variable (variability in production) could be explained by the independent variables included in the function. The cost of machine labour was found to be negatively influencing the variability in production and was also found to be significant at one per cent level. The major uses of machinery, as reported by the respondents, were in weeding and application of plant protection chemicals. The result shows that increased use of machinery decreases the variability in production. The human labour and area under cultivation were found to be positively significant at five and 10 per cent respectively. These implied that an increase in cost of labour and area under the crop could increase the variability in mean output and can prove risky. The responses of farmers also suggested that larger farms were facing greater yield and financial losses during a crisis situation. Even though the cost of plant protection chemicals was found to have a positive influence on the average production, it did not affect the variability in production.

Table 4.19 Estimates of Cobb-Douglas risk function for coffee

Model summary			
Multiple R	0.782		
Coefficient of multiple determination (R^2)	0.611		
Adjusted R^2	0.565		
Estimates			
Independent variables	**Coefficient**	**Standard Error**	**t statistic**
Cost of human labour (₹)	1.133**	0.554	2.045
Cost of machine labour (₹)	-0.287***	0.109	-2.640
Cost of fertilizers (₹)	-0.023	0.140	-0.167
Cost of plant protection chemicals (₹)	0.109	0.097	1.123
Experience in farming (Years)	0.784	0.620	1.263
Area under cultivation (Hectares)	1.569*	0.865	1.814

Note: 1. *** denotes significance at one per cent level
2. ** denotes significance at five per cent level
3. * denotes significance at 10 per cent level

4.4.1.2 Estimation of farm level production risk in black pepper

The farm level production risk of black pepper was estimated using Cobb-Douglas production function by following the Just and Pope method. The estimates from the average production function of black pepper are given in Table 4.20. The coefficient of multiple determination was 0.635 which means that 63.5 per cent of the variation in output could be explained by the independent variables used in the function.

The cost of fertilizers and area under cultivation were found to be positively significant at one per cent level. These findings were in agreement with the general hypothesis that use of fertilizers and increased acreage under the crop would increase the output.

Table 4.20 Estimates of Cobb-Douglas average production function for black pepper

Model summary	
Multiple R	0.797
Coefficient of multiple determination (R^2)	0.635
Adjusted R^2	0.589

Estimates

Independent variables	**Coefficient**	**Standard Error**	**t statistic**
Cost of human labour (₹)	-0.017	0.157	-0.108
Cost of machine labour (₹)	0.090	0.030	1.437
Cost of fertilizers (₹)	0.047***	0.033	2.979
Cost of plant protection chemicals (₹)	-0.037	0.029	-1.278
Experience in farming (Years)	-0.361	0.217	-1.664
Area under cultivation (Hectares)	0.907***	0.223	4.070

Note: *** denotes significance at one per cent level

The results of risk function of black pepper estimated using Cobb-Douglas production function showed a lower value of 0.472 for the coefficient of multiple determination (Table 4.21). This suggested that there could be extraneous factors other than the included variables which were affecting the variation in production of black pepper. The cost of fertilizers and area under cultivation were found to be significant at one per cent level, which implied that increased use of fertilizers and farms with larger area under the crop were more prone to variability in production. This finding was in conformity to that of Fufa and Hassan (2003), who reported greater risk in larger fields and in those using more fertilizers. The cost of machine labour was also found to be positively significant at five per cent level in affecting the variability in production. The major mechanical operation in black pepper plantations was weeding using brush cutters. An increase in area under the crop naturally requires more machine labour, and therefore this finding is justified.

Table 4.21 Estimates of Cobb-Douglas risk function for black pepper

Model summary	
Multiple R	0.687
Coefficient of multiple determination (R^2)	0.472
Adjusted R^2	0.405

Estimates

Independent variables	**Coefficient**	**Standard Error**	**t statistic**
Cost of human labour (₹)	-0.487	0.410	-1.189
Cost of machine labour (₹)	0.186**	0.086	2.167
Cost of fertilizers (₹)	0.245***	0.078	3.125
Cost of plant protection chemicals (₹)	-0.010	0.076	-0.135
Experience in farming (Years)	-0.836	0.564	-1.481
Area under cultivation (Hectares)	1.698***	0.580	2.929

Note: 1. *** denotes significance at one per cent level
2. ** denotes significance at five per cent level

4.4.1.3 Estimation of farm level production risk for coconut

The results of the average production function for coconut estimated using Cobb-Douglas production function are given in Table 4.22. The model was a very good fit, with 81.1 per cent of the variation in output explained by the independent variables. The cost of fertilizers showed highly positive relationship with output and was significant at one per cent level. The cost incurred for labour and area under cultivation also showed positive relationship with output at 10 per cent level of significance. As discussed earlier, the finding that output increases with increase in human labour, fertilizer application, and area under cultivation was in harmony with the *a priori* expectation. The estimates of the risk function for coconut estimated using Cobb-Douglas production function are presented in Table 4.23. The fitted production function could explain 53.5 per cent of the variation in output with the independent variables used in it. The cost of human labour was found to have a positive relationship with the variability in output at five per cent level of significance. The area under cultivation was also found to be positively related to the variation in output at 10 per cent level of significance.

Table 4.22 Estimates of Cobb-Douglas average production function of coconut

Model summary	
Multiple R	0.900
Coefficient of multiple determination (R^2)	0.811
Adjusted R^2	0.723

Estimates

Independent variables	**Coefficient**	**Standard Error**	**t statistic**
Cost of human labour (₹)	0.451*	0.245	1.839
Cost of machine labour (₹)	-0.062	0.053	-1.171
Cost of fertilizers (₹)	0.260***	0.051	5.049
Cost of plant protection chemicals (₹)	0.018	0.066	0.275
Experience in farming (Years)	0.208	0.557	0.373
Area under cultivation (Hectares)	0.668*	0.366	1.825

Note: 1. *** denotes significance at one per cent level
2. * denotes significance at 10 per cent level

Table 4.23 Estimates of Cobb-Douglas risk function for coconut

Model summary	
Multiple R	0.731
Coefficient of multiple determination (R^2)	0.535
Adjusted R^2	0.320

Estimates

Independent variables	**Coefficient**	**Standard Error**	**t statistic**
Cost of human labour (₹)	2.850**	1.290	2.209
Cost of machine labour (₹)	-0.404	0.279	-1.447
Cost of fertilizers (₹)	0.247	0.271	0.913
Cost of plant protection chemicals (₹)	0.027	0.349	0.077
Experience in farming (Years)	-0.723	2.929	-0.247
Area under cultivation (Hectares)	2.044*	1.924	1.662

Note: 1. ** denotes significance at five per cent level
2. * denotes significance at 10 per cent level

The analysis of production risks of the three crops showed that area under the crop has a positive relationship with output, but it also increased the risk in production in all three of them. The increased use of labour caused production risk in coffee and coconut, while the use of fertilizers increased variability in black pepper production. The cost incurred in the use of machinery was found to increase the variability in production of black pepper, while was found to decrease the variability in coffee.

4.4.2 Identification of risks faced by the farmers in Wayanad district

The sample respondents were asked to rank the risks that they faced in the order of most important one to the least. Five risks *viz.*, climate change and natural calamities, low price and price fluctuation of products, shortage of labour, incidence of pests and diseases, and water scarcity were identified and analysed using the Garret ranking technique. Table 4.24 shows the result of Garret ranking of the risks faced by the farmers in Wayanad district.

Table 4.24 Risks encountered by farmers in Wayanad district

Sl. No.	Risks encountered	Mean Garret's score	Rank
1	Low price and price fluctuations of commodities	56.25	I
2	Climate change and natural calamities	55.40	II
3	Shortage of labour	48.50	III
4	Water scarcity	47.60	IV
5	Incidence of pests and diseases	42.50	V

With a mean Garret's score of 56.25, the most important risk faced by the farmers in Wayanad district was found to be the low price and price fluctuations of commodities. The instability in prices of agricultural commodities and prevalence of lower prices during the harvest season were common occurrences in Wayanad, where the agricultural economy was significantly dependent on plantation crops and spices. The crops like black pepper, coconut, arecanut, etc which occupy a major portion of the gross cropped area in the district showed significant instability in prices, as could be observed from the results of Cuddy-Della Valle instability index (Table 4.15). The fluctuation of prices and prevalence of lower prices during harvest season directly impacted the crop production and management decisions of the farmers, and hence their economic well-being. The fact that these are perennial crops and have several years of pre-bearing period also worsens the scenario. The farmers have limited flexibility in their cropping pattern, which forces them to continue growing them, even if they are not profitable or other profitable alternatives exist.

The second major risk in agriculture, as reported by the sample respondents, was climate change and natural calamities. With a mean Garret's score of 55.40, it was slightly behind the first constraint and affected the crop production for many of the farmers. According to them, the impact of climate change became more discernible in the past five to eight years, with summer months becoming hotter, monsoons becoming stronger, and summer showers becoming frailer. The climate change has a direct impact on coffee, which occupies the largest area in the district. The flowering of coffee is dependent on the receipt of summer showers and an increased atmospheric temperature can also cause dropping of flowers. The district faced its worst form of natural calamity as the floods of 2018. Almost all parts of the district were affected, Mananthavady block was the worst hit, and crop losses were as high as 100 per cent. Pulpally and Mullankolly Panchayats in Panamaram block are highly prone to drought, making them highly susceptible to any form of climate change. The Pulpally Panchayat is also infamous for its farmer suicides during the droughts in the first decade of the 21st century.

Shortage of labour was ranked as the third major risk by the sample respondents with a mean Garret's score of 48.50. Agriculture is a labour intensive business and the extent of mechanisation, especially in plantation crops, is limited. In those regions lying in the neighbourhood of tribal hamlets, the labour required for agricultural production were traditionally being provided by them. The improved standard of living of the tribal groups due to various government interventions, coupled with the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) which assures a minimum 100 days of waged labour to the labourers resulted in acute shortage of labourers in the district. The reduced interest of youth in agriculture worsened the scenario, resulting in the wages to rise beyond the levels of economic feasibility.

The fourth rank among the risks faced by farmers, with a mean Garret's score of 47.6, was water scarcity. As mentioned earlier, the Panamaram block of Wayanad is highly prone to drought, where the water scarcity is a major risk in agriculture. Lack of irrigation during summer leads to wilting and drying of crops. Some of the farmers even reported an average annual loss of 10 per cent of crops due to wilting and drying. The decrease in frequency and intensity of summer showers pose a great threat to farmers who do not have access to irrigation. The shortage of water during the early vegetative phase of plantation crops like coconut and arecanut could result in reduced yielding potential throughout its productive life period.

The incidence of pests and diseases was ranked last among the risks encountered by the farmers in Wayanad district. It was ranked fifth with a mean Garret's score of 42.50. The major diseases occurring in the district are fungal diseases like quick wilt of pepper, black rot and berry dropping of coffee, mahali in arecanut, soft rot in ginger, etc. None of the farmers reported pest attacks to be serious enough to cause economic losses. Even though incidents of larval feeding and rodent attacks in tuber crops, mites in coconut, fruit borers and sucking pests in vegetables, bugs in rice, etc occurred in the district, farmers did not report them as a major risk in agricultural production as they could be controlled by adopting appropriate measures.

The above listed five sources of risk were ranked by all the respondents, irrespective of the blocks. However, many respondents from the Kalpetta block reported varying degrees of crop loss due to the attack of wild animals, especially monkeys. A few among them even found this as the major risk to agricultural production in their fields. Coffee berries eaten up by peacocks, banana fruits plucked away by monkeys, cassava fields attacked by wild boars were a few to cite among the various wild animal attacks that the farmers faced in Wayanad district.

4.4.3 Loss in production of major crops and its contributing factors

The percentage loss or reduction in production of major crops with respect to their expected production were computed for each of the sample respondent for the year 2019-20 based on their expected and actual yield data. The respondents were asked if they have faced any loss in production during the previous year. If yes, then the expected and actuated production were recorded to compute the percentage loss in production and the factors responsible for the loss in production were also noted. Table 4.25 shows the crop wise distribution of farmers based on varying levels of loss in production of major crops.

Table 4.25 Crop-wise distribution of farmers at various levels of loss in production of major crops

Yield loss (percentage)	Number of farmers					
	Black pepper	**Coffee**	**Arecanut**	**Ginger**	**Coconut**	**Banana**
None	12 (21.8)	17 (29.3)	20 (50.0)	2 (28.6)	11 (55.0)	17 (47.2)
0-10	0 (0)	2 (3.4))	1 (2.5)	1 (14.3)	0 (0)	0 (0)
10-20	1 (1.8)	6 (10.3)	7 (17.5)	2 (28.6)	1 (5.0)	4 (11.1)
20-30	4 (7.3)	9 (15.5)	2 (5.0)	0 (0)	2 (10.0)	7 (19.4)
30-40	12 (21.8)	8 (13.8)	4 (10.0)	1 (14.3)	1 (5.0)	5 (13.9))
40-50	6 (10.9)	7 (12.1)	1 (2.5)	1 (14.3)	3 (15.0)	2 (5.6)
50-60	4 (7.3)	0 (0)	2 (5.0)	0 (0)	0 (0)	0 (0)
60-70	8 (14.5)	5 (8.6)	3 (7.5)	0 (0)	1 (5.0)	0 (0)
70-80	7 (12.7)	4 (6.9)	0 (0)	0 (0)	0 (0)	0 (0)
80-90	0 (0)	0 (0)	0 (0)	0 (0)	1 (5.0)	0 (0)
90-100	1 (1.8)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.8)
Total	**55**	**58**	**40**	**7**	**20**	**36**

Note: Figures in parentheses indicate per cent to column total

Among the 100 respondents, coffee was the major crop grown by the highest number of farmers. Out of the 58 coffee farmers, 29.3 per cent did not report any loss in production, whereas 41.4 per cent reported losses ranging from 20 to 50 per cent. Black pepper was grown by 55 farmers, of which 21.8 per cent reported no loss in production and 32.7 per cent reported 30 to 50 per cent loss in production. Arecanut and banana were grown by 40 and 36 farmers respectively. Fifty per cent of the arecanut farmers and 47.2 per cent of the banana farmers did not report any loss in production. About 55 per cent of the 20 coconut farmers reported that there was no loss in production, while 30 per cent of them faced losses ranging from 20 to 50 per cent. Even though only seven farmers were cultivating ginger, five of them (71.4 per cent) reported loss in production.

It is worth mentioning here that rubber was excluded from the above analysis because most of the rubber farmers were not tapping the rubber trees, resulting in zero production and thereby making the production loss estimation difficult. The reasons attributed by the farmers for the loss in production of various crops are presented in Table 4.26.

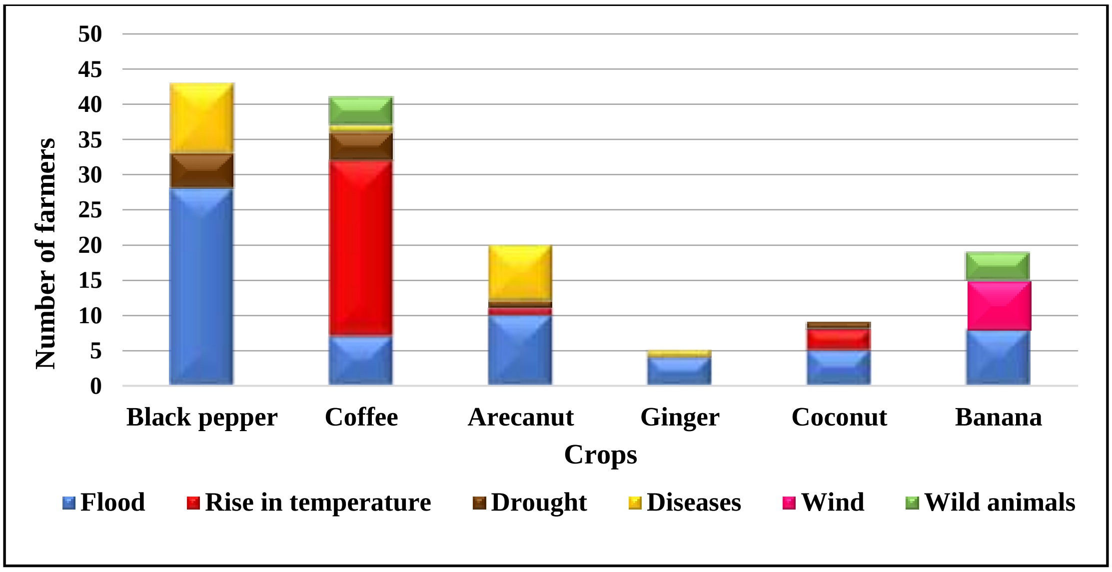
Table 4.26 Distribution of respondents based on reasons for loss in production of major crops

Reasons for yield loss	**Crops**					
	Black pepper	**Coffee**	**Arecanut**	**Ginger**	**Coconut**	**Banana**
Flood	28 (65.1)	7 (17.1)	10 (50.0)	4 (50.0)	5 (55.6)	8 (42.1)
Rise in temperature	0 (0)	25 (61.0)	1 (5.0)	0 (0)	3 (33.3)	0 (0)
Drought	5 (11.6)	4 (9.8)	1 (5.0)	0 (0)	1 (11.1)	0 (0)
Diseases	10 (23.3)	1 (2.4)	8 (40.0)	1 (20.0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	7 (36.8)
Wild animals	0 (0)	4 (9.8)	0 (0)	0 (0)	0 (0)	4 (21.1)
Total	**43**	**41**	**20**	**5**	**9**	**19**

Note: Figures in parentheses indicate per cent to column total

From Table 4.26, it could be observed that flood was the major reason for loss in production of crops like black pepper, arecanut, ginger, coconut, and banana during the year 2019-20. As reported by the farmers, flood causes crop loss not just by water stagnation in the field, but also by the decaying of roots due to excess moisture content in the soil as a result of poor drainage. The major cause of loss in production of coffee, to the tune of 61 per cent, was the rise in temperature and subsequent wilting and dropping of flowers. Figure 29 diagrammatically shows the proportion of losses in production due to various reasons for each of the crop.

Figure 29 Crop-wise distribution of respondents based on reasons for loss in production



It could be summarised from Table 4.26 and Figure 29 that black pepper was the crop with the highest loss in production, with 78 per cent of black pepper farmers reporting a loss. Flood was found to be a reason for loss in production of all the crops, and it was the major reason for loss in all of them except coffee. The rise in temperature was reported to be the major reason for loss in production (61 per cent) in coffee. In coffee and banana, attack of wild animals were also reported by seven and 11 per cent of the respondents respectively.

4.4.4 Risk specific coping strategies

The risks faced by the farmer respondents were identified and ranked in section 4.4.2. Along with this, open ended questions on the specific coping strategies adopted by respondents were also enquired. The coping strategies adopted by the respondents for each risk encountered by them are discussed in this section.

4.4.4.1 Coping strategies for low price and price fluctuations of commodities

The coping strategies adopted by the sample farmers for confronting the low price and price fluctuation of their products are given in Table 4.27. It could be observed from the table that 79 respondents adopted at least one coping strategy to manage the low price and price fluctuations. Out of the 79 respondents adopting coping strategies, 45.6 per cent adopted storage as one of the coping strategy. Farmers cultivating plantation crops like coffee and black pepper reported that if they can afford to wait, they store their produce after harvest as the price was usually the lowest during and immediately after the harvesting season.

The reduction of consumption expenditure, including household expenditure, and pre-harvest agreements equally formed the second major preferred coping strategies of the farmers in Wayanad district. The pre-harvest agreement is particularly practiced in the case of crops like arecanut and banana, wherein the trader visits the field and gets into an agreement with the farmer mainly on the basis of the expected yield and price. It is then the trader’s responsibility to harvest the produce and pay the negotiated amount to the farmer, regardless of the actual quantity of the produce.

Diversifying into more number of crops was found to be the next preferred strategy, which reduced the risk of dependence on a single or a few number of crops. The reduction of the expenditure in farming and sale of the produce through Vegetable and Fruit Promotion Council Keralam (VFPCK) formed the fifth and sixth coping strategies, in terms of the number of farmers adopting them. It was found that value addition as a coping strategy was the least preferred one and was followed only by 7.6 per cent of the farmers.

Table 4.27 Risk coping strategies for low price and price fluctuations of products

Sl. No.	Risk coping strategies	Number of respondents
1	Storage	36 (45.6)
2	Reducing consumption expenditure	15 (19.0)
3	Pre-harvest agreements	15 (19.0)
4	Crop diversification	12 (15.2)
5	Reducing farming expenditure	10 (12.7)
6	Sales through VFPCK	9 (11.4)
7	Value addition	6 (7.6)
	Total number of respondents adopting coping strategies for low price and price fluctuations of products	**79**

Note: Figures in parentheses indicate per cent to the total number of respondents adopting coping strategies for low price and price fluctuations of products

4.4.4.2 Coping strategies for climate change and natural calamities

The strategies adopted by the sample respondents to cope with climate change and natural calamity are given in Table 4.28. Since drought and increased temperature during summer months formed the major climate risks in Wayanad district, 45.7 per cent of the 46 respondents, who adopted at least one coping strategy, found irrigation to be the best possible coping strategy. Fifteen per cent of them enrolled in crop insurance schemes for protection against possible crop loss due to natural calamities. Among the respondents adopting at least one coping strategy, 13 per cent each were found to practice crop diversification and reduce the consumption expenditure to get over the risks posed by climate change and natural calamities.

Table 4.28 Risk coping strategies for climate change and natural calamities

Sl. No.	Risk coping strategies	Number of respondents
1	Irrigation	21 (45.7)
2	Crop Insurance	15 (32.6)
3	Crop diversification	6 (13.0)
4	Reducing consumption expenditure	6 (13.0)
	Total number of respondents adopting coping strategies for climate change and natural calamities	**46**

Note: Figures in parentheses indicate per cent to the total number of respondents adopting coping strategies for climate change and natural calamities

4.4.4.3 Coping strategies for shortage of labour

Table 4.29 gives the coping strategies adopted by the sample respondents in response to shortage of labour for agricultural activities. Ninety-three out of the 100 respondents in the study reported that they adopted one or the other forms of coping strategies to overcome the shortage of labour. Majority of them (66.7 per cent) tried to overcome this risk by using own labour and family labour in their fields. This strategy was possible only for farmers having comparatively smaller land holding. Farm households with more family members taking part in agricultural activities could also reduce employing hired labourers, but such farm households were very few in number. However, as the land holding size and the number of activities increase, the family labour alone cannot meet the requirements of the farm. Employing labourers from other states formed the second preferred strategy (36.6 per cent) to overcome labour shortage. This was only possible in areas where the labourers from other states were available. The practice of bringing labourers from other states was not feasible for a farmer who was having labour requirements only during particular periods in a year and also when the activity in question required skilled labourers. Even though mechanisation was considered as the best alternative to labour shortage, the possibilities for the use of machines or mechanical means in plantation crops like coffee, black pepper, arecanut, etc were limited. Getting into pre-harvest agreements formed the least preferred strategy because this kind of agreements were available only for a few crops like arecanut, banana, and coconut. When farmers got into such agreements, they were also relieved from the burden of harvesting and bringing the produce to the market.

Table 4.29 Risk coping strategies for shortage of labourers

Sl. No.	Risk coping strategies	Number of respondents
1	Own and Family labour	62 (66.7)
2	Other state labourers	34 (36.6)
3	Mechanisation	28 (30.1)
4	Pre-harvest agreements	21 (22.6)
	Total number of respondents adopting coping strategies for shortage of labour	**93**

Note: Figures in parentheses indicate per cent to the total number of respondents adopting coping strategies for shortage of labour

4.4.4.4 Coping strategies for water scarcity

Water scarcity was ranked fourth among the various risks faced by farmers in Wayanad district. As discussed in section 4.4.2, those farmers who had access to irrigation facilities used irrigation as the best coping strategy against water scarcity and drought. Sixty-nine respondents reported that they adopted some kind of coping strategy in response to water scarcity and all of them invariably used irrigation (Table 4.30). Interestingly, three respondents (4.3 per cent) among them reported that diversifying to lesser water intensive crops could also be used as a coping strategy.

Table 4.30 Risk coping strategies for water scarcity

Sl. No.	Risk coping strategies	Number of respondents
1	Irrigation	69 (100)
2	Crop diversification	3 (4.3)
	Total number of respondents adopting coping strategies for water scarcity	**69**

Note: Figures in parentheses indicate per cent to the total number of respondents adopting coping strategies for water scarcity

4.4.4.5 Coping strategies for incidence of pests and diseases

The pest and disease incidence was found to be the last among the risks faced by farmers in Wayanad district. The coping strategy adopted in response to pest and disease incidence are given in Table 4.31. Out of the 86 respondents who adopted at least one coping strategy, 75.6 per cent followed chemical control measures and 25.6 per cent followed organic control measures against pest and diseases. The figures clearly indicated that farmers preferred chemical control measures over organic alternatives. Also, the 25.6 per cent respondents who followed organic control measures were not organic farmers per se, but they were not using any chemicals for the control of pests and diseases. Six respondents reported that crop diversification could help in control of pests and diseases, as plantations with one or few numbers of crops provided congenial conditions for their growth and spread.

Table 4.31 Risk coping strategies for incidence of pests and diseases

Sl. No.	Risk coping strategies	Number of respondents
1	Chemical control	65 (75.6)
2	Organic control	22 (25.6)
3	Crop diversification	6 (7.0)
	Total number of respondents adopting coping strategies for incidence of pests and diseases	**86**

Note: Figures in parentheses indicate per cent to the total number of respondents adopting coping strategies for incidence of pests and diseases

4.4.4.6 Coping strategies for attack of wild animals

Attack of wild animals was not ranked among the various risks faced by the farmers in Wayanad district as this was limited only to few places, especially in Kalpetta block. However, in those areas, wild animals posed great risk to cultivation of crops. The measures adopted by farmers in those areas to protect their crop from the attack of wild animals are given in Table 4.32. Eleven respondents reported that they adopted some form of measure for the protection of their crop from wild animals. Safekeeping or providing security for their crop during night by staying awake in the field was found to be followed by seven respondents (63.6 per cent), while five of them (45.5 per cent) installed fences around their fields for the protection of crops.

Table 4.32 Risk coping strategies for attack of wild animals

Sl. No.	Risk coping strategies	Number of respondents
1	Safekeeping at night	7 (63.6)
2	Fencing	5 (45.5)
	Total number of respondents adopting coping strategies for attack of wild animals	**11**

Note: Figures in parentheses indicate per cent to the total number of respondents adopting coping strategies for attack of wild animals

4.4.5 Crop diversification as a risk coping strategy

Crop diversification was found to be the major risk coping strategy adopted by the farmers of Wayanad against an array of risks, including price risk, climate risk, water scarcity, and incidence of pest and diseases. The crop diversification indices for all the sample respondents during 2019-20 were estimated to identify the extent of crop diversification, both in terms of number of crops and share of each crop in the total cultivated area. The results of the crop diversification analysis made using Herfindahl Index (H.I.), Ogive Index (O.I.), Entropy Index (E.I.), Modified Entropy Index (M.E.I.), and Composite Entropy Index (C.E.I.) are discussed below.

4.4.5.1 Herfindahl Index

The crop diversification of sample farmers, measured using Herfindahl Index, are presented in Table 4.33. A value of one denotes monocropping and diversification increases as the value becomes closer to zero. As could be observed from the table, 55 per cent of the sample farmers were categorized in the group with H.I. value ranging from 0.3 to 0.5. It could be inferred from this observation that moderate levels of crop diversification were observed in the farm households of Wayanad. This finding is also supported by the results of crop diversification from secondary data which was discussed earlier in this chapter (section 4.3). None of the farmers surveyed had a diversification index of less than 0.2, indicating that there were no high levels of crop diversification in their farms. Even though the number of farmers decreased as the H.I. value increased, 15 per cent of farmers were found to have an H.I. value of one, which indicated monocropping. The practice of monocropping was mainly observed in crops like paddy, banana, black pepper and coffee.

Table 4.33 Distribution of farmers according to Herfindahl Index

Range of H.I. values	Number of respondents
0 to 0.1	0 (0)
0.1 to 0.2	0 (0)
0.2 to 0.3	8 (8)
0.3 to 0.4	26 (26)
0.4 to 0.5	29 (29)
0.5 to 0.6	13 (13)
0.6 to 0.7	4 (4)
0.7 to 0.8	2 (2)
0.8 to 0.9	3 (3)
0.9 to 1.0	15 (15)
Total	**100**

Note: Figures in parentheses indicate per cent to column total

In an effort to identify any possible relationship between the land holding size and crop diversification of a farmer, a correlation analysis was performed between the H.I. values of respondents and the area of their holding. The results showed a correlation coefficient of -0.254, significant at five per cent level, indicating a weak negative correlation between the H.I. values and area of the holding. This means that as the land holding size increases, the H.I. value decreases (or crop diversification increases). A strong negative correlation was not found between land holding size and H.I. because area was not the major factor determining crop diversification in the district. The predominant crops in the respondents' farms were plantation crops like coffee, black pepper, arecanut, and coconut. These could be grown as mixed crops and farmers were mostly found to grow at least two of these perennial crops together. The H.I. values estimated for all the sample respondents, along with their total area of holding are given in Appendix IV.

4.4.5.2 Ogive Index

The distribution of sample farmers according to the Ogive Index, which is based on the number of crops they grow, are given in Table 4.34. Since O.I. shows the departure of a farmer from equal allocation of land among various crops, O.I. is best interpreted along with the number of crops grown by each farmer.

It could be observed from Table 4.34 that farmers with lesser number of crops have a tendency to distribute them equally over their total land area. Fifteen per cent of the total respondents cultivated a single crop and thereby were having an O.I value of zero. Among the farmers who cultivated two crops, 44.4 per cent equally allocated the land area between those crops. For the farmers who were growing three crops, 62.6 per cent had an O.I. value less than 0.2, which indicated a fairly proportionate allocation of land area among the crops. As the number of crops increased, the number of farmers with higher values of O.I. also increased, indicating a disproportionate allocation of area among the crops. The O.I. values of all the sample respondents, along with the number of crops cultivated are given in Appendix V.

Table 4.34 Distribution of farmers according to Ogive Index and number of crops cultivated

	Number of respondents growing N number of crops						
Range of O.I values	**N=1**	**N=2**	**N=3**	**N=4**	**N=5**	**N=6**	**N=7**
0	15 (100)	16 (44.4)	0	0	0	0	0
0 to 0.1	0	10 (27.8)	14 (43.8)	2 (25.0)	2 (25.0)	0	0
0.1 to 0.2	0	1 (2.8)	6 (18.8)	1 (12.5)	2 (25.0)	0	0
0.2 to 0.3	0	2 (5.6)	5 (15.6)	3 (37.5)	0	0	0
0.3 to 0.4	0	2 (5.6)	5 (15.6)	0	0	0	0
0.4 to 0.5	0	0	0	1 (12.5)	0	0	0
0.5 to 0.6	0	2 (5.6)	0	0	0	0	0
0.6 to 0.7	0	0	0	0	0	0	0
0.7 to 0.8	0	3 (8.3)	2 (6.3)	0	1 (12.5)	0	1 (100)
0.8 to 0.9	0	0	0	1 (12.5)	1 (12.5)	0	0
0.9 to 1.0	0	0	0	0	0	0	0
1.0 to1.1	0	0	0	0	2 (25.0)	0	0
Total	**15**	**36**	**32**	**8**	**8**	**0**	**1**

Note: Figures in parentheses indicate per cent to column total

4.4.5.3 Entropy Index

The Entropy Index is a measure of crop diversification with a zero lower boundary and a varying upper boundary according to the number of crops under consideration. In this case, zero denotes complete crop specialisation or monocropping and diversification increases with the increase in E.I. value. Like O.I., the E.I. also measures deviations from equal area allocations to all the crops. The E.I. values of the sample respondents were classified according to the number of crops grown (with same upper boundary) and their distribution is presented in Table 4.35. Such a classification was made to facilitate the comparison between farmers growing different number of crops and between those growing same number of crops. Without this classification, the comparison between farmers would be difficult as the range of E.I. was different for different farmers.

It is evident from Table 4.35 that the number of farmers growing two or three crops increased as the E.I. values increased and approached its upper boundary. This implied that farmers growing two or three crops allocated fairly proportionate land area for each of the crop. This was not the case for farmers growing four or five crops and their distribution was fairly even throughout different ranges of E.I. This means that as the number of crops increased, the area allocated for individual crops was not following a particular trend. Fifteen farmers were found to have an E.I. value of zero, indicating monocropping and one farmer, who raised seven crops, had an E.I. value of 0.711. The E.I. values of all the sample respondents, along with their corresponding upper boundaries are given in Appendix VI.

Table 4.35 Distribution of farmers according to Entropy Index and common upper boundary

Upper boundary= 0.30103 (N=2)		Upper boundary= 0.47712 (N=3)	
Range of E.I.	**Number of respondents**	**Range of E.I.**	**Number of respondents**
0 to 0.10	3 (8.3)	0.30 to 0.32	1 (3.1)
0.17 to 0.18	2 (5.6)	0.32 to 0.34	1 (3.1)
0.21 t 0.22	2 (5.6)	0.34 to 0.36	0 (0)
0.24 to 0.25	2 (5.6)	0.36 to 0.38	2 (6.3)
0.26 to 0.27	0 (0)	0.38 to 0.40	0 (0)
0.27 to 0.28	1 (2.8)	0.40 to 0.42	4 (12.5)
0.28 to 0.29	0 (0)	0.42 to 0.44	5 (15.6)
0.29 to 0.30	10 (27.8)	0.44 to 0.46	11 (34.4)
0.30 to 0.30103	16 (44.4)	0.46 to 0.47712	8 (25.0)
Total	**36**	**Total**	**32**
Upper boundary= 0.60206 (N=4)		**Upper boundary= 0.69897 (N=5)**	
Range of E.I.	**Number of respondents**	**Range of E.I.**	**Number of respondents**
0.44 to 0.45	1 (12.5)	0.50 to 0.51	2 (25.0)
0.50 to 0.51	1 (12.5)	0.55 to 0.56	2 (25.0)
0.55 to 0.56	1 (12.5)	0.65 to 0.66	1 (12.5)
0.56 to 0.57	2 (25.0)	0.66 to 0.67	0 (0)
0.57 to 0.58	1 (12.5)	0.67 to 0.68	1 (12.5)
0.58 to 0.59	1 (12.5)	0.68 to 0.69	0 (0)
0.59 to 0.60206	1 (12.5)	0.69 to 0.69897	2 (25.0)
Total	**8**	**Total**	**8**
Upper boundary=0.845098 (N=7)		**Upper boundary=0 (N=1)**	
E.I.	**Number of respondents**	**E.I.**	**Number of respondents**
0.71133	1	0	15

Note: Figures in parentheses indicate per cent to column total

4.4.5.4 Modified Entropy Index

Modified Entropy Index overcomes the limitation of Entropy Index by introducing a constant scale from zero to one. A farmer with M.E.I. value of zero is practicing monocropping, whereas a farmer allocating equal area to all his crops will have M.E.I equal to 1. Similar to Ogive Index, M.E.I. is also best interpreted along with the number of crops grown. Table 4.36 shows the distribution of farmers according to different ranges of M.E.I.

From Table 4.36, it could be inferred that 15 farmers practiced monocropping and hence had the M.E.I. value of zero. The equal allocation of area among various crops grown was indicated by a M.E.I. value of one. It was found that 16 farmers, who cultivated two crops, allocated equal area among both the crops. More than 80 per cent of the farmers who cultivated two, three, or four crops were having a M.E.I. value greater than 0.8. Respondents growing five or more crops were all having a M.E.I. value of greater than 0.7. The M.E.I. did not indicate much discrepancies in the allocation of area based on the number of crops grown by the farmers. The M.E.I. values of all the sample respondents, along with the number of crops grown by them are given in Appendix VII.

Table 4.36 Distribution of farmers according to Modified Entropy Index and the number of crops cultivated

	Number of farmers growing N number of crops						
Range of M.E.I. values	**N=1**	**N=2**	**N=3**	**N=4**	**N=5**	**N=6**	**N=7**
0	15 (100)	0	0	0	0	0	0
0 to 0.1	0	0	0	0	0	0	0
0.1 to 0.2	0	0	0	0	0	0	0
0.2 to 0.3	0	0	0	0	0	0	0
0.3 to 0.4	0	3 (8.3)	0	0	0	0	0
0.4 to 0.5	0	0	0	0	0	0	0
0.5 to 0.6	0	2 (5.6)	0	0	0	0	0
0.6 to 0.7	0	0	2 (6.3)	0	0	0	0
0.7 to 0.8	0	2 (5.6)	2 (6.3)	1 (12.5)	4 (50)	0	0
0.8 to 0.9	0	2 (5.6)	6 (18.7)	1 (12.5)	0	0	1 (100)
0.9 to 1.0	0	11 (30.6)	22 (68.8)	6 (75.0)	4 (50)	0	0
1	0	16 (44.4)	0	0	0	0	0
Total	**15**	**36**	**32**	**8**	**8**	**0**	**1**

Note: Figures in parentheses indicate per cent to column total

4.4.5.5 Composite Entropy Index

Composite Entropy Index carry forward the advantages of M.E.I. and it also gives due weightage to the number of crops. It is also bound between zero and one, with zero indicating complete crop specialisation and one complete diversification. The crop diversification of sample farmers, measured using C.E.I., are presented in Table 4.37.

Table 4.37 shows that 15 farmers had a C.E.I. value of zero, indicating monocropping. Majority of the respondents (78 per cent) had C.E.I. values between 0.4 and 0.8. This range indicated a shift from crop specialisation to high levels of crop diversification. Therefore, based on the C.E.I. values, it could be concluded that the sample respondents followed moderate to good levels of crop diversification. The highest number of farmers (31 per cent) were in the category with C.E.I. values ranging from 0.4 to 0.5, followed by 28 per cent in the 0.6 to 0.7 category.

Table 4.37 Distribution of farmers according to Composite Entropy Index

Range of C.E.I. values	**Number of farmers**
0	15 (15)
0 to 0.1	0 (0)
0.1 to 0.2	3 (3)
0.2 to 0.3	2 (2)
0.3 to 0.4	2 (2)
0.4 to 0.5	31 (31)
0.5 to 0.6	11 (11)
0.6 to 0.7	28 (28)
0.7 to 0.8	8 (8)
0.8 to 0.9	0 (0)
0.9 to 1.0	0 (0)
Total	**100**

Note: Figures in parentheses indicate per cent to column total

To identify any possible relationship between the area of the holding and the crop diversification measured using C.E.I., a correlation analysis was carried out. A weak positive correlation of 0.259 with significance at five per cent level was found to exist between the two. As in the case of Herfindahl Index, a strong correlation between crop diversification and area of the holding could not be established in this case, and all the arguments made there would hold true in this situation also. The C.E.I. values of all the sample respondents, along with the total area of the holdings are given in Appendix VIII.

4.4.6 Crop insurance as a risk coping strategy

Crop insurance schemes are considered as a straightforward method for coping with risk. In crop insurance schemes, the farmers pay an insurance premium set by the insurance company at a specified stage of the crop growth. In the event of crop loss, the farmers will be paid the insured amount and thus they are protected from the unforeseen production risks.

The study revealed that crop insurance schemes were popular only among the banana farmers, and even then majority of them were not the beneficiaries of the scheme. Even though crop insurance schemes exist for other crops, farmers have not enrolled in them. The analysis of various crop insurance schemes for Wayanad district in the year 2019 showed that the district was having crop insurance schemes under Pradhan Mantri Fasal Bima Yojana (PMFBY) and Restructured Weather Based Crop Insurance Scheme (RWBCIS) for both kharif and rabi seasons, which were implemented by the Ministry of Agriculture and Farmers Welfare, Government of India. The PMFBY covered only banana and tapioca in Wayanad during the reference period. The district also had crop insurance scheme operated by the Government of Kerala, which covered the major crops like coffee, arecanut, coconut, and black pepper. The farmers were generally not showing interest towards the weather based insurance schemes because of its area based approach and lack of individual claim settlement provisions. None of the sample respondents were enrolled in RWBCIS. Needless to say, the procedural formalities and delay in claim settlement process made farmers averse to such insurance schemes.

The state crop insurance scheme is a kind of peril insurance programme, in which the compensation would be made available only when there is a total crop loss. Since yield losses were not compensated, farmers of plantation crops, especially coffee, were not showing any interest towards this scheme. Unlike plantation crops, banana was highly prone to crop loss by wind, flood, and other natural calamities. Therefore, it gave the farmers a better incentive to enrol in a crop insurance scheme. Also, the mandatory requirement from the part of a farmer to be registered in a crop insurance scheme to get credit from banking institutions also resulted in increased enrolment by banana farmers in crop insurance schemes. The distribution of sample respondents who enrolled in crop insurance scheme for banana in the year 2019 and the details of insurance premium and claim amount are given in Table 4.38.

Table 4.38 Details of enrolment of sample farmers in crop insurance scheme for banana

<table>
<tr><th>Enrolment status</th><th>Number of farmers</th></tr>
<tr><td>Enrolled</td><td>15 (41.7)</td></tr>
<tr><td>Not enrolled</td><td>21 (58.3)</td></tr>
<tr><td>Total number of banana farmers</td><td>36</td></tr>
<tr><th colspan="2">Details of insurance scheme</th></tr>
<tr><th>Premium amount</th><th>Claim amount</th></tr>
<tr><td>₹3 per plant</td><td>₹100 per plant before flowering
₹300 per plant after flowering</td></tr>
</table>

Note: Figures in parentheses indicate per cent to the total number of banana farmers

It could be observed from Table 4.38 that 41.7 per cent of the 36 respondents who cultivated banana were enrolled in the crop insurance scheme. Even though banana was one among those crops which experienced high degree of crop loss in Wayanad, it could be observed that majority of the farmers were not beneficiaries of the crop insurance scheme. This suggested that the incentives from enrolling in the crop insurance scheme were comparatively lower as opposed to the premium amount. During the field survey, many of the farmers reported non-receipt of claim amount even for the year 2017, which indicated that there were considerable delays in settlement of claims. After consideration of all the above aspects, it could be understood that crop insurance scheme was not seen as a viable risk coping strategy by the farmers of Wayanad district.

4.4.7 Income diversification as a risk coping strategy

The diversification of income sources is an effective approach of risk management. Having income from multiple sources ensures financial stability, even when there is an adverse fall in income from any one source. Income diversification can be mainly in the form of on-farm, non-farm and off-farm diversification measures. On-farm income diversification includes activities that are related to agriculture and animal husbandry, while non-farm income diversification comprises of activities outside agriculture. The distribution of the sample respondents according to various sources of income diversification are presented in Table 4.39.

From Table 4.39 it could be observed that dairy was the major source of income diversification for the farmers in Wayanad district, with 44 per cent of the respondents relying on it as an additional source of income. Even though the range of net income from dairy varied from ₹5,000 to ₹6,00,000 per farmer, an average net income of ₹1,12,981 indicated a reasonable revenue for majority of the farmers with dairy as an additional income source. The average net income from poultry was estimated as ₹3,087. Lack of commercial outlook in poultry could be attributed as the major reason for comparatively lower revenue from it. Six per cent of the farmers followed aquaculture and earned an average annual net income of ₹43,000. Other on-farm diversification measures included piggery and apiculture. A total of 50 farmers (50 per cent) were found to adopt on-farm income diversification measures, and they obtained an average annual net income of ₹1,16,055 from these diversification measures.

Thirty-eight per cent of the respondents were found to be getting income from non-farm sources, with an average annual net income of ₹4,52,687. Organising a shop, business or other contractual activities formed the major non-farm income diversification measures, with an average annual net income of ₹1,26,583. It was found that one respondent owned a crop nursery. Twenty-five per cent of the respondents reported to have income from other sources which included pension, interest on deposits, rent, and cash receipts from their children. Getting employed as a daily wage labourer was found to be an off-farm income source for eight respondents. The on-farm, non-farm and off-farm annual net incomes of the sample respondents are depicted in Figure 30.

Table 4.39 Distribution of sample farmers according to various income diversification measures

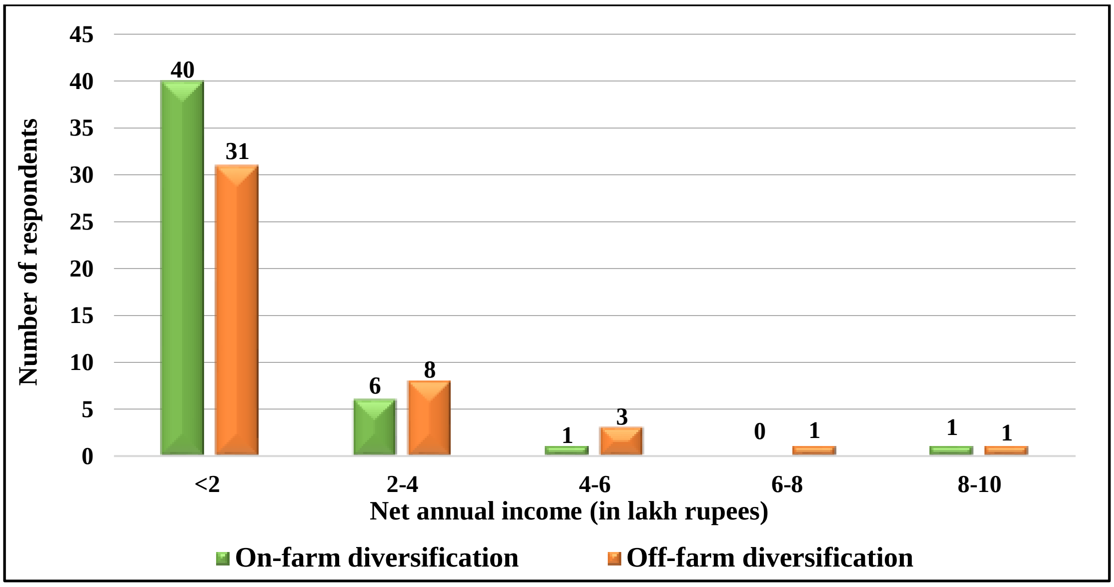
On-farm income diversification measures and resultant revenue				
Diversification measures	**Number of farmers**	**Average net income (₹)**	**Lower range (₹)**	**Upper range (₹)**
Dairy	44 (44)	1,12,981	5,000	6,00,000
Poultry	7 (7)	3,087	300	10,500
Aquaculture	6 (6)	43,000	3,500	2,00,000
Piggery	2 (2)	2,70,000	40,000	5,00,000
Apiculture	1 (1)	12,000	12,000	12,000
Total number of farmers adopting at least one measure	50 (50)	1,16,055	1,810	10,00,000
Non-farm income diversification measures and revenue from them				
Diversification measures	**Number of farmers**	**Average net income (₹)**	**Lower range (₹)**	**Upper range (₹)**
Shop/ Business/ Contract	12 (12)	1,26,583	15,000	2,30,000
Nursery	1 (1)	10,00,000	10,00,000	10,00,000
Others	25 (25)	2,31,480	40,000	6,50,000
Total number of farmers adopting at least one measure	38 (38)	4,52,687	15,000	10,00,000
Off-farm income diversification measures and revenue from them				
Daily wage	8 (8)	1,07,500	25,000	2,40,000
Summary				
Respondents with both on-farm and non-farm diversification measures	22 (22)	2,58,048	25,500	12,00,000
Respondents with either one or all income diversification measures	74 (74)	2,02,281	2,500	12,00,000
Respondents without any one of the diversification measures	26 (26)			
Total number of respondents	**100**			

Note: Figures in parentheses indicate per cent to the total number of respondents

It was observed that 74 per cent of the respondents were having either one or all the income diversification sources. Also, 22 per cent of the respondents were found to have both the on-farm and non-farm income diversification measures. The average annual net income of the respondents with either one or all the diversification measures was estimated as ₹2,02,281 and the same for those with on-farm and non-farm diversification measures was ₹2,58,048. A difference of 21.6 per cent in average annual net income between these two categories indicated that on-farm income diversification measures were comparatively as remunerative as non-farm measures. Also, 26 per cent of the respondents were found to not having any of the income diversification sources.

The fact that 74 per cent of the respondents had one or the other source of additional income underlines the struggle of farmers in depending on agriculture as the sole income source. For a farmer, it might be difficult to adopt any of the non-farm income diversification measures. However, it is possible for the farmer to adopt an on-farm income diversification measure, even under conditions of limited resources. Since on-farm income diversification measures are comparatively as remunerative as the non-farm measures, it could be inferred that adopting an income diversification measure was a viable strategy for coping with agricultural risks in Wayanad district.

Figure 30 Distribution of sample farmers based on net annual income from on-farm and off-farm income diversification measures



4.4.8 Sale of assets as a risk coping strategy

The risks and the ensuing consequences faced by the farmers are often so devastating that they may have to sell a portion of their assets to overcome the tough situation. Selling of their assets to cope up with the risks cannot be considered as an advisable strategy for reducing the impact of risks. The details on the sales of various assets made by the sample respondents during the last five years are presented in Table 4.40.

Table 4.40 Distribution of respondents based on sales of assets

Sale value (in lakh ₹)	Category of assets			
	Land	Gold	Trees	Animals
0-1	6 (66.7)	2 (100)	25 (78.1)	18 (78.3)
1-2	2 (22.2)	0	7 (21.9)	3 (13.0)
2-3	0	0	0	0
3-4	1 (11.1)	0	0	0
4-8	0	0	0	0
8-9	0	0	0	2 (8.7)
Total	**9**	**2**	**32**	**23**

Note: Figures in parentheses indicate per cent to column total

It could be observed from Table 4.40 that a total of 66 (66 per cent) respondents have made at least one of the transaction in the last five years. Out of the 32 respondents who sold their trees in the last five years, the value of sales done by 78.1 per cent of them were under one lakh rupees and for the rest 21.9 per cent, the sales were valued between one and two lakhs. As majority of the sales were made for small amounts, it indicated a sheer need for money by the farmers. Out of the 23 farmers who have sold their animals in the last five years, 78.3 made a transaction below one lakh rupees. However, the entire sales of animals cannot be considered as a risk coping action, because selling of pregnant and senile animals are common and done routinely. Nine respondents reported the sale of land during the past five years, while two respondents reported the sale of gold during the same period. The sale of land and gold were mostly reported to be made for meeting the family needs and contingencies like marriages and medical treatments.

The finding that 66 per cent of the respondents sold at least one of their assets in the last five years was an important indicator on the serious risks in agriculture faced by the farmers in Wayanad district.

4.4.9 Availing credit as a risk coping strategy

The risks faced by the farmers will affect the production as well as marketing activities in different ways, causing instabilities in income. The most commonly followed practice by the farmers to address the shortage of money income was availing credit. Farmers can avail credit through formal and informal (institutional and non-institutional) sources depending upon their credit worthiness and personal relationships. Even though the credit from formal sources may require pledging of securities against sanctioning of the loans, these loans are considered as better alternative as these institutions are legally regulated. The status of the sample respondents based on their sources of credit and the amount borrowed are given in Table 4.41.

It was found that 81 per cent of the 100 respondents have availed some form of credit. When 74.1 per cent of the total 81 respondents who availed credit have borrowed from a single source, 23.5 per cent and 2.5 per cent have borrowed from two and three sources respectively.

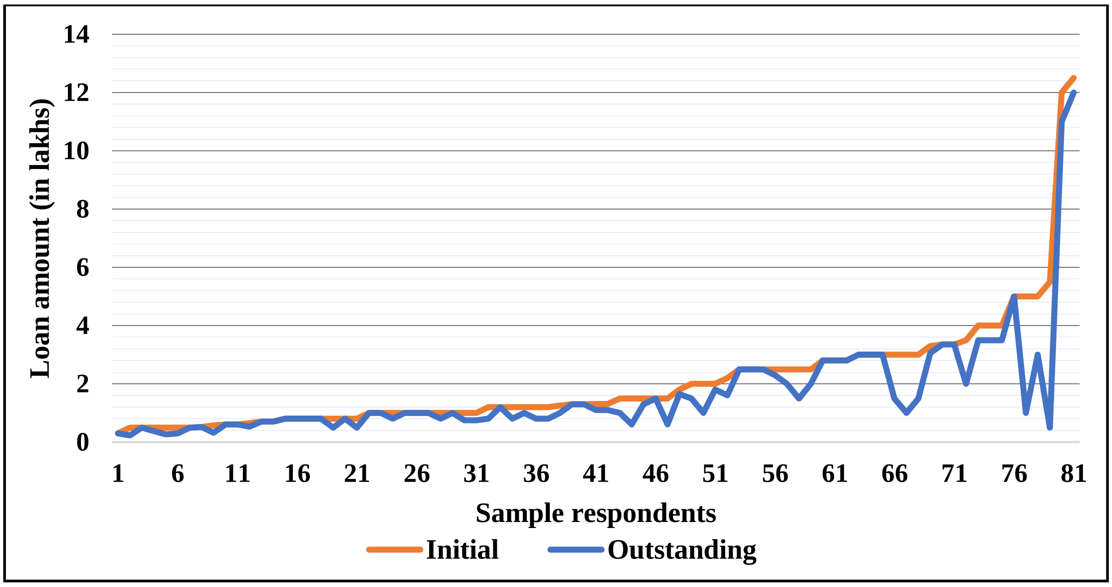
From Table 4.41, it could also be inferred that nearly 80 per cent of the amount borrowed from any of the sources were below three lakh rupees, indicating increased capital requirement of the farmers for day to day operations of the farm. The highest number of borrowers were from Co-operative banks (39 borrowers) and was followed by Gramin bank with 22 borrowers. Farmers reported that co-operative banks operated in a more customer friendly manner and at least a few of the employees in the bank were also known to them. Sixteen respondents reported availing gold loan for meeting their monetary requirement, followed by 15 farmers availing credit from the nationalised banks. Four respondents each were found availing credit from private banks, Kudambasree units and money lenders. It was also observed that out of the 81 respondents who availed credit, only 5 per cent were borrowing from money lenders (non-institutional sources).

Table 4.41 Distribution of respondents based on sources and amount of credit

Loan amount (in lakhs)	Source of credit						
	Nationalised bank	Co-operative bank	Gramin bank	Private bank	Kudumbasree	Gold loan	Money lender
0-1	7 (46.7)	25 (64.1)	13 (59.1)	0	2 (50.0)	8 (50.0)	0
1-2	5 (33.3)	8 (20.5)	4 (18.2)	1 (25.0)	2 (50.0)	2 (12.5)	1 (25.0)
2-3	2 (13.3)	4 (10.3)	4 (18.2)	2 (50.0)	0	3 (18.8)	2 (50.0)
3-4	0	0	0	0	0	3 (18.8)	0
4-5	1 (6.7)	0	1 (4.5)	1 (25.0)	0	0	1 (25.0)
5-6	0	0	0	0	0	0	0
6-7	0	0	0	0	0	0	0
7-8	0	0	0	0	0	0	0
8-9	0	1 (2.6)	0	0	0	0	0
9-10	0	1 (2.6)	0	0	0	0	0
Total	**15**	**39**	**22**	**4**	**4**	**16**	**4**

Note: Figures in parentheses indicate per cent to column total

Figure 31 Principal and outstanding loan amounts of sample respondents



The amount of credit availed by the 81 respondents and their outstanding amount, as on January 1, 2020 are given in Figure 31. It could be observed from the figure that almost entire loan amount was outstanding for farmers availing lower amounts of credit. The repayments made were higher among the farmers who availed larger amounts of credit. The reason for this might be the larger absolute amount of money which the farmer has to pay as interest for larger amounts of credit. Also, farmers availing credit under Kisan Credit Card (KCC) scheme, which are usually lower amounts, got interest subsidy from government upon prompt repayment. This encouraged the farmers to renew their KCC loans annually to gain the interest subsidy, rather than to pay off the loan. Since farmers did not report loans and debts as a major problem, credit facilities in the district could be considered as dynamic.

4.4.10 Government support to farmers

The Pradhan Mantri Kisan Samman Nidhi (PM KISAN) is a flagship programme of the central government involving direct money transfer to the farmers. The eligible farmers were entitled to three instalments of ₹2,000 each per year, making a total of ₹6,000 annually. Initially the programme was limited to farmers having a land holding size of less than two hectares, but the cap is now removed and all the farmers were eligible for the programme, provided they met the other requirements. The distribution of beneficiaries according to enrolment in PM KISAN programme is given in Table 4.42.

Table 4.42 Distribution of beneficiaries according to enrolment in PM KISAN programme

	Beneficiary	**Planning to enrol**	**Indifferent**	**Total**
Number of respondents	72 (72)	15 (15)	13 (13)	**100**

Note: Figures in parentheses indicate per cent to row total

When interviewed about the PM KISAN programme, all the respondents reported that they were aware about the programme and its benefits. Seventy-two per cent of the respondents reported that they have enrolled in the programme and received the entire amount in their bank account. Fifteen per cent of the respondents reported that they were planning to enrol in the programme and 13 per cent were indifferent towards it.

4.5 INDIVIDUAL RISK APPETITE AND ITS DETERMINANTS

The individual risk appetite of the sample respondents forms the basis for decisions they make regarding any economic activity. This risk taking capacity can influence his day to day activities, thereby affecting the welfare of the family. The individual risk appetite of the sample respondents was measured on a scale of five by employing two methods. The first method involved self-assessment questions and second method made use of the risk assessment game. The risk appetite of an individual is determined or influenced by an array of socio-economic characteristics and situations. This section describes about the individual risk appetite of the sample farmers as well as the socio-economic factors that influence the risk appetite of these respondents.

4.5.1 Socio-economic profile of the respondents

A clear understanding about the socio-economic profile of the respondents is essential to interpret the choices they make in farm and family matters. This is also a prerequisite in understanding the choices they make in the game employed to assess their risk appetite, as well as in their self-assessment of risk appetite. The following section describes the socio-economic status of the sample respondents on the basis of their age, sex, education, occupation, farming experience, family size, land holding size, and annual income. The social behaviour of the respondents was also analysed by considering their participation in various social groups and activities.

4.5.1.1 Age profile

The distribution of sample respondents according to their age profile is given in Table 4.43. It could be observed from the table that majority of the respondents were aged more than 50 years (75 per cent), with 36 per cent aged between 50 and 60 years and 33 per cent aged between 60 and 70 years. Twenty per cent of the respondents were between 40 to 50 years of age, followed by six and four per cent between 70 to 80 and 30 to 40 years of ages respectively. Only one respondent was found to be below 30 years. The result indicated that majority of the farming population in the district were middle aged or above, indicating lack of interest of youth in agriculture.

Table 4.43 Distribution of respondents based on age profile

	Age group						
	20-30	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**Total**
Number of respondents	1 (1)	4 (4)	20 (20)	36 (36)	33 (33)	6 (6)	**100**

Note: Figures in parentheses indicate per cent to row total

4.5.1.2 Gender

Table 4.44 shows the distribution of sample respondents based on gender. It could be observed that male farmers formed 97 per cent of the sample respondents. It could be inferred from this observation that most of the farmers in the district are male, but the fact that majority of the women in the households, if not all, do participate in agricultural activities shouldn't be overlooked.

Table 4.44 Distribution of respondents based on gender

Sex group	Number of respondents
Male	97 (97)
Female	3 (3)
Total	**100**

Note: Figures in parentheses indicate per cent to column total

4.5.1.3 Educational status

The details on the educational status of the sample respondents are presented in Table 4.45. Majority of the respondents (74 per cent) were found to have high school level education or above, with 35 per cent having high school level education, 21 per cent with higher secondary level education, 13 per cent with degree qualification and 5 per cent with a professional degree or post-graduation. Twenty per cent of the respondents had upper primary level education and six per cent had primary or below primary level education.

Table 4.45 Distribution of respondents based on educational status

Education (in no. of years)	Number of respondents
Primary (0-4)	6 (6)
Upper primary (4-8)	20 (20)
High school (8-10)	35 (35)
Higher secondary/ VHSE (10-12)	21 (21)
Degree (12-15)	13 (13)
Post-graduation/ Professional degree (15-20)	5 (5)
Total	**100**

Note: Figures in parentheses indicate per cent to column total

4.5.1.4 Occupational status

Table 4.46 shows the distribution of sample respondents based on their primary occupation. Agriculture was found to be the primary occupation of 92 per cent of the respondents. Five per cent of the respondents were pensioners who retired from government service and 2 per cent were daily wage labourers. One respondent was found to be self-employed, with a processing unit.

Table 4.46 Distribution of respondents based on occupation

	Occupation				
	Agriculture	**Daily wage labour**	**Pensioners**	**Self employed**	**Total**
Number of respondents	92 (92)	2 (2)	5 (5)	1 (1)	**100**

Note: Figures in parentheses indicate per cent to row total

4.5.1.5 Experience in farming

The distribution of respondents based on their farming experience is given in Table 4.47. It could be observed from the table that 32 per cent of respondents having farming experience between 30 to 40 years, followed by 26 per cent and 18 per cent of respondents with 20 to 30 years and 40 to 50 years of experiences respectively. Only five per cent of the respondents were having a farming experience of less than 10 years. Interestingly, two per cent of the respondents were having farming experience of more than 50 years. The finding that majority of farmers are having farming experience of more than 20 years could be understood from the age profile of the respondents discussed in the earlier section.

Table 4.47 Distribution of respondents based on farming experience

	Experience in farming (in years)						
	0-10	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**Total**
Number of respondents	5 (5)	17 (17)	26 (26)	32 (32)	18 (18)	2 (2)	**100**

Note: Figures in parentheses indicate per cent to row total

4.5.1.6 Family size

Table 4.48 gives the distribution of sample respondents based on their family size. It could be observed from the table that majority of the farmers (48 per cent) had families with four members, followed by five and three members in the families for 24 and 11 per cent of the farmers respectively. The families with more than five members accounted for 15 per cent of the total sample.

Table 4.48 Distribution of respondents based on family size

	Number of family members						
	2	**3**	**4**	**5**	**6**	**7**	**Total**
Number of respondents	2 (2)	11 (11)	48 (48)	24 (24)	10 (10)	5 (5)	**100**

Note: Figures in parentheses indicate per cent to row total

4.5.1.7 Land holding size

The size of the land holding directly determines the production and income of a farmer. Table 4.49 shows the distribution of sample respondents based on their land holding size. It could be observed that majority of the respondents were marginal farmers, with 60 per cent reporting a land holding size of less than one hectare. Twenty-three per cent of the respondents were small farmers and 14 per cent were semi-medium farmers. It was also found that two per cent and one per cent of the respondents were medium and large farmers respectively.

Table 4.49 Distribution of respondents based on land holding size

	Land holding size (in hectares)					
	Marginal (0-1 ha)	**Small (1-2 ha)**	**Semi-medium (2-4 ha)**	**Medium (4-10 ha)**	**Large (>10 ha)**	**Total**
Number of respondents	60 (60)	23 (23)	14 (14)	2 (2)	1 (1)	**100**

Note: Figures in parentheses indicate per cent to row total

It was found that 11 respondents also cultivated on leased-in land and all of them were banana farmers. The average size of leased-in land was 0.75 hectares and the average rent paid was ₹43,000 per hectare per year.

4.5.1.8 Annual income

The income forms a major determinant in the financial decisions of a farmer and influences his risk taking capability. Table 4.50 shows the distribution of sample respondents based on their annual income. It was observed that majority of the farmers were having low levels of income, with 53 per cent of respondents having an annual income of less than two lakh rupees, followed by 22 per cent reporting an annual income between two and four lakh rupees and 10 per cent reporting an annual income between four and six lakh rupees. It could also be observed that only eight per cent of the farmers were in the highest income category of above 10 lakh rupees.

Table 4.50 Distribution of respondents based on annual income

	Annual income (in lakhs)						
	0-2	**2-4**	**4-6**	**6-8**	**8-10**	**>10**	**Total**
Number of respondents	53 (53)	22 (22)	10 (10)	4 (4)	3 (3)	8 (8)	**100**

Note: Figures in parentheses indicate per cent to row total

4.5.1.9 Social behaviour

The distribution of sample respondents based on their social behaviour is given in Table 4.51. An important observation to be made here is that 75 per cent of the respondents were members of either a Self-Help Group (SHG) or Co-operative society, indicating a strong peer group interaction and coordination. Seventeen and 14 per cent of respondents were members of Non-Governmental Organisations (NGO) and Farmer Producer Companies (FPC) respectively. Even though majority of the sample farmers were middle aged or above, it was found that 40 per cent of the total respondents were members of agricultural groups in social media and 47 per cent were subscribers of agricultural magazines. The training programmes in agriculture were attended by 56 per cent of them and 44 per cent of the respondents were also members of a political party. All these findings suggested a strong and active social life of the farmers in the district.

Table 4.51 Distribution of respondents based on social behaviour

Social groups	Member
SHG/ Co-operative society	75 (75)
Non-Governmental Organisation	17 (17)
Farmer Producer Company	14 (14)
Agricultural group in social media	40 (40)
Agricultural magazine	47 (47)
Agricultural training programme	56 (56)
Political party	44 (44)

Note: Figures in parentheses indicate per cent to the total respondents

4.5.2 Evaluation of risk appetite of farmer respondents

Risk appetite of the sample respondents were measured using direct risk question and lottery game, following Holt and Laury (2002). Risk question involved asking the respondents to rank themselves on a scale of five according to their self-perceived risk taking nature and the lottery game involved the ones who ranked themselves choosing one among the five options presented to them. The risk question and the choices in the lottery game were so designed such that option one represents the most risk averse and option five represents the most risk loving attitude. Results of the self-assessment risk questions and the choices made in lottery games by the sample respondents are summarised in Table 4.52.

The results of the self-assessment gave useful insights on how the farmer respondents perceived themselves behaving in a risky scenario. However, this cannot be taken as their actual risk appetite as they were not actually confronted with any real risky option. On the basis of the self-assessment risk question, majority of the respondents assessed themselves as moderately risk taking, with 52 per cent respondents choosing option three. Eighteen per cent of the respondents ranked themselves as extremely risk taking by choosing option five, followed by 13 per cent choosing option four (risk taking). The respondents who viewed themselves as risk averse were lower in number, with 10 per cent choosing option two (risk averse) and seven per cent choosing option one (extremely risk averse). As a whole, it could be understood that majority of the farmers in the district view themselves as good risk takers.

Table 4.52 Results of risk question and lottery game

Chosen option	**Distribution of respondents**	
	Self-assessment	**Lottery game**
1- Extremely risk averse	7 (7)	35 (35)
2- Risk averse	10 (10)	8 (8)
3- Moderately risk taking	52 (52)	34 (34)
4- Risk taking	13 (13)	6 (6)
5- Extremely risk taking	18 (18)	17 (17)
Total	**100**	**100**

Note: Figures in parentheses indicate per cent to column total

The option that a farmer chooses in lottery game gives a more precise estimate of his actual risk appetite, since he is confronted with a real risky choice. The option that a farmer chooses in the game is a better proxy for his actual risk appetite than any self-assessment made by him. The results of lottery game showed that 35 per cent of the respondents were extremely risk averse, choosing option one. The moderately risk taking farmers (option three) accounted for 34 per cent of the total respondents and 17 per cent were found to be extremely risk taking (option five). Eight and six per cent respondents were in the risk averse (option two) and risk taking (option four) categories respectively. The results of the lottery game suggested that majority of the farmers in the district were risk averse in nature.

The results from the self-assessment question and lottery game were contradictory to one another. The risk question suggested that majority of the farmers in the district were risk takers, while majority of the farmers were risk averse on the basis of the lottery game. A chi-square test was performed to check whether the self-assessment of the respondents were significantly different from the elicited risk appetite. A chi-square value of 112.45 was obtained for the above data, while the critical value of chi-square for four degrees of freedom was 9.49 at five per cent level of significance. So it was concluded that the risk appetite of the respondents elicited through risk question and risk game were significantly different. This is an important finding from the policy stand point because it was found that even if the farmers thought of themselves to be risk taking, they were not so in practical situations. This showed that dissemination of any new technology or adoption of innovation required deliberate interventions on the part of the extension agencies.

A comparison between the self-assessed and elicited risk appetite of the respondents showed that only seven per cent of the farmers reported themselves to be extremely risk averse, but the actual number turned out to be five times higher. When 52 per cent of the respondents reported themselves to be in the middle of the scale, the actual figure was observed as 34 per cent. The number of respondents reporting themselves to be extremely risk takers were almost consistent with the actual figures (18 per cent and 17 per cent respectively). This was also the case of respondents reporting themselves as risk averse and those who actually turned out to be so (10 per cent and eight per cent respectively). Since the proportion of farmers who reported themselves as risk takers were fairly consistent with the actual figures, the comparison between the two suggested that the farmers who considered themselves as moderate risk takers, or in the middle of the scale, were actually avoiding the risk when presented with an actual risky choice.

4.5.3 Factors influencing risk appetite of farmers

The previous discussion suggested that the farmers in Wayanad district were not risk taking in nature. The risk appetite of a farmer is influenced by various socio-economic factors which may be beyond his control. In order to identify the factors influencing the risk appetite of famers, a multiple linear regression was carried out with the risk appetite of the respondents derived from the lottery game as the dependent variable and various socio-economic factors identified as the independent variables. A logistic regression estimation was also carried out to understand how these socio-economic variables affects the categorisation of a farmer as either risk taking or risk averse.

4.5.3.1 Multiple linear regression

A multiple linear regression was carried out to understand how the socio-economic characteristics of the respondents influenced their risk appetite. The socio-economic factors used in the regression were age, experience in farming, education, land holding size, net revenue from agriculture, and non-farm income. The results of the multiple regression are given in Table 4.53. The coefficient of multiple determination was found out to be 0.587 for the model, meaning that 58.7 per cent of variations in the dependent variable could be explained by the independent variables included in the model.

The results of the regression between the risk appetite and the factors influencing it showed that four out of the six independent variables employed were significantly influencing risk taking nature of farmers at various levels of significance. The education and land holding size were the two factors which were positively and significantly influencing the risk appetite of respondents at one per cent level of significance. Educated farmers were capable of better understanding a risky situation and could more efficiently analyse it to make decisions. They would be more open to changes and willing to venture into new activities or management practices if they were convinced about its benefits. Farmers with large sized land holdings could afford to experiment a new crop or activity in a portion of their field, without affecting the regular farm activities. They would also be in a constant lookout for better management practices that could reduce their expenses. Often, they also had sufficient financial background to take risks. This might be the reason for the large sized farm owners in having more risk appetite than others.

Table 4.53 Estimates of multiple regression on factors influencing risk appetite

Model summary			
Multiple R	0.693		
Coefficient of multiple determination (R^2)	0.587		
Adjusted R^2	0.351		
Estimates			
Independent variables	**Coefficient**	**Standard Error**	**t statistic**
Age (Years)	-0.009	0.022	-0.388
Experience in farming (Years)	0.032*	0.019	1.685
Education (Years)	0.162***	0.047	3.423
Land holding size (Hectares)	0.355***	0.129	2.752
Net revenue from agriculture (lakh ₹)	0.040	0.048	0.835
Non-farm income (lakh ₹)	0.125*	0.065	1.909
Constant	-0.304	1.123	-0.271

Note: 1. *** denotes significance at one per cent level
2. * denotes significance at 10 per cent level

The experience in farming and non-farm income were both found to be positively influencing the risk appetite of sample respondents at 10 per cent level of significance. Experienced farmers knew the crop management practices, climatic and soil conditions, and suitability of a new activity in the field better than the inexperienced farmers. Therefore, they were capable of making better decisions than their counterpart when presented with a risky situation. Farmers who were dependent on agriculture as a single source of revenue might not be ready to take risks, as their sole income source would get affected if anything goes wrong. When the farmers have additional income sources, they can afford to take risks, as income from other sources would offset the possible losses from a risky venture. This reason could be attributed for the farmers who have non-farm income to be more risk takers.

Even though age was found to have a negative influence on risk appetite, it was found to be non-significant. This suggested that the risk taking behaviour was not influenced by age and old farmers were as capable of taking risk as the young farmers, *ceteris paribus*. The net revenue from agriculture was also not found to be influencing the risk appetite of respondents, which suggested that the farmers who were making higher revenue from agriculture may not necessarily be higher risk takers. Summarising the findings, it could be concluded that education, size of land holding, experience in farming, and non-farm income were the key factors which influenced the risk appetite of a farmer.

4.5.3.2 Logistic regression

The multiple linear regression performed above gave an idea about how the socio-economic factors influencing the risk taking behaviour of a farmer. The dependent variable in the multiple regression was the risk appetite of respondents measured on a scale of one to five. In order to get a better understanding on the categorisation of farmers as risk averse or risk taking in nature, a binary logistic regression was performed. Respondents who chose option one and two were classified as risk averse and those who chose option four and five were classified as risk taking in nature. Respondents who chose option three were removed from the analysis as they could not be precisely included in either of the groups. The results of the logistic regression carried out are given in Table 4.54.

Nagelkerke R^2 value for the regression was found out to be 0.732. Even though the coefficient of multiple determination in linear regression and Nagelkerke R^2 value in logistic regression are not exactly the same and estimated by different methods, broadly their interpretation can be made in a similar fashion. Therefore, it can be said that 73.2 per cent variations in the dependent variable could be explained by the independent variables used in the model. The chi-square value for the model at six degrees of freedom was also found to be significant, which reassured that the model is a good fit. Also, the model was found to be correct in predicting 87.9 per cent of the cases, with 93 per cent accuracy in predicting risk averse farmers and 78.3 per cent accuracy in predicting risk taking farmers.

Table 4.54 Estimates of logistic regression on factors influencing farmer categorisation

Model summary			
Nagelkerke R^2	0.732		
Chi-square	49.998 (df= 6)	Significance value	0.00
Percentage correct	87.9% (93% for risk averse and 78.3% for risk takers)		

Estimates

Independent variables	Coefficient	Standard Error	Odds ratio	z value
Age (Years)	-0.142	0.099	0.868	2.067
Experience in farming (Years)	0.061	0.092	1.063	0.439
Education (Years)	0.172	0.257	1.188	0.451
Land holding size (Hectares)	2.163***	0.79	8.701	7.508
Net revenue from agriculture (lakh ₹)	0.765***	0.379	2.149	4.072
Non-farm income (lakh ₹)	1.150***	0.523	3.157	4.825
Constant	-1.677	4.409	0.187	0.145

***Significant at one per cent level

Table 4.54 shows that out of the six socio-economic factors used in the logistic regression, land holding size, net revenue from agriculture, and non-farm income were having significant positive effect in the categorisation of farmers as risk averse or risk taking at one per cent level of significance. The log odds of land holding size, net revenue from agriculture, and non-farm income were estimated as 2.163, 0.765, and 1.150 respectively for a farmer to be risk taking, *ceteris paribus*.

The odds ratio for land holding size was estimated to be 8.701, meaning that a unit increase in land holding size (one hectare) could increase the chances of a farmer being risk taking by 8.701 times, *ceteris paribus*. For net revenue from agriculture and non-farm income, the odds ratios were 2.149 and 3.157 respectively. These implied that an increase in net revenue from agriculture and non-farm income by one unit (one lakh) would increase the chances of a farmer being risk taking by 2.149 and 3.157 times respectively, *ceteris paribus*.

The net revenue from agriculture was not found to be a significant factor influencing the risk appetite of a farmer in the multiple regression analysis, but logistic regression suggested that it was a significant factor which positively influenced the risk taking behaviour. The reason for this ambiguity is that, by the removal of respondents who placed themselves in the middle of the scale in the lottery game, a better relationship could be established between risk taking nature and net revenue from agriculture. Majority of the respondents tend to be placing themselves in the middle of the scale, irrespective of their net revenue from agriculture, and therefore multiple regression could not establish a significant relationship between the two. The finding that farmers with greater net revenue from agriculture had greater chances of being risk takers was in agreement with the general assumption that farmers with greater income could afford taking risk, as the impact of a failure may not be so hard on them when compared to farmers with lower revenue from agriculture.

Summary and Conclusion

5. SUMMARY AND CONCLUSION

The present study entitled “Risk analysis of agricultural economy of Wayanad” was aimed at identifying and analysing the risks faced by the farmers in Wayanad district, along with the coping strategies adopted by them. The study also elicited the individual risk appetite of the respondents and the factors influencing the risk appetite. Risks and instabilities prevalent in the district at the macro-level were analysed using secondary data. The primary level data was collected from 100 representative households in the district

The performance of the agricultural economy of Wayanad was analysed using Compound Annual Growth Rates (CAGRs), decomposition approach, and growth accounting approach. The analyses were carried out for the period from 1981-82 to 2018-19, which were then divided into four sub-periods, such that each sub-period represents a decade. The estimates of the CAGRs in area under crops showed that acreage under arecanut increased during the whole period, while that of paddy decreased during the entire period. The area under coconut, rubber and tea declined in the last three decades, while that of black pepper, ginger, cashew, turmeric, and banana declined during the last couple of decades. The CAGRs in production showed positive trend for coconut during the entire period, while the production of mango was found to increase during the last three decades. The crops like arecanut, black pepper, banana and tea showed positive CAGRs during three of the four decades, , while coffee, paddy, cardamom and cashew showed negative CAGR during three fourth times. The CAGRs in productivity of crops showed a positive trend for coconut and paddy throughout the whole period, while the crops like coffee, arecanut and turmeric showed a declining trend in productivity.

The decomposition of sources of differences in the production of coffee, arecanut, rubber, coconut, black pepper and paddy were carried out to differentiate the effects of area, productivity and interaction of area and productivity. The effects of area, productivity and their interaction were found to be positively influencing the changes in production of coffee and coconut in the district. A positive productivity effect and negative area and interaction effects were observed for rubber and paddy. In the case of arecanut and black pepper, the area effect was positive, while productivity and interaction effects were negative.

The growth accounting approach was carried out to estimate the influence of area, productivity, and price in the changes in revenue from arecanut, rubber, coconut, and black pepper. The positive influence of area and price, along with negative influence of productivity were seen in the case of arecanut and black pepper. The influence of area and price were almost equal in the case of arecanut (49.7 and 55.4 per cent respectively), while price was showing predominant influence in the changes in revenue from black pepper (99.1 per cent). Positive influence of all the three components were seen in the case of coconut and rubber, with price having the major influence in both the crops (39.8 and 49.4 per cent respectively).

The risks and instabilities in the agricultural economy of Wayanad district were analysed using trend break studies, Just and Pope production and variance functions, Cuddy-Della Valle instability index, and chain index and link relatives. The Chow test for analysing the trend break in acreage under crops like coffee, arecanut, rubber, coconut, black pepper and paddy showed statistically significant trend breaks in all the crops. Coffee was the first crop to show a trend break, followed by paddy, black pepper, rubber, arecanut and coconut. The trend after the break in crops like arecanut, coconut, rubber and coffee were still positive. Paddy showed a lower rate of decline in acreage after the trend break, while black pepper showed a significant shift to downward trend following the break. The estimates of Chow test for trend break in production of these crops showed significant trend breaks in production of coffee, arecanut, rubber and black pepper, while the trend break in production of coconut and paddy were found to be insignificant. Except for coffee and coconut, all the other crops showed a shift to downward trend after the trend break.

The climate risk in Wayanad district was analysed using Just and Pope production and variance functions for coffee, arecanut, rubber, coconut and black pepper. The production functions showed that area exerted a highly significant and positive influence on the production of all crops. It was found that higher deviations from the average annual temperature resulted in a decline in production of coffee in the district. Also, standard deviation in average annual precipitation was found to negatively affect black pepper production in the district. This implies that higher rainfall over lesser number of days in an year can reduce the production of black pepper in Wayanad district. The average annual temperature was found to positively affect the production of coconut, while it negatively affected the production of rubber in the district. There were no significant influence of climatic parameters on the production of arecanut. The Just and Pope variance function did not show any significant influence of climatic parameters on the variance in production of these crops. Even though climatic parameters were found to influence the production of crops, they had no significant influence on their yield variability.

The instability in prices of major commodities were analysed using Cuddy-Della Valle instability index. The results showed that black pepper exhibited the highest instability in prices during all the four decades (1980s, 1990s, 2000s and 2010s). Except for second decade, rubber was showing the least instability in prices. Coconut and arecanut were showing similar trends in price instability, arecanut being on the lower side in all decades except the third sub-period. The results suggested the existence of moderate to high levels of instability in the prices of major crops in Wayanad district.

All the risks and constraints in the agriculture economy will be manifested in the income of the farmers in one way or the other. The instability in income from the primary sector of Wayanad district was analysed using chain index and link relatives. The chain index for the year 2018-19 was found out to be 276.22, indicating that the income from primary sector in Wayanad increased by 276.22 per cent in 2018-19 as compared to the initial year of the analysis (1982-83). The increase was the highest in 2004-05, where the income grew by 629.83 per cent as compared to the initial year. The link relatives showing the year to year changes in income were highly volatile, with a maximum of 193.6 per cent in 1984-85 and a minimum of 63.2 per cent in 2001-02. This suggested that the income from primary sector in Wayanad district was highly instable.

The crop diversification in Wayanad district was analysed using five different indices. The Herfindahl Index (H.I.) and Composite Entropy Index (C.E.I.) measured diversification by taking into account the number of crops and the area allocated for each crop, while Ogive Index (O.I.), Entropy Index (E.I.), and Modified Entropy Index

(M.E.I.) measured diversification as the deviance from equal allocation of area among the crops. The results from all five indices suggested that there were good levels of crop diversification in the district. Diversification was the lowest during 1983-84 (H.I.= 0.26, O.I.= 4.17, E.I.= 0.81, M.E.I.= 0.62 and C.E.I.= 0.59) and the highest during 2006-07 (H.I.= 0.17, O.I.= 2.34, E.I.= 0.96, M.E.I.= 0.74 and C.E.I.= 0.70). There has been a slight decline in crop diversification after 2006-07, but still the recent estimates in 2018-19 (H.I.= 0.22, O.I.= 3.34, E.I.= 0.91, M.E.I.= 0.70, and C.E.I.= 0.66) were reasonable enough to suggest good levels of crop diversification in the district.

In order to identify the risks encountered by the farm households, primary data was collected from all the four developmental blocks in the district. A total of 100 respondents were interviewed to get necessary information about the various risks encountered by them, risk coping strategies adopted, crops grown, other enterprises undertaken, and socio-economic characters. Farm level production risk was estimated for coffee, coconut and black pepper using a modified form of Just and Pope production and variance functions. Area was found positively influencing the production in all the three crops. The use of human labour and plant protection chemicals were found positively influencing the production of coffee, while the use of fertilizers had a positive impact in the production of black pepper. In case of coconut, the use of human labour and fertilizers were found positively influencing the production. The analysis of the variance function showed that increased acreage resulted in higher variance in production of all the three crops. Increased use of labour caused production risk in coffee and coconut, while the use of fertilizers increased yield variability in black pepper. The cost incurred in the use of machine labour was found to increase the variance in production for black pepper, while it decreased the yield variability in coffee.

Garret ranking technique was employed to identify the risks faced by the farmers during production and marketing process. Low price and price fluctuation of products was ranked as the major risk faced by the farmers. Climate change and natural calamity was ranked second, shortage of labour was ranked third, and water scarcity was ranked fourth. Incidence of pests and diseases was ranked last among the various risks. The respondents in Kalpetta block also reported the attack of wild animals as a threat to crop production in their fields. The farmers were then asked about the specific coping strategies that they adopted against these risks. It was found that storage, reducing consumption expenditure, pre-harvest agreements, crop diversification, reducing farming expenditure, sales through VFPCK, and value addition were practiced to cope with low price and price fluctuations. Irrigation, availing crop insurance, crop diversification, and reducing consumption expenditure were practiced to cope with climate change and natural calamity. Shortage of labour was managed by own and family labour, bringing labourers from other state, mechanisation, and pre-harvest agreements. Irrigation and crop diversification were practiced in response to water scarcity. Chemical control, organic control, and crop diversification were used against pests and disease incidences. Attack of wild animals were prevented by safekeeping during night and construction of fences around the fields.

Crop diversification was found to be a risk coping strategy adopted by the respondents against a number of risks. Crop diversification of the respondents were analysed using H.I., O.I., E.I., M.E.I., and C.E.I. to draw meaningful results. It was found that out of the 100 respondents, 15 per cent followed monocropping. Fifty-five per cent of the respondents were having moderate levels of crop diversification. More than 80 per cent of the farmers who cultivated either two, three, or four crops were found to moderately allocating equitable area among those crops. The crop diversification of the sample respondents were found to be moderate to good.

The enrolment in crop insurance scheme was found to be limited to banana farmers. Out of the 36 banana farmers, only 41.7 per cent were found to be the beneficiaries of crop insurance scheme. The reasons for lack of interest among farmers towards crop insurance scheme were identified as the exclusion of yield loss from insurance claims and the delay in claim settlements. Seventy-two per cent of the respondents were found to be the beneficiaries of PM KISAN programme, with 15 per cent planning to enrol in the coming year. Credit facilities were used for overcoming the money shortage by 81 per cent of the respondents. Co-operative banks were the most popular source of credit, with 39 per cent of the respondents borrowing from them. Only four per cent of the respondents were found to borrow money from money lenders and informal sources.

Income diversification was another way of coping with risk, by reducing the dependency on agriculture as the sole income source. It was found that 74 per cent of the respondents had an income source other than agriculture, in the form of on-farm, non-farm, and off-farm sources. Fifty per cent and 38 per cent of the respondents were found to adopt on-farm and off farm income diversification measures respectively. Dairy was the most popular among on-farm income diversification measure, while pensions, cash receipts from children, rent, and interest on deposits formed the major off-farm income source. The sale of assets were undertaken by the respondents as a distress way of coping up with risks. It was observed that 32 per cent of the respondents sold trees, 23 per cent sold animals, nine per cent sold land, and two per cent sold gold during the last five years.

The individual risk appetites of the respondents were elicited using risk questions and risk games. Risk question showed how respondents asses themselves as risk takers, while risk game would give an actual elicitation of their risk appetite. The results of the self-assessment showed that 52 per cent respondents assessed themselves to be moderate risk takers, followed by 18 per cent as extremely risk takers, 13 per cent as risk takers, 10 per cent as averse, and seven per cent as extremely risk averse. However, the actual elicitation of risk appetite by the risk game showed a contradictory result. Thirty-five per cent of the respondents were found to be extremely risk averse, 34 per cent to be moderate risk takers, 17 per cent to be extremely risk takers, eight per cent to be risk averse, and six per cent to be risk takers. The reason for this contradiction was that the respondents who assessed themselves as moderate risk takers in the risk question turned out to be extremely risk averse on actual elicitation.

The factors influencing the risk appetite of respondents were analysed using multiple regression and logistic regression. Socio-economic factors like age, experience in farming, education, land holding size, net revenue from agriculture, and non-farm income were used as independent variables in the analysis. The results of the multiple regression showed that experience in farming, education, land holding size, and non-farm income were significant and positively influenced the risk appetite of the respondents. The logistic regression was then carried out to identify the factors that could be used to classify a farmer as risk taker or risk averse. The results showed land holding size, net revenue from agriculture, and non-farm income as the significant positive factors influencing the classification of a farmer as risk taker or risk averse. A unit increase in land holding size (one hectare), net revenue from agriculture (one lakh), and non-farm income (one lakh) were found to increase the chances of a farmer being a risk taker by 8.7, 2.2, and 3.2 times respectively, ceteris paribus.

Policy suggestions

- District administration can devise a labour supply portal wherein the farmers can register their requirement for labourers at their respective Krishi Bhavans. The portal can act as a facilitating mechanism to channel the flow of labourers from other states to the registered farmers.
- Establishment of storage facilities for commodities like coffee, black pepper, rubber, and other plantation crops, along with issue of electronic receipts. This will help the farmers to store their products and get credit, if needed, against their products, rather than going for distress sales soon after harvest. The electronic receipts would help in easy linkage with credit and reduces the procedural formalities in sanctioning loans.
- Modifying the current crop insurance scheme to accommodate claim settlement for yield losses. Also, the claim settlement delay has to be minimised to attract more farmers into subscribing crop insurance.
- Implementation of dynamic price stabilisation mechanism or price deficiency payment for the major crops in the district. The government could set a threshold level of price for the commodities based on their annually revised cost of cultivation. When the market price falls below this threshold price, the shortfall amount should be compensated by the government.
- Establishing farmers' markets to help the farmers to move up the value chain of commodities. Also, collective marketing could help farmers in realising higher prices for their produces.
- Since the social circle of farmers were found to be dynamic in the district, promotion of income diversification measures through SHGs, NGOs, FPOs, or other similar groups could reduce the dependency of a farmer on agriculture as a sole livelihood source.

- Measures to provide quick assistance for farmers during natural calamities like floods, droughts, and heavy winds. Special protection measures have to be devised for farmers living in proximity to forest, where man-animal conflicts are high.

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Appendices

APPENDIX I

Sources of secondary data with the duration

Particulars	Period	Sources
Area, production, and productivity of crops in Wayanad district	1981-82 to 2018-19	Directorate of Economics and Statistics
Prices of black pepper, arecanut, coconut and rubber	1981-82 to 2018-19	Spices Board, Directorate of Arecanut and Spices Development, Coconut Development Board and Rubber Board
Income from primary sector in Wayanad district	1981-82 to 2018-19	Kerala State Planning Board
Daily rainfall in Wayanad district	1981-82 to 2018-19	Regional Agricultural Research Station, Ambalavayal
Daily temperature in Wayanad district	1981-82 to 2018-19	Srivastava, A. K., Rajeevan, M., and Kshirsagar, S. R. 2009. Development of a high resolution daily gridded temperature data set (1969-2005) for the Indian region. *Atmos. Sci. Let.* 10: 249-254

APPENDIX II

Interview schedule

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF HORTICULTURE, VELLANIKKARA, THRISSUR

Department of Agricultural Economics

Risk analysis of agricultural economy of Wayanad

Interview Schedule

Farmer No: **Block:**

Panchayat:

1. Name & address of farmer :

2. Phone number :

3. Age :

4. Experience in farming (Yrs.) :

5. Family details

Sl. No.	Education (Years)	Occupation	Annual income (lakh ₹)
1. Self		Primary- Secondary-	
2			
3			
4			
5			

6. Total operational holding

Area of Operational Holding (ha)	Wetland (acre)	Amount (₹/per acre)	Garden land (acre)	Amount (₹/per acre)
Owned (excluding leased out)				
Leased-in				
Leased-out				

7. Area, production and cost of cultivation of all crops

Sl. No.	Name of crop	Single/ Mixed	Area (Acre) (Specify No. for mixed)	Production (Specify unit)	Average price (Specify price/unit)	Gross expenditure (₹)				Gross revenue (₹)
						Labour	Machine	Fertilizers	Plant protection chemicals	
1										
2										
3										
4										
5										
6										
7										

8. Details of crop yield under normal and stressful conditions (2019-20)

Sl. No.	Crop	Normal Yield (expected)	Stress condition	Yield (Stress)	Yield reduction (%)
1					
2					
3					
4					
5					

Risk elicitation

9. Where will you rank yourself in the following scale based on your risk taking capacity?

Scale	Particulars	Chosen rank (tick the respective row)
1	Extremely risk averse	
2	Risk averse	
3	Moderately risk taking	
4	Risk taking	
5	Extremely risk taking	

10. Choose one, and only one, option from the following. A coin will be flipped after that and you will receive the lottery according to the option you chose and the outcome from the flip.

Options	Lottery		Chosen option (Tick the respective row)	Outcome
	Tail	Head		
1	Rs. 100	Rs. 100		
2	Rs. 75	Rs. 125		
3	Rs. 50	Rs. 150		
4	Rs. 25	Rs. 175		
5	Rs. 0	Rs. 200		

11. What are the major risks that you face in agricultural production?

Sl. No.	Source	Rank	Coping Mechanisms (AS per rank)
1			1. 3. 2. 4.
2			1. 3. 2. 4.
3			1. 3. 2. 4.
4			1. 3. 2. 4.
5			1. 3. 2. 4.
6			1. 4. 2. 5.
7			1. 4. 2. 5.

12. Do you have insurance coverage for any crops? YES/ NO If YES;

SL No.	Crop	Area under coverage (Acre)	Total premium paid (₹)	Insured amount (₹)
1				
2				
3				

13. On-farm income diversification measures

Sl. No.	Source	Gross expenditure (₹)	Gross income (₹)
1	Dairy		
2	Poultry		
3	Fish farming		
4	Apiculture		
5	Piggery		
6			

14. Non-farm income diversification measures

Sl. No.	Source	Gross expenditure (₹)	Gross income (₹)
1	Nursery		
2	Shop/business/contract works		
3	Daily wage labour (off-farm)		
4			

15. Details of other transactions in past 5 years

Sl. No.	Transaction	Year	Quantity	Amount (₹)
1	Selling of land			
2	Any other property			
3	Buying of any property			
4	Cutting down of trees/selling			
5	Selling of Animals			
6	Any other			

16. Social behaviour of farmer

Sl. No.	**Organization/ Group**	**Yes/No**
1	Panchayat or local administration	
2	SHG/ Co-operatives	
3	NGO	
4	FPO	
5	Agri groups in Social Media	
6	Farm publications	
7	KB, SAU or KVK training programs	
8	Political party	

17. Are you a beneficiary of PM KISAN scheme? YES/ NO

18. Details of credit:

Have you availed any credit? Yes / No (Specify year also)

Sl. No.	**Sources of Finance**	**Year**	**Loan Amount (₹)**	
			Taken	**Outstanding**
1	Nationalized bank			
2	Co-operative bank			
3	Gold Loan			
4	Money lender			
5	Friends & relatives			
6	Others			
7				
8				

APPENDIX III

Climate data of Wayanad district

Year	Mean temperature (ºC)	S.D of temperature (ºC)	Precipitation (mm)	S.D of Precipitation (mm)
1983	24.165	1.858	1781.6	158.576
1984	23.632	1.623	2251.6	189.852
1985	23.895	1.621	1728.3	153.755
1986	24.202	1.746	1818.6	129.007
1987	24.453	1.578	1426.5	100.724
1988	24.155	1.643	1985.7	164.830
1989	23.862	1.508	1822.6	169.805
1990	23.829	1.502	1681.4	136.350
1991	24.094	1.771	1986.4	143.399
1992	23.859	1.695	2318.2	196.040
1993	23.957	1.715	2133.2	154.697
1994	23.926	1.514	2690.8	244.396
1995	23.937	1.459	2317.6	164.650
1996	23.693	1.593	1982.4	164.870
1997	24.194	1.357	2151.4	151.110
1998	24.479	1.830	1728.5	149.228
1999	23.949	1.414	1558.8	143.702
2000	23.901	1.435	1743.8	127.561
2001	24.054	1.501	1446.1	94.986
2002	24.196	1.525	1108.5	88.633
2003	24.631	1.671	1520.6	108.330
2004	24.096	1.493	1899.8	132.762
2005	24.108	1.540	2168.2	186.699
2006	24.039	1.499	2047.8	132.690
2007	23.919	1.688	2023.2	184.600
2008	23.823	1.297	1731.0	135.212
2009	24.158	1.494	2077.4	231.878
2010	24.348	1.719	1851.8	135.407
2011	23.869	1.349	2069.4	158.694
2012	24.211	1.515	1320.8	97.502
2013	24.161	1.644	2247.4	217.137
2014	24.421	1.483	2151.0	195.868
2015	24.455	1.267	1689.9	127.424
2016	24.850	1.848	1229.8	114.631
2017	24.647	1.556	1780.6	118.683
2018	24.296	1.376	3093.0	282.970
2019	23.350	1.707	2654.0	247.526

APPENDIX IV

Herfindahl Index and land holding size of sample respondents

Sl. No.	Herfindahl Index	Total area (Ha)	Sl. No.	Herfindahl Index	Total area (Ha)
1	0.446	1.376	39	0.375	0.808
2	0.500	0.566	40	0.401	0.384
3	1.000	0.202	41	0.401	0.384
4	0.457	1.538	42	0.360	4.045
5	0.507	1.738	43	0.506	0.728
6	0.248	7.689	44	0.334	0.44
7	0.500	1.822	45	1.000	0.404
8	1.000	0.607	46	0.500	0.404
9	0.500	0.566	47	1.000	0.404
10	0.500	0.81	48	0.500	0.808
11	0.342	1.538	49	0.460	2.831
12	0.375	0.809	50	0.352	0.727
13	1.000	0.81	51	0.595	8.092
14	0.500	1.012	52	0.625	1.618
15	0.625	0.404	53	0.360	2.022
16	0.372	1.113	54	0.361	2.63
17	0.278	0.606	55	0.406	4.768
18	1.000	1.214	56	0.365	2.325
19	0.500	0.404	57	0.366	2.184
20	1.000	0.303	58	0.413	0.607
21	0.359	1.015	59	0.440	2.022
22	0.556	0.303	60	0.571	0.445
23	0.520	1.012	61	0.680	1.011
24	0.335	1.659	62	0.365	2.325
25	0.520	1.011	63	0.413	0.607
26	0.517	0.991	64	1.000	0.404
27	1.000	0.202	65	1.000	1.012
28	0.207	1.1	66	0.406	4.768
29	0.260	1.01	67	0.680	1.011
30	0.265	0.707	68	0.365	2.325
31	0.309	0.909	69	0.893	2.144
32	0.500	0.808	70	1.000	0.243
33	1.000	0.404	71	0.356	0.444
34	0.500	0.404	72	0.500	0.808
35	0.446	1.376	73	0.755	1.416
36	0.507	1.738	74	0.347	0.485
37	0.457	1.538	75	0.352	0.946
38	0.517	0.991	76	0.500	0.364

x

77	0.335	1.659
78	0.207	1.1
79	0.500	0.808
80	1.000	0.808
81	0.388	2.832
82	0.236	4.855
83	0.500	0.808
84	0.220	2.021
85	0.301	0.929
86	0.301	0.929
87	0.413	0.785
88	1.000	0.101

89	0.893	2.144
90	0.375	1.617
91	0.507	1.738
92	0.500	0.566
93	0.375	0.809
94	0.520	1.012
95	0.520	1.011
96	0.893	2.144
97	1.000	0.243
98	0.356	0.444
99	0.500	0.808
100	0.755	1.416

APPENDIX V

Ogive Index and the number of crops grown by sample respondents

Sl. No	Ogive Index	Number of crops	Sl. No	Ogive Index	Number of crops
1	0.338	3	39	0.125	3
2	0.000	2	40	0.204	3
3	0.000	1	41	0.204	3
4	0.371	3	42	0.441	4
5	0.014	2	43	0.012	2
6	0.734	7	44	0.001	3
7	0.000	2	45	0.000	1
8	0.000	1	46	0.000	2
9	0.000	2	47	0.000	1
10	0.000	2	48	0.000	2
11	0.026	3	49	0.838	4
12	0.126	3	50	0.055	3
13	0.000	1	51	0.785	3
14	0.000	2	52	0.251	2
15	0.25	2	53	0.080	3
16	0.116	3	54	0.083	3
17	0.111	4	55	1.028	5
18	0.000	1	56	0.095	3
19	0.000	2	57	0.829	5
20	0.000	1	58	0.240	3
21	0.078	3	59	0.321	3
22	0.111	2	60	0.714	3
23	0.040	2	61	0.360	2
24	0.006	3	62	0.095	3
25	0.040	2	63	0.240	3
26	0.034	2	64	0.000	1
27	0.000	1	65	0.000	1
28	0.033	5	66	1.028	5
29	0.04	4	67	0.360	2
30	0.061	4	68	0.095	3
31	0.235	4	69	0.787	2
32	0.000	2	70	0.000	1
33	0.000	1	71	0.067	3
34	0.000	2	72	0.000	2
35	0.338	3	73	0.511	2
36	0.014	2	74	0.042	3
37	0.371	3	75	0.759	5
38	0.034	2	76	0.000	2

77	0.006	3	89	0.787	2
78	0.033	5	90	0.125	3
79	0.000	2	91	0.014	2
80	0.000	1	92	0.000	2
81	0.164	3	93	0.126	3
82	0.181	5	94	0.040	2
83	0.000	2	95	0.040	2
84	0.100	5	96	0.787	2
85	0.203	4	97	0.000	1
86	0.203	4	98	0.067	3
87	0.238	3	99	0.000	2
88	0.000	1	100	0.511	2

APPENDIX VI

Entropy Index and its upper boundary for the sample respondents

Sl. No	Entropy Index	Upper boundary	Sl. No	Entropy Index	Upper boundary
1	0.401343	0.477121	39	0.451545	0.477121
2	0.301030	0.301030	40	0.431719	0.477121
3	0.000000	0.000000	41	0.431719	0.477121
4	0.372250	0.477121	42	0.507233	0.602060
5	0.298031	0.301030	43	0.298402	0.301030
6	0.711333	0.845098	44	0.476895	0.477121
7	0.301030	0.301030	45	0.000000	0.000000
8	0.000000	0.000000	46	0.301030	0.301030
9	0.301030	0.301030	47	0.000000	0.000000
10	0.301030	0.301030	48	0.301030	0.301030
11	0.471317	0.477121	49	0.446408	0.602060
12	0.451359	0.477121	50	0.465614	0.477121
13	0.000000	0.000000	51	0.317178	0.477121
14	0.301030	0.301030	52	0.244071	0.301030
15	0.244219	0.301030	53	0.458086	0.477121
16	0.449909	0.477121	54	0.459436	0.477121
17	0.577465	0.602060	55	0.509788	0.698970
18	0.000000	0.000000	56	0.457560	0.477121
19	0.301030	0.301030	57	0.552383	0.698970
20	0.000000	0.000000	58	0.421270	0.477121
21	0.458734	0.477121	59	0.412508	0.477121
22	0.276435	0.301030	60	0.329065	0.477121
23	0.292320	0.301030	61	0.217203	0.301030
24	0.475882	0.477121	62	0.457560	0.477121
25	0.292215	0.301030	63	0.421270	0.477121
26	0.293583	0.301030	64	0.000000	0.000000
27	0.000000	0.000000	65	0.000000	0.000000
28	0.692338	0.698970	66	0.509788	0.698970
29	0.593315	0.602060	67	0.217203	0.301030
30	0.587072	0.602060	68	0.457560	0.477121
31	0.552869	0.602060	69	0.094263	0.301030
32	0.301030	0.301030	70	0.000000	0.000000
33	0.000000	0.000000	71	0.463340	0.477121
34	0.301030	0.301030	72	0.301030	0.301030
35	0.401343	0.477121	73	0.177954	0.301030
36	0.298031	0.301030	74	0.467928	0.477121
37	0.372250	0.477121	75	0.554761	0.698970
38	0.293583	0.301030	76	0.301030	0.301030

77	0.475882	0.477121
78	0.692338	0.698970
79	0.301030	0.301030
80	0.000000	0.000000
81	0.436041	0.477121
82	0.658846	0.698970
83	0.301030	0.301030
84	0.676170	0.698970
85	0.560742	0.602060
86	0.560742	0.602060
87	0.414165	0.477121
88	0.000000	0.000000

89	0.094263	0.301030
90	0.451452	0.477121
91	0.298031	0.301030
92	0.301030	0.301030
93	0.451359	0.477121
94	0.292320	0.301030
95	0.292215	0.301030
96	0.094263	0.301030
97	0.000000	0.000000
98	0.463340	0.477121
99	0.301030	0.301030
100	0.177954	0.301030

APPENDIX VII

Modified Entropy Index and the number of crops grown by sample respondents

Sl. No.	Modified Entropy Index	Number of crops	Sl. No.	Modified Entropy Index	Number of crops
1	0.84118	3	39	0.94639	3
2	1.00000	2	40	0.90484	3
3	0.00000	1	41	0.90484	3
4	0.78020	3	42	0.84250	4
5	0.99004	2	43	0.99127	2
6	0.84172	7	44	0.99953	3
7	1.00000	2	45	0.00000	1
8	0.00000	1	46	1.00000	2
9	1.00000	2	47	0.00000	1
10	1.00000	2	48	1.00000	2
11	0.98783	3	49	0.74147	4
12	0.94600	3	50	0.97588	3
13	0.00000	1	51	0.66477	3
14	1.00000	2	52	0.81079	2
15	0.81128	2	53	0.96010	3
16	0.94297	3	54	0.96293	3
17	0.95915	4	55	0.72934	5
18	0.00000	1	56	0.95900	3
19	1.00000	2	57	0.79028	5
20	0.00000	1	58	0.88294	3
21	0.96146	3	59	0.86458	3
22	0.91830	2	60	0.68969	3
23	0.97107	2	61	0.72153	2
24	0.99740	3	62	0.95900	3
25	0.97072	2	63	0.88294	3
26	0.97526	2	64	0.00000	1
27	0.00000	1	65	0.00000	1
28	0.99051	5	66	0.72934	5
29	0.98548	4	67	0.72153	2
30	0.97511	4	68	0.95900	3
31	0.91830	4	69	0.31313	2
32	1.00000	2	70	0.00000	1
33	0.00000	1	71	0.97112	3
34	1.00000	2	72	1.00000	2
35	0.84118	3	73	0.59115	2
36	0.99004	2	74	0.98073	3
37	0.78020	3	75	0.79368	5
38	0.97526	2	76	1.00000	2

77	0.99740	3
78	0.99051	5
79	1.00000	2
80	0.00000	1
81	0.91390	3
82	0.94260	5
83	1.00000	2
84	0.96738	5
85	0.93137	4
86	0.93137	4
87	0.86805	3
88	0.00000	1

89	0.31313	2
90	0.94620	3
91	0.99004	2
92	1.00000	2
93	0.94600	3
94	0.97107	2
95	0.97072	2
96	0.31313	2
97	0.00000	1
98	0.97112	3
99	1.00000	2
100	0.59115	2

APPENDIX VIII

Composite Entropy Index and land holding size of sample respondents

Sl. No	Composite Entropy Index	Total area (Ha)	Sl. No	Composite Entropy Index	Total area (Ha)
1	0.560784	1.376	40	0.63093	0.808
2	0.5	0.566	41	0.603227	0.384
3	0	0.202	42	0.603227	0.384
4	0.520133	1.538	43	0.631872	4.045
5	0.495019	1.738	44	0.495636	0.728
6	0.721472	7.689	45	0.666351	0.44
7	0.5	1.822	46	0	0.404
8	0	0.607	47	0.5	0.404
9	0.5	0.566	48	0	0.404
10	0.5	0.81	49	0.5	0.808
11	0.658557	1.538	50	0.5561	2.831
12	0.630669	0.809	51	0.650587	0.727
13	0	0.81	52	0.443183	8.092
14	0.5	1.012	53	0.405394	1.618
15	0.405639	0.404	54	0.64007	2.022
16	0.628644	1.113	55	0.641955	2.63
17	0.719361	0.606	56	0.583473	4.768
18	0	1.214	57	0.639335	2.325
19	0.5	0.404	58	0.632225	2.184
20	0	0.303	59	0.588627	0.607
21	0.640975	1.015	60	0.576385	2.022
22	0.459148	0.303	61	0.459792	0.445
23	0.485533	1.012	62	0.360766	1.011
24	0.664935	1.659	63	0.639335	2.325
25	0.485359	1.011	64	0.588627	0.607
26	0.48763	0.991	65	0	0.404
27	0	0.202	66	0	1.012
28	0.792409	1.1	67	0.583473	4.768
29	0.739106	1.01	68	0.360766	1.011
30	0.73133	0.707	69	0.639335	2.325
31	0.688722	0.909	70	0.156567	2.144
32	0.5	0.808	71	0	0.243
33	0	0.404	72	0.647411	0.444
34	0.5	0.404	73	0.5	0.808
35	0.560784	1.376	74	0.295575	1.416
36	0.495019	1.738	75	0.653822	0.485
37	0.520133	1.538	76	0.634946	0.946
38	0.48763	0.991	77	0.5	0.364
39	0.664935	1.659	78	0.156567	2.144

79	0.792409	1.1
80	0.5	0.808
81	0	0.808
82	0.609266	2.832
83	0.754077	4.855
84	0.5	0.808
85	0.773904	2.021
86	0.69853	0.929
87	0.69853	0.929
88	0.5787	0.785
89	0	0.101

90	0.6308	1.617
91	0.495019	1.738
92	0.5	0.566
93	0.630669	0.809
94	0.485533	1.012
95	0.485359	1.011
96	0.156567	2.144
97	0	0.243
98	0.647411	0.444
99	0.5	0.808
100	0.295575	1.416

RISK ANALYSIS OF AGRICULTURAL ECONOMY OF WAYANAD

By

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ABSTRACT OF THE THESIS

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ABSTRACT

Risk is inevitable in agriculture as the farmers have very limited control over the production and marketing process. The uncertainties in weather, yield, prices, and government policies cause wide variations in farm income. Agrarian crises were prevalent in Wayanad district due to fall in prices of commodities, indebtedness, flood, drought, and instabilities in income. The present study estimated the agricultural risks in Wayanad district, identified the sources of risks and risk preferences of farmers, and assessed the types and determinants of coping mechanisms in the farm households of Wayanad. The study was based on both primary and secondary data. The primary data was collected from 100 respondents across four blocks in the district selected by the proportionate random sampling method, using a pretested interview schedule.

There has been an increase in the Compound Annual Growth Rate (CAGR) of area and production of coffee, arecanut, rubber and coconut from 1981-82 to 2018-19. The decomposition analysis of production of crops showed positive effects of area in coffee, arecanut, coconut and black pepper. The productivity effect was found to be positive for coffee, rubber, coconut and paddy during the same period. Growth accounting analysis showed positive influence of prices on the growth in revenue from arecanut, rubber, coconut and black pepper.

The analysis of trend breaks in area and production of crops carried out using Chow test showed significant trend break in area for coffee, arecanut, rubber, coconut, black pepper and paddy. Except for coconut and paddy, a significant trend break was also observed in the production of other crops. The estimation of climatic risks using Just and Pope production and risk functions showed that standard deviation in temperature and standard deviation in rainfall negatively influenced the production of coffee and black pepper respectively. The mean annual temperature was found to increase the production of coconut, while decrease the production of rubber. None of the climatic factors were found to influence significantly the variability in yield of any of the crops. The analysis of price instability using Cuddy-Della Valle index showed highest instability in prices for black pepper, followed by coconut, arecanut and rubber.

The analysis of instability in income from the primary sector of Wayanad for the period from 1982-83 to 2018-19 using chain index and link relatives showed high income fluctuations. Compared to 1982-83, the income grew by 630 per cent in 2004-05, which then decreased to 276 per cent in 2018-19. The district was found to have very high levels of crop diversification (Herfindahl index < 0.33) during all the years from 1981-82 to 2018-19.

The production risks in Wayanad were identified using primary data by employing Just and Pope production and risk functions. Along with area, the other factors accounting for significant variability in production were identified as cost of human and machine labour for coffee, cost of machine labour and fertilizers for black pepper, and cost of human labour for coconut. Crop loss was found to be the highest in black pepper, both in terms of quantity (50 per cent) and number of respondents facing the loss (43 per cent). Using Garret ranking technique, low price and price fluctuation of products was identified as the major risk, followed by climate change and natural calamity, and shortage of labourers. The major risk coping strategies adopted by the respondents were identified as storage of produce, irrigation, employing family labour, and chemical control of pests and diseases. Other risk coping strategies were subscription of crop insurance, crop diversification (63 per cent respondents having Herfindahl index less than 0.5), income diversification, availing credit, and sale of assets. It was also found that 72 per cent of the respondents were beneficiaries of PM-KISAN programme implemented by Government of India.

The risk appetites of respondents were elicited using risk question and risk game. When majority of the respondents (52 per cent) assessed themselves to be moderately risk taking, risk game showed majority of them (35 per cent) to be extremely risk averse. The significant factors influencing the risk appetite of respondents were analysed using different regression models. Multiple regression showed factors like experience in farming, education, land holding size, and net revenue from agriculture to be significantly influencing the risk appetite. Logistic regression identified factors like land holding size, net revenue from agriculture, and non-farm income to be significantly influencing the classification of respondents as risk averse or risk takers.